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ABSTRACT

The following papers are included in these proceedings: "Weaving Technology and Human Affairs" (B. Hazeltine); "Positivist and Constructivist Understandings about Science and Their Implications for STS Teaching and Learning" (B. Reeves; C. Ney); "A Modular Conceptual Framework for Technology and Work" (D. Blandow); "A Time of Uncertainty: The Impact of the Open-ended Time Frame on Biomedical Ethics" (P. di Virgilo); "Frozen Rhetoric? Public Impact on the Ice-minus Field Trials" (S. Hagedorn); "Beyond the Right to Die: Reality Versus Abstract Issues" (R. Mellican); "Technology Adoption and Sub-Sahara African Agriculture: the Sustainable Development Option" (B. Durosomo); "Environmental Commodification and the Industrialization of Native American Lands" (J. Byrne, S. Hoffman; C. Martinez); "A Structural Approach to the Environmental Crisis: Energy, Environment, and Underdevelopment" (K. Ham; R. Wykoff); "After Eve: Various Women's Approaches to Religion, Values, and Science" (M. Hunt); "A Meditation on Fate and Destiny in a Technological Age" (B. Waters); "Developing Intellectual Processes through Technology Education" (S. Johnson); "Problem Solving in Science, Technology, and Society Education within a Middle-Level Science Curriculum" (W. Peruzzi; D. Cheek); "Robotics: STS Curriculum Strands Integrated with Language Arts and Social Studies for Middle/Secondary Students" (A. Stomfay-Stitz); "Science Fairs for Young Children?" (B. Hauser); "Ten Years Later: Have Opinions about the Environment Changed? A Survey of High School Students 1980 and 1990" (J. Barr); "Research, Innovation, and Project Work for Students and Teachers in Secondary Schools in Slovenia" (S. Zakrajsek); "Coupling Teacher Inservice and Student Science Training Programs" (J. Tashiro; D. Elbert-May; P. Rowland); "A National Comparative Analysis of Minority Pre-Service Teachers in Mathematics and Science" (J. Bazler; M. Gonzalez); "Looking at the Earth in New Ways" (M. Passow; D. Kitzmiller; M. Krohn); "Project 2061: A Working Model" (J. Bazler; M. Charles); "Science, Technology, and Political Choice: Part of the Undergraduate Curriculum" (M. Sage); "Identity and Commitment: Information, Rhetoric, and the Recruitment and Retention of Female Engineering Students" (J. Croissant); "Ethics in the Engineering Curriculum" (M. Alfano); "Using Concepts of Technology to Enhance a Writing Assignment" (J. Renzelman); and "Natural Resource Management for 'Autonomy': Lessons on 'Community' through Environmental Education Simulations" (J. Hamilton' G. Vahoviak). The conference program also is included. (DB)

PROCEEDINGS OF

THE SEVENTH ANNUAL

TECHNOLOGICAL LITERACY CONFERENCE

Alexandria, VA

February 6-9, 1992

Edited by

Dennis Cheek

with a foreword by

Robert E. Yager

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Acknowledgements

NASTS is indebted to Dennis Cheek who for the third year has edited this volume which represents the proceedings for the Technological Literacy Conference VII. His dedication to this task and his efficiency and scholarship is commendable. All NASTS members as well as other STS enthusiasts gratefully acknowledge Dr. Cheek's significant contribution.

NASTS members are appreciative of the 56 conference participants who prepared a formal report of their presentations at the conference sessions and thereby make a significant contribution to the growing STS literature base.

The conference included 141 sessions where a total of 346 members were involved in making the 1991 conference so successful. Although a record for all sessions and presenters is not included in these Proceedings, all who contributed to the conference deserve thanks and acknowledgement for their contributions and involvement. The 1991 conference was indeed rich for sharing STS ideas and materials!

Robert E. Yager
Program Chair for TLC VII
NASTS President, 1992-93

The STS Movement - 1992

Science/Technology/Society (STS) began as a movement in the U.S. at the K-12 levels over ten years ago as Norris Harms used it as one of the focus areas for his NSF-supported Project Synthesis (1977). Certainly there has been STS enthusiasts in schools and colleges for over 50 years. However, it took Project Synthesis, a major effort to define the status of science education and needed new directions in the U.S., to initiate a national STS initiative. To be sure STS was identified as a movement in several European countries, especially in the U.K., some years earlier.

The National Science Teachers Association (NSTA) identified STS as a new direction for school science in both its Position Statements for the 80s and again for the 90s. STS is also a special effort as a part of the National Council for the Social Studies. The American Chemical Society moved into STS with its *ChemCom* project--the first major move to STS in the U.S. within a discipline format.

Two major grants to Penn State University (under the direction of Rustum Roy, Even Pugh Professor of the Solid State) introduced STS as a national effort and a reform. It was this funding that made the annual Technological Literacy Conferences a reality--now seven consecutive years. One of the NSF grants was a Network Project which established contacts with state Departments of Education and helped identify and prepare STS leaders in all 50 states.

Any reform effort like STS can not be realized instantly--if it is to be a real reform. Hence, it is not surprising that the full potential of the National Association for Science, Technology and Society (NASTS) and the Technological Literacy Conferences have not achieved all that was initially envisioned. Nonetheless, the grass roots effort is impressive and many accomplishments can be cited. Certainly the growing number of sessions and contributors to the annual STS conference is noteworthy.

STS has many enthusiasts--and from a variety of sources (disciplines) and academic levels. STS is basic to science, the social sciences, the humanities, engineering--indeed--the total school and college curriculum. Many see STS as the connector for a fragmented educational system.

Some see STS primarily from a curriculum perspective. To such persons STS is represented by instructional materials. Unfortunately if this is the only perspective, there is great danger that the same modes of instruction will be used to deal with new materials/topics. Others see STS to coincide with constructivist ideas of learning and hence with teacher behaviors (instructional strategies). As teachers change in terms of their goals, obviously the materials they use will change too. However, the materials are but a vehicle to accomplish new goals--goals more related to human learning and a definition of what scientific/technological literacy entails.

Most agree that there are societal problems and problems centering upon the education enterprise. STS is a movement that focuses upon current societal problems and education as a vehicle of society to prepare young people and adults to deal more effectively with the resolution of these problems. The STS movement is likely to succeed as educational reform if it is viewed in the broadest terms. As such it provides a context for teaching and learning that is missing in most classrooms, K-16.

The most significant research affecting scientific/technological literacy is that now commonly called cognitive science which also coincides with the centuries old research/philosophy called constructivism. Research in these fields seems clear: Information amassed by academics can not be transmitted directly to learners via written and/or spoken word. All humans learn by constructing their own meaning. And, this is often contrary to the meaning most teachers try to transmit.

STS is an effort to promote real learning--learning that is consistent to the ideas and procedures held and practiced by academics in various disciplines. The context for STS is real world issues and problems where learners see the important concepts and processes as useful (essential?) for dealing with such problems.

The Proceedings of the annual STS Conference stand as a record of our current thinking and concerns as we endeavor to resolve our problems and to correct past actions that have detiorated our planet and quality of life.

Robert E. Yager
Program Chair for TLC VII
NASTS President, 1992-93

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ISSUES

IN

SCIENCE, TECHNOLOGY AND SOCIETY

General Considerations

WEAVING TECHNOLOGY AND HUMAN AFFAIRS

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OVERVIEW

The Weaver, a periodical dealing with technological literacy, was published from 1982 until 1991 by the Council for the Understanding of Technology in Human Affairs (CUTHA). Its full title was The Weaver of Information and Perspectives on Technological Literacy. This report gives its history and objectives and describe its contents. The report then looks at how that content changed, as the content of the periodical may reflect what was actually happening in the teaching of technological literacy. In 1984 we surveyed our readers, seeking to learn their perceived needs and the results of that survey are summarized below. Some themes reoccur in articles. These themes may also give insight into what was happening and they are discussed. I will attempt to give some conclusions about technological literacy education. Finally, a brief history of CUTHA is included.

HISTORY AND OBJECTIVES

The Weaver was first published in the fall of 1982. The first editor was Ms. Edith Ruina, who also served as Program Coordinator for CUTHA. Our editorial policy and tone were set, to a great degree, by Ms. Ruina who was very successful at attracting authors with significant things to write. The successes of the Weaver are due in large measure to the insight and resourcefulness of Edith Ruina. While Ms. Ruina was editor we had an office on the MIT campus. In the spring of 1987 Dr. Stephen Cutcliffe of the Technology Studies Resource Center at Lehigh University took over general editorial responsibility for the Weaver with members of the editorial committee serving as guest editors for particular issues. The present author served as Chair of the Editorial Committee during the life of the Weaver.

Our intention had been to publish two issues a year. We, in fact, published fifteen issues over the ten years. Issues ranged from eight to sixteen pages. We chose a heavy paper and tabloid format to make the periodical distinctive and credible. Our final mailing list contained 5025 names. Some of these names were undoubtedly duplicated, but copies were also distributed to people not on the mailing list — to save postage.

We were funded in large part by the Alfred P. Sloan Foundation through the New Liberal Arts Program, and we are grateful to the Sloan Foundation for their support. CUTHA received funds from the educational foundations of Alcoa, General Electric, Gulf Oil, Westinghouse, from the C. W. Bendum Foundation and the Falk Medical Fund. We are also grateful to these foundations for their support. The Weaver was always distributed at no charge.

Our first several issues had statements about objectives: "to capture the imagination and commitment of people from many disciplines at varied institutions who recognize the importance of technological literacy", (Ruina, Vol 1, No 1), "to write about experiments in progress and about technological matters that might aid educators" (Ruina, Vol 2, No 1), to "provide information that faculty members will find useful in their own teaching" (Truxal, Vol 1, No 2) . We were concerned that the field, teaching technology to liberal arts students, was considered not quite substantial so an objective was to indicate its significance, present and future. Our objectives differed from STS type publications because we wanted to focus on technology itself, not on the relationship between technology and other disciplines. We decided also that computer science was outside our sphere of interest.

I should explain why we are no longer publishing. By the spring of 1990 both the CUTHA board and the Weaver editorial committee decided that we had accomplished, as well as we could, our goals. (The history of CUTHA is reviewed at the end of this paper.) The editorial committee noted that other publications were disseminating effectively information about courses and programs. We noted that courses and programs were present on many campuses and were thought about on campuses that did not yet have programs—the idea of technological literacy seemed accepted. The

Sloan New Liberal Arts program had made available much teaching materials and information to assist both people preparing courses and those deciding if such courses should be offered. Also, our funding was running out so, rather than seek new funding, we decided, as described by a committee member, to follow the example of William Bennett—declare the war won and cease publication.

CONTENT

The subject and focus of the articles—the content—reflects, of course, the biases of the six or so members of the editorial committee. It also, though, reflects what was available, what was happening in the field. Titles of the 95 major articles published in the 15 issues are listed in the Appendix I. Besides these 95 articles each issue contained book reviews, an issue overview written by the editor, and a listing, entitled "Loose Threads", of meeting announcements, quotations, notices and so forth. The subjects of the major articles seem to fit into ten categories, as shown in Table 1.

Description of a particular technology	26	Articles
Societal influences on tech. or tech. influences on society	15	"
Discussion of content, what should be taught?	15	"
Example of what is taught, description of specific courses	10	"
Justification for teaching technological literacy	9	"
Organization of technological literacy efforts	6	"
Use of technology in teaching or elsewhere	5	"
Technology and the humanities	3	"
Review of meetings or programs	3	"
Definition of technological literacy	2	"

Table 1 SUBJECTS OF MAJOR ARTICLES

The subjects listed in Table 1 reflect, we trust, the major issues in teaching technology to liberal arts students. Technology itself is important, as is the way technology relates to other aspects of human affairs. Content and structure of courses and programs poses real questions. The relative attention, shown in Table 1, given to the various subjects indicates what our authors and the editorial committee thought important. It does seem consistent with our readers' interest obtained from a survey described below.

We thought it important to explain what engineering, social science, or the humanities deal with in practice. The 26 descriptions of particular technologies noted above focused on what engineers do. Several other articles focused on what social scientists and humanists do, for example, risk management or understanding how values influence technological choice. Titles of the 36 articles that focused primarily on technical matters in engineering, humanities, and social science are given in Appendix II. This list indicates the wide range of specialties, from bioengineering to history, that appeared to us to be useful in understanding technology and its implications and that can be successfully taught to liberal arts students.

The Weaver also described particular courses as examples of what has been successful. A list of the courses which were described in some detail is given in Appendix III. Again, this list may be useful in showing the range of course topics that are effective. The first three courses on the list deal with, among other topics, farming, foundries, stability of arches used in Roman buildings, the Third World, and television. (The number of courses in Appendix III differs from the number of pertinent articles in Table 1 because some articles described several courses.) The Sloan Foundation supported another publication, The NLA News, which focused partly on describing effective courses: once the NLA News was underway the Weaver did less with course descriptions.

Another tactic for looking at course content is to consider the perspective of the authors — for example, the same person could write about energy from the point of view of an engineer or of an educator. The perspective of an author gives clues about what he/she felt important. My judgement of the perspectives used in the various Weaver papers is shown in Table 2.

Education	48	Articles
Engineering or science	21	"
Social science	16	"
Good of society	5	"
Humanities	4	"

Table 2 PERSPECTIVE OF THE AUTHORS

The authors seemed to think course content and teaching needed attention the most. Most of the authors were employed by colleges and universities but not all—the first issue contained articles by the Vice President of Honeywell Corporate Information Systems and by the Vice President of Scientific Research at Ford Motor Company. The last issue contained two articles by the retired Chief Executive Officer of Hughes Aerospace.

Ten of our issues dealt primarily with a single subject. These subjects are listed in Table 3.

SUBJECT	VOL.	NO.
ENERGY	2	2
BIOENGINEERING	3	2
ROBOTICS	3	3
COURSES IN TECHNOLOGICAL LITERACY	4	1
CHEMISTRY	5	1
HUMANITIES	5	2
INTERNATIONAL	6	1
INFORMATION TECHNOLOGY	7	1
SOCIAL SCIENCES	8	1
SPACE	9	1

Table 3 SUBJECTS OF SINGLE SUBJECT ISSUES

The reader survey indicated that single subject issues were preferred, but not overwhelmingly. Most of the articles in single subject issues were solicited so courses or approaches not known to the editorial committee tend to be excluded.

Other topics would be appropriate for single theme issues. The next issue, if we had not ceased publication, was planned to be about technological intrusions on privacy. I think we should have done more about environmental matters. The chemistry issue did include one article—"Chemistry and the Environment" (Spindel and Kaspar, Vol 5, No 1). The humanities, in general, also should probably have received more attention, particularly aesthetics, along the lines of David Billington's course in structures (Chaplin, Vol 2, No 1) or Martin Brody's ideas about electronic music (Brody, Vol 5, No 2).

TRENDS

I have tried to see if the content tended to change in any consistent way over time. The early issues paid much attention to defining technological literacy and justifying the concern about it. The middle issues, Volumes 3 through 5, included a good deal about specific technologies and courses. Many articles in the final set of issues considered how societal concerns influenced technological decisions. One author put it "mythology drives large projects" which may be why the space program is now in trouble (Rahl, Vol 9, No 1). These trends may simply reflect the changing interests of the editorial committee but they are consistent with what the author has observed elsewhere—a decrease in the overall need to make technological literacy acceptable, but an increase in the number of specific situations where technological literacy is needed. The trend in U. S. technology does seem to be toward a focus on systems and away from devices, again consistent with the way Weaver articles changed.

Certainly, as mentioned above, later issues of the Weaver contained much less on specific courses and discussions of what to teach. Part of this is due to the excellent coverage of courses by the NLA News. Part of it may be due to more general agreement as to what should be taught. Part also may be due to the present availability of teaching material, much of which was developed with support from the Sloan Foundation. A look at the book review section of the Weaver would show also that the number, and the appropriateness for teaching, of books about technological literacy increased markedly during the ten years of publication.

SURVEY

In the spring of 1984, after five issues of the Weaver, we surveyed our readers. About 1600 questionnaires were sent out and about 200 returned. Some of the results are summarized in Table 4.

Where are Weaver readers employed?

Universities	36%
Liberal Arts Colleges	28%
Community Colleges, Tech Inst.	5%
High Schools	7%
Prof. Societies & Foundations	7%
All Others	16%

We had then at least one reader at NSF, OTA, and the Congress but had more at each of these organizations later.

Readers' major interest or field:

Science	25%
Social Science	23%
Engineering	21%
Administration	18%
History of Science	7%
Philosophy	5%

What do people want in the Weaver?

Teaching Suggestions	42%
Reference Material	41%
Engineering Details	17%

Respondents' purpose in reading the Weaver:

Keep up with programs at other schools	37%
Own technological literacy	33%
Ideas for teaching	26%
Learn about CUTHA activities	4%

Table 4 RESPONSE TO SELECTED SURVEY QUESTIONS

Readers were asked in the survey to suggest topics for articles. Articles about nearly all these topics were eventually included. The topics that did not appear were: Agriculture, Artificial Intelligence, Computers, Genetic Engineering, The Global Environmental, Human Factors, Transportation, and Waste.

THEMES

Certain themes were repeated in the set of articles appearing in the Weaver. These are discussed here as they may say something significant about teaching technology to liberal arts students.

Technology's attractiveness to students

"I want to underscore the inherent fascination of technology" (Truxal, Vol 1, No 1). Laser disk players, techno-thrillers, guidance systems for missiles in Iraq show the pervasive interest about technology within contemporary culture. (Marcus & Cravens, Vol 8, No 1). Students do want to take the courses we are describing, although it may take some effort initially to make them known.

How to teach technology to liberal arts students

One question is details vs. the big picture (Compton, Vol 1, No 1) or artifacts vs. systems (Truxal, Vol 2, No 2). Engineering or science faculty members may feel more comfortable with the details but the societal implications, important for technological literacy, may arise from the system. It was observed that patents, often the basis for the historical record, focus on components rather than systems (Malone, Vol 3, No 1).

It seems evident that a hands-on experience for students —project type labs or "real world" measurements—are important but the organization of such activities is hardly trivial. (Engineering faculty may have been lulled into complacency—being able to get away with dull or artificial introductory laboratory experiences—by the docility of the students who remain in engineering programs.) An historian and museum director commented on the "evocative effects of historic artifacts" (Malone, Vol 3, No 1).

Serious consideration has to be given in each case to how much engineering, mathematics or physics background is really essential to understand the technology to be presented. Often the amount of background needed by liberal arts students is much less than a person used to teaching engineering students might expect. The question is not only prerequisites but also postrequisites—what is present or absent in the student's future education that will solidify the content of a course?

Aims in teaching technology to liberal arts students

The term "technological literacy" is certainly ambiguous (Goldman Vol 4, No 1) but some aims seem common to many authors. One aim is to increase understanding of how things are done in the world, to help make the world comprehensible (Trilling, Vol 1, No 1). This aim is sometimes expressed in terms of a democracy's need for an informed citizenry. A second aim is to give another conceptual system, setting the student free to think about the world in another way (Chaplin, Vol 3, No 2). An aim of a liberal arts education is to assist a student in learning her/his own strengths and weaknesses, technological thinking needs to be included. We want students to understand tradeoffs in regard to resources, risks, and social values (Lisensky, Vol 3, No 3). A physicist uses technology to teach critical, quantitative reasoning—through "back of the envelope" calculations (Case, Vol 2, No 2).

Technology compared to science

More confusion seemed to exist in 1982 than in 1990 about how technology differed from science. We stated early that our focus was on the nature of technical processes and products and the thinking that creates them. (Ruina, Vol 2, No 1) One author put it well: "How do we most effectively dispel the myth that science precedes technology and technology precedes social and moral problems?" (Hockney, Vol 1, No 2).

Colleges without engineering departments, in particular liberal arts colleges, are one place where the science/technology distinction is important. Another is secondary schools, because technology courses will be taught by science faculty. A related question is whether technology courses of the kind being discussed would meet science distribution requirements at schools having such requirements.

Society shapes technology

Many examples, especially in our last few issues, showed how technology is shaped by non-technical considerations—the pyramids were intended to serve political purposes, to impress enemies with the power of the state and to unite people in a transcending project (Roland, Vol 5, No 2). The space program may have analogous aims (Rahl, Vol 9, No 1). Comparisons between Japanese and U. S. technology show different social forces which may be a cause of different technological strategies (Grayson, Vol 6, No 1), (Wells & Hastings, Vol 9, No 1).

The converse relationship, technology shaping society, is significant in thinking about many fields; bioengineering—it seems impossible not to use new forms of medical treatment but who will pay?, robotics—will its deployment diminish critically the number of satisfying jobs?, and most other major technological changes. New technology creates ethical dilemmas (Lammers, Vol 3, No 2). It also creates new possibilities for controlling people (Marx, Vol 8, No 1).

Public policy and technology

A concrete way society influences technology is through government policy. Examples of policy issues which would seem to be clarified by knowledge of technology include: (in the order that they received attention in the Weaver) nuclear weapons and S. D. I., health care, the environment, industrial competitiveness, and the space program. Some of the questions are the role of technical experts (Laird, Vol 8, No 1), whether to run the risk of being hostage to a single big project, (Wheelan, Vol 9, No 1), and how television influences the formation of public opinion (Just, Vol 4, No 1). Technology influences policy making in other ways than through devices and systems—it gives a way of doing decision making, using decision trees and risk management techniques (Morgan & Williams, Vol 4, No 2).

Difficulties with College/University administration

If technological literacy is so worthwhile, why is it not evident everywhere? The difficulties with establishing and maintaining a program seem to cluster into two sets—one dealing with the structure of educational institutions, the other with the way some people with influence feel about technology. Themes in the first set will be considered first.

The structure of a university, our authors wrote, make it difficult to start new courses different from existing ones and to maintain such courses after initial funding or initial faculty commitment runs out. Problems including motivating colleagues, establishing a viable institutional base, and protecting career paths—especially of untenured faculty (Trilling, Vol 4, No 1). Even motivated, protected faculty need help in learning new subjects and several schools conducted seminars or other efforts to challenge or stimulate the faculty (Ferguson, Vol 3, No 1; Vitelli, Vol 3, No 1).

Incidentally, the organization of the technology course at Yale seemed worthwhile—the course content is broken down into sections, each corresponding to one credit hour. A faculty person would normally give only one section, not an onerous burden, one presumes. The student completes three sections to get credit for a three hour course (Wheeler, Vol 4, No 2).

Perpetuation of successful technological literacy courses is not to be taken for granted. Innovative courses are often the creation of one person who feels passionately about the subject. Such courses may fit with difficulty into institutionally adopted programs. Transfer of such courses to another teacher may not succeed (Holbrow, Vol 1, No 2). A particular difficulty with some technological literacy courses is that they are interdisciplinary and therefore need strong administrative support.

Difficulties because of attitudes toward technology

Authors also commented on a perceived prejudice toward technology, perhaps condescension, perhaps concern about its effects. "Since our humanity has historically been magnified and liberated by the artifacts of technology, it is somewhat odd that post-industrial men and women tend to denigrate, if not disdain the contributions of technological society" (Chaplin, Vol 5, No 2). This disdain goes back at least as far as the ancient Greeks. In the present Academy it can be expressed as an objection to "vocationalism".

Concerns about the effects of technology may make its acceptance at colleges and universities difficult. Concerns were expressed about what technology can do—reduce the autonomy of office workers (Murphree, Vol 3, No 3), lead to mass nuclear destruction (Wall, Vol 3, No 1), promote elitism through using reproductive technologies to engineer the perfect child (Rothschild, Vol 8, No 1). Not everybody believes technology is neutral. Another concern is the pervasiveness of technological thought—technology has prestructured the way we view the world (Ihde, Vol 5, No 2).

LESSONS

What has been learned from the nine years of the Weaver? One lesson is that it is not easy to teach technology to liberal arts students effectively. Course content, use of examples from the "real world", student background (often small) and interest (often large) must all be considered. Just as worthy of attention as the course plan itself is support for the instructor.

A second lesson is that technology really is part of everything. The list of article titles in Appendix II shows how many different things can be an effective vehicle for teaching technological literacy. Whether technology is taught to inform voters, to arouse aesthetic consciousness, to liberate minds, to develop confidence or something else, it does occupy a significant position in the world our students will enter.

A third lesson is that the idea of liberal arts students learning technology, of technological literacy, does seem now to be widely accepted in colleges and universities. Books and other teaching materials are becoming available. Outside of colleges and universities the outlook is good also. Popular culture and serious periodicals deal with technology in a valid and non-patronizing way. Attitudes do seem to have changed since 1982.

THE COUNCIL FOR THE UNDERSTANDING OF TECHNOLOGY IN HUMAN AFFAIRS

The Council was formed in 1979 at a meeting convened by Prof. Gerald Nadler, then at the University of Wisconsin. Prof. Edward Friedman of the Stevens Institute of Technology served as the first chair . The Board of Directors had a membership of about 20, with people from education, industry and government. In the education group were included representatives from liberal arts colleges, research universities, community colleges and secondary schools. We were pleased with the interest in the Council from many sources in its early days. Prof. John Truxal of SUNY-Stony Brook was the second chair of CUTHA and Prof. Leon Trilling of MIT the third chair.

The main activity of the first few years was to conduct a series of conferences describing activities in teaching technological literacy. The first of these was at MIT and was oversubscribed, attracting more than 100 participants. A second meeting was held a year or so later at Chatham College. These two meetings were aimed at a broad spectrum of people. Future meetings were focused. One was for administrators and faculty at research universities. The rest were regional meetings. These took place at the University of Maryland, Hollins College, in Los Angeles, in Cleveland, and at Rollins College.

A third main activity, very effective when technological literacy was just becoming known, was supplying speakers and panels for meetings of other societies. We, at least members of our board, spoke at nearly all the important educational meetings. The CUTHA board was prepared to find speakers for meetings at colleges. We made some efforts to be a repository of information about technological literacy courses but ceased when that function was undertaken, very successfully, by the NLA center at SUNY-Stony Brook. The Weaver was, of course, another main activity of CUTHA.

It may be worthwhile to mention some activities we attempted unsuccessfully. It appeared fruitful to try to establish relationships between engineering colleges and nearby liberal arts colleges or community colleges without engineering programs. CUTHA announced its availability as a match-maker but found very few takers. We considered organizing the production of a major series of public television programs but were not able to secure the funding needed.

As described in the history of the Weaver, in the spring of 1991 it appeared to the CUTHA Board that we had done all that we could and that other organizations were in a better position to further our general purposes. Thus it seemed best not to search for further funding and the Board voted to disband.

APPENDIX I

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Titles have been abbreviated. Notes and book reviews have been omitted.

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1	1	Can technology be intelligible?	I. Wyman
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1	2	Nuclear war in a liberal education	A. Simmons
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1	2	Computer metaphors	H. Peelle
1	2	Computers as a resource	T. Moberg
1	2	Microcomputers: Tools for tech literacy	T. Liao
1	2	Hers	K. C. Cole
2	1	Wellesley workshop I	M. Chaplin
2	1	Nuclear weapons	W. Durch
2	2	Education in technology	J. Truxal
2	2	Perspectives on energy	L. Kushner
2	2	Photovoltaics	J. Loferski
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3	1	Museums and history of technology	P. Malone
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APPENDIX II

TECHNICAL ARTICLES

Appropriate technology for developing countries
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Clash of values:the Indian tradition and modern science and tech.
Comparative study of US and Japanese space programs
Computer music systems and musical intuition
Digitalizing information
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APPENDIX III

EXAMPLES OF COURSE SUBJECTS

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Appropriate technology
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Nuclear war
Nuclear weapons, computing, decision making
Radio astronomy, manufacturing, CT scanning
TV and politics

POSITIVIST AND CONSTRUCTIVIST UNDERSTANDINGS ABOUT SCIENCE AND THEIR IMPLICATIONS FOR STS TEACHING AND LEARNING

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Most contemporary science teaching focuses on the content of science, while in contrast the teaching about science done in STS courses normally emphasizes the conduct, character, and context of science. Because of the focus on content, teachers of science, including both school teachers and university scientists, as well as their students, are able to avoid consideration of the qualities of science addressed in STS courses. Furthermore, the disjunction between the closed, dogmatic way in which science is usually taught and the open creative nature of science as practiced is well known, whereas the treatment of science in STS courses is usually much closer to science as practiced. The experience of one of us (CN) in teaching both science and STS courses has prompted us to reflect on these disjunctions an.' to advocate rethinking what we teach and how we teach in both science and STS courses.

Our premise is that science is what it is or, rather, the varieties of science are what they are because people have made them that way. <u>And they could be otherwise</u>. Similarly, the various roles that the sciences play in our society and culture have developed for reasons, and they could be different. We also assume that the most effective teaching and learning are achieved when there is a coherence, rather than a disjunction, between what we teach and how we teach, that is, a coherence between what we communicate to students about learning by <u>what</u> we teach and what we communicate to students about learning by <u>how</u> we teach. Our discussion will be framed, without too much oversimplification, as the contrast between positivist and constructivist views of the nature of science, and the implications of those views for STS and science teaching and learning.

We start with our understanding of STS teaching and learning. Steve Cutcliffe has argued that teaching STS means "explicat[ing] ...science and technology as complex enterprises that take place in specific social contexts shaped by, and in turn, shaping human values as reflected and refracted in cultural, political, and economic institutions" (Cutcliffe, 1990: 360). STS teaching and learning thus mean coming to understand interconnections, and the interactive character of all aspects of science and technology with each other and with other social institutions. In addition, it means coming to understand values—what values are, how they evolve, and how people come to hold them. It also means that a multiplicity of perspectives can be taken on science and technology, without being right or wrong necessarily. Beliefs that science and technology are otherwise can hinder both teaching and learning about STS issues.

The view of science embedded in this understanding of STS teaching and learning may be called constructivist (Latour and Woolgar, [1979] 1986; Knorr-Cetina, 1981; Ziman, 1984; von Glasersfeld, 1984; Longino, 1990). It focuses attention on the conduct, character, and context of science—a human activity and a social institution among and interacting with many others. Analytically, we can think of the conduct of science as all those activities and processes which are involved in the creation, development, and validation of scientific knowledge. These may include the collaborative nature of most scientific work, the many and varied approaches people follow in research, and the processes of selection of future scientists through education and other means. Analytically, we may think of the character of science as those qualities and values that shape scientific activities, such as curiosity, invention, and creativity, the search for simplicity or the respect for complexity, the search for regularities in natural phenomena, the norms of behavior of scientists, the relation of scientists to their subjects of study, the roles of language in science, and so on. In practice the conduct and character of science continuously interact and lead to knowledge that incorporates the values of the people and institutions engaging in and supporting science. We call this interacting system of conduct, character, and knowledge "science-practice," by analogy with Arnold Pacey's "technology-practice" (Pacey, 1983). This knowledge is constructed by the people engaged in doing science, using all the resources at their disposal—such as concepts, mathematics, existing science, metaphors and language generally, representations, instruments, and personal experiences and values. There are thus many different approaches to doing science—all still scientific, but different. Doing science involves creativity and invention and interpretation, as well as hard work. Scientific work is done by all kinds of committed people, women and men, and members of all ethnic groups, not just by very bright white men. Almost all of it is collaborative, between individuals, between groups, and between institutions. Scientists are citizens not only of the "republic of science" but also of the countries in which they live, and as such they are responsible for their actions to the communities of which they are a part, including their participation in science-practice (Lowrance, 1986).

Effective STS teaching and learning which incorporate this constructivist view of science should also incorporate a constructivist view of teaching and learning, by focusing on the process of constructing and reconstructing knowledge about science by teachers and students (Osborne and Freyberg, 1985; von Glasersfeld, 1988). It is the experience of one of us (CN) in the classroom that, when students come to understand that science was constructed by people in the first place, for reasons and in specific circumstances, they develop more confidence in their abilities to reconstruct this knowledge for themselves, integrating it with their existing knowledge by questioning, relating, replacing, and speaking. Some even articulate this confidence by saying they have gained permission to do science or think scientifically. Since scientific constructions are made in a variety of ways, the reconstructions that students do can also be done in different ways; teachers can guide students to find ways of learning that are especially appropriate for them, by using as examples the experiences of the teacher and of former students, and historical case study materials. Much or most of the teaching and learning are collaborative enterprises, between teachers and students, and among students themselves. Teaching and learning are thus multidirectional and interactive, rather than one-way and hierarchical (Hassard, 1990). Just as scientists are responsible to each other for the knowledge they construct jointly, students and teachers are responsible to each other for their reconstructions.

The conventional understanding of many textbook writers, teachers, and other people may be called the naive positivist view; it is not to be confused with the philosophical position known as logical positivism. The naive positivist view holds that science is objective knowledge about nature which is universally true; that scientific knowledge is a product that is value free and is produced by a definable scientific method followed by a specific kind of extremely bright person. The scientific knowledge thus produced in the late twentieth-century industrialized West is held to be universally applicable to all peoples, times, and places in the universe, and to be true in an absolute sense rather than a provisional best understanding for the moment. This view connotes that nature is a given, existing "out there" independent of human understanding, interpretation, and construction of it, and that scientists make discoveries by uncovering the secrets of nature (often personified as female). The community and institutions of science are deemed to have their own reason for existence (production of universal, objective knowledge about nature), and they therefore ought to be autonomous, able to govern themselves and to be supported financially by their societies and governments with no strings attached.

Teaching and learning which incorporate this positivist view of science focus on getting the facts straight, memorizing, and intensive practicing to solve problems that are remote from the students' experiences and interests (Tobias, 1990). Science allegedly can be learned only this way, only the best students do it well, and other students cannot really be taught how to do it. Since scientific knowledge is universal and isolated from the context of its production, and scientists are often portrayed as isolated geniuses, it follows that science learning is an individual activity and bears little or no relation to other school subjects or to other parts of the students' lives, their interests or values. Since science is supposedly about discovery, scientists just need to find the right place to "lift the veil" covering nature; the ability to do that cannot be taught, and anyway students have to learn all the already discovered truths first, through a curriculum which is hierarchical and rigid.

The constructivist view of the nature and practice of science set out here incorporates values—the values of individuals, of communities of scientists, and of the larger societies which support scientific activity. Values are principles embedded in all human activity, patterns for behavior; they are the foundation of knowledge and practice. People construct knowledge using all the resources available, and the choice and deployment of those resources as well as the resources themselves depend on these values.

In an STS or science classroom which recognizes this foundation of values, the humanity of students and teachers becomes central (Belenky et al., 1986). Teachers and students are encouraged to ask why they should be interested in this material and to develop reasons which make sense to their situations. Students are also encouraged to address/confront their fears about, for example, studying organic chemistry, since students who are afraid are unlikely to be able to make knowledge their own—to succeed in reconstructing it for themselves—although they might succeed in memorizing enough to pass tests. As scientific knowledge is constructed collaboratively, so the learning, the reconstructions, are collaborative, between students and teacher, among students, between students and texts, between students and materials for hands-on experiences, and they involve questioning, explaining, relating, writing, and drawing, through a rather flexible curriculum. Science is involved in most parts of students' lives and is certainly related to other school subjects: neither the world nor students' lives respect disciplinary boundaries. Examinations are concerned with students' communication of their reconstructions of the material, somewhat less threatening than the usual assumption that examinations are about grades. This kind of learning builds a classroom community, which may well mirror a laboratory community in the collaborative nature of the enterprise and the stake of everyone in the success of all.

The positivist view of science regards values as biases and distortions of judgment, and good scientists succeed in freeing themselves from these destroyers of objective knowledge. In effect, they become pure minds, operating independently of the several communities of which they are a part, rather than rounded human beings situated in contexts.

In a classroom that incorporates this positivist view, the material being taught is primary; students become minds that can learn under any circumstances, independent of the situations of the rest of their lives. This view is reinforced by the idea that, since science is individualistic and competitive, learning must be also. Since science is about the discovery of knowledge which becomes the province of experts, learning is about acquiring the right knowledge from an expert, and the teacher must be an expert to be a good teacher. Learning is about getting good grades on examinations, that is, students become experts of a sort. The classroom becomes an agonistic field, where only a few students can win or place, and most students lose.

As an example of the contrast between a constructivist and a positivist classroom, we consider the process of observation in science. Students in a positivist class probably are confronted with a textbook presentation of "the scientific method," which has observation as one of its steps. It assumes that we can gain objective knowledge about the world through the careful use of our senses in observing. The text and the teacher assume that observation is a simple process, and that all students observe in the same way. Yet students often express anxiety and apprehensiveness about not being able to see what "they are supposed to see" that are rarely addressed (Osborne and Freyberg, 1985).

In contrast, we work with the concept we call science-practice, that is, we focus not on science as method, or science as knowledge, but science as practice, the interacting conduct and character and knowledge of science as actually engaged in by real people. Science as practiced does not have a single "method"; Project 2061/Science for all Americans refuses to discuss "the scientific method," insisting that "there simply is no fixed set of steps that scientists always follow, no one path that leads them unerringly to scientific knowledge." Observation is always done in the context of a specific field and a specific program of investigations, and should not be discussed in overarchingly general terms (Rutherford and Ahlgren, 1990: 5). Yet if not step one of a five- or six-step cookbook "scientific method," observation is still a central part of what scientists do, and still a central feature of the processes of validation of scientific knowledge. Scientists observe a wide variety of sorts of things, using a wide variety of means of observation, and they make choices all the time about what to observe and how.

In a constructivist classroom students and teacher focus on the process of observing, in order to develop an effective "observation-practice." What one sees depends on where one is situated, both literally and figuratively—both on where a student is standing with respect to a demonstration being conducted on a laboratory table, and on what the student's background and personal experience are. That is, what one sees depends on one's perspective. Scientists have chosen to observe what they observe because they "see" through the lenses of the theoretical concepts and constructions of their fields, that is, from a certain perspective which has been developed over time, through the intellectual and social processes of their education, filtered through their own inclinations and interests (Hanson, 1958). Helping students understand this aspect of the construction of scientific knowledge empowers them to "see."

Scientists' lenses shape the kinds of things scientists observe and how they do it. The theories and concepts ground into the lenses often include models for natural phenomena that have been constructed to represent what are regarded as their essential characteristics. Teachers can help students to understand the development—the construction—of particular models, for example, chemistry's model for the atom, in such a way that the students learn to see through the lens of the model: they can look at a beaker of water and "see" interacting molecules in motion. One of us (CN) has presented students a brief video clip from "The World of Chemistry," first without sound and then with sound. After the first showing, students discuss "seeing" a small piece of solid material that smokes and glows when inserted into a beaker containing a greenish substance, resulting in a white solid. The chemist-demonstrator talks of adding metallic sodium to chlorine gas to produce crystalline sodium chloride, releasing energy in the forms of light and heat. The scientist "sees" abstract models the students were unaware of! Scientists then make use of such abstract models to construct explanations of natural phenomena. A central aspect of science teaching and learning is helping students make such models and explanations their own, part of their own lenses.

This description of the construction of lenses and the providing of a particular perspective should not be strange—because it does not only apply to scientists. We all operate this way. The lenses of each of us, our perspectives on the world, are developed over time from our families, educations, occupations, interests, and inclinations, that is, from who we are and where we are situated. The scientist's perspectives on the world are one set, but by no means the only one. We may even have several perspectives, which we shift as if we were using multifocals. Those various perspectives are not likely consistent with each other, though they may be coherent—they are all uniquely ours. Helping students understand this multiplicity of perspectives, of which science is one set, and theirs is one, makes science more accessible to them and does not ignore or devalue what they bring to, or who they are in, classrooms and laboratories. This position is not relativism: it does not say that every perspective, every observation is equally valid in science. It does not say that the student's perspective is as valid as a trained scientist's perspective in science. It says that science is a perspective or a set of closely related perspectives, with its own internal sets of criteria and standards for the practices that go by that name. Students can and should learn about the scientific perspectives because science has been and is such an important part of our culture. As citizens they need to understand both the power and the limits of science; this is a critical element of STS teaching.

We have presented multiple levels of coherence between a constructivist view of science and a constructivist view of teaching and learning because we believe that classroom teaching and learning are more effective when such a coherence exists. The discovery learning approach of the late 1960s may not have been widely implemented because of the disjunction between its somewhat constructivist approach and the positivist view of science current at the time. Effective science and STS education may be strengthened by focusing on the coherence in the classroom and in curriculum materials between a constructivist view of science and constructivist learning theory, the coherence between constructed knowledge and constructed learning.

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A Modular Conceptual Framework for Technology and Work[1]

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Introduction

Technology has to be considered a very complex discipline based on the network of relationships among the individual, nature, society and knowledge. There is also a causal link between development of society and development of technology. The context in which technology operates involves all spheres of daily life of all people and indicates the effectiveness of societies as a whole. Therefore the relationships between people and technology are best characterized as development relations and in this special dimension may be considered as irreversible.

Technology is: "...the know-how and creative process that may utilize tools, resources and systems to solve problems and to enhance control over the natural and man-made environment."[2]

The purpose of this paper is to present, from our German perspective, the basic principles that frame a coherent theory relating technology and work, both in their existing condition as well as technology's developmental/innovation aspect.

We have, in Germany, and now I mean in both of the formerly separated halves, a well developed system of technological education -- in both its important dimensions: General education and vocational education.

In Germany, teachers of physics, mathematics, language and history work along side the technology teacher. The subject taught by the latter is generally named with some combination of *Technic*, *Work*, and *Economics*. The approach used for the 11th, 12th and 13th school years varies from Land to Land (Germany now consists of 16 Lands).

[1]Thanks to Michael Dyrenfurth, Professor of Industrial Education, University of Missouri-Columbia, for assistance in translating, discussing and interactively detailing the ideas contained in this paper
[2]UNESCO. (1985). International Symposium on the Teaching of Technology within the Context of General Education. Paris, France: Author.

More well known however is Germany's exemplary, results-oriented system of vocational education. We term it a Dual System because both schools and companies cooperate in delivering it although the responsibilities of both are strictly defined and separated. In addition, we also have a complete system of higher and advanced technology education in our universities and technical colleges/institutes[1]. Both sets of institutions prepare both technologists and engineers. In addition to the traditional range of programs for such people (e.g., mechanical, electrical...) these institutions also are beginning to offer a set of new programs. These include: Environmental technology, Medical technology, Communications technology, Instructional technology, Bio-technology, Recycling technology, Technological cybernetics, Optical technology and Economic information technology.

From my perspective, the multiplicity of specific preparatory programs, and the private sector's demand for the immediate utility of new hires, generates a serious problem. In essence graduates are capable in a significant number of specifics, but larger, more long-range and powerful capabilities seem to be seriously slighted. In addition the ability to properly cope with information in today's information intensive environment, the ability to structure problems, and to frame strategies for the problem solving/innovation process, will become more important. Note that we use the term problem solving/innovation deliberately because the outcome of this process is for our purposes always something new or non-existent in the consciousness of the *doer*.

The three principal examples of the latter are:

1. The understanding and overview of the structure of production processes and the principles of technology.

2. The understanding of the strategies and structure of product innovation

3. New information-masses as a part of innovative thinking

Given the preceding, it is clear that the educational systems must learn to better prepare people for technological careers. An essential aspect of this improvement is that they learn to address the three preceding capabilities in an interactive fashion.

[1]Interesting is the trend that the graduates of the technical colleges/institutes, who even possess one less year of preparation, are in greater demand than those of normal universities.

1. The understanding and overview of the structure of production processes and the principles of technology.

Explanation of this point begins best with a short historical example[1].

Prehistory until about 1500	Transition/ prerequisites 1500-1800	Development 1800-1850	Consolidation 1850-1920	Transition to systems theory since 1920	
Practical oriented	Knowledge oriented	Process oriented		Methodology oriented	Strategy oriented
Technical knowledge/skills	Systematic descriptive technical knowledge	Classical technical disciplines		Engineering and technological disciplines	
Practical methodical knowledge ↓ technological knowledge ↓ Constructive technical knowledge→	Development of the natural scientific mechanics → Constructive technical knowledge (descriptive) ↓ Technological knowledge (descriptive) ↓ ↓ Specific general engineering (technology)→	Traditional disciplines of the mechanical cycle (machine building) Technological disciplines Mechanical technology ↓ ↓ Division into techniques ↓ ↓ Classical production engineering	Differentiation into → ↓ ↓ internal external ↓ ↓ structure (basic components) industrial branches Chemical, etc. technology ↓ ↓ Division into processes ↓ ↓ Classical process engineering	Formation of an independent theory of machine design from the classical engineering and technological disciplines	Formation of an independent theory of innovation processes based on the methodology of engineering and technological disciplines

Blandow/Dyrenfurth/Lutherdt, 1991

Figure 1. Unity of construction (design) and technology (engineering) in the structure of the sciences.

The figure documents a long history involving key questions about the relationships between science, technology and engineering continually arise. Similarly the tension between general versus specialization in technology-oriented education is a perennial thorn.

If this perennial reoccurrence is actually the case, one must ask, what causes it to emerge with such regularity? Two answers appear with similar frequency. One involves the acceptance/respect of one discipline's

[1]Lutherdt, M. (1990). Zu den konstituierenden Elementen ausgewählten technischen Wissenschaften. Wissenschaftliche Zeitschrift der Pädagogischen Hochschule "Dr. Theodor Neubauer". 26(2). [Erfurt, Germany-East]

practitioners for those of another. Frankly, I've thought about offering an "interdisciplinary tolerance" course at my institution.

The second, and more important problem, is the lack of recognition of those in a discipline for their field's necessary interactions with and dependence on essential components of other disciplines. Therefore we must be clear about two insights:

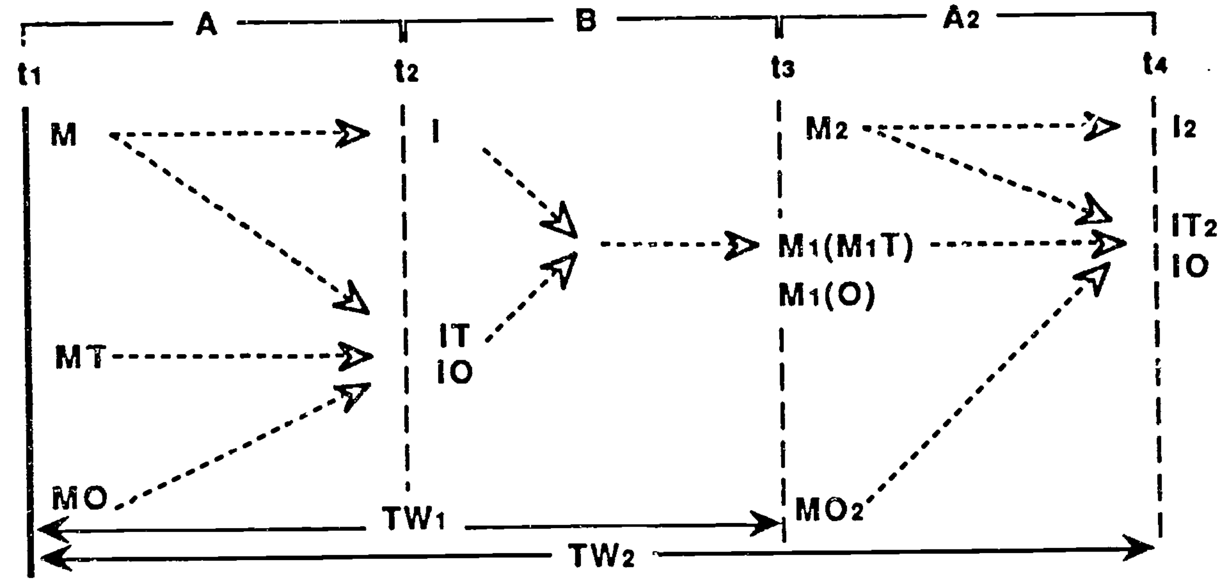
1. There exist natural overlaps among disciplines

2. The further development of society depends on the interrelationships among disciplines and the differences of their individual perspectives and approaches.

To examine the relationships of the unity of disciplines versus their uniqueness, I use the concepts shown in Figure 2. From the author's point of view, the key to developing the capability for arriving at the proper answers is to find the right starting points in one's research activities. Especially for technological subjects, the keys to all technological solutions are found in the terms z and Δz (see Figure 3).

The condition or situation, the changing of conditions or situations, the relations between input and output and feedback are the key points for understanding technical artifacts as well as technological processes.[1] Note the pertinent question here is in fact the key question. It is not so important to know what is being produced. Instead, the salient issue is what changes and processes are being used -- i.e., how are we processing!

[1]Blandow, D. (1990). A Modular Concept for Technology Education and Work. Fulbright Colloquium paper. London, UK: Southbank Polytechnic.

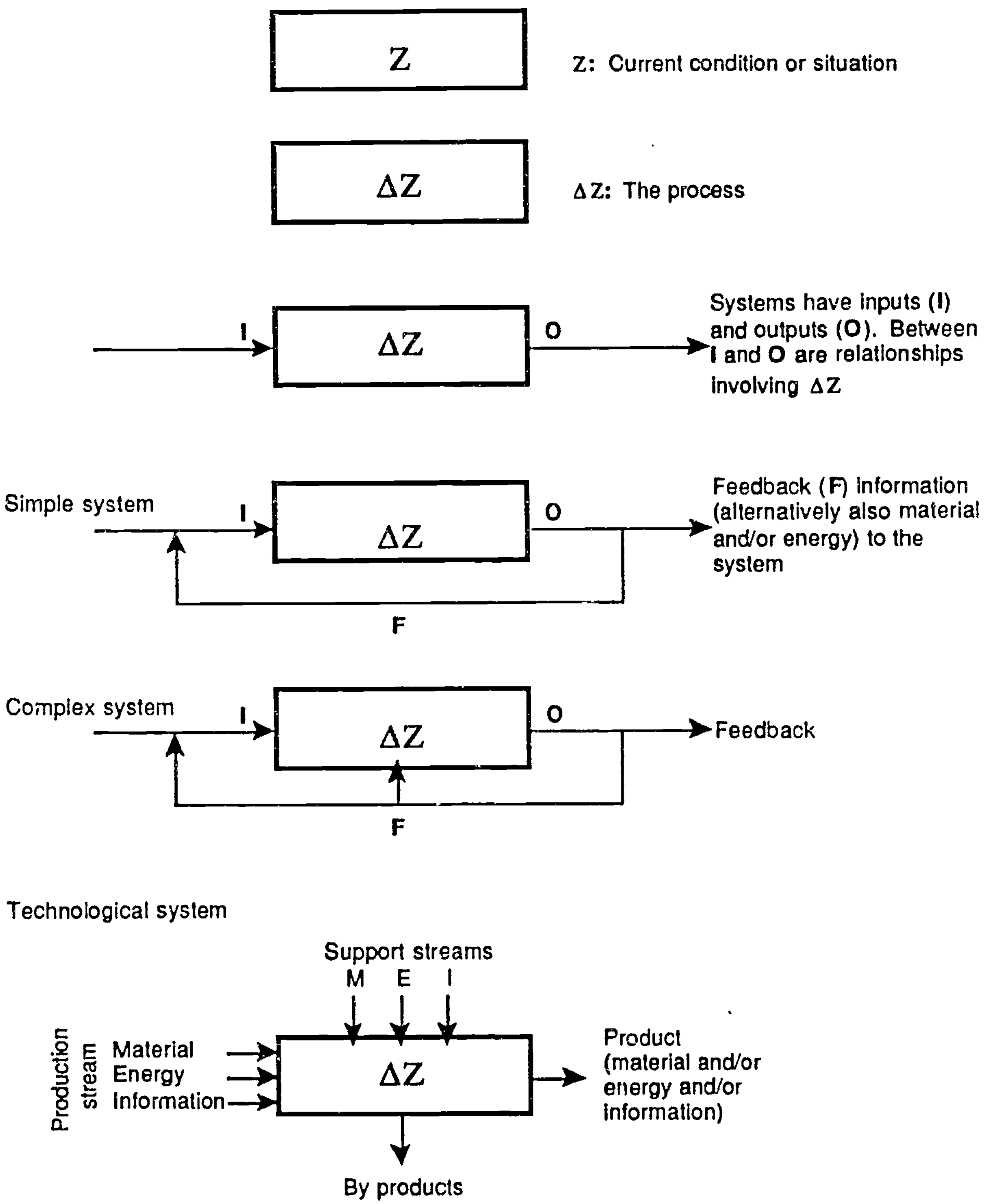


Blandow/Dyrenfurth, 1991

Legend

M	=	The material (natural) researched by scientists (e.g., physicists, chemist, biologist)
MT	=	The material, man-made object, that is developed by the technical scientist or engineer
MO	=	The organization arrangement and practical means (established by technologists)
I	=	The ideal as a result of the insights of scientists
IT	=	The ideals as a result of the insights of technical scientist or engineer
IO	=	The ideals as a result of the insights of the technologist
$M_1(M_1T)$	=	The new man-made object
M_1O	=	The new man-made organization arrangement
A	=	The domains of scientists and technical scientist or engineer where they operate independently of other disciplines
B	=	The domains where scientists and technical scientist and engineers they operate interactively with other disciplines as a team.
TW_1	=	The domain of technological assessment
TW_2	=	The domain of technological and economic assessment
$t_1 \ldots t_3$	=	Time for the first cycle
$t_2 \ldots t_3$	=	Research and development time for the second cycle

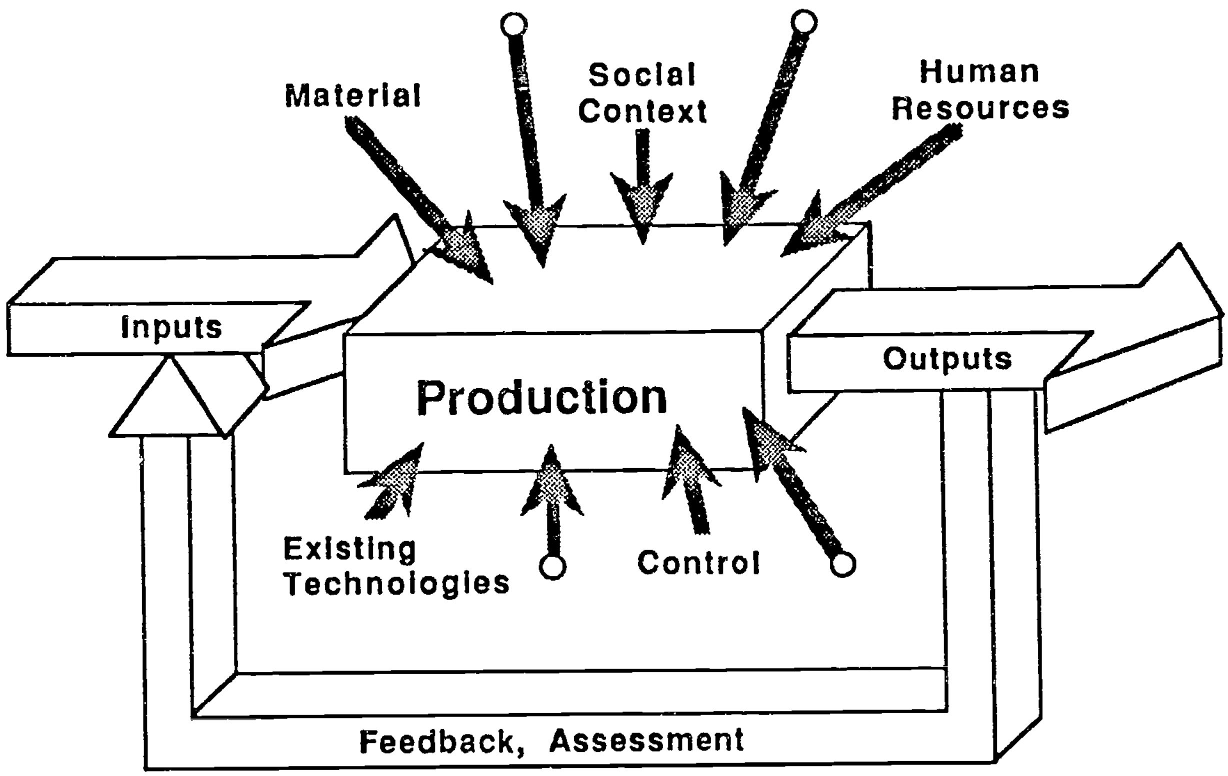
Figure 2. Model to explain the unity and uniqueness of various disciplinary perspectives views in the production cycle



Blan.low/Dyrenfurth, 1991

Figure 3. Key elements of production systems

Naturally there are also general models which resulted from research to establish an overview. Figure 4 is one such model.



Blandow/Dyrenfurth, 1991

Figure 4. Model for the production process

The German approach emerges from the dynamic tension between the reductionist methodology involving specification of elements (as in Figure 3) and the holistic systems view such as the example depicted in Figure 4. Of interest now is the question of how one reconciles these two poles of approach. Our goal was to establish characteristic planes between these poles in order to identify key constants that facilitate understanding and enhance generalizability. Examination leads to the same four key frames of reference and they are used at all levels of my overall model.

1. The change of condition/situation Z1, Z2, Z3.

2. The process, ΔZ.

3. The location and/or point of time characteristics.

4. The technical artifacts or means.

In reality, these four key frames of reference interact in various planes and levels (see Figure 5).

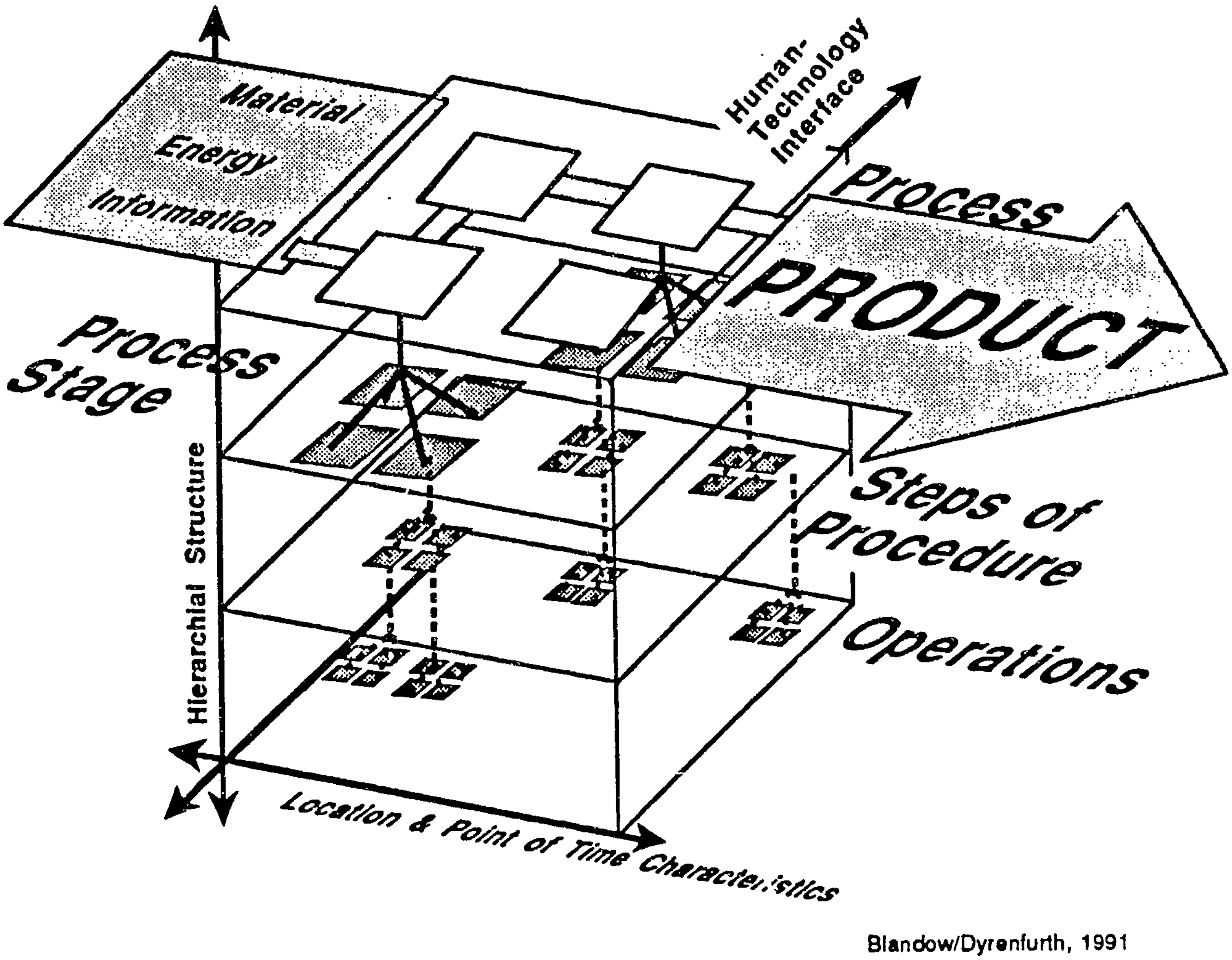


Figure 5. Hierarchical structure of production processes

This structure, shown in Figure 5, may be used to describe, explain and/or analyze production in any of the realms typically used. It is most important to note that the model is equally applicable to the traditional industrial realms of paper, metal, wood, and plastics work; as well as to the food processing industry, e.g., cheese, sugar, meat and milk processing; or the process industries such as petro-chemical, waste-water, and bio-technical. Furthermore, although not as frequently applied because of history, the model clearly also fits agriculture. From this illustration, it becomes clear that we know much about each individual level. We know much detail about material, energy and information -- but the principles that each embodies are less well known. Even less well known than these are the principles governing vertical linkage between the levels. Another great weakness is our ability to formulate variables and make decisions. The same situation is observed in the hierarchical system of technical artifacts shown in Figure 6.

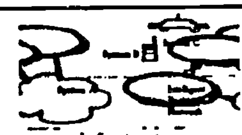
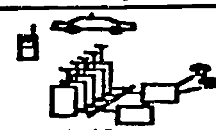
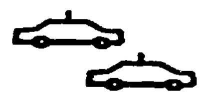
Level Six	Cybernetic Systems	
Level Five	Integrated Networked	
Level Four	Networked Systems	
Level Three	Systems	
Level Two	Standard Assemblies	
Level One	Standard Components	

Illustration: Tim Trogden Blandow/Dyrenfurth, 1991

Figure 6. Hierarchical system of technical artifacts

Made visible however, is the concept that hierarchy can be used to establish understandable order -- just like we learned from our study of technical artifacts (see Figure 6). The relationships between these two models, the hierarchical model of production processes and the hierarchical model of technical artifacts, are critically important but they fall outside the scope of this paper's main discussion.

The first result[1] of our work to make sense of technology was a useful structure to make sense out of the multiplicity of production by creating a matrix of the three pillars (materials, energy, information) against the nature of change (shape, structure, location, time) was shown in Figure 7.

Object of work	Nature of Change			
	Form/Shape	Altering	Location	Time
Material	Material shaping	Reconstituting	Materials handling	Aging, Wine, Patina
Energy	Energy processing	Energy conversion	Energy transfer	Half-life
Information	Information handling	Information processing	Communication	Obsolescence

Blandow/Dyrenfurth, 1991

Figure 7. Matrix between objects of work and nature of change

If one includes the principles of technological organization together with the preceding matrix, one arrives at the principles of production. This combination, depicted in Figure 8, has not yet been found elsewhere in the literature. When found or developed, however, it would become a most useful tool to help understand the correlation between the several planes (as in Figure 5) and to understand the strategy of their combination for solving specific technologic/innovation challenges.

[1]Blandow, D. & Wolffgramm, H. (1975). Zur Spezifik der fachwissenschaftlichen Grundlagen der Ausbildung von Diplomfachlehrern für Polytechnik. Wissenschaftliche Zeitschrift der Pädagogischen Hochschule "Dr. Theodor Neubauer". 11(1), pp. 5-14. [Erfurt, Germany-East]

Sample goals of process operation	Implications of the Goals on:			
	Changing conditions or situations, Z_1, Z_2, Z_n	The process, ΔZ	Location and point of time characteristics	The technical artifacts/means
Minimization of resources	Capitalization on material characteristics [Material structure]	Process integration WRT time [Work hardening]	Production timing (continuous/intermittent) [continuous casting, Just-in-time organizing]	Energy supply at point of use [Solar telephone, integral wheel-motors]
Increase of variability	Substitution, Alternative sequences [Recycled material aggregate]	Adaptation [Photochromatic glass]	Flexible reactions [Combine threshing drum pressure]	Standardized components [Microchip logic elements]
Increase of stability	Feedback systems [Sensor technology, Dash warning indicators]	Networking, optimization [Feedback driven control systems, assembly line buffers]	Quality assurance [Zero defect programs]	Parallel/redundant structure [Pilot/co-pilot]
Reduction of production cycle time	Activation characteristics [Catalysts, hardeners]	Increase of energy/work density at the work station [halogen lights, microcomputers]	Parallel processing, assembly lines [automobile manufacturing, Matrix computers]	Increase of frequency [Newspaper production]
Reduction of product planning and setup time	Standardized stock, modular construction components [Rolled steel, 4x8 panels, DIN paper]	Utilization of standardized (modular) process elements [Canned cycles in NC machines]	Modular machines, handling systems [Flexible manufacturing systems]	Automatic tool/jig fixture changers, robots [Computerized plant change over]
Increase in ecological responsibility	•••	•••	•••	•••
•••	•••	•••	•••	•••

Blandow/Dyrenfurth, 1991

Figure 8. Implications and goals of process operations

Consequences of point 1

Our scientific research yielded several insights that make things easier for teachers and researchers.

1. When one combines the constants of objects with the constants of processes of technology, one establishes one plane of my overall model (see Figure 9).

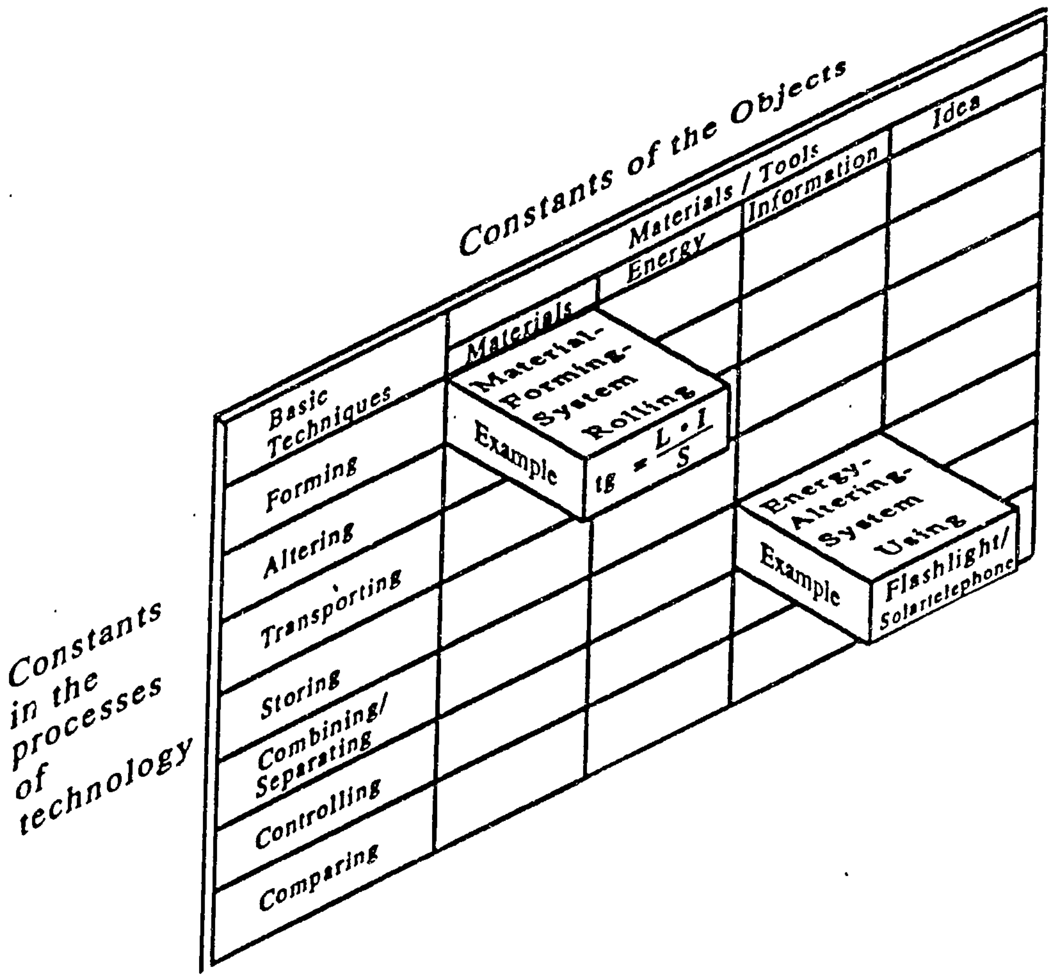


Figure 9. Model plane 1: Constants of objects vs constants of technological processes

2. The second plane is formed by combining the constants of the processes, with the constants of the objects. Then, by adding the constants of technology interaction sites one generates a three dimensional model that represents a matrix of technological activity. Selected provocative examples might include (also see Figure 10):

   - Energy transport in space
   - Material transport in hospitals
   - Information storage in water
   - Energy storage in water
   - Material altering in space
   - Information forming in factories

   Note that these are not merely academic musings or wishful thinking. Immediately behind them emerge questions regarding the emerging possibilities of technological capability. For example, and one step more concrete than the preceding, are:

   - Lasers as surgical tools
   - Electrophoresis gene identifying
   - Lasers as dynamic measuring devices
   - Biotechnology use in laboratories

   Furthermore, the emergence of such technological possibilities brings with it a responsibility to incorporate an inclination towards such forward looking tendencies into our various technician, technologist and technology educator curricula.

3. The large field of production principles (see Figure 8) is also used as an activity guide during our degree programs when we prepare students and researchers for practical work as engineers and teachers of technology.

4. Technology is interdisciplinary and all its applications represent compromises.

5. With the increase of relations between materials and energy (e.g., refer to column ΔZ in Figure 8) we can distinguish between laws of development and laws of structure (see Figure 11).

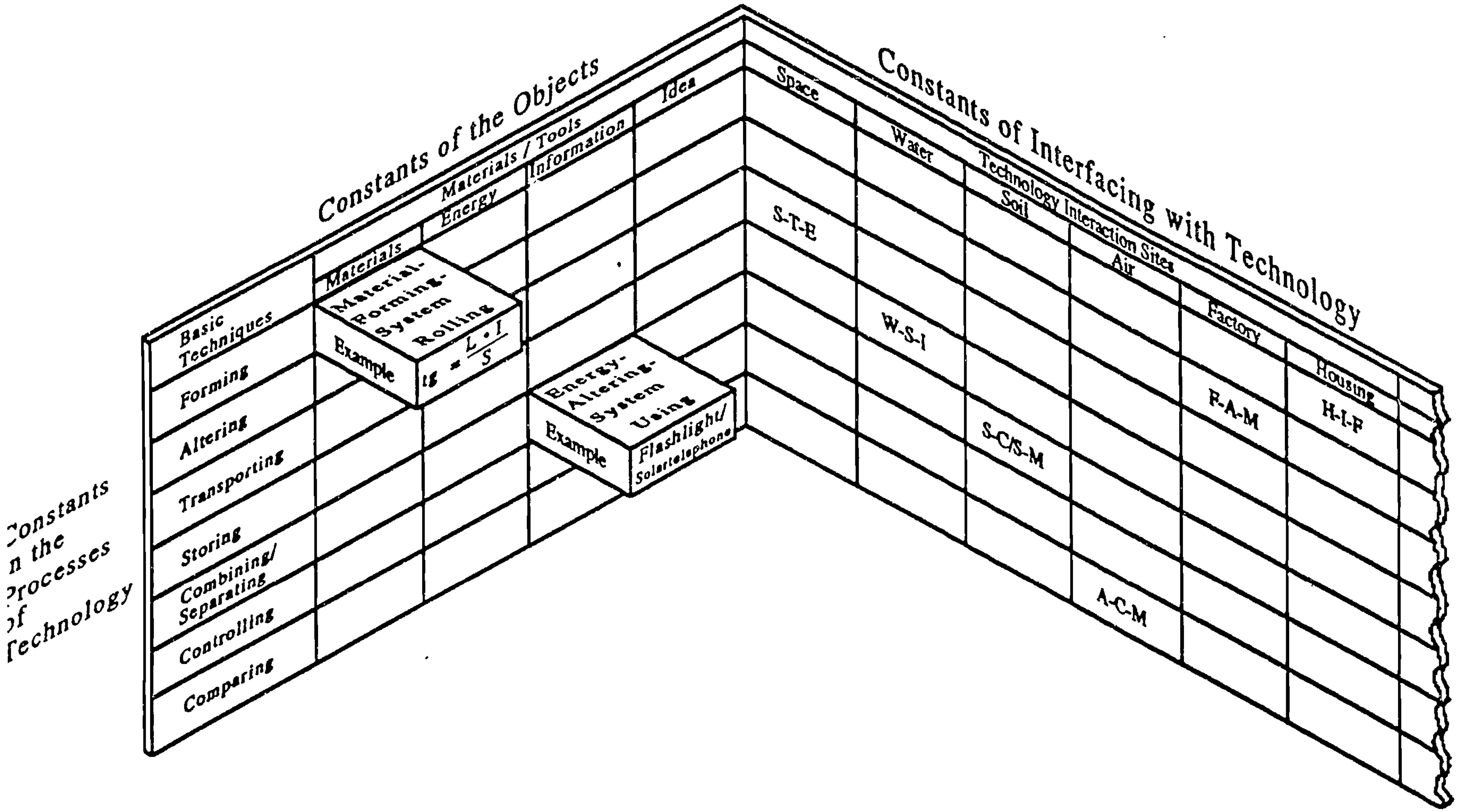


Figure 10. Model planes 2 and 3: Constants of technological processes vs objects vs interaction sites

Types of laws	Changing conditions or situations, Z_1, Z_2, Z_n	The process, ΔZ	Location and point of time characteristics	The technical artifacts/means
Structural laws	Coupling Feedback Parallelity	Structure of active principles • Form • Energy • Movement • Location • State	Degrees of freedom Flexibility Hierarchy Variability Adaptation	Flows are closed Σ Material = 0 Σ Energy = 0 Σ Information = 0
Development laws	Integration of function Continuous/ Intermittent Integration of present production with new developments	Increase of energy density, Integration of production and recycling	Shortening of the information flows Reduction in changeover time Increased variability of mass-produced items	Flexible workstations Increased output per unit mass Multiple use components

Blandow/Dyrenfurth 1991

Figure 11. Types of laws for understanding the structure and development of production processes.

6. The predominant focus of each domains of activity involved in the production process is depicted in Figure 12.

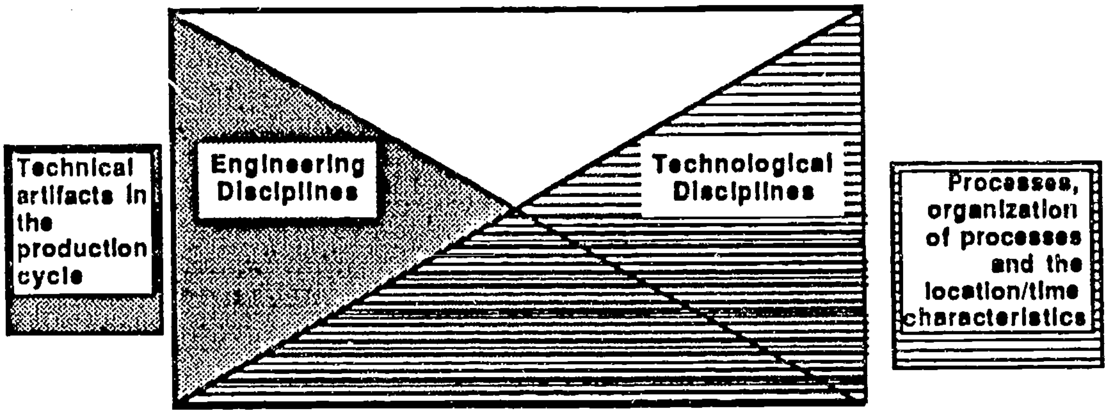


Figure 12. The dominant focus of engineering and technological disciplines

7. For instructional purposes, eight groups of themes emerged as important:
   a. Principles for determining the structure of technical and technological processes with respect to:
      - Structure of processes
      - Changing conditions
      - Location and time characteristics
      - Structure of technical artifacts
   b. Principles of development of technical and technological conditions:
      - Structure of processes
      - Changing conditions
      - Location and time characteristics
      - Structure of technical artifacts

2. The understanding of the strategies and structure of innovation

The recognition and solution of technological problems, the purposeful development of technical artifacts, the strategies, methods and tools of assessment are the alternative to a technical education, which is based on various traditional disciplines. This new element will involve the perception of systems and principles from single fields, will necessarily lead to connection, will train creativity and competence for decision of the personality etc.

Whenever one generation succeeds the other, even within product generations, innovation will be based on nearly the same principle, the Multiplicity in Unity. The example of ICARUS, Figure 13, points out that important concept. He was forced to learn to survive and to translate his wish for freedom into activities to keep busy. It was his vision of a palatable future, stimulated by the example of the freedom of birds flying over him, that triggered his innovation--his modeling of their wings.

Figure 13. The fable of Icarus

Gilbert's 'Icarus'. Reproduced by courtesy of A. & C. Black Ltd.

He builds wings and attempted to escape. The conclusion is known. This example's lessons for today's situation is shown in Figure 14.

Problematic situation (thought initiator) ➡ Overcoming thought barriers ➡ envisioning possible solutions ➡ model development (resolution of contradictions) ➡ development of approach strategies ➡ development of time and activity plan ➡ execution of the plan ➡ evaluation of the results (mostly through experiments) ➡ new situation/problematic situation.

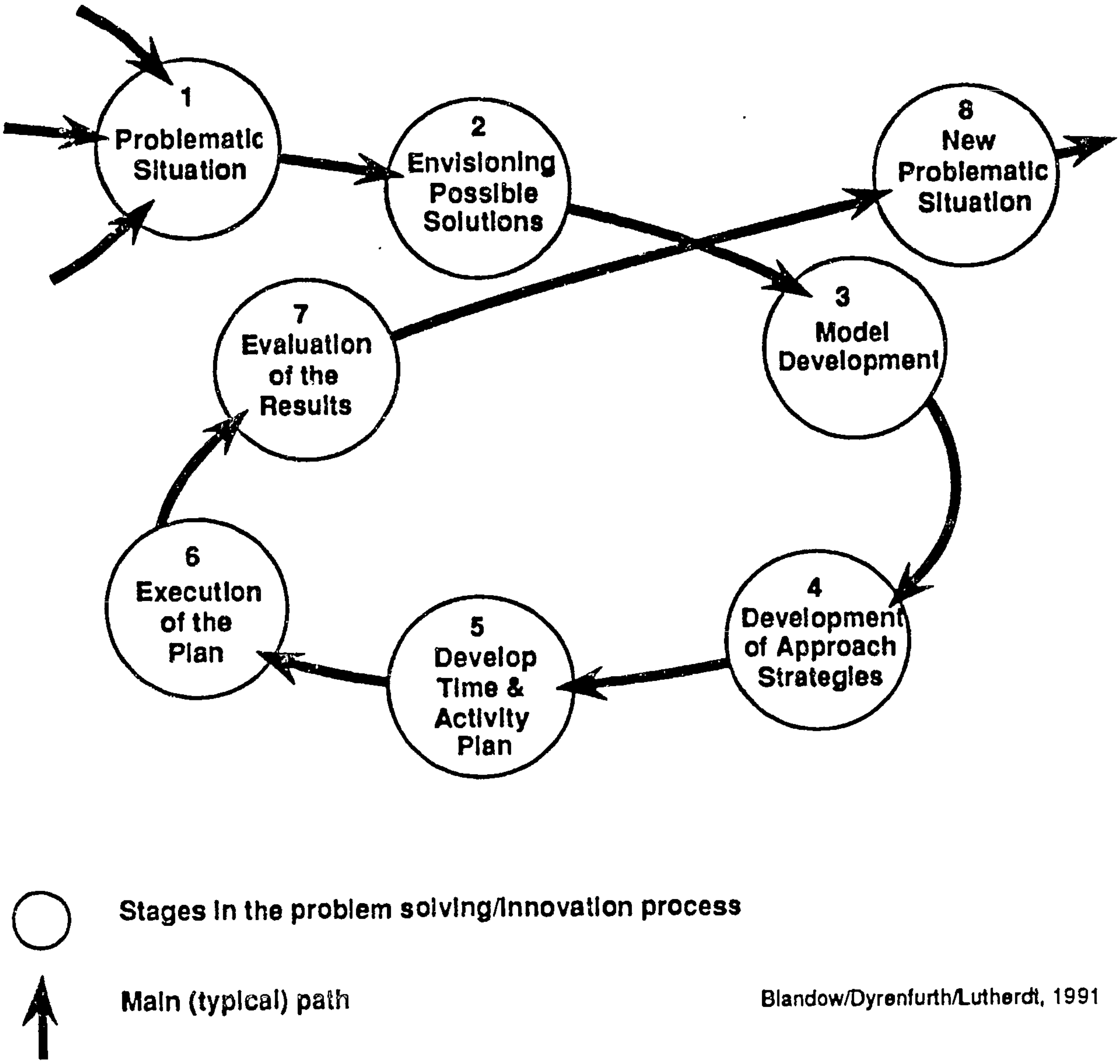


Figure 14. Stages in the problem solving/innovation process

The cycle is important today. The example from the fable shows us today, as it did in the past, the relationships between the tangible world, our mental concepts of it, the initiating value of our concepts/visions and the power of translating our ideas into practice via a systematic strategy. In further figures we depict the same concepts albeit with addition of time and economics as factors[1,2] (see Figure 15).

But this example also shows us, which barriers we experience in our thought processes and how difficult it is tc overcome them[2,3]. The main point, however, is that we can now complete the modular concept from the activity point of view. With the seven key stages identified by analysis of over 100 documents, and our knowledge of the characteristics of the typical barriers, we are able to genuinely help people develop the thought processes necessary for effective technological problem solving/innovation.

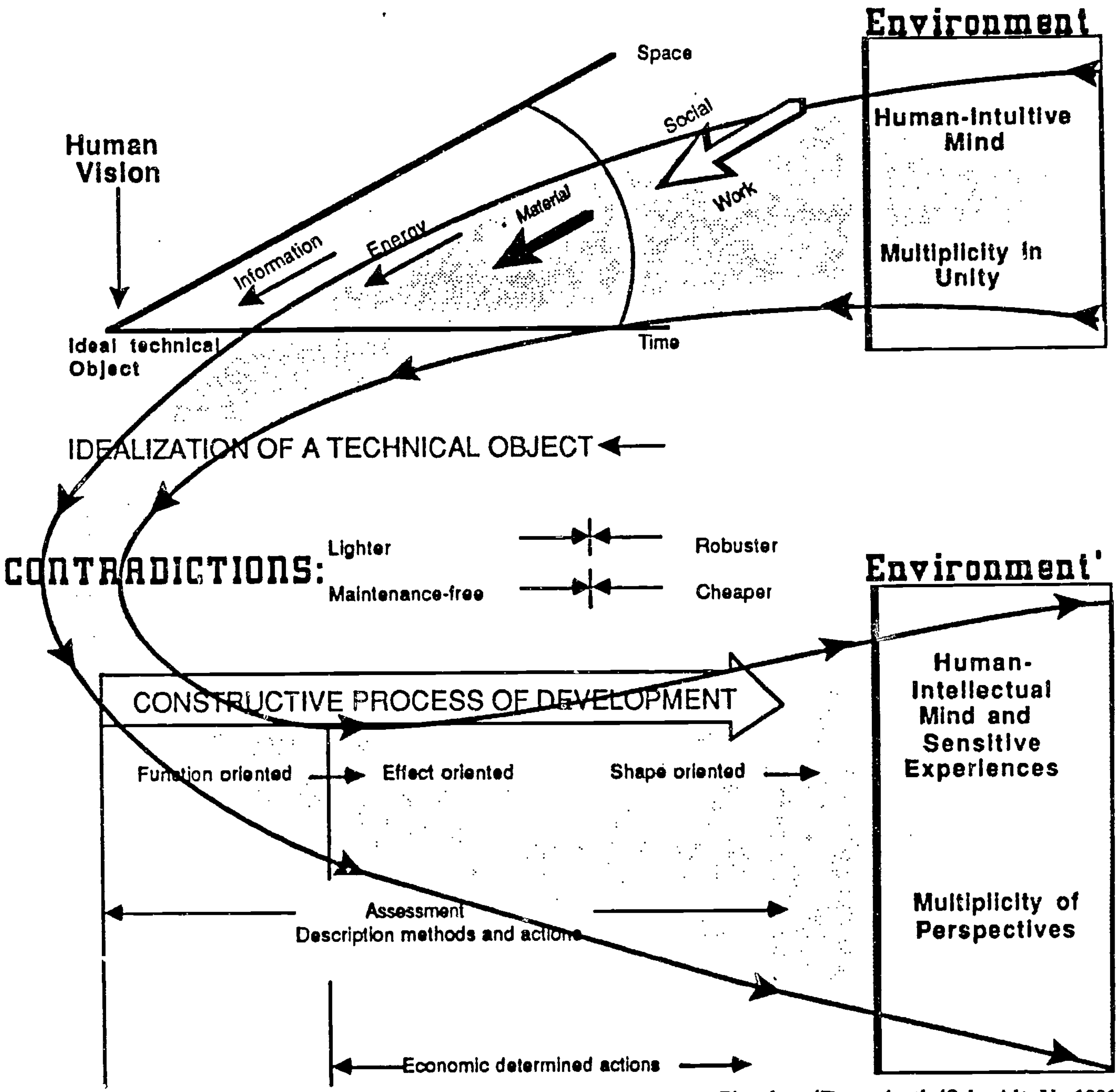
All over the world, from Icarus to today, the problematic situation is the starting point for all activities. But today, internationally, up to 60 percent of the total development and lifetime of a product are used to overcome the 1st and 2nd barriers (the recognition of trends and the definition of function, contradictions and ideal systems). Therefore, consequences for technology education concerning the need--aim--motive and problem transformation are inevitable (see Figure 16, 17, 18, 19)

[1]Dyrenfurth, M. J. (1990). Rethinking technology education in the secondary school: Missouri's approach to technological literacy. Paper prepared for the Landesfachkonferenz Polytechnic--Arbeitslehre, Thüringen, German Democratic Republic, April 27-30, 1990.

[2] Dyrenfurth, M. J., et al. (1988). Resources for industrial technology education programs. Technology Education Division, ITEMS 1. Alexandria, VA: American Vocational Association.

[2]Klix, F. (1980). Erwachendes Denken. Berlin, FRG: Deutscher Verlag de Wissenschaften.

[3]Rubinstein, S. L. (1968). Das Denken und die Wege seiner Erforschung. Berlin, FRG: Deutscher Verlag de Wissenschaften.



Blandow/Dyrenfurth/Schmidt, V., 1991

Figure 15. Concrete-abstract-concrete' -- The routes of technical thinking

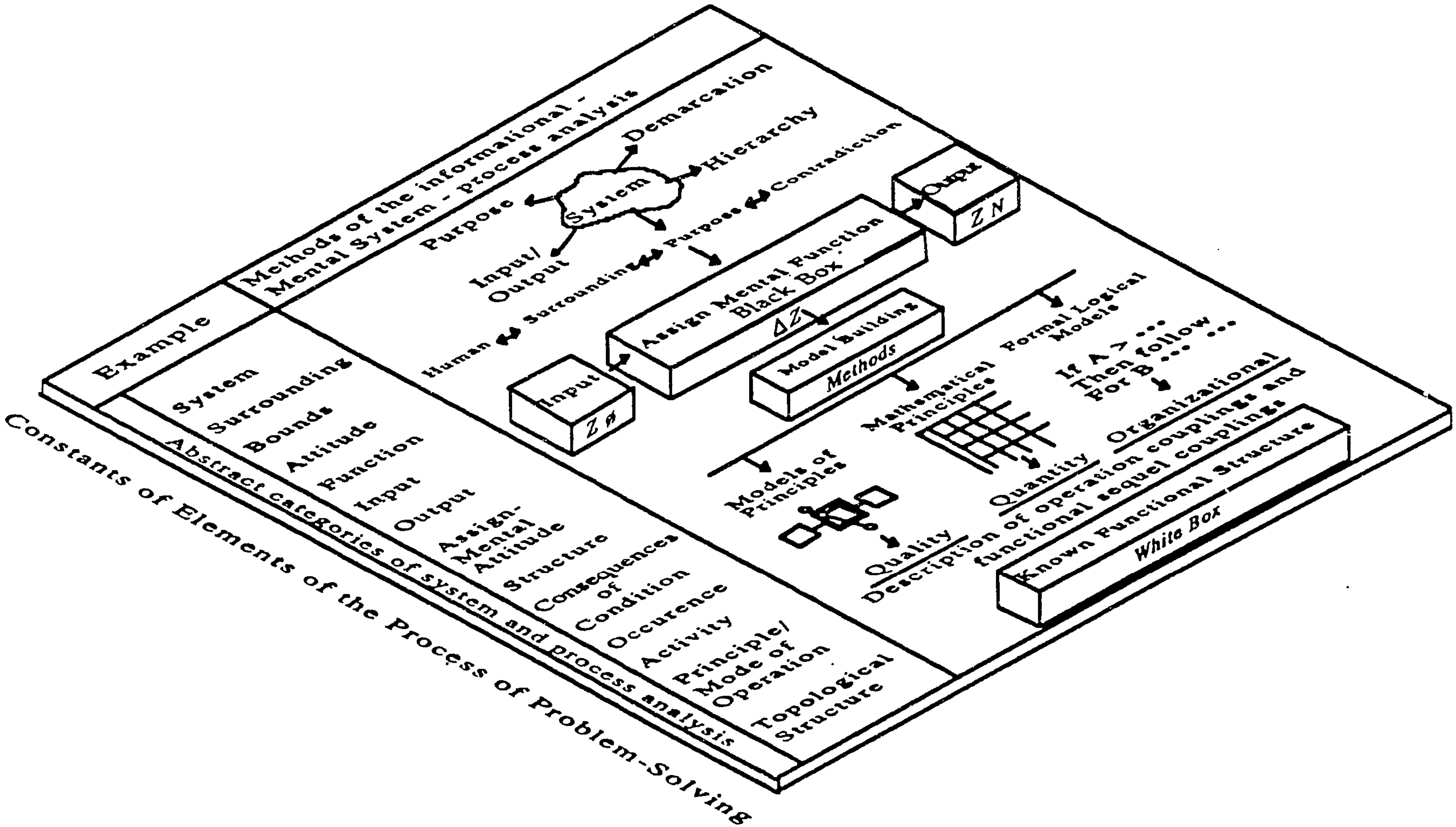
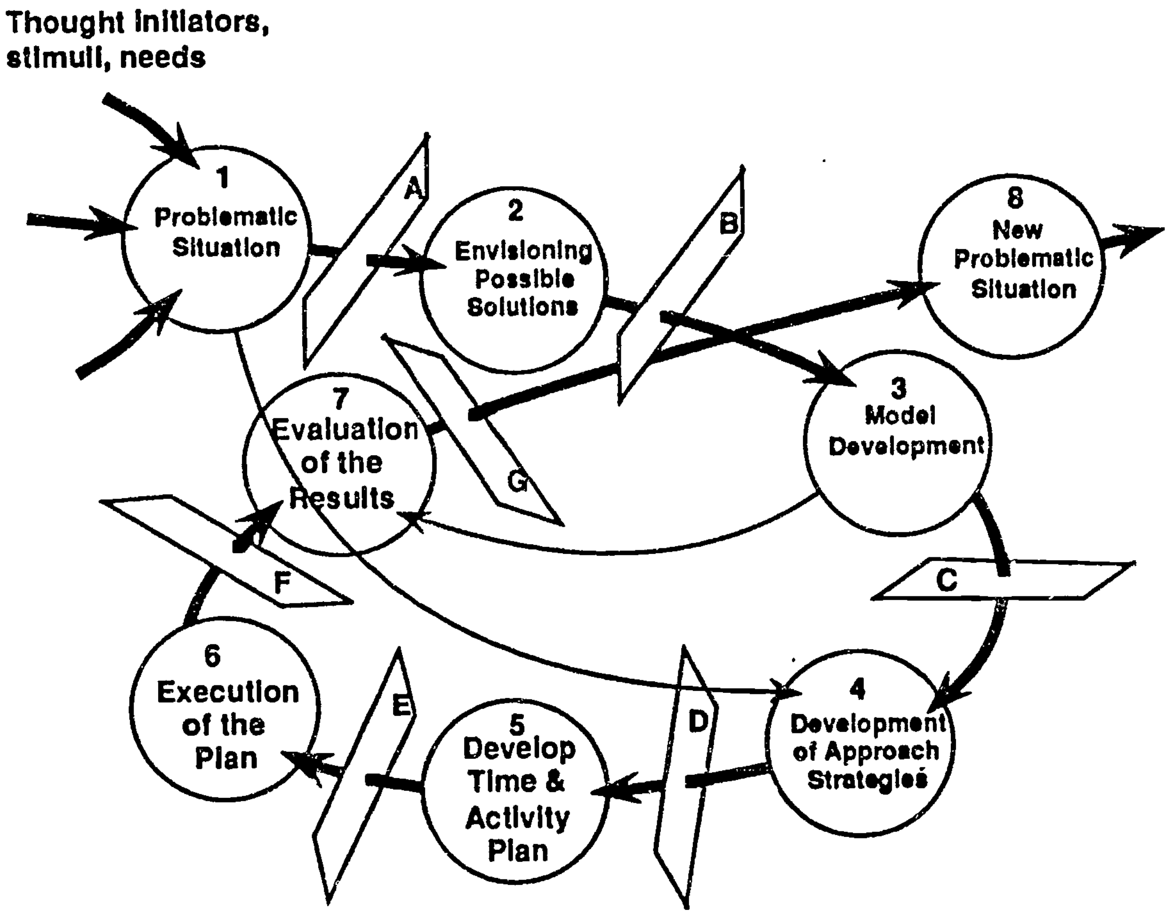


Figure 16. Constants in the elements of the process of problem solving/innovation



A. Recognition of trends, needs, ...
B. Definition of function, contradictions, ideal system
C. Solution of contradictions, variables, exploration of natural laws
D. Realizing of principles, development of material/energy/information system
E. Dimensioning of the elements/ manufacturing/testing
F. Modifying/optimizing the solution
G. Recognition of solution's weak points

Stages in the problem solving/innovation process — Main (typical) path

Barriers to the problem solving/innovation process — Alternative paths

Blandow/Dyrenfurth/Lutherdt, 1991

Figure 17. Stages of problem solving/innovation, barriers and paths

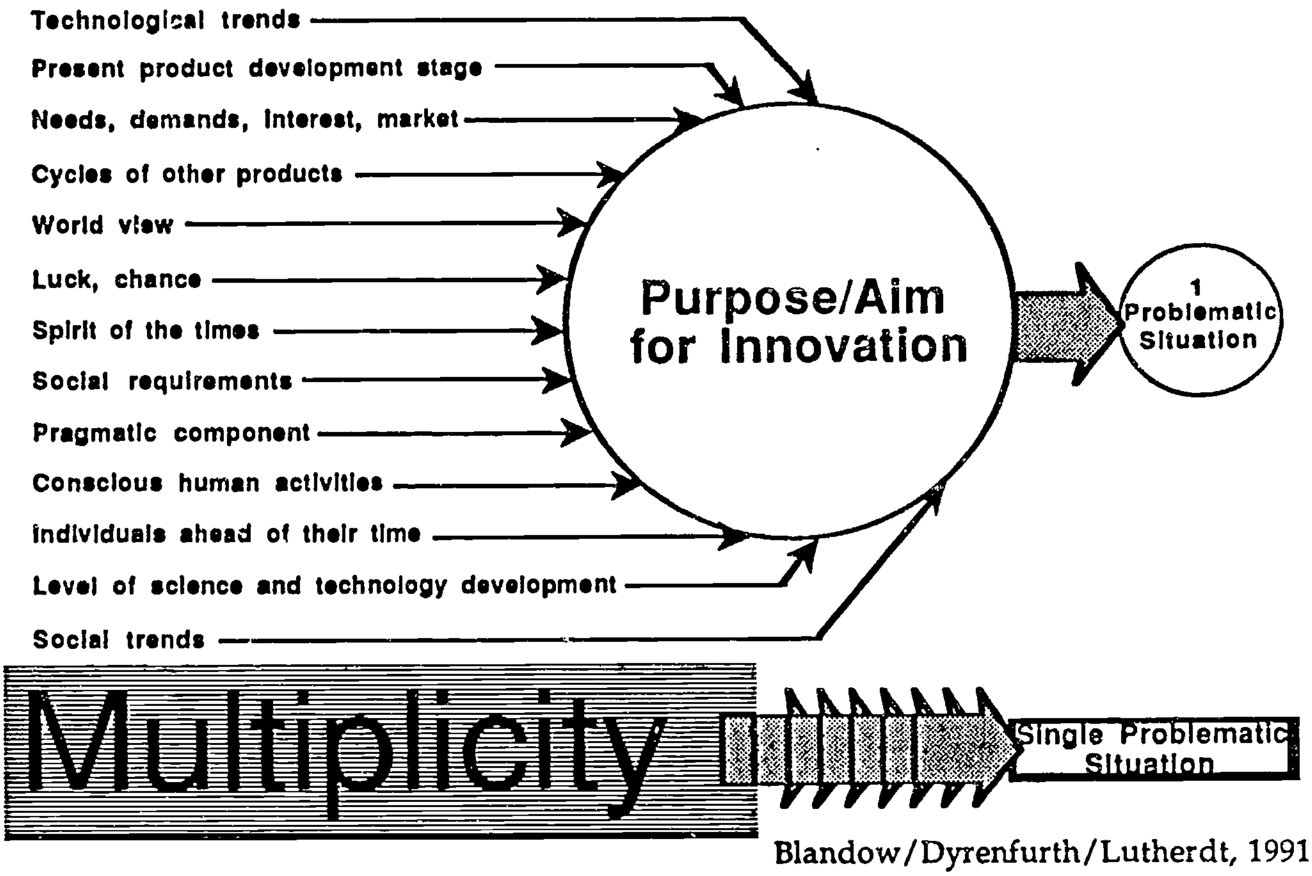


Figure 18. Strategies for overcoming need-aim barriers

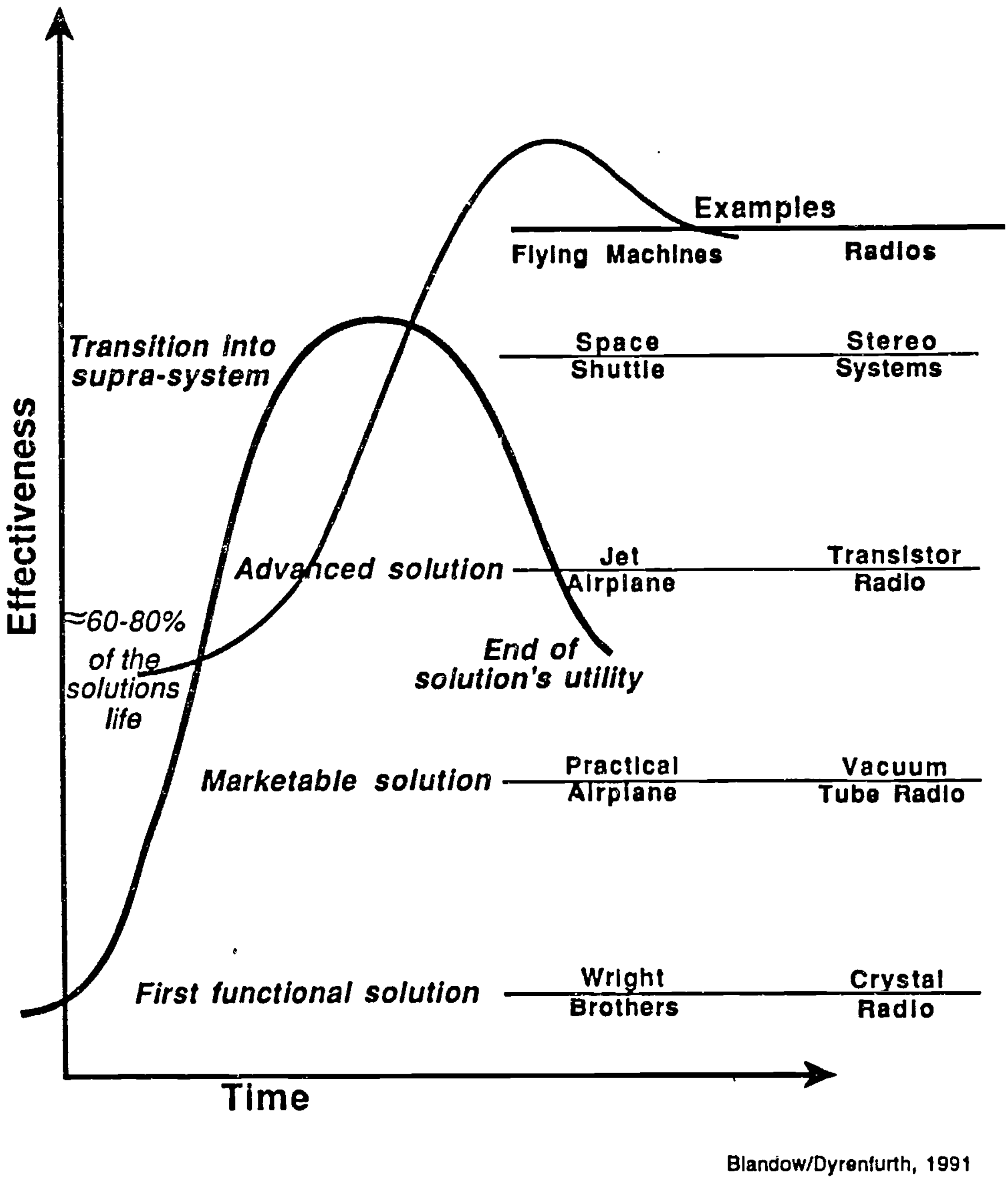


Figure 19. Developmental stages of products

Consequences of point 2

1. The approach used to define a problem or task is most decisive because along this route of abstraction and decomposition creative solutions will be generated by observing technical/technological principles and the reality given:
   - consideration of trends and formation of ideals,
   - using contradiction as a heuristic means,
   - planing, put into practice and evaluating experiments
   - initiative spirit situations (brain-wave, association,...)

   The results of our findings are also summarized in Figures 20, 21[1]. As was stated previously, the problem solving/innovation process necessitates the overcoming of transition barriers which requires the access to and proper utilization of, different information-masses. These information-masses are each unique in terms of hierarchy structure, nature of information and accessing method. Remember that not all steps in the problem solving/innovation process need to be used in every situation. The logical consequence of this is also that not all barriers are encountered every time.

   How to find contradictions and to define them will be demonstrated in the *Worksheet for the formulation of contradictions to trigger innovation*. The heart of the matter involves the identification of the requirements, their grouping by appropriate characteristic, and the framing of the key contradictions.

   Thinking in contradictions will help the people in charge, by their own creative characteristics, to find new orders for answering their purpose.

   They will continue to restructure and rearrange their thoughts which will also be kept in tension and motion due to verbal operations such as formulating the contradictions.

[1]Blandow, D. (1988). The system of polytechnic education in the GDR. In J. Raat, R. van der Bergh, F. de Klerk Wolters & M. de Vries, (Eds.), Basic Principles of School Technology, Volume 1, pp. 116-136. Eindhoven, The Netherlands: Eindhoven University of Technology.

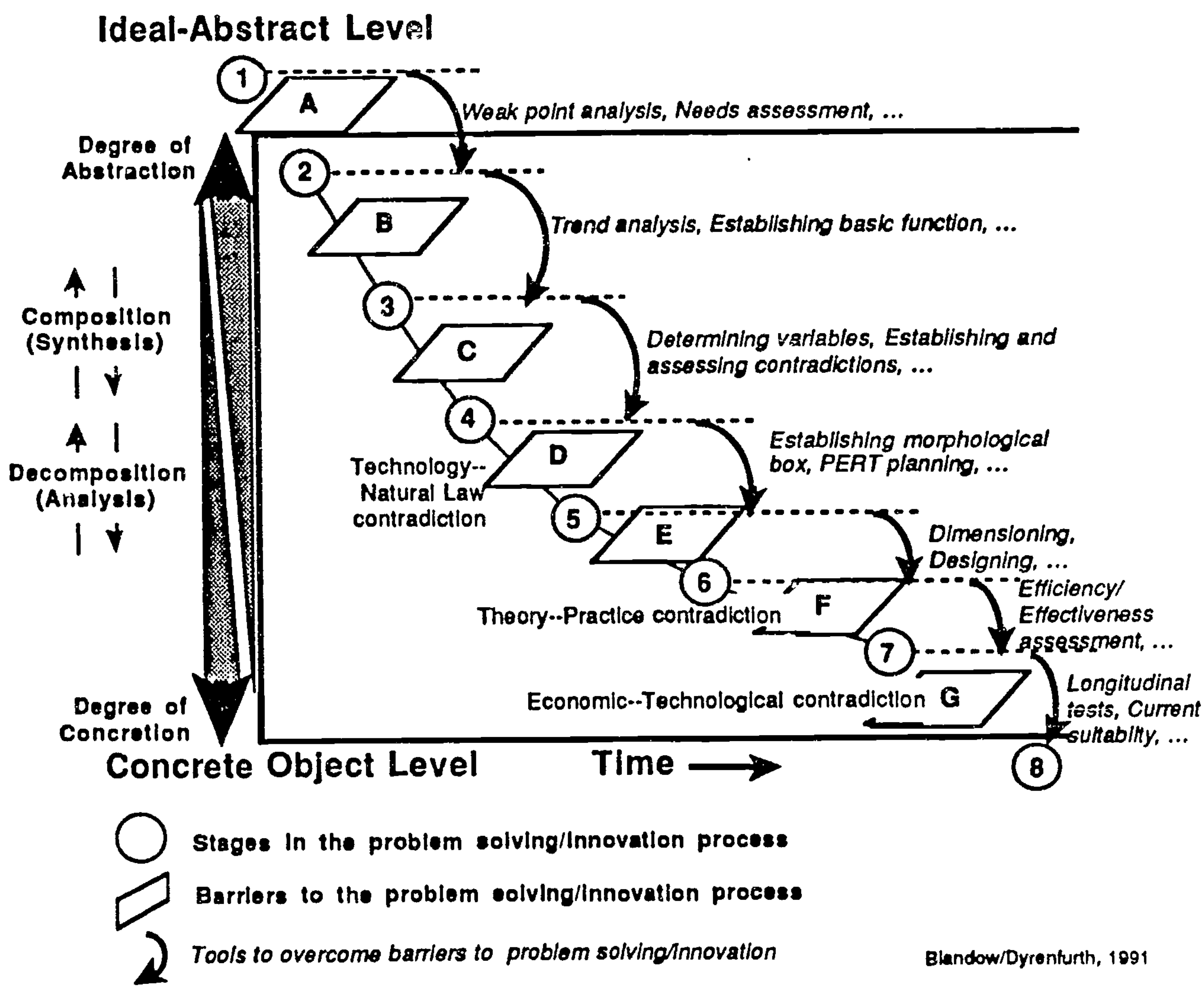


Figure 20. Tools for overcoming barriers to problem solving/innovation when moving from abstract to concrete and from concrete to abstract, continues

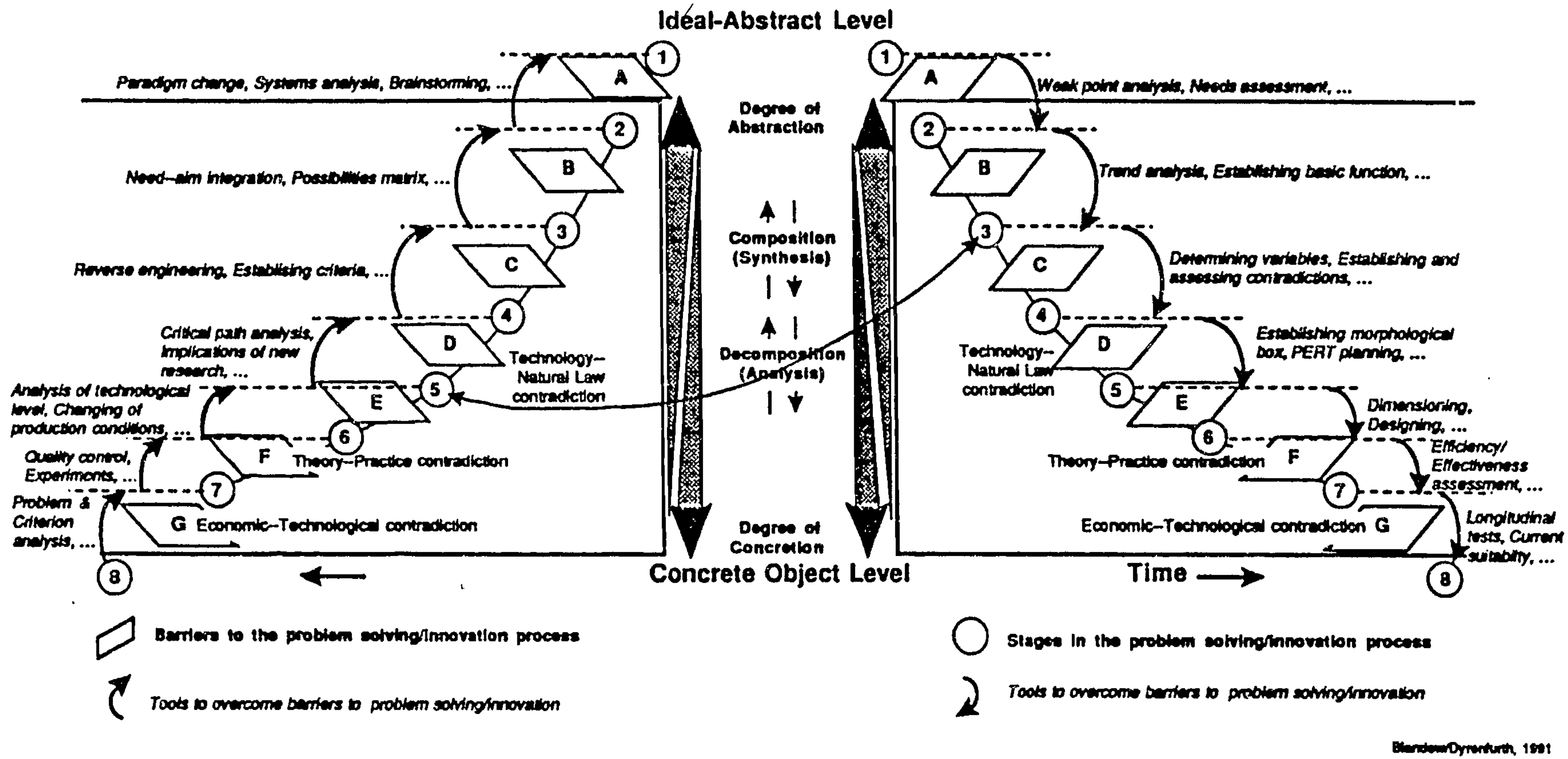


Figure 21. Overview of problem solving/innovation stages, barriers and characteristic tools to enable establishment of solution strategies

2. Recognition and solution of technical problems will happen in sequence of emerging of technical contradictions, their solution and further emergence. The first step taken in working on contradictions will be abstraction[1]. In a heuristic way, we will find on our road to determine the tasks, levels of abstractions (related to the above explained four elements of production).

   - social-economic-technological contradictions for the completeness of the technical system to be developed

   - technological contradictions between the process ΔZ and the conditions Z_1, Z_2, Z_3, Z_n

   - technological- technical contradictions for any partial systems (partial function)

   - contradiction based on both, technology and nature within a partial system.

3. We have thought as contents of an innovation methodology laws of:

   - the development of social and individual needs,standards, resources,

   - the development of the market and of demands

   - laws of:
     -the structure and development of technical systems
     -the structure of technological assessment
     -the constants in the human technological interface

   - laws of:
     -the social creativity and the structure of information systems used on different levels in the process of problem solving

   - and so called heuristic principles, rules
     -principles of recognizing problems (of contradictions, of ideals)
     -principles of problem solving (association analogy, variation, combination,...)
     -principles of materialization (dimensioning, designing,...)

[1]Blandow, D., & Schneider, G. (1974). Polytechnische Bildung und Technikwissenschaft. Wissenschaftliche Zeitschrift der Pädagogischen Hochschule "Dr. Theodor Neubauer". 10(2), 33 ff. [Erfurt, Germany-East]

4. To arrive at solutions involves the problem solving process. The simplest views of problem solving may be depicted by a sequence and/or path network of alternative solution steps and solution stages as shown in Figure 22.

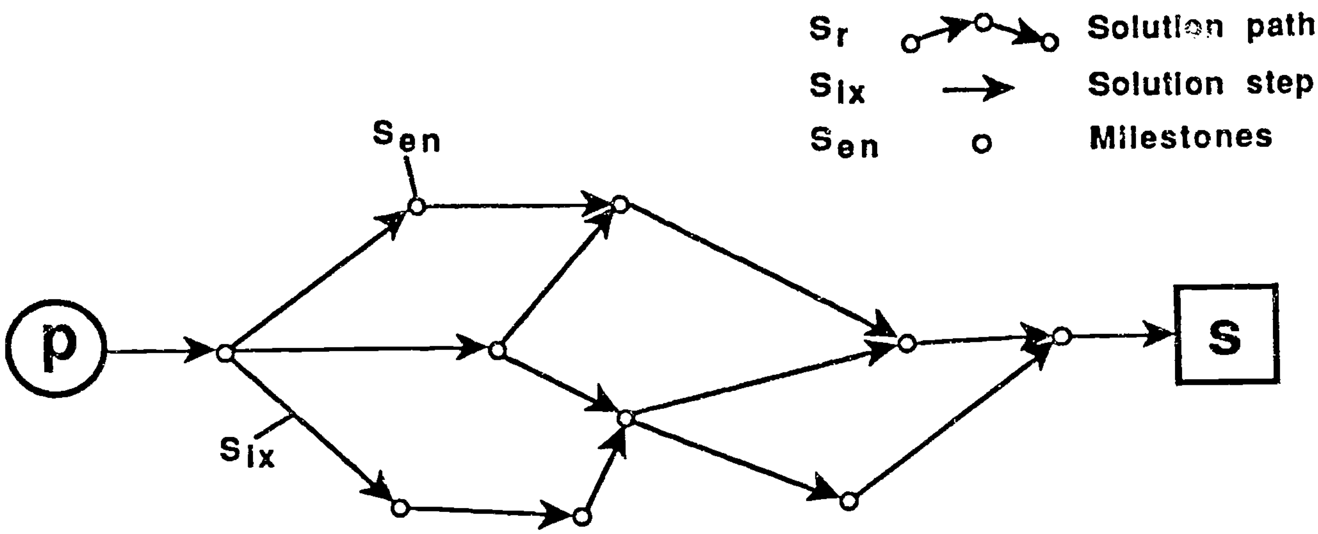


Figure 22. Problem - solution path alternatives

The way from p to s leads:

- along a solution road S_r	- in data processing
- through a solution network S_n	- set (strategies)
- with the solution steps S_i	- program (algorithms)
- and the solution elements S_e	- data (facts), milestones.

From this model we can come also to a hierarchically structured network of problem solving as well as to the modelling of the production process[1]. From the latter, we also come to the constants in the human-technological interface (see Figures 23 and 24).

[1]Blandow, D., Hille, H. & Lutherdt, M. (1988). Forschungsbericht der Forschungsgruppe Polytechnik–Innovationsmethodik. Report to the Akademie der Pädagogischen Wissenschaften, Berlin. Erfurt, Bundesrepublik Deutschland: College of Education.

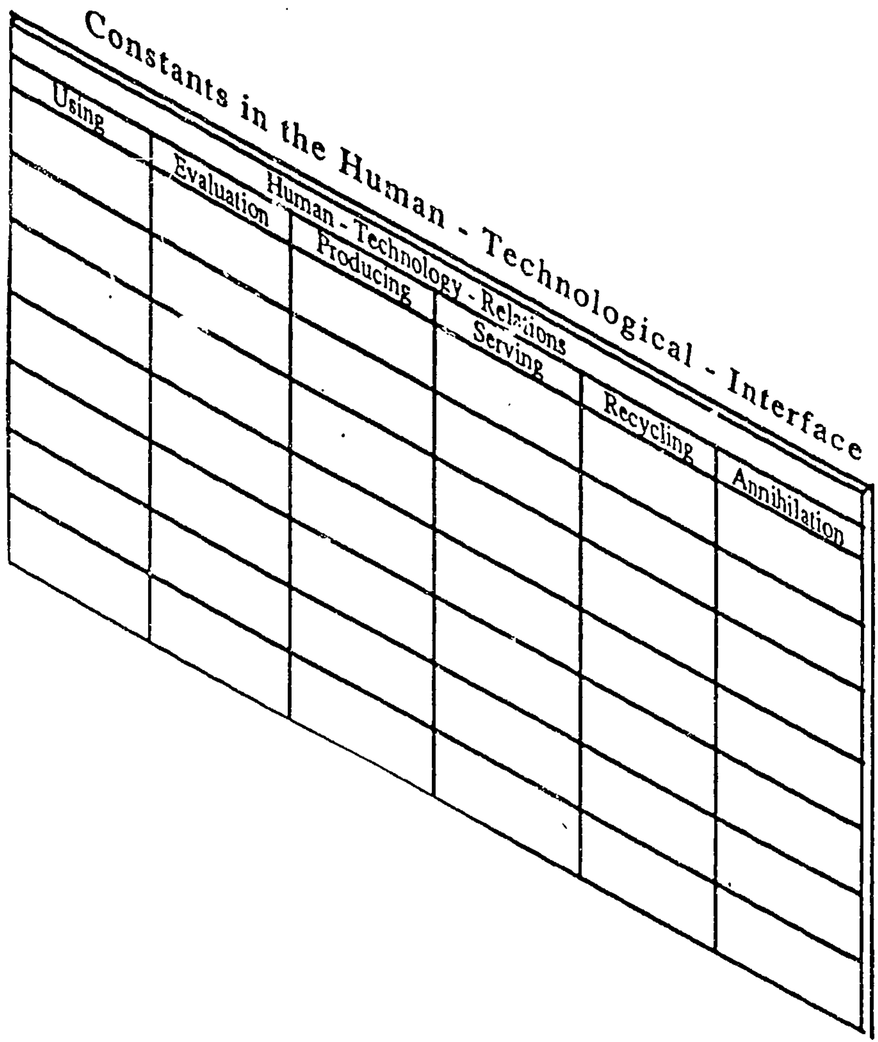


Figure 23. Constants in the Human-Technology interface

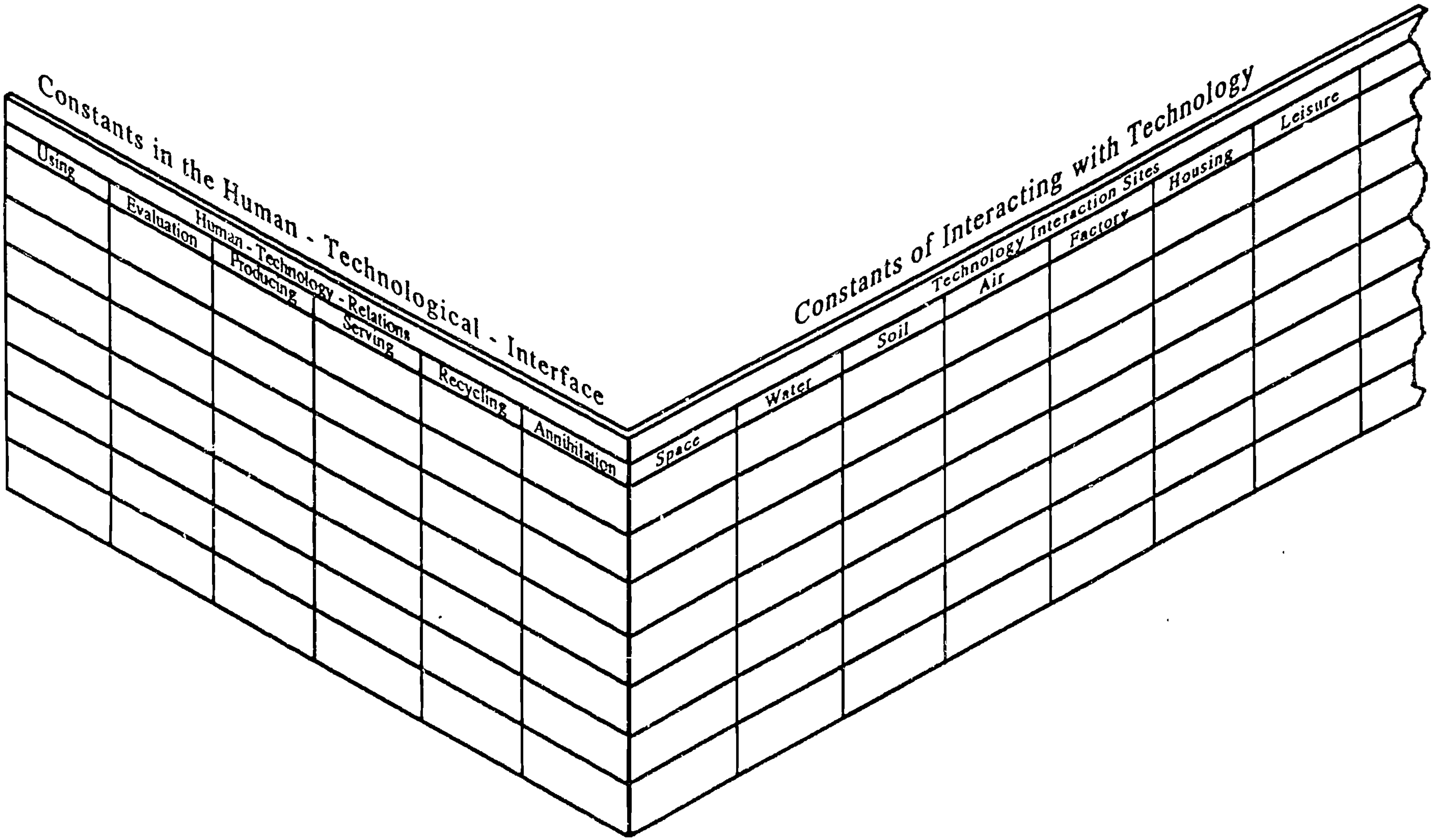


Figure 24. Constants of objects vs processes of technology vs interaction sites

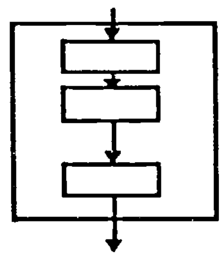
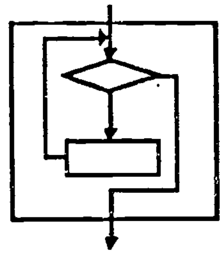
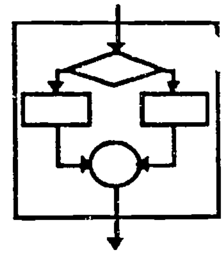
Basic Structure	Sequence	Feedback	Alternative
			
• Knowledge	....	If Next...	If Then ...
• Comprehension	Go To ...	....	....
• Application	....	...	...
• Analysis	....	...	...
•	....	...	...
• ...	....	...	...

Illustration: Tim Trogden — Blandow/Dyrenfurth, 1991

Figure 25. Basic types of human activities

5. The constants in the Human-environment relationship, such as using, evaluating, etc. can be folded against the other planes of my technology model to create new interaction fields. With such a concept of modular planes one has a useful instrument/methodology to organize the multiplicity of technological applications/examples and on the other hand, it enables teachers and teacher educators to generate thousands of ideas and examples for teaching activities, insights and the furthering of innovative thinking (see Figure 26).

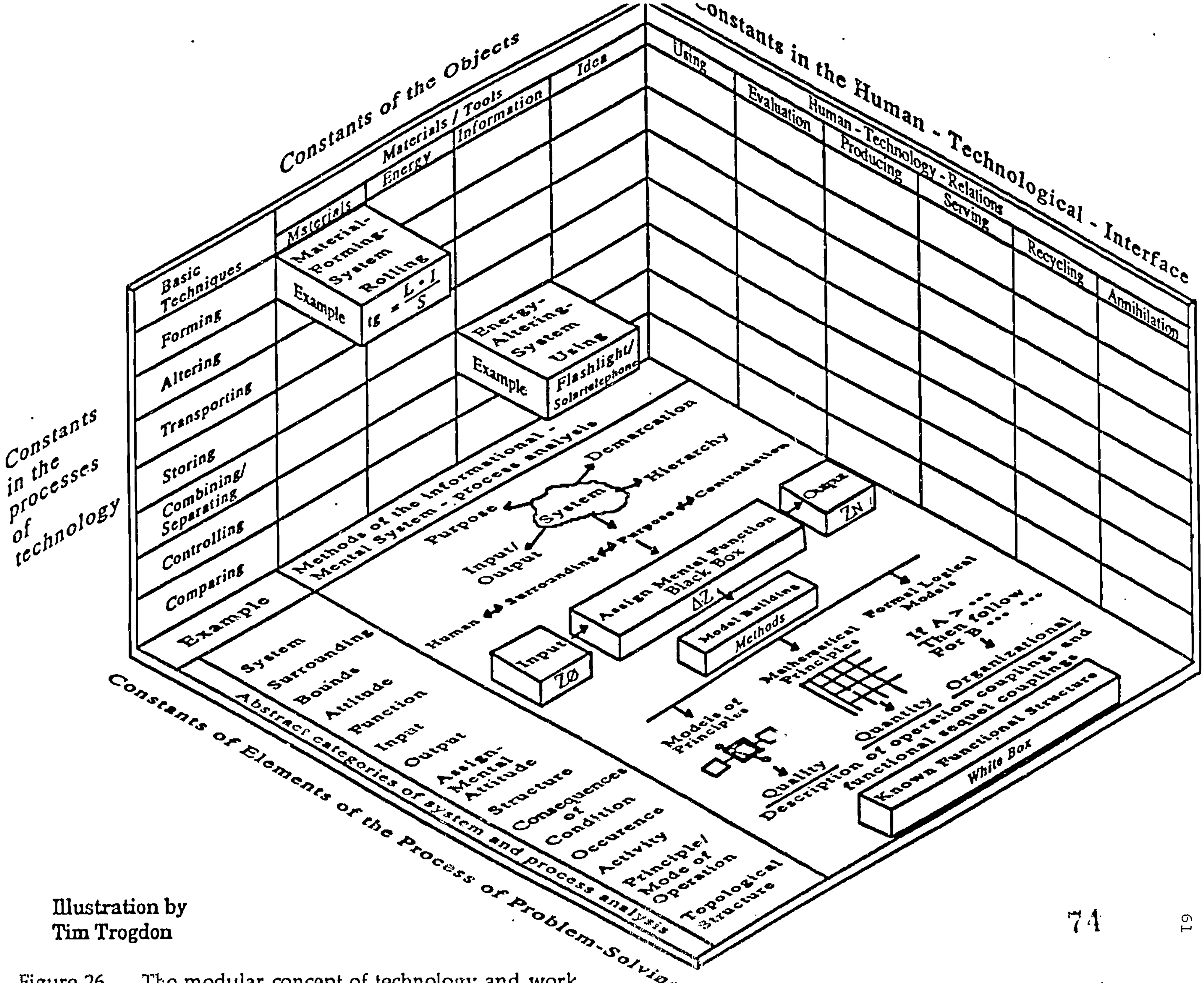


Illustration by
Tim Trogdon

Figure 26. The modular concept of technology and work

3. New information-masses as a part of innovative thinking

The Human-Technology relationships are curious (see Figure 15). As more and more insights are developed and put into practice, each generation finds it increasingly difficult to work with these accumulated practices because of their exponentially increasing number and complexity. The main evidence of this, the well known knowledge--time problem, makes itself particularly visible in the information explosion. To overcome this problem, capabilities such as the following are being addressed:

- Information interpretation (no sequence implied)
- Information structuring
- Information elimination
- Information acquisition
- Information reduction
- Information production
- Information combination
- Information selection
- Information ...

To understand the fundamental process of the irreversible Human--Technology relationship, one must first change paradigms and acknowledge information both as a product and as a key target for assessment. For our strategy-oriented concept (see Figures 1 and 15), it is important to note that each barrier and the strategy necessary to overcome it requires mastery of its own information-mass. In this paper we are providing only selected examples of our theory. A more completely detailed explication of the theory will be presented as a foundation paper for the International Conference on the Concept and Strategy of Technology Education as a Part of General Education[1], which will be held in Germany-East, in April 1992.

Consequences of point 3

To demonstrate the application of the theory, and to heighten your interest, we have provided three examples.

- Information-mass to overcome the Function--Ideal Model barrier (see Figure 27).
- Information-mass to overcome the Function--Structure barrier (see Figure 28[2]).
- Worksheets for overcoming the Environment-Need barrier (see Figures, 29, 30[3]).

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[1]To receive the call for papers and further information about this conference, contact Dr. D. Blandow, College of Education, Nordhäuser-Strasse 63, 5063 Erfurt, Germany-East or Dr. Michael J. Dyrenfurth, 103 London Hall, University of Missouri-Columbia, Columbia, MO 65211, Fax: 314-882-5071, BITNET: PAVTMIKE@UMCVMB.

[2]Hill, B. (1987). Methoden des Erfindens und ihre Nutzung zur Förderung technisch begabter Schüler neunter Klassen. Thesis for Dissertation A. College of Education, Nordhäuser-Strasse 63, 5063 Erfurt, Germany-East

[3]Schmidt, V. (1989). Bewerten technischen Objekte--ein methodologischer Ansatz zur Erschliessung der Komplexität der Technik. Thesis for Dissertation B. College of Education, Nordhäuser-Strasse 63, 5063 Erfurt, Germany-East

Category	Trends	Examples
Space (volume)	Greater utilization Miniaturization More intensive use Greater effect/more results More variable space	Multilayer circuitboards VLSI Satellites, telemetry buoys Vertical storage warehousing Year-round schools Overhead conveyors Conference centers
Time	Parallel usage Greater effect/more results More elastic interrelationships Greater damage/problems when deviation occurs	Batch production Demand oriented support systems (e.g., airports) Just-in-time manufacturing Flexible manufacturing
Material	Application domains increase in range Increase in types Purity increases Smaller amounts New combinations Increased use of more characteristics Increased reuse	Thin-wall casting Composites Recycling Computerized layout Artificial aging Thermoglass Biological computers
Energy	Reduced transport loss Increase in storability Increased convertibility Greater recovery Increased intensity More co-generation More use of micro-processes in macro applications	Plasma-laser technic Bio-solar energy Co-generation, e.g., incinerator/power station Optical technology Superconductivity
Information	Increased processing speed Increased specialization/tailoring Increased storage volumes Increased vulnerability to mass errors Increased networking Simplified access Greater consequences of mistakes	Computer generation International databanks and communication networks Computer hackers/Viruses System-wide failures (blackouts) Privacy of information Super computers Personal computers Hierarchical networks

Continues

Blandow/Dyrenfurth/Schmidt, V., 1991

Figure 27. Trends of demands on technology to guide formulation of the effectiveness equation, continues

Category	Trends	Examples
Societal Values	Increased ecological concern	Automobile emissions laws, Environmental Protection Agency, Recycling initiatives, Land fill regulation
	Increased participation in life-long learning	Videotape delivered instruction, distance learning, Adult education, HRD programs
	Globalization/world perspectives	Ozone layer protection regulations, International economic competition, Rain forest protection
	Social consciousness	Old folks community, Barrier-free design, Noise control zones
	Resource consciousness	Energy conservation, Projection of resource supply, Incineration and compacting of waste, Reforesting prgrms.
Working Conditions	Ease of assembly	Simpler parts; Jigs & fixtures, New adhesives, New processes e.g, ultrasonic welding, Velcro
	Serviceability	Increased access by design, Computerized warehousing, Module replacement
	Ergonomics	QWERTY keyboard, Adjustable chairs and work surfaces, Redesign of jobs
	Reduced maintenance	Self-maintaining systems, Redesign of components, Throw-away parts/products
	Safer	Non-contact processing, Automated safety systems, Improved personal protective devices, ABS systems
	Ease of monitoring	Integrated system reporting, Error-only display, Recommendation suggestion, Artificial intelligence
	Less demanding (physically)	Power steering, Automatic transmission, Robotics

Blandow/Dyrenfurth/Schmidt, V., 1991

Figure 27. Trends of demands on technology to guide formulation of the effectiveness equation

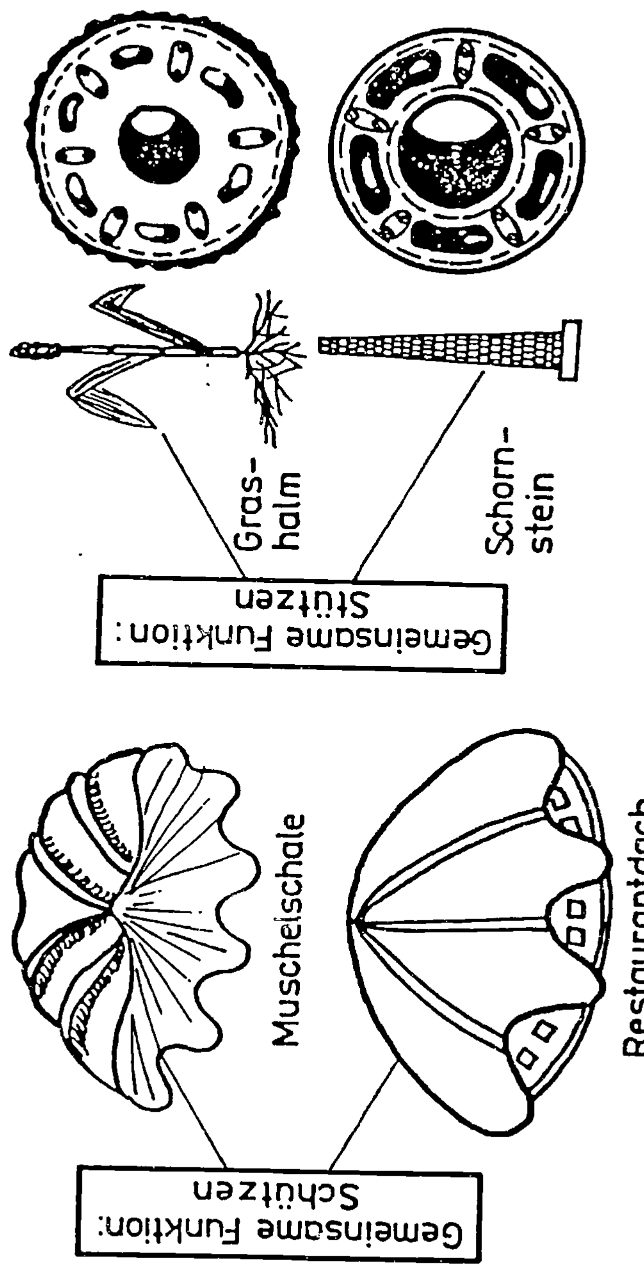
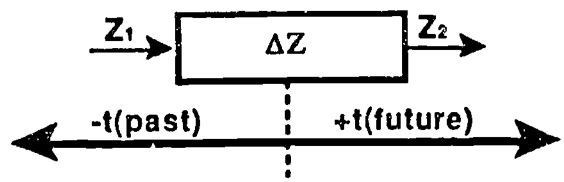


Figure 28. Example from the catalog of ideas to overcome the Function--Structure barrier

Worksheet for Trends Analysis

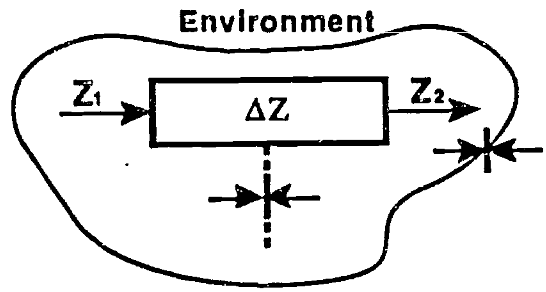


Structure	ΔZ, the ways and means of change (process) that changes the conditions/situations (Z_1, Z_2, Z_n,...) is charted in chronological sequence and the most likely next development is extrapolated on the basis of the trend curve.
Characteristic questions	How were the changes of conditions/situation (Z_1, Z_2, Z_n,...) accomplished? What technical means and/or processes (ΔZ) are likely developments along the trend line
Situation 1. Automobile radio station selection 2. Home windows	**Known Trends** 1. Faster travel, digital tuning, integrated controls, international symbols, error readouts, self-correcting circuits, ... 2. Greater durability, thermal-control/insulation, noise abating, stronger, easier cleaning, variable trim, light transmission control (amount and direction), ...
Potentially new examples	Automobile radio station selection: Steering wheel mounted controls; self-seeking according to type; emergency message superimposition; ... Home windows: Adjustable, i.e., thermostat-controlled heat absorption/rejection setting; variable light transmission and direction; image diffusion control;...
Your suggestions (any situation)	

Blandow/Dyrenfurth/Lutherdt, 1991

Figure 29. Worksheet for trend analysis

Worksheet for Identifying Contradictions



Structure	ΔZ, Effectiveness $= f(\text{Trends, needs, demands}, \ldots)$ Factors $E \Uparrow = f(e_1\Uparrow, e_2\Uparrow, \ldots, e_n\Uparrow)$ Components $e_1\Uparrow = f(x_1\Uparrow, x_2\Uparrow, \ldots, x_5\Uparrow)$ Components $e_2\Uparrow = f(y_1\Downarrow, y_2\Uparrow, \ldots, y_5\Downarrow)$ $E \Uparrow = f(x_5 \rightarrow \mid \leftarrow y_5)$ Identification of contradictions that operate within ΔZ and between the outcomes and the environment through analysis of factors and their composition
Characteristic questions	What contradictions operate within ΔZ and/or between its output and the environment? How can one counteract the individual effects, trends, demands, ...
Situation 1. Buildings 2. Ironing (clothes) 3. Bicycle lighting	**Known Examples and [Contradictions]** 1. Pneumatic structures [Area vs Mass], Moving form construction [Size vs Time], ... 2. Teflon-soled irons [Friction vs Pressure], Temperature controlled iron [Fabric protection vs Operator inteliigence]... 3. Generator powered light [Light vs Effort], [Light vs maintenance], ...
Potentially new examples	1. Energy efficient buildings [Material mass vs Energy storage], Environmentally protective buildings [Internal oxygen generator vs Complexity] 2. Induction powered iron [Energy supply vs Mobility], Magnetically pressured iron [Downward force vs Operator fatigue] 3. Visibility to others [High visibility vs Power demand], Forward lighting [Energy source vs Operator effort]
Your suggestions (any situation)	

Blandow/Dyrenfurth/Lutherdt, 1991

Figure 30. Worksheet to identify contradictions

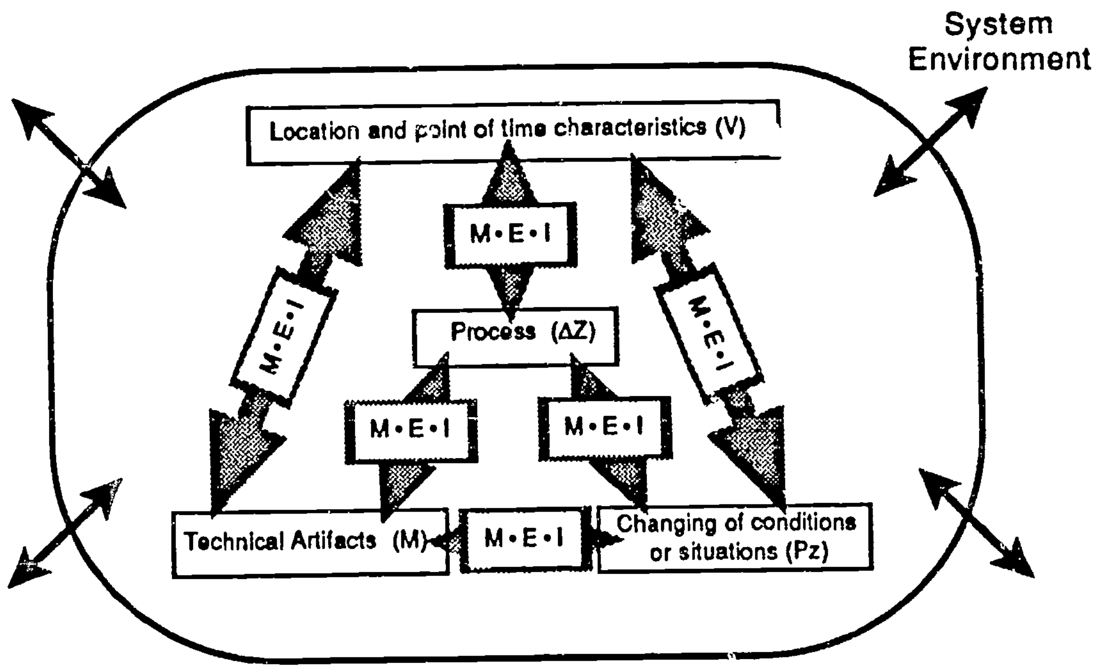
Contradiction -->|<--	Examples
Stiff ->|<- Elasticity	Spring, tree branch, tire
Porous ->|<- Holder	Filter, unglazed clay pot, skin
Dry ->|<- Humidity	Moss, Pampers, bandaids
Loose ->|<- Rigidity	Polystyrene bead boards, ice cream
Open ->|<- Enclosure	First law of thermodynamics, window
Accelerating ->|<- Delay	Energy conservation systems (commuter trains, elevators)
Light ->|<- Darkness	Infrared imaging, radar
...	...
...	...

Blandow/Dyrenfurth/Kahmann, 1991

Figure 31. Worksheet for the formulation of contradictions to trigger innovation

To properly understand the problem solving/innovation process and to properly develop this capability in others, it is not sufficient to merely depict the key stages it involves--these are typically well known. One must also depict the information-masses that must be mastered and the barriers that must be overcome. Most important, however, is the learning of the intellectual tools and strategies (their organization) necessary to master each information-mass and surmount each barrier.

Some of the implications of the preceding for education about technology (in general education) may be seen in Figures 32 and 33. The first shows the overall structure of, and number of permutations possible in, our modular theory of technology and work. The second shows the relationship of individual specific competencies to overview competencies. This figure also depicts the relationship of knowledge of individual facts to knowledge of strategies. Through these, one can reestablish both the actual concept of foundations, as well as their manifestation, for education about technology.



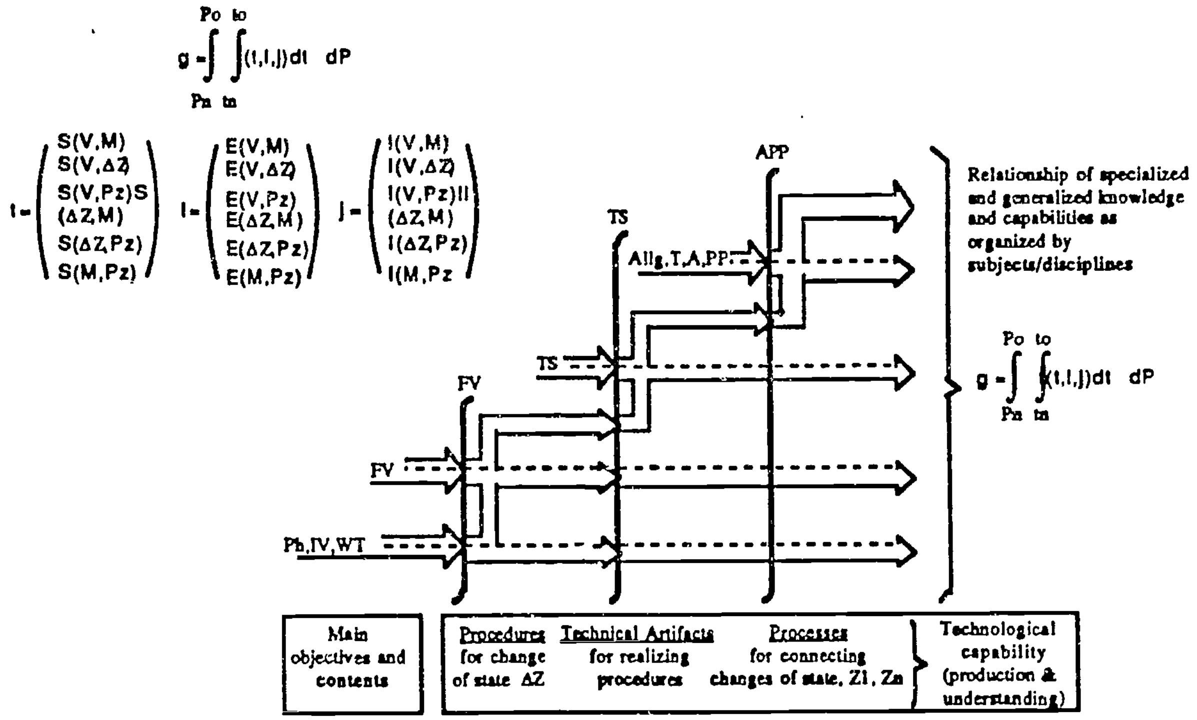
Legend

g	Product (material, energy, information, biological, synthetic)
◄◇►	Material, energy and information couplings
Pn ∫ Po	Stages of production
tn ∫ to	Location and/or point of time characteristics
⇒	Component of the curriculum that contributes overview, system understanding and generalization skills.
⇢	Specific competencies (e.g., occupational, technical, language...)
∫	Integration into human capability, a new quality (kind) is established
FV	Process of manufacture
Ph	Physics
I V	Informatics
WT	Properties of materials
TS	Technical subject/disciplines including mechanical engineering, technics of automation, electrotechnics/electronics, ...
Allg. T	General technology
APP	General production processes

Illustration: Tim Trogden Blandow/Dyrenfurth, 1991

Figure 32. Overall structure of, and number of permutations possible in, the modular theory of technology and work

Total function:



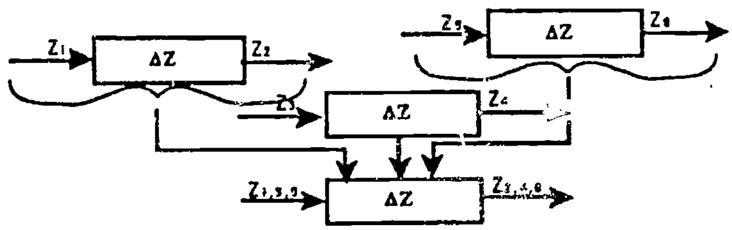
Legend

g	Product (material, energy, information, biological, synthetic)
↔	Material, energy and information couplings
$\int_{Po}^{Pn}$	Stages of production
$\int_{to}^{tn}$	Location and/or point of time characteristics
⇒	Component of the curriculum that contributes overview, system understanding and generalization skills.
⇢	Specific competencies (e.g., occupational, technical, language...)
∫	Integration into human capability, a new quality (kind) is established
FV	Process of manufacture
Ph	Physics
IV	Informatics
WT	Properties of materials
TS	Technical subject/disciplines including mechanical engineering, technics of automation, electrotechnics/electronics, ...
Allg. T	General technology
APP	General production processes

Illustration: Tim Trogden — Blandow/Dyrenfurth, 1991

Figure 33. Relationships between specialized and generalize understanding and capabilities in the education about technology

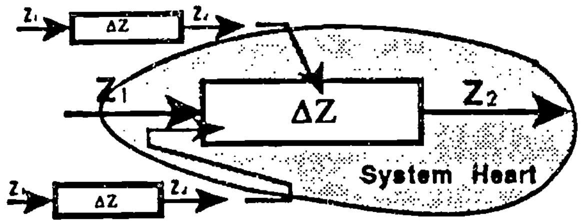
Worksheet for Need--Aim Integration



Structure	Integration of several here-to-fore separate processes (ΔZ) that operated at different times, and at potentially different locations, into a single new process
Characteristic questions	What functions can be combined either with respect to time and/or location? How can the characteristics of the applicable materials, energy and information elements be used to trigger integration?
Situation 1. Reading 2. Mirrored vanity cabinet 3. Automobile tire 4. Urban planning	**Known Examples** 1. Illuminate magnifying glasses, ... 2. Fan equipped vanity to prevent fogging,... 3. Tubeless tires, ... 4. "Green-roofs" (terraced plantings)
Potentially new examples	1. Reading mechanisms equipped with text-to-voice conversion, light and copying/storage devices,... 2. Vanity equipped with temperature regulated (anti-fogging) mirror, television, telephone and dictation apparatus,... 3. Airless tires, Automatic, on-vehicle, pressure regulated tire inflation system 4. Solar/ecological domed cities, ...
Your suggestions (any situation)	

Blandow/Dyrenfurth, 1991

Worksheet for System Analysis



Structure	Determining of the location of ΔZ by specifying the environment, the system's hierarchial structure (sub- and supra systems), and the importance of the various processes (ΔZ)involved.
Characteristic questions	Where and how were the most important/characteristic changes of conditions/situation (Z_1, Z_2, Z_n,...) accomplished? What are the system's sub- and supra-systems and how are they related to the overall goal?
Situation	**Known Examples**
1. Automatic lathe	1. Automated work parameter maintenence via non-contact instrumentation and cybernetic control systems,...
2. Coffee machine	2. Identification of variables that affect coffee taste and quality and their incorporation into an adjustable consumer product, ...
3. City traffic management	3. Identification of traffic flow streams and their influencing factors (including social ones) and their control via networked signals and work release announcements.
Potentially new examples	Furthering of automatic lathe by incorporating parameter-determined in-process tool sharpening and resetting of tool offset, ... Incorporation of individual taste control (as contrasted to strength);... Individually programmed routing systems for vehicles based on satellite mapping and traffic parameters.
Your suggestions (any situation)	

Blandow/Dyrenfurth, 1991

Summary and Conclusion

It was our goal to present an overview of the structure and the distinguishing features of technology. With the view of the developmental stages in traditional technical and technological disciplines; which evolved from the practical-oriented approaches, through knowledge-, process- and methodology-oriented approaches to the strategy-oriented approach; it should be emphasized that this involves a most critical change of paradigm from a subject- or discipline-oriented one to one that is much more focussed on goals to be accomplished. The specific problem to be surmounted is the predominant focus, not the individual disciplines that will make-up the solution. An integrative perspective is necessary, taking from each discipline what it has to offer and then synthesizing these contributions into a solution that addresses the problem in a new way.

From these point the key elements of modern structured technology were indicated. They were the process, the changing of conditions or situations, the location and point of time characteristics and the technical artifacts or means. These key elements are involved in all levels of hierarchically structured production processes. This also yielded the insight that such views of technology are useful in all of technology's arenas including those of agriculture, industry, chemical processes as well as in home economics for example. Also identified were the goals for the development of an organizational structure of processes. These served to guide the development of the elements of processes.

In the paper's second part the determining factor in the human-technology relationship--particularly in the field of production--is identified as the further development/advancement of capability -- not the mere satisfaction of need. From this point, new questions arise with respect to the handling of information-masses as well as the capabilities for choosing the appropriate storage and retrieval mechanisms. The development process involves seven key stages: Recognition of a problematic situation (thought initiator), overcoming thought barriers, envisioning possible solutions, model development (resolution of contradictions), development of approach strategies, development of time and activity plan, execution of the plan, evaluation of the results and recognition of the new situation/problematic situation.

Given the presented concept of a modular view of technology and work, we have synthesized two kinds of thinking. One is object-oriented thinking and the other is a kind of innovative thinking. By combining these two approaches with the modular concept, and then emphasizing the development of strategies, we hope that the result of our work can be used for a diverse set of problem situations--both industrial and educational as well!

Health and Biomedicine

A TIME OF UNCERTAINTY
THE IMPACT OF THE OPEN-ENDED TIME FRAME ON BIOMEDICAL ETHICS

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> L'éthique, c'est comme le visage humain; publier des idées sur l'éthique, c'est comme de voir son image en photo, ou en peinture. Nous trouvons rarement qu'un portrait nous flatte, ou même nous ressemble; de même, nous nous révoltons à la perspective que nos idées soient figées à un moment donné, empêchant qu'elles évoluent et changent.
> Peggy Golde to Fritz Redlich 1973.

All too often, we are reluctant as a society to look at our own changing face and adapt our ethics and our moral education to reflect the signs of the times. This reluctance generates communication gaps in the fabric of our society which are often glossed over with empty rhetoric and statistics. The vacuity of this rhetoric and the failure to instruct physicians in the successful reading of a medical discourse combine to doom any future efforts by the physician to upgrade his medical skills to almost certain failure. Without a course in the practical analysis of medical statistics and the methodology exploited to collect these statistics, the physician cannot successfully read advanced articles in his profession. Many current issues in medicine are related to this fundamental comunication gap. In this discussion, which resulted from an attempt to supplement the medical curriculum with proposals for interdisciplinary courses linking the humanities and medicine, some of the issues raised by these courses are related to currently controversial issues for which the professional medical worker has been inadequately prepared: the new eugenics based upon recombinant DNA, variability in medical practice, rationing of medical care and the treatment and diagnosis of incurable diseases. Most of these issues have only become urgent public concerns in the past decade as technology exercised a greater influence on medical practice.

In the last decade, this reluctance to change time honoured traditions has, perhaps, had its greatest impact on the medical profession. Nonetheless, as Gadamer (1967:211) observes that,perhaps, technology has also had its greatest impact upon our society without properly preparing it for the new efficacy:

> Die mathematisch-quantitative Erfassung der Gesetzlichkeiten des Naturgeschehens ist auf eine Isolierung von Ursache- und Wirkungszusammenhängen gerichtet, die dem menschlichen Handeln Eingriffsmöglichkeiten in nachprüfbarer Genauigkeit gestatten. Der mit dem Wissenschaftsgedanken der Neuzeit verknüpte Begriff der Technik nimmt so auf dem Gebiete des Heilverfahrens und der Heilkunst spezifisch gesteigerte Möglichkeiten in die Hand. Das Machenkönnen macht sich gleichsam selbständig.

Unfortunately, if the new instantaneous realization of the will through technology brings "Machenkönnen" within humanity's grasp, it seems to have done so at the expense of understanding.

Cultural Personal and Societal Suicide

The communication gap discussed above appears as a mental death--an ineffable gap in the meaning of life--in both the medical curriculum and our society. Is this sense of mental death permeating our society a longing for the body to join the mind in an eternal sleep liberated from the burdens of a life which we are unprepared to control? The sense of uncertainty surrounding the desires of those incapacitated by incurable diseases like Nancy B. weighs heavily upon the minds of physicians who wonder whether the patient is actually expressing a real desire for death or a desire for control over what remains of their life. Nancy B. was a young woman afflicted with a neurological wasting disease whose life was sustained by a respirator in a Quebec City hospital. Nancy B. was no longer capable of any physical movement but her faculties remained unimpaired. In October of 1991, Nancy B. expressed her desire for a cessation of life support to her physician. The physician and hospital felt that they could not grant this wish without a court order. Although Nancy B. successfully went through legal proceedings in order to terminate her life which gave her the right to end her life in January 1992, she waited yet another month to request this termination for reasons of her own. With the recent publication of a practical guide to suicide, Final Exit (1991), we, as professionals, are called upon to address one of medicine's thorniest issues, death, its diagnosis in incurable diseases, its impact on global population and its relationship to the genome. The fact that a practical guide to suicide filled a communication gap in our society reflects upon the ontological status of disease and a social disease which led a troubled society to this conclusion. In fact, Jean-François Malherbe (1984:11) concludes that we have already sacrificed our nature on the altar of technology and that we, as thinking beings, do not drive the technology with our identity but are driven and delineated by the technology at hand:

> Au travers de tout ce développement biomédical, c'est la signification de la vie humaine qui change, ou plus précisément l'image que les hommes et les femmes se font de la vie et leur propre vie... Or, les images héritées de l'homme, de la femme, du couple, de la famille, de la parentalité, ne "collent" plus avec ce qui devient possible par le développement des technosciences biomédicales. L'on pourrait résumer la transformation culturelle profonde qui s'opère en ce domaine en disant qu'au cours naturel des chose se substitue de plus en plus la libre intervention (technique) de l'homme.

Liberty in the Mind and Science

However, Malherbe's appraisal of our mental ecology is too limited because he forgets humanity's ability to find freedom in the confines of a purely mechanistic device like the brain as Eccles emphasizes (1973:217):

> All I have to say is that free will is a fact of experience. It is something each of us experiences. No one would have imagined free will to exist if he hadn't experienced it, by which I mean the ability to carry out actions that have been planned in thought.

If humanity can express freedom where a mechanistic universe tells us that none exists then we can condition our reaction to reality and even to the hard realities of technology. The ability to adapt to the situation means that education can intervene in the communication between technology and any specialized sub-group of humanity through proper conditioning of our responses. Because of the problem of a perceived mental deficit, defined by the gap resulting from the failure to integrate technology into our a societal concern, the status of death, needs to be re-evaluated as both an ontological and problematic entry in the contemporary knowledge base. Who should address this communication gap which has surfaced in everyday life?

Interdisciplinary Uncertainty:Training the Patient and Physicians

The field of biomedical ethics is not without problems for faculties of medicine from the standpoint of staffing. Who should teach these courses which are often involved with material beyond the range of medicine? Clearly, lawyers who are already heavily represented fill the pragmatic need for a frame of reference in the societal context. However, given the far reaching effects of the current medical crisis, is a legal opinion sufficient? How many of the following questions posed by Françoise Baylis and Jocelyn Downie (1990:1), which are frequently confronted by physicians, can be answered in a purely legal context:

> A patient recently diagnosed as HIV positive requests that his wife not be informed of his HIV status. Should his wishes be respected or should his wife be told?
>
> An elderly patient has carcinoma of the prostate. Should he be told of the diagnosis against his son's wishes?
>
> A mother refuses medical treatment for her child on religious grounds. Should her religious convictions be allowed to limit her child's access to health care?
>
> A couple requests prenatal diagnosis for the purpose of sex selection. Should this request be granted?
>
> A competent, incurably ill patient rejects the continuation of life-sustaining treatment. Should her wishes for the withdrawal of treatment be respected?
>
> The family of a patient in a persistent vegetative state requests the discontinuation of artificial hydration and nutrition. Should this be done?
>
> A mother of three who admits to alcohol abuse requires a liver transplant. Given the shortage of cadaver organs, should this person be considered eligible for a transplant?
>
> An anencephalic infant is born. Should her organs be used for transplantation?

Most of these questions are not clearly resolved under the law nor in medical practice: they fall into the domain of clerkship and an apprenticeship in medical ethics. The philosophy of moral obligation and ethical decision making which constitutes deontology grows out of the clerkship experience which is alien to most theoretical domains. Unlike science in general, medicine cannot shut out extraneous detractors from theoretical issues and stabilize theories of health for long periods of time which might not be fully working theories in the real world. Thus, a conflict like the practicality of quantum physics at the sub-atomic level and its impracticality at the level of astro-physics cannot be tolerated in medicine. Since medical theory is of real and significant importance to the subjects involved, a pragmatic margin between theory and practice must be acquired by the physician as a working theory of "medical practice." This second and secondary phase of medical practice, which is difficult to teach within the constraints of medical theory, constitutes a pragmatic ethics of medical practice acquired during clerkship. The problems of a propensity for a purely mechanistic approach to medical ethics has made it necessary for the medical profession to try to declare a formal statement about deontology as a principle of medical research and the availability of its results (Rapport de la commission nationale de l'informatique, 1978-80). In the context of daily medical practice it seems that article 1108 of the Code civil (Fagot-Largeault, 1985:117-118) most adequately defines protection of the patient even beyond the limits of their consent which might not be based upon sound judgment:

> --que le consentement du sujet soit libre et éclairé". Si le sujet est juridiquement incapable de contracter, le consentement est donné par son représentant légal (autorité parentale pour les mineurs; tuteur, curateur ou mandataire, pour les sujets relevant de la loi sur les incapables majeurs du 3 janvier 1968). La liberté du consentement exclut toute coercition ou pression exercée sur le sujet ou son représentant. Pour que le consentement soit éclairé, "la nécessité d'une information claire et précise du malade est reprise dans la jurisprudence. Cette information doit en particulier toujours préciser les risques et les avantages de la thérapeutique proposée et les comparer à ceux des éventuelles autres méthcdes utilisables."
> --que la cause du contrat ne soit "ni illicte ni immorale". Selon l'arrêté du 16 décembre 1975, "il est nécessaire que les essais cliniques s'effectuent sous forme d'essais contrôlés", de préférence en double insu, et contre un produit de référence (s'il en existe un) plutôt que contre un placebo. L'interprétation restrictive que fait la jurisprudence de cette clause rend illicites les essais conduits suivant une autre méthode. Les règles déontologiques impliquent l'immoralité de tout essai dont la finalité n'est pas thérapeutique. En l'état actuel des choses, seuls les essais contrôlés thérapeutiques sont donc à la fois licites et moraux.

This clerkship is a second phase of apprenticeship based upon the sense deontology expressed above which probably cannot be formally theorized--in effect, it is unclear at present whether biomedical ethics can be formalized. The integration of humanities and medical courses is envisaged in the spectrum of activities popularly called clerkship which Gebsattel (1953:251) proposes as a second phase of medical practice:

> Und so drängt alles dahin, die Handlung des Arztes fester zu verankern. Geschehen kann das aber nur, wenn dir im Sinn der ärztlichen Vollhandlung, ideell und grundsätzlich, der Sache nach wirklich schon verankert ist. Insbesondere drängt sich diese Forderung auf, wenn wir, experimentierend, die zweite Phase der ärztlichhen Hilfeleistung, in der diese sich selbst als Diagnostik und Therapie versteht, probeweise verabsolutieren. Dann zeigt sich, dass hinter der Fassade glanzvoller Erfolge durch die naturwissenschaftliche Medizin nicht nur eine zunehmende Somatisierung und Technisierung der Medizin sich eriegnet, sondern

> ebenso eindrucksvoll eine wachsende Desorientierung des Mediziners."

How can we control or even cure the effect of a "growing disorientation" of the Health Care Worker caused by Technology? Who has the background to help physicians make these daily decisions thrust upon them by advanced technology?

The problems are of a philosophical, perhaps religious nature--at least all of the issues touch upon the sanctity and dignity of life. In light of this overlapping of values, it seemed that perhaps the curriculum in medical ethics could be supplemented by the humanities profitably and that both faculties could better prepare their graduates by training better patients and physicians. Thus, in the technological age we could assume that even if a humanities or engineering student was not going to face these problems as a physician, the individual would certainly profit from the training in dealing with these problems as patients. Clearly, morality cannot be legislated nor can it be derived from technological advances: it is that element missing in Gadamer's "Machenkönnen"-- a variety of "Machensollen" which delineates humanity's free will. We must recall that many of these problems were concealed in a patronizing paternalistic Code of Medical Ethics (1847) in the nineteenth century and that this tradition continued into a much freer age :

> The obedience of a patient to the prescriptions of his physician should be prompt and implicit. He should never permit his own crude opinions as to their fitness, to influence his attention.

The paternalistic model of health care has changed: there is now a Patient's Bill of Rights (Veatch, 1984:38). Patients are encouraged to assume responsibility for their health and to explore preventative measures to guard their health.

Variation in Medical Practice and the Science of Uncertainty

All physicians are advised that their profession is such that they will need to continually read articles about current procedures in order to treat their patients efficaciously. However, articles in medical journals are often couched in a medical discourse which obscures the criteria influencing the reported occurrence of any given condition such as consistency and change over time, performance versus efficacy, ethnicity, and societal agency. Although most physicians believe that these considerations are secondary concerns in the clinical setting, in reality the impact of these secondary features on an article often slants the information in such a way that we end up with articles contradicting each other while using the same data. What foods and other substances are actually considered carcinogens? What are the parameters for statistics about a condition or treatment reported in the article? Although most sciences delimit these parameters with great accuracy, medicine's societal dimension prevents it from separating the clinical from the societal data. In effect, at times what appears to be extremely high figures for clinical procedures such as testing actually reflect societal abuses such as physician induced need for the testing or partial ownership of the testing facility by the physicians involved (Eisenberg, 1986). Such abuses of medical testing can often be misinterpreted as representing specific health concerns in a given location or popoulation by physicians who are unaware of the underlying motivation for the higher frequency of testing. The discovery of abuse in the medical profession is not a simple issue for new physicians to handle.

The nature of medicine, that is to say a system where close cooperation in crises between members of the medical team is of the utmost importance, precludes the breeding of animosities on a hospital staff or in a university setting as the result of indiscriminate reporting of perceived irregularities. For this reason, an important aspect of a course on medical discourse must be the discussion of discretion in reporting infractions to medical authorities and boards. The first stage in the process should be to approach the individual involved, but our educational system is so circumspect about the reporting of infractions that the new physician often has to approach a highly placed authority figure in order to discover what his obligations are in such situations. Of course, in many cases such an inquiry is tantamount to registering a complaint.

Genes, Genius and Genetic Defects

Undoubtedly, genome research has had a great impact on the medical profession's conception or mental image of disease: the image of disease has become much more holistic reflecting an interrelatedness between diseases and a new medical taxonomy based upon genome research. This same taxonomy has an impact upon our society which has not yet fashioned holistic tools for dealing with issues like the early diagnosis of Huntington's disease, prenatal diagnosis of cystic fibrosis and diabetes or retardation and birth defects in the fetus. Clearly, a new class of medical worker is needed and has been anticipated by the genetics community (Genome, January 1992:1):

> Explaining this information to individuals, helping them decide whether or not to be tested, and counselling them about the results can be a sensitive, complex, and time-consuming process for genetics professionals. Increasingly, individuals with no known family history of CF are also asking their health professionals about testing. Because the number of trained genetics professionals is unlikely to be sufficient to meet the rising demand for genetic services, other health providers must know how to respond to such requests.

The consequences of testing are not simple. First, the test results are a form of comunication about a genetic uncertainty in the individual which can limit their choice of mate, their employment opportunities, the free choice of health insurance and even their life expectancy. No DNA test can be separated from the comunication gap which it is intended to fill--uncertainty. If we consider the fact that, at present, there are not enough health care professionals to respond to a single genetic concern like cystic fibrosis, how many more such professionals will be needed to respond to the needs of individuals facing the uncertainty of a myriad of genetic tests? Many of these professionals can be drawn from the pool of health care professionals who should no longer be involved in invasive procedures. Many uncertainties are unleashed in the genetic test: "... knowing the sequence of an organism's genes will not make it possible to predict how that organism will function because genes are not "blueprints" of the organism." (Genome, January 1992); "Advocates of the Human Genome Initiative point to the fact that it will provide tools for the early diagnosis of gene-based diseases. They also claim that this will speed the discovery of cures. But early diagnosis is of questionable value in the absence of therapies, and specifying the genetic basis of a disease will only rarely produce better therapies in the foreseeable future." (Genome, January 1992); and "As tests become simpler to administer and their use expands, a growing number of individuals will be labelled on the basis of predicative genetic information. This kind of information, whether or not it is eventually proved correct, will encourage some sectors of our society to classify individuals on the basis of their genetic status and to discriminate among them based on perceptions of long-term health risks and predictions about future abilities and disabilities. The use of predictive genetic diagnoses creates a new category of individuals who are not ill, but have reason to expect they may develop a specific disease some time in the future: the healthy ill." (Genome, January 1992). What is a holistic identity for the individual whose life is determined by a timed uncertainty, a fatal or incurable disease?

Uncertain Miracles and the Celebration of Life

Yet another fatalism has been spawned by the cryptic codes of the genome. Limits are being imposed upon the expectation of an individual's achievement because of a genetic pattern. This last problem in genome research constitutes an intellectual death imposed upon the individual's will and determination which is as fatal as any of the physical diseases described above. Clearly, a taxonomy or genetic mapping is not a holistic response to the crisis of discovering that a mysterious code is going to fatalistically determine the course of your life or the life of someone close to you, nor is it an effective antidote for the many conclusions drawn from genome research (Lieblich, 1982; Singer and Berg, 1991) which are premature or poor indicators of the measure of uncertainty in life. Although a return to the eugenics which fostered the racial purity laws in Germany during the 1930's must always remain as the greatest fear for the medical community, there are, nonetheless, several deadly sins which are inherent in the very concept of recombinant DNA. Among the most deadly is the temptation to mitigate the question of sequence and the fact that many gene sequences occur frequently, but seem not to elicit the same expression at the level of the chromosomes. As a result, the rewriting of a genetic expression by introducing a recurrent genetic code might very well have greater impact upon the silent genes than is immediately apparent. Recent successes with recombinant DNA have unfortunately mitigated this risk and reduced the high level of precaution which typified earlier genetic experiments. The brochure called "New Tools for Tomorrow's Health Research" (1991:10) recognizes this problem in an optimistic light:

> The anatomy of a gene consists of two basic parts: the coding region, which serves as the blueprint for a protein; and the regulatory regions, which act like switches to turn on the gene when it's time for it to direct production of protein. Protein coding regions may make up as little as 5 percent of the DNA in the human genome. Many researchers suspect that the DNA making up the rest of the genome will provide new information about the molecular machinery of human cells. This DNA, referred to as "junk" by some, appears to play an important role in regulating gene activity, as well as in the essential organization of chromosomes. Understanding the chromosomal environment surrounding a gene may be just as important as mapping and

sequencing the gene itself.

The intellectual "laisser-aller" expressed as a mechanistic view of medicine negating the person has always been a problem and is a problem which increases with the case loads of large urban hospitals as any shortcut to diagnosis is always welcome. However, the two major problems in genetic diagnosis and therapy seem to be in the temporal order of sequencing and the apparently silent genes. The problem of temporal sequencing is stated as follows by Maxine Singer and Paul Berg (1991:196):

> A fundamental characteristic of both prokaryotic and eukaryotic organisms is the capacity to regulate the expression of their genes differentially. By controlling which genes are expressed and which are silent, or by adjusting the rate at which different genes are expressed, cells adapt their phenotypes to particular extra- and intracellular environments. Genes are often expressed in temporal sequence, the activation of one gene triggering the expression of one or more others, ultimately leading to a cascade of functions.

A concern for safeguards was more prevalent in genetics in its nascent stage than is now the case. The second problem is related to both the silent expression of genes and host-vector combinations which involve E. coli strain K12 (Singer and Berg, 1991:263):

> Shortly after recombinant DNA work began, some scientists expressed concern about the possibility of microorganisms--cells of viruses--containing "foreign" DNA inserts having unexpected and perhaps hazardous properties. Those concerns prompted a search for suitably enfeebled host-vector systems to limit the possibility of infecting laboratory workers or other living things. Certain naturally occurring or laboratory substrains of E. Coli K12 themselves proved unlikely to survive or spread outside of very special experimental conditions not usually found in nature. Modifications of E. Coli K12 and other strains by both classical genetic and recombinant DNA techniques enlarged the repertoire of enfeebled hosts. In some cases, the containment considerations and experimental requirements overlapped. But in others, the debilitated strains added considerably to the technical challenge of experiments. As evidence accumulated to indicate that many of the hypothetical hazards are highly improbable or nonexistent (at least for the vast majority of experiments being conducted), the need for enfeebled host-vector systems became less important.

As has been evident from previous experience, every assumption of safety in science has proven unfounded. Much of the progress in recombinant DNA research is based upon the use of polymerase chain reactions (PCR) described as follows by the Human Genome Project (1991:16):

> The polymerase chain reaction, now widely used in research laboratories and doctor's offices, relies on the ability of DNA-copying enzymes to remain stable at high temperatures. No problem for Thermus aquaticus, the sultry bacterium from Yellowstone that now helps scientists to produce about 1 million copies of a single DNA piece in about three hours.

In nature, most organisms copy their DNA in the same way. PCR mimics this process, only it does it in a test tube. When any cell divides, enzymes called polymerases make a copy of all the DNA in each chromosome. The first step in the process is to "unzip" the two DNA chains of the double helix. As the two strands separate, DNA polymerase makes a copy using each strand as a template.

The four nucleotide bases, the building blocks of every piece of DNA, are frequently symbolized A, C, G, and T to represent their chemical names: adenine, cytosine, guanine, and thymine. The A on one strand always pairs with the T on the other, whereas C always pairs with G. The two strands are said to be complementary to each other.

To copy DNA, polymerase requires to other components: a supply of the four nucleotide bases; and something called a primer DNA polymerases, whether from humans, bacteria, or viruses, cannot copy a chain of DNA without a short sequence of nucleotides to "prime" the process, or get it started. So the cell has another enzyme called a primase that actually makes the first few nucleotides of the copy. This stretch of DNA is called a primer. Once the primer is made, the polymerase can take over making the rest of the new chain...

So the Taq (Thermus aquaticus) polymerase begins adding nucleotides to the primer, and makes a complementary copy of the template. If the template contains an A nucleotide, the enzyme adds on a T nucleotide to the primer. If the template contains G, it adds C to the new chain, and so on to the end of the DNA strand. This completes one PCR cycle.

There are two problems inherent in this process: the polymerase and its primer copy any DNA, including the germ line, with little regard for silent gene expression; secondly, the polymerase chain reaction can be described in three paragraphs and performed at almost any site from a laboratory to a doctor's office. How can we envisage an adequate response to the human crisis which a careless use or misuse of PCR might precipitate in the clinical setting?

The most urgent problem is in the area of communication. A new class of medical personnel is needed to respond to the public's need for a prognosis. The word, prognosis, which projects a "knowledgeable and informed interpretation" of a disease's uncertainty or of the significance of a diagnosis based upon the genetic evidence brings to mind the image of the neuropsychologist. The neuropsychologist's most significant contributions to the clinical environment are the measurement of deficits and prognosis for the subject's recovery in a familial and societal context. However, the neuropsychologist can only serve as a theoretical model for the new class of medical personnel because their task is specifically focused on neurological disorders. Professionals with training similar to that of the neuropsychologist who are not social workers but who constitute a specific appendage to the medical profession are needed throughout the profession to make the ethical leap from diagnosis to prognosis.

In addition to expertise in the particular area of medicine which they support, these medical workers will need to grapple with ethical issues like abortion, the conservation of life, euthanasia, the law and medicine, and the concept of a quality of life. The major factor in guiding a patient and their family through the prognosis is the interpretation of the uncertainty of time in terms of a disease's progress. How capable will the patient be in two months, two years--ten years (Lezak, 1989)? What constitutes improvement in the subject's performance (Lezak, 1983)? What goals can we set for tomorrow--for next year (Fagot-Largeault, 1985)? What can my child become with this handicap (Rapin, 1982; Denoff and Tarnopol, 1971). What are the implications of my decisions within my religious belief (Smith, 1989); (Nelson, 1984; Levi Meier, 1979); (Bleich, 1981)?

Currently, the medical profession is restructuring its identity in terms of health rather than disease. The new class of medical workers modelled on the neuropsychologist seems to be part of this evolutionary process. Just as health is ontologically the opposite face of disease, prognosis is ontologically the opposite of diagnosis. On the one hand, diagnosis is the exclusive domain of the physician who explains the causes of disease creating its ontology for the patient. On the other hand, prognosis looks to the healthiest future possible, suggesting that this domain is necessarily ontologically opposed to the physician's task. How can an ethical position be derived from this paradox? In short, the medical worker must become two voices pointing to the two possible ontological states in the human condition: disease and health.

The Meaning of Death

Robert Veatch (1989) illustrates the difficulty of delineating death in the case study of Pelle Lindbergh who on November 10, 1985 drove his red Porsche into a concrete wall in front of a Somerdale, New Jersey school. The Washington Post reported the next day "Flyer Goalie Lindbergh is Declared Brain Dead." Over the next few days the New York Times, reported that he was "clinically dead" and that after the removal of his organs for transplant that "he died yesterday afternoon." Veatch is correct in asking whether the surgeons killed him on Tuesday by removing his organs, if we take the naive point of view of someone unaware of the communication gap in medicine regarding death. Since the statutory laws vary from state to state and are different in New Jersey and Pennsylvania, Lindbergh would have been dead in Pennsylvania before he would have died legally in New Jersey. What is death--brain death, heart death, respiratory death or whole organism death? The purpose of this discussion is not to resolve the problems raised but to illustrate the kinds of questions which need to be resolved in a new bioethical curriculum equipped to deal with the technological age.

Uncertain Miracles and the Celebration of Life

One of the most difficult tasks for the neuropyschologist whose career is an interminable clerkship, where almost every decision-making process is situation specific, unforeseen and of a prognostic nature, is the evaluation of learning disabilities. In cases of dyslexia, many localizations in the brain contribute to the overall deficit which is often not, as many believe, linked to intelligence nor potential. Because reading is a process where the visual and auditory cortices interact, the dyslexic might be verbally at a genius level and still incapable of reading a single syllable word. Moreover, dyslexia can be environmentally induced because of the role of the frontal lobes in all cerebral activities involving interhemispheric crosstalk. Since the prefrontal and frontal lobes reflect our strategies for resolving real life situations and our attitudinal dispositions, a negative environment can have an impact on learning abilities without indicating any permanent cerebral deficit. Therefore, caution must be exercised in using standardized tests to evaluate learning disabilities. These judgments often determine an individual's future in a goal-oriented society and may represent only part of the overall picture or a temporary and transitional state--this is the case for maturational lag which is commonly misdiagnosed as a permanent learning disability in our educational system. Much of the mythology surrounding mental handicaps can be dispelled by introducing a course in case studies into the medical curriculum in which the physicians, who should ideally have hands-on experience with psychometric testing, could examine the expert administration and interpretation of psychometric testing (Denhoff and Tarnopol, 1971:65-118). Clearly, if educators and physicians are going to be in an environment where they are exposed to cerebral functions, they should have at least an orientation in neuropsychology in the new curriculum.

Integrated Theory and the Integrity of Life

Christianity which has largely dominated medical development in the modern age is based upon the peculiar statement by its founder that he is the Alpha and the Omega:

> 11 He that is unrighteous, let him do unrighteousness still: and he that is filthy, let him be made filthy still: and he that is righteous, let him do righteousness still: and he that is holy, let him be made holy still.
> 12 Behold, I come quickly; and my reward is with me, to render to each man according as his work is.
> 13 I am the Alpha and the Omega, the first and the last, the beginning and the end.
> 14 Blessed are they that wash their robes, that they may have the right to come to the tree of life, and may enter in by the gates into the city.
> 15 Without are the dogs, and the sorcerers, and the fornicators, and the murderers, and the idolaters,and every one loveth and maketh a lie.
> 16 I Jesus have sent mine angel to testify unto you these things for the churches. I am the root and the offspring of David, the bright, the morning star. (Revelation, 22:11-16).

In effect, a closer examination of the relationship between the Hippocratic oath's Greek origins and the reality of the "Great Code's" influence on popular beliefs in the twentieth century does much to clarify some of the mysteries and the air of the quasi-sacred surrounding the medical profession. All of the elements which weave the biblical discourse into the medical discourse are present in this passage from revelation (righteousness as a cure linked to physical "filthiness" and disease) salvation, (through accord with the commandments) and finally, the divine right to cure the diseases of the world (as the sins of the world are cured through a return to the Tree of Life from the Tree of the Knowledge of life and death). One cannot help but wonder if the medical profession would not find itself among the sorcerers without some moral guidance. As many physicians as patients fall into the trap of confusing the link between biblical logos with medical discourse. No element of Christian culture has tried with greater determination to apply the concept of the Alpha/Omega statement to life than the medical profession (that is to say, the restoration of order in the world through the absorption of the individual back into the universal). In essence this biblical bioethics is based upon the reversal of formalism and individuation. Of course, as we noted above, Malherbe senses that this effort is failing and Christianity's efforts and culture are being dissipated by continuing to pursue these same goals.

Undoubtedly, there is no question of abandoning the well wrought machine of Christian medical ethics tightly bound to the Hippocratic Oath, but perhaps it needs new engines to drive it towards its various goals. Perhaps, the Christian "logos" and its ethic cannot embrace the alpha and omega--all creation as individual occurrences--without perceiving it from another point of view or maybe many other points of view. The most accessible perspective, and one which should be the focus of a course in comparative religion in the new medical curriculum, is the Jewish perspective. The mention of the letters, "alpha" and "omega," seems to have inspired a confusion about the concept of biblical unity in the Christian community which has been transferred to the medical profession. The segmentation of the Christian body leads to confusions about death and total death, arising from an apparent assumption that death is partial or ambiguous. The correction of this complicated view of death can be effected for the physician by referring them to the greater context of Christianity, the Middle Eastern traditions shared with Judaism, Islam and other religions of the ancient period. The persistence of Plato's works and their fundamental ambiguity about the body/soul division have attracted only Western science to the Greek context although, in reality, the basic tenor of Western medicine derives its decision-making process from its roots in Judaism. Unlike other Mediterranean religions, Judaism and many of its contemporaries favoured a monotheistic view of the universe which often permeated even the material world. The Jewish identity in the ancient Middle East was largely defined in terms of its monotheism where no pluralism was allowed, "Hear, O Israel: The Lord our God is one Lord" (Deuteronomy, 6:4). However, the concept of unity is not limited to the much quoted Shema but is a cornerstone of Judaism. Many of the problems raised above are resolved in the Judaic sense of an integrated universe and body resulting from the creation:

> Therefore only a single human being was created in the world, to teach that if any person has caused a single soul of Israel to perish, Scripture regards him as if he had caused an entire world to perish; and if any human being saves a single soul of Israel, Scripture regards him as if he had saved an entire world. (Sanhedrin 37a).

It is the premise of this paper and the courses proposed that these precepts borrowed from Judaism are applicable to each and every human being. Other medical oaths borrowed from Chinese (Tao Lee, 1989) and Muslim (Abdul Rahman, C. Amine and Ahmed Elkadi, 1989) traditions emphasize the universality of the concept of death as a totally integrated event.

As the populations of the world move from centre to centre with greater freedom a need for a new medical "logos" will be defined by patient expectancy. Many of these needs can be dealt with theoretically by examining the role of the physician in various cultural traditions in an elective course. These traditions constitute universals which can lead to a new medical "logos" filling the gap created by technology in our contemporary sense of the world. Undoubtedly, medicine is the most intimate of the human sciences and it is for this reason that a shift in the overall definition of the "scientific logos" should start in the medical curriculum. Knowledge of patient expectancy can create not only a better working relationship between patient and physician but also alleviate the number of lawsuits arising from intercultural misunderstandings. On the other hand, many of the legal and ethical problems related to Christian sects are actually derived from a strict interpretation of God's proclamation of himself as the world's physician:

> And he said: if thou wilt diligently hearken to the voice of the Lord thy God, and wilt do that which is right in His eyes, and wilt give ear to His commandments and keep all His statutes, I will put none of the diseases upon thee, which I have put upon the Egyptians, for I am the Lord that healeth thee. (Exodus 15:26).

Clearly, it is from this passage that guilt related to disease is derived in Christianity and Judaism, but a greater problem is posed. To what extent is the physician the surrogate of God in healing humanity and at what point does the physician defile the creation with his interventions? In this paper, I have explored this paradox as the basis for courses in biomedical ethics, directed specifically at those in the clinical setting concerned with the morality of prognosis.

Faced with the ever-increasing burden of financing the medical support system, industrialized urban nations need to initiate training programs for the new class of health workers which promises to resolve problems like accessability, rising medical costs and the quality of medical care. Undoubtedly, as is the case for every technological advance, this practice will shortly be adapted to the needs of the world's diverse health systems, thus achieving universality in a technologically secular culture as Engelhardt (1986) suggests:

> Bioethics is an element of a secular culture and the great-grandchild of the Enlightenment. Because the 1980s have been marked in Iran, the United States and elsewhere by attempts to return to traditional values and the certainties of religious beliefs, one must wonder what this augurs for bioethics in this special secular sense. However, because the world does not appear on the brink of embracing a particular orthodoxy, and if an orthodoxy is not imposed, as say in Iran or the Soviet Union, bioethics will inevitably develop as a secular fabric of rationality in an era of uncertainty. That is, the existence of open peaceable discussion among divergent groups... about public policy issues bearing on health care will press unavoidably for a neutral common language. Bioethics is developing as the lingua franca of a world concerned with health care, but not possessing a common ethical viewpoint. (p. 5).

As is always the case for any "logos", its frame of reference should remain open so that it can encompass the greatest number of individual occurrences. As any medical curriculum is further constrained by the availability of courses, a description of the particular courses in any given curriculum designed with the concerns expressed above in mind might be misleading as, in our case, many of the courses already existed in other faculties and needed only to be designated as interdisciplinary and made available to the appropriate student population. However, in smaller colleges where this may not be the case, one might find that the faculty enjoys participating with their own inventiveness in developing these courses which are both interesting and morally fulfilling.

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FROZEN RHETORIC?: PUBLIC IMPACT ON THE ICE-MINUS FIELD TRIALS

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In the last ten years, newspapers and news magazines seem to contain many dramatic stories of clashes between scientists who ignore safety in the pursuit of knowledge and fame and fortune--and members of the public who ignorantly wish to bar any progress under a banner of environmentalism and ethics. These stereotypes foster a belief that such a clash is inevitable and mask positive examples of cooperation and the beginning of understanding. The first release of a genetically engineered organism (GEM), the so-called "ice-minus" (ice^-) bacterium, is such a success story.

Biotechnology has the distinction of being both an old and a new science. It is old if we define it as the manipulation of inherited traits to improve plants and animals. In this light, biotechnology has been practiced since the dawn of agriculture. In fact, many of the same concepts are still used today in the uncontroversial practices of traditional plant and animal breeding. It is the "new" science which is very controversial: the science which uses new techniques, in particular, manipulation of DNA (deleting or adding certain segments) to change resultant offspring.

The late 1950s, 1960s, and early 1970s were heady years for the practitioners of biotechnology. There was an excitement in the formation of a new science and in the numerous discoveries that were made. Potential was the watchword, not restraint. A cloud appeared on the horizon in 1974 with the publication in Science (Berg 1974) of a letter entitled "Potential Biohazards of Recombinant DNA Molecules." Signed by Nobel Prize winner Paul Berg and other scientists, the letter expressed concern with the rapid expansion of the science and the potential for harm that many experiments seemed to pose. This public disclaimer of lack of omniscience on the part of scientists who were conducting potentially dangerous experiments was not comforting to a public whose positive image of all scientists had drastically been eroding from many other assaults.

On February 24-27, 1975, an International Conference on Recombinant DNA Molecules was held at the Asilomar Conference Center, California. The organizing committee for the conference stated that:

> The new techniques, which permit combination of genetic information from very different organisms, place us in an area of biology with many unknowns. Even in the present, more limited conduct of research in the field, the evaluation of potential biohazards has proved to be extremely difficult. It is this ignorance that has compelled us to conclude that it would be wise to exercise considerable caution in performing this research (Berg 1975: 1981-4).

Recommendations of containment for safe conduct of hazardous experiments and an actual temporary moratorium on certain types of research were expanded upon from the Berg letter in Science.

In particular for our discussion, the Science letter called for the National Institutes of Health (NIH) to form a committee to review all experiments that dealt with manipulation of DNA, [recombinant DNA (rDNA)]. The Recombinant DNA Advisory Committee (RAC) was formed on October 7, 1974. It was expressly set up to perform an advisory, not regulatory, function in reviewing proposed rDNA experiments. It formulated guidelines for scientists concerning design and execution of laboratory experiments (Federal Register 1976).

The RAC was set up to preview all laboratory experiments that involved NIH funding. As it turned out, even organizations (such as private industry) that did not hold NIH funding availed themselves of the RAC review process, whether from genuine concern or for legal protection. But a problem arose when experiments were needed which could not easily be done in a laboratory setting. Some crops, such as corn, are very difficult to work with in a limited confinement area. Larger scale work with access to real (not simulated) random natural occurrences, as done with traditional plant breeding techniques, was needed.

In September of 1982, the RAC received the first submission for the controlled field release of a genetically manipulated bacterium from two University of California scientists, Nickolas Panopoulos and Steven Lindow (RDNA Advisory Committee 1982). Basically, the common bacterium *Pseudomonas syringae* secretes a protein which can serve as a nucleus for the formation of ice crystals on plant leaves. The ice freezes and expands, and plant tissues are crushed and damaged or destroyed. The research plan in front of RAC proposed to delete the part of the DNA of the organism that regulated the release of the protein. Such ice-nucleating minus (INA$^-$, ice-minus) bacteria had already been found in nature, but in small numbers. Preliminary laboratory tests of these mutant *P. syringae* showed that without the ability to secrete the protein, plant ice damage could be held off until several degrees lower temperature (as far as 25^{O}F), a potentially great agricultural savings.

Almost all RAC meetings are open to the public, and notices for meetings and results of meetings are regularly published in The Federal Register. The first proposal for release of ice-minus was voted down by the RAC and sent back to the originating scientists for revision, in particular asking for a less-ambitious testing program (fewer organisms, less variation in trial sizes). A modified proposal was submitted in April, 1983, and wide-spread notice of the subsequent printing in The Federal Register (Federal Register 1983) of the RAC approval vote set off a very public, very controversial stage for the new science of biotechnology.

General objections were raised concerning any release of GEMs into the environment. Many nonscientists (and some scientists, too, especially ecologists) felt that too little was known about potential harm from ANY non-laboratory release, not just release of *P. syringae*. Ice-minus, as the first proposal for field testing of a GEM to be considered by RAC, became a test case. Few non-scientists aware of the case seemed to have faith in the efficacy of RAC guidelines which were not legally binding for every release or mandatory for anyone not receiving NIH funding. Many felt uncomfortable with guidelines which only suggested proper format and procedure to individual researchers. There were many individuals and organizations that favored a return to the Asilomar moratorium on many rDNA experiments, whether in the laboratory or with wider releases. Perhaps many of the fears are best summed up by Jeremy Rifkin concerning biotechnology in general:

> . . . in the mere act of using it, we have the potential to do irreparable psychological, environmental, moral and social harm to ourselves and our world (Van Biema 1988: 14).

Table 1 presents a chronology of events, starting with the first submission of the ice-minus proposal to RAC to the first release of *P. syringae*. (This includes another proposal for release of *P. syringae* by Advanced Genetic Sciences. Ironically, this second proposal received final release approval at the same time as the first, beating the University of California researchers into the field by five

Table 1.
Chronology of Regulatory and Research Events Preceeding Field Experimentation with Ice *P. Syringae* Strains[1]

9/17/82	First submission of proposal for field release to NIH
1/10/83	NIH approval withheld due to questions regarding proposed experiment
3/3/83	Second submission to NIH
6/1/83	NIH approval for field test
9/14/83	Injunction filed against NIH and threatened against The University of California (UC); NIH sued
4/84	UC and NIH sued
5/14/84	Hearing in US District Court, Washington, DC
6/84	Injunction against UC upheld
11/84	Interim EPA guidelines require notification of EPA of experiments involving "modified pesticides"
12/84	UC appeal to injunction not heard
1/21/85	NIH approves finding that Ice$^-$ poses "no significant impact"
3/15/85	EPA determines Experimental Use Permit (EUP) required for field experiment
5/85	Environmental Impact Assessment (EIA) completed by UC and NIH
5/85	Appeals court rules UC, NIH must provide EIA
7/85	EIA submitted to Federal Court by NIH
7/85	EUP requirements completed by UC researchers
12/17/85	NIH agrees to accept EPA review as equivalent to NIH review and approval
12/30/85	EUP data filed by UC with EPA
4/17/86	UC-sponsored public informational meeting at Tulelake, CA
5/12/86	EUP issued by EPA to UC researchers
5/86	UC Regents delay test due to community and grower concerns
6/1/86	Modoc Co. Board of Supervisors pass resolution against experiment
7/11/86	Siskiyou Co. Board of Supervisors pass resolution opposed to experiment
7/86	UC Rgents approve test after further internal review
8/19/86	CA court issues temporary restraining order delaying test until at least 5/87
9/86	CA Attorney General instructs CA Dept. of Food and Agriculture to require Environmental Impact Report (EIR)
9/86	UC starts preparation of EIR
10/16/86	UC holds public meeting on community concerns
12/17/86	Draft EIR issued by UC
3/87	EIR complete
4/87	EIR approved by UC
4/29/87	Experimental test begins with planting of treated potato tubers

[1]Lindow 1990: 65.

days!) This period of lawsuits was characterized by great frustration by both sides apparently poised on each side of a gulf of conflict:

-biotechnologists frustrated by a public which seemed to be unable to comprehend the scientists' consideration of risks and benefits and which seemed to consider any biotechnology automatically to be morally and ethically wrong; and

-members of the general public frustrated over scientists who seemed to be unable to comprehend their valid concerns over safety and regulation of a previously self-admitted potentially dangerous science.

Much of the activity of the period can be summed up as:

> the story of the first concerted effort by scientists to foresee and forestall the possibility of harm, however inadvertent. It is the history of that extraordinarily well-intentioned effort somehow gone sour, the public unsure what to believe and scientists sure only that the controversy became unbelievable (Federoff 1986: 19).

One of the immediate results of the lawsuits, and in particular Judge Sirica's decision for an injunction against ice-minus releases, involved a change of attitude, at least by governmental officials. Instead of the guidelines of the RAC, responsibility for approval of field releases of these organisms was shifted to a more regulatory format with the Environmental Protection Agency (EPA). Most involved seemed to feel that RAC had done an admirable job attempting to deal with a situation it was not set up to cope with; however, the main reasons given for this shift were:

1. RAC had pervue only over experiments using rDNA--but many biotechnology techniques for creating GEMs did not fall under this category.
2. RAC guidelines were not binding where no NIH funds were involved (including industry, private researchers, and even other governmental agencies). It didn't matter that most industries did comply with the guidelines: they were not legally required to do so!
3. RAC had not established a structure for appeal or review of their decisions, and they had no legal requirement not to be arbitrary in their decisions.
4. Experiments needing supervision could stray far afield of NIH's main mission.
5. RAC had no structure, facilities, or manpower to handle the expected voluminous applications for field testing.

Researchers had to meet the requirements of RAC, EPA, and eventually the State of California. Finally, in April, 1987, a California judge announced that "the experiments are not unleashing some deleterious bacteria that are going to consume the city . . . or anywhere else" (Time 1987: 63). On April 24 Advanced Genetic Sciences released their product with altered *P. syringae*, "Frost Ban," and on April 19, 1987, researchers from the University of California released their ice-minus preparation, four years and seven months following their first proposal to RAC.

Many on both sides of the controversy may well ask, "where is the success in this story?" Lawsuits and bitter recriminations appeared to be the weapons of both sides. Even after approval was granted, vandals attacked both release sites attempting to halt the tests after legal routes had been exhausted. Perhaps not all involved will agree, but success can be accomplished even through a realization that not all conflict is bad, that well-intentioned disagreement can lead to further understanding and cooperation. In this vein, seven major successes can be viewed:

1. Recognition by many scientists that the public MUST be involved in science policy. Ultimate decisions on science policy are often influenced by non-scientists. An unwillingness to share information about both positive and negative aspects of biotechnology could lead to a negative reaction to, and perhaps banning of, all biotechnology.

> These questions are scientific, and the scientific community must take the lead in producing answers that will foster public and Agency understanding. Failure will result in further public misunderstanding of biotechnology and, ultimately, will produce no winners (Nicholas and Levin 1984: 576).

Many public objections raised against the ice-minus releases involved a lack of trust. The Monterey Bay Unified Air Pollution Control District stated they were not *per se* opposed to agricultural projects of this type, but at first little information had been shared with local officials: "They were asking us to sign a blank check!" (Roanoke Times and World News 1986: A14).

Officials monitoring the field trials have been extensively criticized for the negative image given to biotechnology with the heavy media coverage of the events. In particular, the officials have been criticized for giving an impression of great danger or menace to a situation they claimed to be free of significant risks. The science fictional "moon suit" used by the scientist applying the ice-minus preparation and the very large monitoring towers situated around the test site were particularly hard criticized as being menacing. From the luxury of hind sight, with prior publicity and information sharing, the public could have reacted favorably to the strong budgetary concerns which did in fact dictate these particular practices.

Dissemination of understandable information is critical for cooperation and not fear between biotechnologists and members of the general public. According to H. McNabb: "if we as scientists are going to expect the general public to go along with this, we have to go the extra mile . . . ." (Wheeler 1989: 73).

2. The public's awareness of the impact biotechnology has and will have on their lives, and the bringing to public debate the practical and ethical questions that accompany the new science. Ignorance of the issues involved leads to fear and a very real chance of rejecting biotechnology entirely, discarding potentially enormous benefits without having really carefully considered all dangers. According to P.W. Huber:

> The most important thing opponents of biotechnology have going for them in the long run is the gap between the actuality of risk and the public perception (Baskin 1987: 614).

Using the ice-minus field trials as an example, public reaction was originally loud and generally negative. But with further sharing of information (even if done in the spirit of "damage control" after the fact), many individuals and organizations which were originally fearful of the field testing concept came to accept its low probability of risk with potentially great benefit--if more extensive monitoring controls were instituted.

3. A closer scrutiny of the semantics of regulatory documents. A case in point involves the RAC's intensive defining activities--does the phrase "*deliberate* release" connote evil or illicit or hidden intentions?

4. Knowledge replacing hypothetical scenarios. Original precautions were in many cases considered examples of "overkill." But is enough recognition given to the fact that this was the <u>first</u> authorized release of GEMs into the environment? Scientists no longer have to plan around a worse-case hypothetical scenario: a great deal of valuable information has been gathered from the releases done so far. Oversight of some parts of such experimentation have been returned to local Institution Review Committees, and there has been a reduction of the regulations--and paperwork--demanded preceding such a release. See Tables 2 and 3 for a

Table 2.

Chronology of Advanced Genetic Sciences (AGS) Field Trials[1]

Date	Chronology of Events
11/84	-EPA receives notification
1/85	-EPA completes preliminary risk assessment; reviews submission and EPA risk assessment
2/85	-EPA requests additional information of AGS and informs company Experimental Use Permit (EUP) required
7/85	-EPA recieves EUP applications
8/85	-EPA anounces receipt of EUPs in The Federal Register and public comment period begins
9/85	-Public comment period closes
8-9/85	-Reviews of EUPs received by EPA
11/85	-EPA grants EUPs; testing may begin
11/85	-EPA sued by Foundation on Economic Trends
2/86	-AGS outdoor testing (rooftop) disclosed
3/86	-EPA audits AGS and suspends EUP; plant pathogenicity testing to be repeated
7/86	-EPA reviews and approves AGS plant pathogenicity testing
12/86	-AGS proposes and describes test sites
2/87	-EPA approves test sites and reinstates EUPs
4/87	-AGS sued and injunction requested in state court. Request denied; strawberry plot vandalized
4/24/87	-INA^- bacteria applied to test site in Contra Costa Co., CA; EPA and CA conduct monitoring
6/87	-Test concludes; AGS monitoring continues
8/87	-AGS submits summary of results of test
9/87	-AGS submits amended EUP application to conduct second small test at same location
11/87	-EPA approves amended EUP
12/87	-AGS begins second test (fall and spring applications)
2/88	-Second application of INA^-
12/88	-Progress report from company received by EPA

[1]Milewski 1990:336.

Table 3.

Chronology of Crop Genetics International Field Trial (CGI)[1]

Date	Chronology of Events
12/87	-EPA receives Experimental Use Permit (EUP)
1/88	-EPA announces receipt of EUP in <u>The Federal Register</u> and public comment period begins
3/88	-Public comment received; preliminary risk assessment completed
4/88	-EPA subcommittee evaluates submission and EPA risk assessment
5/88	-EPA grants EUP
6/88	-CGI initiates field trial
1/89	-CGI requests extension, expansion of EUP; submits data accumulated in field trial in support of request

[1]Milewski 1990: 337.

comparison of the time taken for the approval of the first field trials (ice-minus--four years, 7 months; AGS--2 years and 5 months) and the following proposal for application (Crop Genetics--one year, 5 months).

5. An awareness on the part of the members of the public involved in this approval process that there was a genuine good will and concern and care on the part of the scientists involved. No Dr. Strangelove appeared. Even bitter opponents of biotechnology were impressed by the concern and sense of cooperation.

6. Development of official channels for cooperation (or at least co-existence) among scientists, members of the public, and different levels of Federal, State, and local governments. In the ice-minus field trials officials from both the EPA (given Federal monitoring responsibilities) and the State of California shared some data collection and results.

7. Replacement of guidelines by regulatory statutes. This is perhaps the one result of the ice-minus that many will disagree is a success. Many scientists are very concerned with the switch from guidelines (ultimate responsibility for the conduct of the experiment remaining with the scientists) and the regulatory mode (ultimate responsibility for oversight lying with appropriate governmental agencies).

There are problems--many Federal agencies were not prepared to handle regulatory functions similar to those demanded by biotechnology. Categories for delineating which agency handles which type of experiments are at times crude: they are based on principles which originated long before the new science of biotechnology emerged. Once agency responsibility is determined, a "Catch 22" takes effect--agencies need volume of applications to streamline the present processing, and applications will be slow coming in when regulations are in their currently rigid and demanding forms. Such a ponderous and lengthy process tends to discourage practical testing of theory and laboratory experimentation, which often progress very rapidly.

But the process is slowly improving. And in the present climate of public mistrust for the motives of scientists and safety of biotechnology in particular, a stricter regulatory framework may be for the best until a public trust of science and scientists is re-established.

> It is indeed unfortunate that this first effort to forsee harmful outcomes of well-intentioned experiments became so embattled. What we have understood from this experience is the difficulty for us as an open society

> of developing effective ways of venturing cautiously into the unknown, neither minimizing nor exaggerating the dangers, neither immobilizing ourselves with restrictive regulations nor proceeding without care (Federoff 1986: 27-8).

The door has been opened for cooperation between the public and biotechnologists. Individuals do not have to be bitterly entrenched on either side of an impassible gulf of misunderstanding. Recognition by the public of their responsibility for learning about biotechnology and recognition on the part of scientists of the public's legitimate concerns will lead to a further trust on both sides. This will lead to more open communication, and ultimately, cooperation and understanding.

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BEYOND THE RIGHT TO DIE: REALITY VERSUS ABSTRACT ISSUES

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Introduction

The troubling and complex issues surrounding agonizing personal and family decisions about life-sustaining treatment and the right-to-die have become the focus of public attention with such headline-making events as the Nancy Cruzan case and the historic Supreme Court ruling on it in its first right-to-die case ever, the suicides assisted by Dr. Jack Kevorkian, the citizen-initiated legislative proposal to make Washington the first state in the nation to legalize certain forms of euthanasia, and Derek Humphrey's best-selling suicide manual, Final Exit. Nancy Cruzan, like Karen Ann Quinlan before her, has become part of our language as a compelling symbol of the fight for the rights of patients to control the use of medical technology on themselves.

As the Nancy Cruzan case probed for new ground along the legal and ethical frontier of the technologically created "twilight zone of suspended animation where death commences while life, in some form, continues," [Cruzan, 110 S. Ct. 2841, 1990: 2863 (Hereafter, cited as Cruzan, 1990)] the American public was able to witness the reality behind the abstract, technical issues through two documentary films, Frontline's "The Right to Die?" program on Nancy Cruzan and Frederick Wiseman's six-hour documentary "Near Death," depicting the daily life and decisions of the medical intensive care unit at Boston's Beth Israel Hospital.

In this paper, by reflecting on the reality of life-sustaining decisions and practices as conveyed in these two documentaries, I will examine: (1) the discrepancy that exists between the reality of these personal and family tragedies and the theories that are supposed to inform and guide those caught up in these experiences; (2) what accounts for this discrepancy; and (3) the shift in public attitudes toward the right to die.

Reflections on "Near Death"

Frederick Wiseman's film "Near Death" is a six hour documentary on decisions about life-sustaining treatment. Shooting in black and white and using his fly-on-the-wall technique, Wiseman spent six weeks in the medical intensive care unit at Beth Israel Hospital in Boston with his camera and microphone. As a silent observer and listener to the daily life of the medical intensive care unit, Wiseman, with no narrative or overarching commentary, captures doctors and nurses struggling to save or prolong lives while sometimes wondering aloud (but only among themselves) whether their efforts are worthwhile. Throughout the film, doctors, nurses, and families wrestle with a central question: Should a life be prolonged if there is little or no chance for even a partial recovery?

It is a compelling and important depiction of an inescapable drama of life-and-death decisions, once a matter of fate, now largely a matter of human choice. It is a significant film for several reasons. As Wiseman has stated, all of his films focus on the social, cultural, and political institutions that affect our lives: "'What I have been trying to do with my films is to present a portrait of American life through institutions that are common to the lives of many of us....(and) death in a hospital is one of the most important issues of our age.'" (Reid, 1989: 29)

Certainly, advances in medical technology have altered the social conditions of death from the home to hospitals and long-term care institutions. Since the 1960's death has become an institutional event, with over 80% of deaths occurring in them. This institutional setting, and the power of medical technology exercised in them, has at the same time transformed the physiological conditions of death in ways that are for many alarming. As described in the Cruzan Supreme Court decision, the 80% of Americans who die in hospitals are "likely to meet their end...'in a sedated or comatose state; betubed nasally, abdominally and intravenously; and far more like manipulated objects than like moral subjects.'" (Cruzan,1990: 2878) It is through these institutions, then, that we embody and implement our values about health, caring for the sick, and death.

Also, despite the national attention and import attached to highly publicized cases like that of Nancy Cruzan, this film adds weight to the indications that a quiet consensus is developing around decisions involving life-sustaining treatments. The American Hospital Association has estimated that 70% of deaths in the United States are already somehow timed or negotiated with all concerned parties privately concurring on the withdrawal of some death-delaying technology or not even starting it in the first place. (Malcolm, 1990: 6)

However, surprisingly enough, despite the human control over the timing of death due to technological interventions, and the legally and ethically recognized requirement of informed consent for medical treatment and the patient's right to decide against invasive treatment, the clinical practice portrayed in the film does not provide sharp, clearly defined answers to the central questions: "Who decides about life-sustaining treatment and according to what standard?" (Wolf, 1990: 208) This is particularly puzzling, and troubling, because Beth Israel Hospital is generally viewed, and probably rightly so, as being out in front on the involvement of patients and their families in the medical decision-making process. Beth Israel has a strong, clearly stated policy on patient involvement and autonomy because it was the subject of a important study ten years ago that found explicite discussion with patients about do-not-resuscitate orders was uncommon, yet physicians were wrong a substantial amount of the time in intuiting the wishes of their patients. In this study, only 19% of the patients who had been resuscitated had been asked earlier whether they wished CPR i. it became necessary, even though 86% of the patients were competent and nearly all of the physicians favored participation of patients in these decisions "at least sometimes." Only 10% of the physicians (15 of 151) who believed in discussing resuscitation with patients actually talked with their patients before administering it. Twenty-one percent had discussed it with the family. (Bedell & Delbanco, 1984)

In many respects the conduct of the doctors and nurses portrayed in "Near Death" is nothing less than admirable. In regard to attempting to inform their patients and/or families about the medical options and pending decisions that have to be made, no one could ask for more in terms of the time, understanding patience, and compassion they give to the task. They are ever attentive to the particular needs and human dynamics of each case. In fact, it is precisely the truly outstanding human and professional qualities of the attending physicians and staff that make the problems involving informed consent so striking and troubling.

It goes without saying that the process needed to sufficiently prepare patients and families for making treatment or termination decisions is a difficult, time consuming one. While on one level of behavior the attending physicians seem committed to it, on another level they seem to be ambivalent about whether to allow patients and/or their families to make the final decision. The sharpest illustration of this occurs in the case of a seventy-three year old incompetent patient facing extubation whose wife must decide whether to refuse future reintubation. In a discussion about this decision between the patient's wife, son, and doctor, the son asks the doctor, "And that's a decision for the family to make. Is that right?" Instead of directly answering yes, as he should have according to accepted theory and official hospital policy, the doctor equivocates:

> Well, it's a decision we all have to participate in together. In a sense, you can say it's a medical decision, if there is no medical hope, or that hope is so remote that it really is ridiculously unlikely, can we medically subject him to that? On the other hand, you can say it is a decision for the family because it really is a decision to terminate life-support, because that's what the tube involves....If we don't see it exactly the same way, we really cannot move forward with the plan....

That last statement is particularly revealing because earlier a nurse had stated, "Let's be honest; it is only once the decision is reached that the person is going to die. Then they go out and involve the family." Another nurse chimed in, "Include them but don't let them make the decision."

The standard objection to the involvement of patients and families in the medical decision process is that they have neither the knowledge nor capabilities to make the kind of objective, rational decisions needed in such intensely personal and emotional situations. As one nurse stated, "We are giving them too much control...they know nothing about medicine." However, there is one scene that points towards the validating reality of one's own experience that provides the kind of informational basis and insights for informed decisions no training in medicine could ever give. When an elderly patient with end-stage heart disease expresses hesitancy regarding a living will due to a lack of knowledge about such things, the doctor replies,

> Well, it is interesting for you to say that, Mr. Gavin, because I don't know many people who know more about it than you do with what you have been through. You know first hand what all those things are like in a way that most of us never experience until we are in the midst of it. You have already been there so you know very much what those different things are.

"Near Death" also clearly demonstrates a similar argument for the capacity of families to make life or death decisions about family members. There is a common perception that to make hard, reality-based decisions, one must not be too personally involved, that personal feelings and emotions are a hindrance to the rational decision-making process. Now obviously, the more personal relationships and familiarity are involved in making tough decisions the more difficult it is in human terms to make them. But it does not necessarily follow that such personal and lifelong knowledge is an obstacle to intelligent decisions. After all, such experience is an inescapable part of the informational matrix of the decision; so it would be peculiar, indeed, that a better informed, more objectively rational, decision can be reached by setting aside and ignoring information.

The practical issue at stake in the cases here is the humane, best-interest decision regarding life-sustaining treatment. The feelings, emotions, attitudes, and ideas generated through lifetime relationships are not arbitrary elements of the reality of the situation. They are crucial facts to be noted and factored into the decision process. As Justice Brennan asked in arguing against the majority opinion

> "that where it is not possible to determine what choice an incompetent patient would make, a State's role as *parens patriae* permits the State automatically to make that choice itself...: Is there

> any reason to suppose that a State is *more* likely to make the choice that the patient would have made than someone who knew the patient intimately? To ask this is to answer it. (Cruzan, 1990: 2877)

One of the most inspiring aspects about this film is seeing individuals in the most emotionally intense, intimately personal situations making, and being expected to make, rational decisions about life and death. And they are making them without professional training, sometimes without even being well educated. Despite this, they are able to consider all the relative facts of the situation, weigh the pros and cons of every option, and reach a rationally defensible, even if not always unchallenged or unambiguous, decision. As clear a portrayal of this process as could be found is the right-to-die case of Nancy Cruzan in which Frontline documented the decision-making process of her family. As Mr. Cruzan so excruciatingly expressed while standing outside the U. S. Supreme Court waiting for his daughter's case to be heard:

> Of all the people in the world, why is it me that's here? I'm as ill-prepared as anyone. I don't have the money I'd like to be able to do what I'd like to do. I don't have the education to express myself the way I'd like to. But most of all, I don't have an extra daughter that I want to give up. (Frontline, 1989: 14-15)

Thus, in many ways films like "Near Death" and the Frontline documentary on Nancy Cruzan are noble salutes to the many layers of family involvement, the deeply personal and individualized nature of decisions about death, and the complexity of love.

Discrepancy between Reality and Theory

In view of the clarity of theory and official hospital policy on patient/family automony regarding decisions about life-sustaining treatment, the question remains why ambiguity characterizes the reality of clinical practice. The film makes clear it is not simply the matter of culpable failure on the part of physicians. The problem seems to be more fundamental and pervasive than that. One clue may lie in one of the most amazing features of the film: two words one never hears are "death" or "dying," except occasionally in the more philosophical discussions among the staff, whereas the title "Near Death" accurately reflects the status of the patients featured in the film. Instead, such phrases are used as, "on the edge," "the end stage of his disease," "important to acknowledge what we are afraid of," "on the borderline between surviving and not." Even in these instances, the doctor will often quickly add, "but he has fooled us before," or "we have to be humble about our ability to predict the future."

It is also true that in some instances family members are unable to speak directly about the pending death of their loved one. For example, when the wife of an elderly man with end-stage heart disease states, "He is going down hill...He's been through an awful lot. It's going to come to an end," the doctor asks, "Have you talked to him about that." The wife answered, "I don't want to talk about it....It's a touchy subject." In viewing the film one reaches a point where one cannot help but think of Tolstoy's The Death of Ivan Ilych and the lack of candor that poisoned Ivan's relationship to those around him and further isolated him into the anguish of his own suffering.

What accounts for this lack of directness and candor? While one can attribute a denial process on the part of patients and family, how does one explain the behavior of the physicians? Dr. Weiss, one of the doctors portrayed in "Near Death," provides a clue when he states,

> You have to be a true believer to use this stuff. The problem is the culture. We blind ourselves to do this...it borders on religious faith....And doctors in our day and age are extremely reluctant to say, 'We can't do anything for that.' We have no way to help that." (Whereas in truth) so much of this stuff is heavy flail for relatively small or no gain....There's nothing more discouraging than this. The psychological toll on us and the families, it's really grim.

What we see reflected here and throughout the film is one of the major driving forces of modern, high-tech medicine: a denial of the limits of the possible. This denial of limits is a defining feature of the culture of medical research and clinical practice. As Dr. Weiss expressed above, it functions at the depth of a "religious faith," a faith that is reinforced both by every medical advance and the general faith in science that permeates our age and culture. As Michael Ignatieff has written,

> Cultures that live by the values of self-realization and self-mastery are not especially good at dying, at submitting to those experiences where freedom ends and biological fate begins. Why should they be? Their strong side is Promethean ambition: the defiance and transcendence of fate, material, and social limit. Their weak side is submitting to the inevitable. (Ignatieff, 1988: 32)

Another factor that seems to be as work here is that life-sustaining treatment involves medical practice at what Daniel Callahan, in his book What Kind of Life, calls "the ragged edge" of medical progress, "that edge which represents the limits of our present knowledge and skills, ever transcendable, never conquerable." (Callahan, 1990: 154) It is precisely that progress not yet achieved that provides the impetus to medical research and clinical practice toward yet greater achievements. But no matter what miracles medicine seems capable of performing, there always remains that "ragged edge" along the frontier of progress where death, pain, and suffering remain to be conquered.

If the reality of death is avoided, the language of hope and possibilities is not. As stated several times in the film, "there is always that one in a million chance." While this is perfectly understandable in human terms, in order to both help sustain the patient and family and provide motivational support to doctors and staff to extend the best care possible, it nevertheless carries serious implications. This is sharply indicated in a statement by a physician arguing for continuing chemotherapy in an apparently hopeless case of cancer. She states, "If you believe there is no hope, this chemotherapy is a hoax and cruel." That is precisely the problem: it is! The attending physician of the intensive care unit, (who earlier in the film, when informed that an oncologist went along with a wife's decision to stop treatment on her dying husband, expressed surprise and said, "Some of those oncologists, boy, they live in fantasyland.") replies simply: "It is important to recognize the reality. You say it is giving up, but that view implies we have something to offer. We don't." He also raised the crucial question: "Are we managing her chance to live, or are we managing her death? If we are managing her death, I don't think we need that."

One of the major problems of an endeavor driven by faith and hope, like that of medical practice and research at the "ragged edge," that views all progress to date as a prelude to further progress, is that it creates the overwhelming bias to treat, to keep going, hope against hope, no matter how overwhelming the odds. For example, among the facts presented in the Supreme Court decision on Nancy Cruzan is the following:

> Out of the 100,000 patients who, like Nancy have fallen into a persistent vegetative state in the past twenty years due to loss of oxygen to the brain, there have been only three even partial recoveries documented in the medical literature. The longest any person has ever been in a persistent vegetative state and recovered was twenty-two months. (Cruzan, 1990: 2868)

Yet, even in the face of such facts, the burden of proof, as in the Cruzan case, remains almost entirely on those who want to stop. Pushed to its extreme, you get the case of the thirty-three year old cancer patient in "Near Death" who died from the toxicity of the chemotherpy. A doctor matter of factly remarked during the autopsy, "This is an example of curing this tumor, but the cure is deadly." As Daniel Callahan states, "The capacity of the present system to stimulate unlimited hopes, to lead to demands for optimal cure, and to engender resentment when desires are not met or procedures cost too much to afford is extraordinary." (Callahan, 1990: 209)

Even though the doctor's primary responsibility is to do whatever is in the best interests of the patient, the power and dynamics of medical technologies seem to take on a drive of their own regardless of the best interests or wishes of the patient. Yet, excessive treatment can be as injurious to the patient's welfare as incorrect or inadequate treatment. No one can easily say no because the medical bias toward aggressive treatment and the preservation of life no matter what the cost flows out of, and is at one with, many of our most cherished and fundamental political and cultural values: respect for individual life, rights, and freedom of choice; our faith in progress; and our refusal to set or accept limits. (Callahan, 1990: 66)

When the pervasive force of these values are combined with the continuing record of medical advances, any stoic acceptance of biological fate is equated with fatalism and passivity. It is "giving up." Nothing less than total control over illness and disease seems to be acceptable. "The desire to control death may be a modern conceit, a kind of hubris against nature. But it is one based on modern technology." (Goodman, 1990: 25) Medical practice is thus pushed into the realm of preserving organ function beyond the capacity of the person, whose organs they are, to endure. The outer bounds of reason would seem to be passed, and the language of absurdity takes over when life-extending technologies sustain lives worse than death, and curing the tumor kills. As Daniel Callahan asks, "Can we not understand how odd, how literally bizarre it is, that the greater the success of medicine in improving life and extending health, the greater the fear of illness and death and the greater the fear that the same medicine will oppress us in our dying?" (Callahan, 1990: 243)

Changes in Public Attitudes toward the Right to Die

Many would argue, as Callahan himself does, that this fear, and the inner logic of the very cultural values that have brought us to this point, have generated a sense of crisis and led to a shifting in public attitudes toward, and an open discussion of, assisted suicide and legalized euthanasia. Even the harshest critics of Derek Humphrey's suicide manual admit that he has struck a responsive chord that reflects a deep-seated fear of losing control to medical technology at the end of life and a distrust that physicians and hospitals will respect one's wishes. (Knox, 1991: 12) A body attached interminably to a machine has replaced the mushroom cloud as the terrifying specter of our age.

Others see this shifting as an erosion and undermining of these traditional cultural values. These latter see the movement from the removal of a respirator in the 1976 Karen Ann Quinlin case to the removal of feeding tubes in the Cruzan case as a slippery slope that leads directly to Dr. Kevorkian's mobile suicide clinic and legalized euthanasia. For example, when the judge ruled that Nancy's feeding tubes could be removed, the International Anti-Euthanasia Task Force denounced the decision as "'a frenzy to kill Nancy Beth Cruzan'" that "'has set in place the cornerstone for a full-scale euthanasia program.'" (Malcolm, 1990, p. 6) Well, as Nostradamus allegedly once said, "Prediction is difficult, especially about the future." (Annas, 1988: 31)

While there are legitimate concerns about the direction cases like those from Quinlan to Cruzan may portend and the possibilities for abuse, I think one of the more fundamental problems is the way these right-to-die cases are viewed through the prism of abstract values without sufficient regard for their particular realities. A classic example of this would be the common approach to these cases as a clash between a commitment to the sanctity of life versus an emphasis on the quality of life. Twenty-two years ago, in an editorial entitled, "A New Ethic for Medicine and Society," the journal California Medicine created a fire storm of controversy by stating that the traditional Western ethic of the intrinsic worth and equal value of every human life regardless of its state or condition that had been the cornerstone of medicine was "being eroded to its core and may eventually even be abandoned" by a new quality of life ethic that placed relative, rather than absolute and equal value on every human life. The editorial concluded this will lead "inevitably to death selection and death control whether by the individual or by society, and further public and professional determination of when and where not to use scarce resources." (Editorial, 1970: 126) The controversy was fueled by the journal's benign acceptance of this shift.

The main problem with structuring the problem of life-extending technologies in this way is that it overlooks a fundamental fact. That fact is, as Pogo put it, "The future ain't what it used to be." Advances in medical technologies have obviously radically transformed "the future," i.e., the natural, physiological conditions of human life to such an extent that, as one court ruled, "in certain, thankfully rare, circumstances the burden of maintaining the corporeal existence degrades the very humanity it was meant to serve." (Cruzan, 1990: 2868) To talk of the removal of an artificial nutrition technology that did not even exist twenty years ago as a violation of the natural order of a life that would have ended on the first night of the accident without massive technological intervention is mystifying.

To reduce the struggle of the Cruzan family to a decision against the preservation and sanctity of life is to distort the reality of Nancy's plight. Without a reality check, ethical ideals or legal norms become either instruments of victimization or abstractions that are sterile and empty of human experience; in highly publicized cases they distort complex, delicate human problems with a cacophony of views and concerns into a battle zone. When there are legitimate concerns, such as opening the door to abuses of the weak or by unloving parents, the proper response is not the safeside victimization of patients like Nancy Cruzan by keeping them prisoners of life-sustaining technologies. As Judge Backmar wrote in his dissenting opinion to the Missouri Supreme Court ruling that barred the removal of nutrition and hydration from Nancy, "The principal opinion attempts to establish absolutes, but does so at the expense of human factors. In so doing it unnecessarily subjects Nancy and those close to her to continuous torture which no family should be forced to endure." (Cruzan, 1988: 429-30)

Even Chief Justice Rehnquist, in writing the U. S. Supreme Court's ruling that upheld the Missouri Supreme Court decision, implicitedly acknowledged that the ruling might very well not be just for Nancy: "Missouri's requirement of proof in this case may have frustrated the effectuation of the not-fully-expressed desires of Nancy Cruzan." (Cruzan, 1990: 2854) However, he defended this possibility on the basis that "the Constitution does not require general rules to work faultlessly; no general rule can." (Cruzan, 1990: 2854) Formal, abstract considerations, then, triumphed over the facts and circumstances of Nancy Cruzan's particular situation. The result, as Justice Stevens stated in his dissenting opinion, is that this "permits the State's abstract, undifferentiated interest in the preservation of life to overwhelm the best interests of Nancy Cruzan...." (Cruzan, 1990: 2879) To prevent this, Justice Stevens argued that, while the question before the Court "is both general and profound, we need not, however, resolve the question in the abstract. Our responsibility as judges both enables and compels us to treat the problem as it is illuminated by the facts of the controversy before us." (Cruzan, 1990: 2879) In taking this approach, Justice Stevens concluded that "in light of the facts and circumstances particular to her...there is no reasonable ground for believing that Nancy Beth Cruzan has any *personal* interest in the perpetuation of what the State has decided is her life." (Cruzan, 1990: 2879 & 2888)

Conclusion

Whatever conclusion one may draw from the kinds of cases portrayed in "Near Death" or highly publicized court cases like the Nancy Cruzan case, the essential point is to retain respect for the value and dignity of individual human life while not becoming slaves to our available technologies or to abstract values. To do this in regard to life-sustaining technologies requires us to confront our own mortality and take seriously, individually and socially, the words of

George Bernard Shaw: "Do not try to live forever. You will not succeed." (Annas, 1990: A4)

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A Glimpse at Change in Mental Health Care: Planning for the Baselines in Technological Literacy

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Abstract

The evolution of our cities has precipitated an arduous lifestyle for the apolitical and oppressed, particularly the mentally ill and customers of mental health services. New roles and structuring of the delivery systems are occurring through an advancement of technology and improvement of the socio-technical systems. Within Kentucky approximately 1.45% of the adult population are experiencing the transition to mental health care (MHC). These nearly 60,000 individuals' lives are not only being affected by policy change but are being dramatically altered with the rapid technological shifts and discoveries at the National Institute of Mental Health. The system of technological literacy is heightened with the combined presence cf the United States Congressional Resolution's Decade of the Brain and the increased levels of national, state and local family lobbying.

However, schisms result from technological shifts and research as the customers of mental health services begin to develop their politic. The numbers of consumers when compared to the total United States population are small but the economies and style to which business structures its services increasingly becomes important.

I. Introduction

Some for the Glories of This World; and some
Sigh for the Prophet's Paradise to come;
    Ah, take the Cash, and let the Credit go,
Nor heed the rumble of a distant drum!

-Rubaiyat of Omar Khayyam-

Primarily in MHC, the technologcies and associated therapies used by the professional requires an attempt to create a "metalanguage" with the customer of mental health care Foucault (1961) . Communicating in this format of mental awareness is a style to which we, as a society, have yet to become fully aware of inherent idiosyncrasies. The degree to which we straighten out peoples rather than attitudes is certainly open for discussion.

However, the scientists struggle with a process by which the exploration is framed. Regardless of Kuhn's (1970) recognition for the role of paradigm shifts, greater attention is being focused on the role of planning. The extent to which planning encompasses, reflects and compliments this activity is perhaps associated with its boundaries (Baumberger, 1977:18).

Several principles need to be described. First, planning like mental health is a meta-dialogue which invokes the past, present and future into modalities. Planning is the verb of the chromosome at the cellular organizational level and generates the "insanity" of beauty for what Barbara McClintock was pursuing in the idea of chromsomal behavior in corn (Keller, 1983:126-136). Her tenacity for knowing was unbridled in getting inside the organism's minute processes.

Secondly, is there a plan for MHC? Much of MHC lacks focus according to one director of a community mental health clinic Bracco (1992). But, the essence of the dilemma might be found in the title of a working document by the Kentucky State Department of Mental Health. The No Name Plan mimics the confusion inherent with the mental health field, i.e., under funding, under staffing, and under programming in the Kentucky Department of Mental Health (1991:title page).

Third, the base line is the process by which mental health care is structured with democratic rules of play. The technology of MHC is structured around the policies of patient care. The technology in MHC is the shifting materialistic structure and social intervention (sic). Complex medical education and social work prepares the care giver(s) for only half of the solution. The dignity of rights created by the recipient in awareness provides the other element in this complex equation. The socio-technical boundaries afford humans both dynamic and static opportunities to experience nuances of our world. Bateson's effort to create a commensuratomy of mind and structure naturally found nonsense in the question, "Where does the mind of a blind man's cane end?" (Bateson, 1972:459). The scale of the technological artifact might be contributing to this dilemma perspective (Winner 1980:121-136).

Speaking from the perspective of one who has experienced manic depression, the knowledge of awareness in an episode was both random and structured as the brain cells were firing "out of control." The technology of pharmaceuticals have not always provided the stabilized base line. Subsequently, the combined effects have not produced an acceptable socialization of mental illness.

As a planner, this way of learning has been a part of my knowing and reconciling the biotic, abiotic and cultural structures inherent to the subsystems of an urban area Dorney & McLellan (1984:19).

Further, the literacy of socio-technology occurs when the elements of structure create modalities of both stochastic and deterministic learning. Technology by itself says nothing. Mental health by itself says nothing. But when all of the component elements of MHC are examined in context, then we have literacy, i.e., knowledge.

II. History

The presence of MHC has been shaped by the past "mental health practice". The history of providing a balance of integrated care, i.e., technology, medical arts and responding wellness remains ill defined. This is in part due to definitions of a city where diverse societies may not have a coherence of values (Duhl, 1988:3). One of the variables for creating the dilemma in MHC is the customer/consumer, albeit the recipient of the service. The customer has been silently expressive of what he or she experiences.

This is not to imply that the values of interaction are less worthy of ethically motivated interaction (Pirsig, 1991:398-399). Simply, the metaphors are aloof of common interaction or the metalanguage is missing (Laing, 1970). The essential question though is "Where is the history as prepared through the customer's eyes?" Without a clear past, the individual, practitioner, institutions and government create an unacceptable non-negotiable future.

From one perspective, the combined technology of improved transportation and the development of the medical arts, created a sovereign entity. The structure of the hospital subsequently created the role for mental asylums (Starr, 1982:72):

> The mental asylum created not only a new
> institutional market for doctors,
> but also a new sphere in which
> they could exercise authority.

The important aspects of exercising authority over a captivated client subsequently established the religious politic of a sovereign profession. But from the end care perspective, the institutional role essentially served more to "isolate" the individual from the community rather than removal of the individual to the institution. The rapid growth of cities and changing economies of scale created new roles and practices for the medical profession during this period of material advancement. In the United States the institutions have been given credit with shaping psychiatry rather than psychiatry shaping the institution (Starr, 1982:73).

By comparison the earlier reforms of the French Revolution were introduced with the belief that the mentally ill could be cured (Starr, 1982:73). Regardless of the moral, but non judgemental implications, the real advocates for change during this era were doctors. Mental asylums offered opportunities for advancement, i.e., a keen environment "to exercise judgement and control where there was relatively little resistance to authority" Starr (1982:73).

Some customers of MHC have been able to write about the MHC experience. Clifford Beers, a Yale graduate wrote candidly about his "treatments" during the 1800's. The beatings, starvation, cuffs and other restraining devices brought the public's attention to a "modern" but inattentive system Beers (1981:177). His capacity to work with the National Committee for Mental Hygiene and the American Foundation for Mental Hygiene brought awareness of the social problems associated with mental health treatements to the american public. However, his reformist attitude was lost in the general milieu of extending the frontiers of psychiatry Torrey (1988:47).

Another customer, Ian Boisen developed the pastoral counseling methodolgy from his experiences as a mental health customer during the early 1900's. By using an organizational format, Boisen established a typology of the "spiritual domain" inherent to mental illness Boisen (1955). The margin of safety in MHC though, has increased to an order that the technologies of today's medicating and psychologies of care mandates an update of his methodology.

III. PRESENT

Hollywood has attempted to fantasize the relationships inherent to mental health for some time. Popular movies have included The Snake Pit, One Flew Over the Cuckoo's Nest and Terminator Two. An informal survey of a local video store indicated that Terminator Two highlighted the demand; twenty-seven (27) tapes of the same heading were available for rental. Briefly, the story plays with robotics, the future, and the perceived madness associated with mental health facilities. All mimic the reality of the mental illness experience.

At the personal level of technology the Video Cam Recorder (VCR) allows one to experience feelings of one moment and see the results in the next seconds. Video reading has been one of the most beneficial technolgies integrated into the provision of mental health services Bracco (1991). But the capacity for portraying the concept of knowing knowing (sic) remains qualitatively complex. A recent effort by Hollywood to film the "intellectual subject" of creating quality was refused for filming by Robert Pirsig. His book Zen and the Art of Motorcycle Maintenance carefully developed the structure of knowing and recognizing qualities (Pirsig, 1991:343-345). Ethics would appear to have been lost in this translation to the cinema world.

In Lila, Pirsig pursues the thought patterns associated with quality, but in the process states that the decisions are made on an ethical basis. This is not just any decision but all decisions are made in this context. Even to the exchange and mind thought process (sic) developed with a character in need of MHC Pirsig (1991:398). In our society, we have methodical ways to remove people from highly ordered, technological environments. But the capacity by which we empower those to find their way back into the mainstream has those elements of historical abandonment with resultant chaos.

The realm of MHC currently falls within a range defined by: a friend, the family doctor, the private psychotherapist, i.e., psychiatrist or psychologist to the rarified team care such as those typfied by the Menninger Clinic.

The appropriate technologies associated with MHC range from simple blood work to current Brain Imaging Work, inclusive of computed tomography (CT) scans, positron emission tomography (PET) studies, and nuclear magnetic resonance imaging (MRI) studies. This comparison is offered merely as an attempt to compare some scalar qualities associated with the technologies in current MHC practice. Technology and development costs without a coherent plan create expansion without reform and quality.

The tension between technology's development and advancement of knowledge were acknowledged in a story about titration of two hospital wards testing a placebo and a new drug. Results indicated there was a definitive possibility for great advancement but, when further inspection occurred, the change was traced to the wards' consumption of two different brands of coffee. The science and technology in mental health are quite sensitive and sometimes moving without apparent direction Bracco (1991). Further indices in the meaning of the supportive technologies are found in an excerpt from a video by the National Institute of Mental Health (1990).

Much of the MHC experience has been a static dialogue, i.e., professionals and staff treat the customer with minimal participatory response. Subsequently there is a growing demand for complex, targeted medications and therapies involving astute, sensitive people. As Doris Quinn, Director, Customer Knowledge and Quality Improvement of the Hospital Corporation of America suggests, "discipline specific knowledge will not be enough." (1992).

These activities are being framed by policies at the national, state and local levels of governing processes. For example, "The Joint Resolution on the Decade of the Brain" was passed in 1989 by the United States Congress. From a political perspective, this measure gave more legitimacy to the professional, not so much to the customer (Bracco, 1991).

Also, in 1991, Public Law 9066 was signed into existence by President Bush and will afford access by the disabled to the corridors of common ground. This will be accomplished through the placement of technologies in our environment which range in size from a micro-chip to that of an inclined plane. The more ultimate expression though will be recognized in humane interaction. Cities designed to meet the needs of their inhabitants begin to perform in a more attuned manner.

However, the fragmented care system enables rather than empowers 50% of the mentally affected. In our current system less than half will return to establishing a stabilized life pattern upon being released from the hospital setting Anthony (1989:1). If change is to occur that would create some vitality and community in the mental health community (and perhaps the larger urban area), a political upheaval needs to occur Oates (1992).

The solution to the problems though might often be an after thought. Even physical disabilities, while accomodated are not designed and accounted for in the work place Harsh (1991). The technology of sustaining MHC has been identified with 1) housing, 2) case management and 3) employment Kentucky Mental Health Department (November,1991).

IV. Future

Today economies are being built upon a shortage of the "tool" or what Boyd (1979:7) calls "masterly inactivity." In other words, the total dimensions of the tool's capacity are not understood by the craftsperson, i.e., the MHC provider. The opportunities where the customer's politic once was silent are beginning to be sensed and verbalized.

Political support for the customer of mental health is found first within a small customer movement. Secondly, the families of those affected by mental illnesses have also the opportunity to be a part of the discussion at some level. Various groups from the government (Protection and Advocacy) and non-government sectors (The Alliance for the Mentally Ill, The Coalition for the Homeless, etc.), provide the social support, organizational development and necssary skills to affect change. Each group attempts to influence legislation or implement a stronger program reflective of that organization's vision.

However, the significance and strengths of this movement are found within the micro-level of consumer activity of mental health. A grassroots network of customers and professionals are trying to encourage the expression of autonomy. A monthly national teleconference and a newspaper clipping network is being coordinated through Sargent College of Boston University's rehabilation program.

In addition, the newspaper, Dendron News, provides a national voice for the customers of mental health. Ironically, the newspaper's title is a derivitive of dendrite, the brain nerve cell -- which is suggestive of the associated technologies and micro awareness of our being.

Further, the macro work environment by which our being is sustained is often hostile to our existence. In some way, the human canaries of the work places are the mentally affected. Some people are more sensitive to the stressors of our environments. The implementation of new technologies create not only physical discomfort, distortion and illness, i.e., chaos and cacaphony but also affect the comfort and health of mind (Zuboff, 1984:124-174). Essentially, a fine tuned ergonomics of the work place is occurring but at a snail's pace. The capacity to create a value-added workforce is just beginning.

Budgetary restraint and recessions severely impact those least able to respond to life's challenge of living. Incentives for ventures are precarious. Besides economic uncertainty, the lack of momentum in programming for social development creates a que of human resources, i.e., unemployment or underemployment on a massive scale. And "a humanity that has been rendered oblivious to its own responsibility to evolution...is a humanity that betrays its own evolutionary heritage Bookchin (1986:34).

Structured relationships based in the representative form of the western mind are being challenged to behave in cogent anticipatory manner by such leaders in management theory as Deming (1983), Juran (1989), Crosby (1979), Bennis (1989) et al. There is an exploration, knowingly or unknowingly, into an awareness of the stochastic element through an applied manner. We are already oriented towards the deterministic way of rapidly seeing the facia. A managed future as a culture is being created.

But the change process is not totally based upon hierachal decision making as some would believe (Steiner, 1990:2). Mental health care that truly functions in a hierarchical function is a mordant. The situation is realized in the inevitablity of restructured (sic) environments.

The moments of evolutionary structuring result from a dichotomized simultaneous process of differentiation (stochastic) and integration (deterministic):

...concrete integrating process occur, that is,

> reproduce themselves and/or change, with and without apparent conflict. Some concrete way of integrating always occurs in science, whether or not it was planned, because integration and differentiation are but the obverse and reverse of one and the same coin.

The resulting boundaries where nothing happens require more change and activity than to achieve local stabilization (Baumberger, 1977:18).

In MHC, the science of health combines with legal structure to the extent that the individual may or may not be overlooked and perhaps dictated to (Torrey, 1988:212):

> A realistic system is one that would allow for legal representation of patients and their right to appeal. It would counterbalance these rights, however, with rights of society to treat individuals who need treatment, and it would require continuing treatment where indicated as a condition for the patient to live outside the hospital.

But the significance of civil liberties may be overlooked without what some social workers refer to as engagement.

V. Conclusion

In a moment of our existence a community of people who have experienced mental illness in technologies dispersed throughout a larger pool of people are caught in various levels of arrogance. To make such a statement though shows arrogance lacking from human interaction. To even think that the pendulum of one world should be forced to agree with the pendulum of another negates an authentic personal action.

If we are to discover the vitality in our communties, the demands of "overseer" management and therapies would fall into disuse. The fears associated with a regulatory climate are problematic; in MHC the effort has often been a double bind. Double binds result when one says one thing and the actions reflect the opposite.

Gradually, as a small group of customers assemble, then change will occur as the "customer voice" will be heard. An equity of learning occurs and shapes the market. In reality, the framing of actions will occur from the inevitability of our socio-technical evolution. In a single moment, the dynamic process of shifting balances is oberved with the third eye of the mind. Hence, empathetic skills need to be developed by those not only in the MHC setting but by the populace, i.e. if a community wants to create sustainable boundaries for human interactions.

Torre's structure for a legal system has been suggested but the concept falls short of reality. Too often the lack of affirmation and opportunity for individual expression negates the intent of existance for justifiable policies.

Finally, social change has been slow in coming to the mental health community. The mental illness myth perpetuates false patterns of human behavior. But when one examines the social change agents such as Ghandi and King, the social awareness for those on the "other side of the mirror" can be recognized. But even King was bound when he spoke by the constraints of semantic limitations:

> We must come to see that the end we seek
> is a society of peace. That will be the day
> not of the white man not of the black
> That will be the day of man as man.

Seeking an end rather than a process limits the imagination. For those affected historically, presently, and by the future the only way to see in a healthy perspective is to rely on the capacity of the mind through the discovery of its dimensions. Hence, a restatement of Omar Kaayam's verse <u>updated</u> to meet an enlightend community about mental health might read:

> Some are caught in the chaos of this world;
> and some live the paradise that was to come;
> Ah, save the cash, and take the credit,
> But heed the rumble of the distant drum!

In closing, some recommendations which might assist with establishing a new cadence of "the distant drum" include the following:

1. Hire a good facilitator to assist with the organizational interactions between consumers, families and professionals.

2. Recognize the mentally affected as perhaps the more politically oppressed group within our society. Seek active and authentic involvement by customers of mental health on community boards. Medications and/or therapies may alter the brain's metabolism but not the experience; a good facilitator will be sure to incorporate unique insight.

3. Stabilize the chaos of rapid policy change and uncertain economies by developing mentor arrangements that assist and/or structure entreprenurial work environments for the individuals' transition back into the community. (A traditional work environment may not match the needs of a human being.) Explore micro-enterprize development.

4. Learn how to learn and lobby your friends, organizations, and elected representatives for a more

visionary mental health program which is accountable and consistant.

5. Develop a community program which emphasizes the historical elements of mental health treatment as it relates to the local, state and national activity.

6. Assist with the development of a clerical education/mental illness program that would integrate the work of Boisen and current theological practices. Efforts should be made to establish active roles for the various players, i.e., the mentally affected, the families, the physicians and staff.

7. Develop an equity of organizational development skills for processing the community's ideas on mental health.

8. Monitor the performance of the programs and services through various instruments, some which might be as simple as a one question survey or more detailed analysis.

9. Identify public policies which might be of assistance.

10. Plan!

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STS and Environment

THE POLITICS OF NUCLEAR DEVELOPMENT IN SOUTH KOREA

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ABSTRACT

Developing countries have been encouraged to consider nuclear power as an alternative to fossil fuel-based electricity generation. To date, 25 developing countries have launched nuclear power projects, mostly with the assistance of the U.S., the former USSR, and France. Developing countries have pursued nuclear power in the belief that it could resolve two energy problems—the need to achieve independence from foreign suppliers and unstable world oil prices and supplies and the need to find a source of commercial energy supply sufficient to fuel industrialization. Some have also sought nuclear power as a foundation for the development of nuclear weapon technology for the purpose of improving national security.

Critics, however, have argued that nuclear power is unsafe and uneconomical. Moreover, it does not offer economic stability but instead deepens the dependency of developing countries on developed-country technology. And it contributes to the proliferation of nuclear weapons.

In this paper, current issues with nuclear development in the developing periphery are explored. The case of South Korea will be used to illustrate the problem of a developing country's reliance on this technology as an energy source. These problems include: political tendencies toward centralization of authority and capital; the heightened role of the military and the creation of a national secrecy and security system around the technology; and the increased technological dependency on developed countries created by reliance on nuclear power. Possible alternatives to nuclear power are examined in the final section of the paper.

I. Introduction

South Korea[1] has developed its nuclear power generation system since the late 1950s with enormous administrative effort by the national government and support from several of the nation's largest corporations and most prestigious research organizations. Its interest in nuclear electricity generation was motivated by: 1) the need to replace electric capacity lost with the country's division after the Korean War[2]; 2) U.S. encouragement of South Korea's development of nuclear power generation technology; and 3) the military's desire to become expert in atomic weapon technology. The global diffusion of nuclear information and technology with the U.S. Atoms for Peace program and expressed U.S. willingness to loan South Korea the necessary capital for plant construction permitted the country to act on its nuclear interest. Electricity produced by nuclear reactors in South Korea now accounts for about half of domestic electricity generation and is the major fuel source of electricity sales since 1986 (KEEI, 1989: 60). There are nine nuclear plants in commercial operation with a total capacity of 7,220 MWe (June 30, 1991), two more are under construction as of July 1992, and an additional one was contracted for at the beginning of 1992. South Korea has become one of the major nuclear countries in the world and has among the highest levels of nuclear electricity generation anywhere (IAEA, 1989: 8-11). According to a generation capacity development proposal of the Korea Electric Power Corporation (KEPCO), South Korea should build 50 more nuclear power plants by year of 2031 to achieve reliable and economical power (KEPCO, 1989: 15). Thus, there is institutional support within the country to intensify its nuclear commitment.

The structure of the South Korea's nuclear power generation system was (and is), however, inherently exposed to a variety of perilous problems: dependent decision-making processes—South Korea's earlier, and even its present, nuclear development relies upon foreign technology, experts and fuel supplies; rapidly increasing construction/operation costs; and waste disposal, safety and decommissioning issues with their associated economic/environmental costs. The managers of the country's nuclear system have focused on supply issues and have not treated these problems as important ones. The fact that there have been no significant accidents caused by malfunction in the current national system of nuclear power generation has allowed KEPCO and others in the government to maintain the view that nuclear power is safe and largely problem-free.

Yet, the image of nuclear power as problem-free is illusory and recognized by a growingly skeptical South Korean public. Consider, for example, the issues of safe disposal of nuclear waste and decommissioning of nuclear plants after full utilization (approximately 40 years). Even if only economic costs are taken into consideration, a summed cost of construction, operation/maintenance, decommissioning and safe disposal of wastes is incomparably higher than that of a fossil-fuel fired power plant of an equivalent electricity generation capacity (Pollock-Shea, 1989: 15; Flavin, 1989: 46-49; Flavin, 1987: 51; and Flavin, 1983: 14-18). But no consideration of these economic factors was undertaken prior to the decision to adopt the path of nuclear development. Instead, the South Korean nuclear industry developed rapidly, as did the world nuclear industry, with economic considerations distorted or ignored. The goal seemed to be nuclear power development *regardless* of the economic costs involved. Besides economic reasons, critics of nuclear power have also raised serious environmental issues concerning nuclear waste management/disposal safety and the decommissioning process. There is no established technology of decommissioning for resolving either environmental threat. South Korea continues to store its plant wastes on site; the government has been unable to identify an acceptable site for burial of wastes; and there is no active research on decommissioning technology, although South Korea's oldest plant (Kori-1) has completed nearly half of its useful life.

In spite of economic problems, environmental issues and growing public concern, institutional support for nuclear power has become virtually a political and economic imperative in South Korean energy policy. Neither social criticism of nuclear development nor the existence of energy alternatives for the future have caused policy makers to consider discontinuation of the current tempo of nuclear expansion. Institutional commitments to sustain the nuclear power system are dominant in the South Korean public decision-making sectors, and strongly supported by the principal business conglomerates, *chaebols*. This paper seeks to explain South Korea's nuclear politics in terms of the global and national conditions which interacted with and supported the rise of the South Korean nuclear system. It employs the theoretical framework developed by Jong-dall Kim (1991) to explain the institutional roots of the country's commitment to nuclear power. The paper will attempt to suggest where South Korean nuclear politics is headed and what might be appropriate alternatives to the imperative logic of nuclear power.

This paper is organized into three sections. First, a historic review of nuclear development in South Korea is addressed. As part of this review, inherent economic and environmental problems in the South Korean nuclear system are identified. Second, the nuclear politics of South Korea are shown to depend upon institutional cooperation between major interest groups in South Korea. Problems in the promotion of nuclear power in South Korea and the rise of anti-nuclear critics are argued to be an outgrowth of emerging social concerns with rising economic costs, growing public values in environmentalism, public fears of nuclear diffusion, and awareness of nuclear failure in other countries. In the final section of the paper, the South Korean nuclear future is discussed. Two issues are raised: what will the future politics of South Korean energy development hinge upon; and what might be an alternative policy proposal.

II. History of South Korean Nuclear Development

A. Creating a Climate for Nuclear Diffusion

Nuclear development in South Korea was made possible by the worldwide diffusion of nuclear information and technology during the mid-1950s. With the famous declaration of "Atoms for Peace" on December 8, 1953, by the Eisenhower administration, the world nuclear industry began to spread out of the nuclear-advanced countries promoting global nuclear technology development. The U.S., as the original nuclear power, sought to step into the world electric power market with highly advanced nuclear technology and information systems. Tremendous governmental support was given to this highly experimental technology (Byrne and Rich, 1986: 143-144). The U.S. government created a nuclear industry first for domestic use and then promoted global nuclear diffusion. It also tried to control the spread of nuclear technology and to preserve the competitiveness of the U.S. nuclear industry in the world market. With the establishment of the International Atomic Energy Agency (IAEA) in 1957, and, later, European nuclear agencies, the potential for worldwide nuclear development already was set in place. This context provided the nuclear option to energy-scarce developing countries like South Korea (Ha, 1982: 221). Additionally, a warm political and military relationship between South Korea and the United States enhanced conditions for nuclear transfer in the earlier stages of South Korean pursuit of this technology.

Nuclear power is sought by developing countries for several reasons, including the international economic and political status it can bring. Nehru felt that India missed the first "Industrial Revolution" due to her lack of technical progress. He believed that economic transformation of Indian society hinged upon the successful development of a nuclear energy program. Nehru's views of the late 1940s were nearly repeated two decades later by Indira Gandhi, who declared that, thanks to nuclear technology, India could take advantage of the coming second "Industrial Revolution" and struggle out of her poverty and ignorance (Byrne and Hoffman, 1988(2): 21-22). She strongly argues as follows:

> Our Programme of atomic energy development for peaceful purposes is related to the real needs of our economy and would be effectively geared to this end. Atomic energy power stations would play a very valuable role in the future not only in the areas where other sources of energy are expensive but as base-load stations working alongside large hydro-electric installations. The significance of all this to our economy which is so heavily dependent on agriculture is tremendous (quoted in Pathak, 1980: 24-25).

The late president of South Korea, Chung-Hee Park, similarly stresses the necessity of nuclear power generation of South Korea in the construction site of Kori-1:[3]

> We are very proud of and happy that this country [South Korea] is constructing the most technology-advanced plant [nuclear power plant] in the late 20th century. As we realize, electricity is what all countries in the world want for economic development. Demand for electricity is increasing fast to meet the manufacturing sector's need and cultivation of our nation-wide living standard.
>
> The government has promoted the undertaking of electrification of agricultural villages for several years. The extent of electrification of agricultural villages was 12 percent in 1964 and 27 percent even in 1970. To continue this trend, however, it is expected to be 70 percent at the end of 1976, which completes the third five-year economic development plan (Park, 1971: 143-144).
>
> Electrification of agricultural villages is currently being undertaken. The amount of electricity generation of our country is about 2,200 MWe and it will be 2,800 MWe at the end of this year [1971], and 6,000 MWe at the ending year [1976] of the third five-year economic development plan, including the 600 MWe of this nuclear power plant [Kori-1], which starts its construction today. We will have more electricity capacity than limitless transmission would require, and even more than our peak requirement.
>
> Until now, we have not shared in enough benefits of electricity in this country, especially in agricultural villages. We can use electricity in the near future in the kitchen and to heat floors in agricultural districts, as well as to power factories and road lamps in urban areas. Awareness of this fact would let us understand how important the promotion of electricity generation is and, by constructing many power plants like this plant [Kori-1], how much benefit from electricity we can receive. Furthermore, it will be possible that we can advance the larger economic development and lead to a higher cultural life (Park, 1971: 144).

President Park delivered his remarks to an audience of local farmers whose agricultural methods were quite traditional. The speech rationalized advanced technology to a traditional community much in the same manner that Prime Minister Indira Gandhi tried to persuade her agricultural country of the need for nuclear power.

The U.S. and the advanced nuclear countries of the West encouraged this developing country by equating modern with the possession of nuclear power. When domestic markets for the technology tightened in the wake of accidents and growing environmental group oppositions, the U.S. and the other nuclear powers saw developing countries as ripe market opportunities which were needed to rationalize the immense investment made in the technology. Sales to relatively poor countries sustained the nuclear industries of the U.S. and Europe during the late 1970s and 1980s. Kim and Byrne well explain this in their study of South Korean nuclear development:

> Nuclear power has been promoted as a limitless energy resource for all, but especially for the resource-poor countries of the periphery and semi-periphery. Recently, the promotional message has been elaborated to define developing countries as a new market for the moribund nuclear power industry of technically advanced countries. The rapidly industrializing countries of the Pacific Rim, especially Taiwan, and South Korea have been a primary target for Western technology and currently represent some of the most intensive users of nuclear power technology in the world (Kim and Byrne, 1990: 212).

A combination of the interests of technology-advanced countries and those of energy-scarce developing countries with rapidly increasing energy demands enabled the nuclear industry to survive and even expand on a large scale around the world.

B. Nuclear Energy in South Korea

1) Early Nuclear Development: 1956-1961

The first official action of the South Korean government to promote nuclear development dates back to *"The Agreement for Cooperation Between the Government of the Republic of Korea and the United States Concerning the Civil Uses of Atomic Energy,"* on February 3, 1956. Governmental efforts focused on nuclear research, information collection and overseas on-the-job training from western nuclear-advanced countries. A slow and steady progress of accumulation of nuclear information and technical know-how, essential for the realization of the nuclear electricity generation in the near future, took place during 1956-1961. These efforts laid the groundwork for the introduction of the first experimental nuclear reactor into South Korea. This first period of development was characterized by governmental research and training programs under the auspices of international cooperation agreement with the U.S.

2) Building a Nuclear Program: 1962-1970

Establishment of Survey Committee on Nuclear Power Generation in 1962 enabled the Office of Atomic Energy (OAE)[4] and governmental agencies (*e.g.*, Ministry of Commerce and Industry, Korea Electric Power Corporation, and Daehan Coal Corporation) to initiate the country's first nuclear program, A Plan for the Promotion of Nuclear Power Generation. The first nuclear program was advocated by the IAEA Nuclear Power Survey Mission after completion of a basic survey in October 1963 (Ha, 1982: 223-224). The South Korean government began operation of a research reactor, TRIGA Mark-II (100 KWe), in 1962. South Korean government already contracted the purchase of this research reactor with the General Atomic Division of General Dynamics Corporation (U.S.) in December 3, 1958 (Ha, 1982: 222).

This second stage of South Korean nuclear development mainly relied on foreign technological and informational support, especially from the U.S. During this period, the South Korean government fostered the rise of a domestic technical group who could design, engineer, and operate the first and subsequent commercial nuclear power plants with the help of foreign institutions (Ha, 1982: 226).

3) Advancement and Mass Nuclear Generation: 1971-1989

After the introduction of the research reactor, South Korean business conglomerates, *chaebols*, were invited by the national government to participate in the nuclear development program. Their sophisticated organization, capital and personnel were needed to indigenize the construction, management and maintenance aspects of the nuclear system. This involvement yielded large benefits to the conglomerates in the form of technology accumulation and enhanced their ability to further expand their enterprise scale and diversity. "Big business" and "more business" were to be the hallmarks of conglomerate involvement in the burgeoning nuclear power field (Kim and Byrne, 1990: 213; and Byrne, Hoffman, and Martinez, 1989: 589).

Table 1. Nuclear Power Plants and Indigenization in South Korea

No.	Project	Period	Main Contractor	Korean Contractor	Indigenization Rate
1.	Kori-1	1971-78	WEICO (U.S.)	Hyundai, Dong-Ah	5%[1] (8%)[2]
2.	Kori-2	1977-83	WEICO (U.S.)	Hyundai, Dong-Ah	5%[1](10%)[2]
3.	Wolsung-1	1976-83	AECL(Canada)	Hyundai, Dong-Ah	16%[1](11%)[2]
4.	Kori-3	1978-85	WEICO (U.S.)	Hyundai	33%[3](37%)[5]
5.	Kori-4	1978-86	WEICO (U.S.)	Hyundai	33%[3](37%)[5]
6.	Youngkwang-1	1980-86	WEICO (U.S.)	Hyundai	42%[3](44%)[5]
7.	Youngkwang-2	1980-87	WEICO (U.S.)	Hyundai	42%[3](44%)[5]
8.	Wooljin-1	1981-89	Framatome(France)	Dong-Ah, KHIC	40%[4](46%)[5]
9.	Wooljin-2	1981-89	Framatome(France)	Dong-Ah, KHIC	40%[4](46%)[5]
10.	Youngkwang-3	1989-96	KHIC[6] (Korea)[7]	Hyundai	72%[4](75%)[5]
11.	Youngkwang-4	1989-98	KHIC (Korea)[7]	Hyundai	72%[4](75%)[5]
12.	Wolsung-2	1993-97	KHIC (Korea)[8]	*	(75%)[2]

Notes:
1. Under turnkey contracts, only a minor portion of equipment manufacturing was indigenized, while design and engineering were not indigenized at all.
2. Balance of plant, etc.
3. Supplementary equipment included in equipment manufacturing portion.
4. Total equipment manufacturing portion.
5. Design and engineering portion.
6. KHIC: Korea Heavy Industries and Construction, Co. (Government-owned corporation).
7. Combustion Engineering, Co. (U.S.) is a foreign sub-contractor for these projects.
8. AECL (Canada) is a foreign sub-contractor for the project.

*. Not decided yet.

Sources: KEPCO, 1989: 13.9-13.10; Kwak, 1989: 244, 258; and Nuclear News, August 1991: 67.

The government-owned KEPCO signed a construction contract for the first commercial nuclear power plant (Kori-1) with Westinghouse Electric International Company (WEICO; U.S.) in 1970 after considering bids from many other foreign nuclear power companies. With this project, the South Korean government launched its efforts to commercially develop nuclear generation and had by 1982 the first nuclear power plant in operation, six under construction, and two pending on contract with Framatome (Ha, 1982: 227). The start of the power plant construction, Kori-1, marked a turning point in the South Korean nuclear program. With this plant, the country moved from a stage of preliminary nuclear development to the execution of a nuclear program for electricity generation. Kori-1 had a capacity of 587 MWe and supplied 6 percent of electricity demand in South Korea.

A part of the plant construction, which started at March 19, 1971, was handled by Hyundai Engineering and Construction, Co. (Hyundai), one of the biggest South Korean business conglomerates. It was involved in assembling the plant structure and other non-core parts of the building process. WEICO oversaw the construction of the core components. Even though Hyundai was not the major contractor, its role brought to the company important experience in handling construction based on long term project periods and huge investment requirements. In this respect, the Kori-1 project initiated the development of a technocracy which would guide the advancement of the nuclear program in South Korea. By the start of Kori-3 and Kori-4 seven years later, more than 90 percent of the civil engineering tasks would be fulfilled by South Korean business conglomerates (Kwak, 1989: 256). Other South Korean business conglomerates, as well as Hyundai, became involved in the nuclear projects and participated in a rapidly developing technology during this period.

As nuclear plant construction progressed, efforts to indigenize the technology, including the core parts, characterized national policy. As shown in Table 1, the rate of indigenization of the nuclear power plants of which construction was completed was less than 50 percent until Wooljin-1 and Wooljin-2. From 1990, ninety percent of indigenization of the reactor construction is scheduled (KEPCO, 1989, 13.9-13.10).

C. Institutionalization of Nuclear Development

In the 1960s, South Korea believed that an abundant supply of energy was required for national economic development. Total energy consumption in South Korea was expected to double between 1966 (25 million TCe[5]) and 1976 (48 million TCe). Furthermore, its electricity demand was projected to increase six-fold by 1976. The South Korean government wanted, as well, an alternative energy source that would reduce its very high dependence on foreign oil (Ha, 1982: 224).

The South Korean government believed that the introduction of nuclear generation could help it learn about the production process of nuclear weapons, but U.S. control of nuclear waste and reprocessing procedures, and unexpected barriers of financial and institutional support thwarted its attainment of nuclear weapons capability. One effort to overcome these limits was the purchase of a CANDU reactor which can yield plutonium to produce nuclear weapons. CANDU is a type of "pressurized heavy-water-moderated and cooled reactor" (PHWR) which was developed by Atomic Energy of Canada, Ltd. (AECL). Another effort to produce nuclear weapons was visualized in the South Korean government's agreement to purchase a French reprocessing pilot plant. This reprocessing plant could have given weapons-fuel manufacturing capacity to the South Korean government. The U.S.-South Korean political relationship, however, caused the government to abandon its efforts to make nuclear bombs. Both the U.S. State Department and Congress tried to block necessary export licenses and Export-Import Bank financing in reaction to the South Korean government's independent behavior. They were not approved until the South Korean government's ratification of the Treaty on Nonproliferation of Nuclear Weapons (March 20, 1975) and cancellation of the South Korean-French deal (January 1976) (Ha, 1982: 227). Thus, it was not technological or informational constraints, but financial and political factors which kept the South Korean government from obtaining nuclear weapons.

After the cancellation of South Korean-French deal, South Korea received full support from the U.S. and Canada for its plant orders of Kori-2 and Wolsung-1 in 1977. As well, the U.S. arranged for sales of two additional plants to South Korea in the increasingly competitive global nuclear market. South Korea's *client status* made South Korean nuclear development highly dependent on the U.S. The dependence, ultimately, drove the country to abandon bargaining with other countries or nuclear companies around the world (Kim and Byrne, 1990: 218).

South Korea elaborated an organization of governmental and private business conglomerate institutions for effective development of nuclear generation. The activity of this institutional system was mordant at the early development stage, restricted to experimental research and information transfer from foreign countries. After the introduction of the first research reactor, TRIGA Mark-II (1962), a full-scale effort to organize an indigenous technological base was launched by the South Korean government. Another research reactor, TRIGA-III, of 2 MWe capacity started to be installed in 1969, and substantially expanded South Korea's nuclear research. The first commercial nuclear project (Kori-1) provided important institutional experience. Ha describes the big change in governmental organization as follows:

> In April 1968, the council [Council for the Promotion of Nuclear Power Generation] assigned major responsibility for the construction and operation of the nuclear power plant to three different agencies: (1) Economic Planning Board; responsible for coordinating the nuclear power program, negotiating foreign loans, and conducting a feasibility study of the program with the cooperation of the Office of Atomic Energy and KECO [Korea Electric Company[6]]; (2) Office of Atomic Energy; responsible for the research and development of nuclear power technology, the safety control of the nuclear power plant, the training of nuclear engineers and technicians, the control of nuclear fuel and spent fuel, and the management of compensation for nuclear damages; and (3) Korea Electric Company; responsible for the engineering and construction of the plant, foreign loan application and contract, and the operation of the plant (Ha, 1982: 225-226).

But this level of institutional organization could not provide technological independence for the country. To gain independence, more institutional development was needed. The government responded by creating new institutions to provide indigenous research and technical training capacities, and to explore possibilities of fuel processing. The Korea Atomic Energy Research Institute (KAERI) and the Korea Nuclear Fuel Development Institute (KNFDI) (which was established in 1976 and, later, merged with the KAERI[7]) played an important role in indigenization of nuclear technology development. Especially, KNFDI promoted the development of the nuclear fuel-cycle technology. With financial and technical help from France, KNFDI completed a fuel-fabrication pilot plant (10 ton/year) and several pilot plants for uranium refining and conversion (Kim and Byrne, 1990: 218).

The Korea Atomic Energy Research Institute (KAERI), which was established in 1959, was assigned to train nuclear power plant employees with the beginning of the first commercial nuclear project. With the combined support of KAERI, WEICO, IAEA, and other foreign consultant companies, the South Korean government was equipped to handle all aspects of training and education from design to engineering, operations, and maintenance. The infrastructure for supplying technicians, engineers and other staffs, essential to the promotion of nuclear generation, was in place by the late 1960s (Ha, 1982: 226).

While South Korea continued to build nuclear power plants even after the Three Mile Island accident, safety issues were seriously taken into consideration. The Nuclear Safety Center (NSC) was established in KAERI in 1982 as a safety management office. Additionally, the Atomic Energy Bureau (AEB) was reorganized as the Atomic Energy Committee (AEC) and placed in the Ministry of Science and Technology (MOST), giving safety issues greater attention by the national government.

WEICO and Atomic Energy of Canada, Ltd. (AECL; Canada) contracted with KEPCO for construction of Kori-2, scheduled to begin in May 1977, and Wolsung-1 to begin in January 1976. The South Korean government emphasized indigenization as a key goal for both projects (Nuclear News, February 1989: 75). Kori-2 and Wolsung-1 were ordered on a "turn-key" basis (as was Kori-1), because South Korea's capacity to indigenize the design phase of the construction projects was a still far from realization. Nevertheless, even these "turn-key" plants furnished slow progress toward indigenization in the sense that they overcame the barrier of technology transfer (Nuclear News, November 1987: 100).

Kori-2 called for a 605 MWe plant of a "pressurized light-water-moderated and cooled reactor" (PWR) design. The plant's generation capacity was larger than Kori-1 by 50 MWe. Construction and reactor supply were delivered by the major contractor, WEICO, while the generator was supplied by General Electric, Co. (GEC; U.K.) and architectural engineering by Gilbert (U.S.). The Kori-2 plant was originally scheduled to operate by February 1983, but was delayed until July 1983. Wolsung-1 has a capacity of 629 MWe. The PHWR deign developed by Atomic Energy of Canada, Ltd. (AECL) was used at Wolsung. It was expected to be completed in late 1982. The major contractor, AECL, installed the reactor and constructed the majority of the plant. NEI-Parsons, Ltd. (Canada) supplied the generator, while Canatom, Ltd. (Canada) furnished the architectural design (Nuclear News, February 1989: 75). Its start-up was delayed until April 1983 (Nuclear News, Mid-March 1980: 38).

No South Korean business conglomerate, *chaebol*, was actively involved in construction of the first three nuclear power plants. As shown in Table 1, South Korea's participation was only 10 percent by supplying labor and construction materials by Hyundai Engineering and Construction, Co. (Hyundai) and Dong-Ah Construction Industrial Co., Ltd. (Dong-Ah). This extent of involvement did not significantly contribute to the indigenization of the South Korea's nuclear industry, although KEPCO was in charge of operation of all nuclear power plants. After the completion of Kori-1 and the start of construction of Kori-2, a computer-based nuclear power plant simulator was shipped to KEPCO in May 1979, 13 months after Electronic Associates, Inc. (U.S.) had received the contract. This simulator (costing over $3 million) was introduced to train operators at the Kori-1 and Kori-2 plants (Nuclear News, May 1979: 68). This is an example of the South Korean government's effort at indigenization of the science and management of nuclear power.

Construction of the next two plants, Kori-3 and Kori-4, was also dominated by foreign companies. Generation capacity of the two plants is 900 MWe each, which represents a significant increase over earlier 600 MWe designs. WEICO supplied the reactors and GEC furnished the generators, while Bechtel Power Corp. (U.S.) was in charge of architectural engineering, procurement and construction for both plants (Nuclear News, February 1989: 75). It was most important for South Korea's indigenization policy that Hyundai was responsible for a major share of the plant's construction. It was the first time that a South Korean company had taken on such a large role, even if it was still only a minority. KEPCO switched the basis of contract from "turn-key" to "non-turn-key" so that contracts were given to several bidding contractors for different components and tasks.

The sixth and seventh plants, Youngkwang-1 and Youngkwang-2, were contracted in 1979. The contracts were similar to those for Kori-3 and Kori-4, except that the generators were supplied by WEICO instead of GEC (Nuclear News, February 1989: 75; and Mid-March 1980: 32). But, as shown in Table 1, the extent of indigenization increased compared to that of the previous two plants. Four plants, Kori-3, Kori-4, Youngkwang-1 and Youngkwang-2, can be characterized as providing a solid foothold for domestic and foreign contractors to work together. These plants served as laboratories of corporate cooperation form 1978 to 1987. KEPCO made six plant contracts with WEICO over 18 years (1970-87), from the beginning of South Korea's nuclear program to the mature indigenization of nuclear technology. Only one plant order, Wolsung-1 did not involve WEICO. Indigenization rates increased to over 40 percent, including supplementary equipment manufacturing and some engineering tasks (See Table 1).

Framatome (France), as a major contractor, received two 950 MWe PWR plant contracts, Wooljin-1 and Wooljin-2, valued at about $443 million each. The company was selected as part of South Korea's supplier-diversification efforts initiated in the mid-1970s (Nuclear News, December 1980: 45-46). Both reactors were supplied by Framatome, while generators were by Alsthom (France). Framatome and Alsthom collaborated on design and engineering for both plants. As domestic participants, Dong-Ah and Korea Heavy Industries and Construction, Co. (KHIC) took a major role in constructing the plants (Nuclear News, February 1989: 76). In this project 46 percent of design and engineering and 40 percent of total equipment manufacture were indigenized (See Table 1). The high indigenization rate of total equipment was important because it meant that the domestic nuclear industry no longer was confined to supplementary equipment manufacture or plant construction.

A French fuel cycle company, COGEMA, won a contract to supply fuel for the two new plants for 10 years (1986-1995). The contract was valued at $485 million. This order was also a result of South Korea's supplier-diversification efforts in the fuel sector (Nuclear News, December 1980: 45-46). Most fuel for nuclear power plants in South Korea had been supplied by the U.S., and hence it was possible for the U.S. to control South Korea's nuclear industry by forcing it to comply with the non-proliferation agreement. Together, the plant construction and fuel contracts between South Korea and France amounted to $1.1 billion which was advanced to KEPCO under the favorable condition of 15 years repayment at 7.6 percent interest rate per annum (Nuclear News, June 1981: 91).

Youngkwang-3 and Youngkwang-4 plants, which were contracted for in April 1987 and are under construction, set a landmark in South Korea's indigenization of nuclear technology. A South Korean corporation, KHIC, received the two plant orders (1,000 MWe each) as a major contractor. KHIC was established in 1962 by the South Korean government. This corporation became one of the largest heavy engineering companies in the Far East, having the capacity to manufacture such nuclear components as reactor pressure vessels and steam generators (Nuclear News, December 1985: 60). South Korean reactor and generator suppliers and an architectural engineer company were eventually introduced into this project. As a result, 75 percent of design and engineering is expected to be domestically achieved (See Table 1). KHIC and Combustion Engineering, Co. (CE; U.S.) supplied reactors and KHIC and General Electric, Co. (GE; U.S.) the generators. Korea Power Engineering Co., Ltd. (KOPEC) and Sargent and Lundy Engineers (S&L; U.S.) collaboratively took part in the architectural engineering, while Hyundai has served as a construction contractor (Nuclear News, February 1989: 76).

KEPCO's role in promoting South Korean nuclear development consisted not only of overseeing foreign companies' involvement, especially in the early stage, but of coordinating the activities of several other domestic organizations. Korea Power Engineering Co., Ltd. (KOPEC), with 98 percent of its stock belonging to KEPCO, was established in 1975 to organize the task of architect-engineering. As of 1985, KEPCO owned 34 percent of KHIC's stock, a major nuclear plant construction contractor. The Korea Nuclear Fuel Company (KNFC), which is responsible for nuclear fuel fabrication and waste management, was established in 1985 with KEPCO owning 76 percent of its stock (Nuclear News, December 1985: 60). Each of these organizations—KOPEC, KHIC and KNFC—are national government corporations managed by this government-owned utility, KEPCO, which is itself the largest national government corporation. In this respect, the South Korean nuclear industry exhibits the high degree of centralization and giantism that others have noted is characteristic of nuclear power. South Korea's successful nuclear program is simply not conceivable without institutionalized centralization and giantism.

III. The Politics of Nuclear Development

A. Bases of Political Support for Nuclear Power

Nuclear technology is an inherently centralized technology. Efficiency (technical and economic) is maximized by amplifying unit generating capacity; nuclear developers plan units with a ceiling size of 1,300 MWe, not just 400-500 MWe which characterize fossil-fuel fired power plants. Progress in nuclear technology, in this sense, requires a form of large-scale organization which emphasizes decision making by highly technically-advanced groups. As Byrne and Hoffman argue, integrated planning and operation of nuclear power systems requires a centralized organization (Byrne and Hoffman, 1988(1): 662). Thus, centralization both in a technological and organizational sense is essential to the utilization of nuclear power. A key step in explaining society's involvement with this technology, therefore, is establishing which political interests are served by the centralization of the power system. Below the military and business interests who stood to benefit from the promotion of nuclear technology are discussed. It is also pointed out that nuclear development progressed without public consent in South Korea.

In almost every society which has developed nuclear power systems, there has been an expectation of manufacturing nuclear weapons. As Byrne and Hoffman state: "Even societies which attempted "peaceful" nuclear development were unavoidably incorporated into the military project" (Byrne and Hoffman, 1988(1): 660). Yet U.S. promotion of world nuclear technology required recipient countries to sign agreements of nonproliferation of nuclear weapons technology. No restriction was placed on the transfer of U.S. nuclear technology for electricity generation to its allies. U.S. financial and technological support of South Korean nuclear development required the country to sign the Treaty on Nonproliferation of Nuclear Weapons and to cancel the South Korean-French deal on a reprocessing pilot plant which could be used to manufacture nuclear bomb fuel. American requirements were seen by some as having less to do with proliferation issues than with excluding the French from what could be a lucrative market opportunity. Nuclear development in South Korea was regarded by government decision makers as unavoidably carrying with it potential for manufacture of nuclear weapons.

Since the end of the Korean War in 1953, South Korea considered itself under threat from North Korea. In fact, North Korea had tried to promote nuclear power for some time. North Korea installed its first research nuclear reactor in 1965, the IRT-1000 (1,000 KWe), with the help of the former Soviet Union. During the seven-year economic development plan (1961-1970[8]), North Korea received Soviet promises of support for the construction of a nuclear power reactor (100 MWe) (Ha, 1978: 1136). Its fulfillment, however, was not achieved until the early 1980s. North Korea is recently reported to have large-scale nuclear reactors and plutonium reprocessing plants which is most important facility for the manufacture of nuclear bombs. Some U.S. nuclear and military information experts anticipate that North Korea will manufacture annually 3 to 6 nuclear bombs with full operation of these facilities as of 1995 (Han-Kuk Ilbo, November 19, 1990: 2).[9]

Under this circumstance, South Korea saw itself as in an "arms race", and sought to be ready to make nuclear weapons if an emergency of national security required it. When the government considered the introduction of nuclear power generation, it anticipated that the society would eventually be able to make nuclear bombs. Because, however, the *client relationship* for nuclear technology transfer established between South Korea and the U.S. gave the latter some role in decisions about development, South Korea could not diversify its own nuclear program with other sources of help or self-sufficiently.

While the U.S. helped the South Korean program of nuclear generation for peaceful use, it controlled the nuclear-weapon technology and facility sources. Even so, indigenization of the technology was sought by the South Korean government. It began from minor involvements of South Korean business conglomerates, *chaebols*, in construction and operation. While on-the-job training and transfer of basic information were necessary for the start-up of nuclear development, and hence the government could not quickly realize the goal of indigenization, eventually a base for indigenization efforts was achieved in South Korea. The active role of South Korean conglomerates in the indigenization of nuclear technology from plant design and construction to operation and maintenance was accomplished to an important degree by the start of the 1980s and the Youngkwang nuclear programs. Kim and Byrne capture the role of the conglomerates in South Korean nuclear technology development:

> Several *chaebols* were able to build engineering and heavy industry companies into their conglomerate structures as a result of their power generation involvements. These conglomerates in turn become the principal sources of work for medium and small scale firms, which over time, have become hierarchically attached to the *chaebols* as suppliers of power plant equipment. ...... [N]uclear power plants were treated as similar to large fossil-fuel fired power plants which the *chaebols* had already indigenized. ...... [T]hese technocrats played essential roles in the development of a nuclear network including the establishment of university departments, engineering and heavy industries, and research centers (Kim and Byrne, 1990: 213, 217).

The military government and private business conglomerates, *chaebols*, worked closely together during the 1970s to achieve civilian and military goals for this technology. South Korea business conglomerates had been involved in the defence industry in various ways since the mid-1970s. Indigenization efforts of conglomerates under governmental control successfully resulted in their dominant role in the domestic defence industry. The government's direct intervention was possible in part because of the economic circumstances of the mid-1970s. In this period, the government had access to abundant capital and hence technology improvement and was able to use its position to plan the military economy. It created the heavy-chemical industry to serve civilian and military needs. Foreign control (mainly of the U.S.) over conventional weapons induced the South Korean government and *chaebols* to integrate independent technology improvement and mass production of military weapons. This would indigenize the weapons industry while spreading technology throughout the economy. As a side effect of this integration, weapons exports by South Korea increased so highly that the industry became one of five largest weapons exporters in the world from 1977 through at least 1985 (Moon, 1986: 244). Moon captures the South Korean government-*chaebols* integration in its domestic military industry:

> [O]ut of the top ten Korean business conglomerates whose annual gross sales are equivalent to over 40 percent of GNP, seven are actively engaged in the defence industry. In fact, they account for the majority of the defence industry, while other defence contractors are small-scale parts manufacturers except for a few firms such as KIA, Poong San Metal, Oriental Precision, and Tong Il Industry. Given that the heavy-chemical industry, which is the backward linkage basis for the defence industry, has been concentrated in these big business conglomerates, it is no wonder that they dominate the defence industry. The fusion of the defence and commercial heavy industries in the hands of these few big conglomerates may transform the emerging military-industrial complex into a powerful political entity (Moon, 1986: 258-259).

This centralized, top-down planning approach was used by the South Korean government in a variety of sectors, including the electricity sector. Nuclear power development in the country is perhaps one of the most compelling cases of top-down centralized planning. South Korean nuclear promotion proceeded through the integration of the government and the *chaebols*. In addition, the national utility company, research institutes and universities fell into place to promote nuclear power. The full-scale development of nuclear power in South Korea followed a pattern similar that found in other nuclear countries. The most advanced nuclear countries—the U.S., and later, highly advanced countries, Canada and France—depended upon the same alliance of governmental and private institutions who combined to promote nuclear fission.

B. Bases of Political Criticism and Opposition

There have been numerous incidents and disasters at nuclear power plants throughout the world. Deaths and major accidents have been a part of the legacy of this technology from the outset. Two died at the Los Alamos plutonium processing plant (U.S.) in 1945-1946; a core meltdown at Canada's experimental Chalk River plant occurred in 1952; a fire at Britain's Windscale plant in 1957 was the first accident at a large-scale facility; three operators died in an explosion at an experimental nuclear reactor facility in Idaho Falls, Idaho (U.S.) in 1961; a partial core meltdown of the Fermi demonstration breeder reactor (U.S.) occurred in 1966; an accident at a Soviet breeder reactor during 1973 has left an area in the Ural Mountains off-limits to human beings to this day; and an electric cable fire at the Brown Ferry, Alabama plant (U.S.) in 1975 nearly triggered a core meltdown of the commercial reactor (Byrne and Hoffman, 1988(1): 658).

The long series of technological or operational incidents has not come to an end. The accident at Three Mile Island, Pennsylvania in 1979 caused the American people to doubt the safety of this technology. Seventeen curies of radioactive gases escaped from the nuclear plant which, some believe, represent a long-term health threat to the area's population. Even if there were no direct health or environmental effects caused by the accident, the U.S. nuclear industry would probably have experienced decline because the social and psychological effects of the accident were so strong. What is undeniable is that no new nuclear plants have been ordered since the Three Mile Island accident.

A meltdown of the Chernobyl-4 nuclear reactor on April 2 , 1986 was much more serious than the Three Mile Island accident and the fire at Windscale, in terms of emissions of radioactive materials and in environmental and human-health effects. The release of 28 megacuries of gases; the evacuation of 130,000 people within a 30 kilometer radius; and risk to 300-400 million people in 15 nations of exposure to radiation dwarfed the dangers to civilian population of any prior nuclear plant incident. From 5,000 to 75,000 people are predicted to die of cancer attributable to the Chernobyl accident (Flavin, 1987).

Studies of the United States government show that core-damaging nuclear accidents will occur only every 10,000 years of reactor operation. With the number of 500 plants likely to be operating worldwide in the year 2000, this would mean one accident every 20 years (U.S. Nuclear Regulatory Commission, 1975; and MacKenzie, 1984). The Three Mile Island accident, however, occurred after 1,500 years of reactor operation, and Chernobyl followed after another 1,900 reactor-years. If this accident rate continues, three additional accidents would occur by the year 2000 with a probability of an accident at every four years. Scientists in Sweden and the former West Germany estimate that there is a 70-percent probability that another such accident will occur in the next 5 and half years (Flavin, 1987: 39-40).

As non-operational and non-technological problems, the nuclear industry has been confronting serious financial problems. The French nuclear authority, the Electricité de France (EDF) has ordered unnecessary and unaffordable nuclear plants of which debt of $32 billion. In the United States, the Washington Public Power Supply System (WPPSS) reported not to enable to pay its debt of $6.7 billion in principal and $23.8 billion in interest on five nuclear plants (Byrne and Hoffman, 1988(1): 658).

A study of the Tennessee Valley Authority (TVA) in 1985 shows the impossibility of the lower operating costs for nuclear power plants. Operating and maintenance costs for nuclear plants between 1970-1986 increased fourfold in real dollars, which means 11.4 percent per year above the inflation rate. During the period of 1981-1985, operating, maintenance and fuel costs of nuclear power plants increased 50 percent, while those of coal plants did 10 percent (Byrne and Hoffman, 1988(1): 659).

South Korea's nuclear program has likewise experienced technical and economic problems. The reasons for plant shutdowns can be many, including routine fuel exchange or regular maintenance. The reasons for unscheduled shutdown of South Korean nuclear stations are described below. Unscheduled shutdowns were 112 between 1975-1985. Among these, more than 70 percent had been caused from mechanical breakdown. Out of 93 mechanical breakdowns, 65 cases (70 percent) have been caused by the use of wrong or defective parts. Other reasons for mechanical breakdowns include errors in construction (13 percent), design errors (12 percent), and poor maintenance (5 percent) (Kwak, 1989: 227).

The most serious incident in South Korea to date was a spill of heavy water at Wolsung in 1984. Even though most of the radioactive water, which was contained inside the reactor, was recovered, what makes the situation worrisome from this incident is that neither the National Assembly nor anti-nuclear activists have access to information on the accident, or to the construction design or safety program information. The South Korean government has kept a tight ring of secrecy around the nuclear system for national security reasons (Clifford, 1989: 55).

Problems at the Wooljin-1 reactor demonstrated the possible dangers of South Korea's aggressive indigenization program of nuclear power plants without project management experience and quality control personnel. The turbine generator was constructed incorrectly, because South Korean technicians did not follow the right order for assembling pieces and bolting the unit together. Only minimal help from the French company, Framatome, was provided for the project. A bolt worked loose and dropped into the turbine at Wooljin-1 shortly after it went into operation. This small mishap forced an entire shutdown for 107 days, with a cost $35.8 million to resume operation (Clifford, 1989: 56). This magnitude of financial damage indicates that nuclear technology is very *"brittle"* (Lovins and Lovins, 1982)—mistakes, even minor ones, can have major economic, as well environmental and health consequences.

South Korea has adopted an indigenization program for two new units, Youngkwang-3 (950 MWe) and Youngkwang-4 (950 MWe). Equipment manufacturing and design engineering would be 72 percent and 75 percent respectively indigenized for this project, compared with 40 percent and 46 percent respectively for the most recently constructed pair of reactors, Wooljin-1 and Wooljin-2 (See Table 1). The estimated cost of the two reactors, however, has already risen from $3.3 billion in 1987 to $4.4 billion in 1989 (a 33 percent increase at constant exchange rates). The three foreign subcontractors (all from the U.S.), Combustion Engineering, Co. (CE), General Electric, Co. (GE), and Sargent and Lundy Engineers (S&L), have already notified South Korea that they expect additional costs to complete their services (Clifford, 1989: 55-56).

While it is in operation, a nuclear power plant may or may not experience an accident. But every reactor, eventually, must be retired raising the prospect of accidents or health/environmental threats. There are three ways to retire a nuclear plant: 1) decontamination and dismantlement immediately after shutdown; 2) storage for several decades to allow radioactive decay prior to dismantlement; or 3) the creation of a "permanent" tomb. Each option involves removing the spent fuel, draining all liquids, and flushing the pipes. These activities pose serious potential dangers to workers, communities and environment. Only the first scenario is practical for South Korea. It would require that tubing and structural surfaces be mechanically and chemically cleaned; irradiated steel and concrete would be disassembled using advanced scoring and cutting techniques; and all radioactive debris would be shipped to a burial ground. This site would then theoretically be available for unrestricted use (Pollock, 1986: 8).

The cost of this process can not be easily fixed since there is no unique or standardized cost estimation methods. According to the Battelle Pacific Northwest Laboratory's upgraded cost estimation, in 1984, of decommissioning a generic 1,175 MWe PWR and a 1,155 MWe "boiling light-water-cooled and moderated reactor" (BWR), the PWR is projected to cost $104 million and the BWR $133 million. When the calculations are site-specific, rather than generic, the cost for decommissioning of a PWR increases 35 percent (Pollock, 1986: 26). Pollock introduces André Grgéut's estimation as a ceiling figure for the costs of decommissioning:

> Three Mile Island plant is so heavily contaminated that dismantlement may exceed the original cost. Although the level of contamination at Three Mile Island is many times higher than will be encountered at most power reactors, cleanup costs there are projected to pass $1 billion before decommissioning itself is contemplated (Pollock, 1986: 27).

Sooner or later, the South Korean nuclear industry will confront the decommissioning project at the Kori-1 site. The South Korean government has selected the first approach due to the lack of land and over-population in the country. But it is hard to imagine how an ex-nuclear power plant site can be used for house construction or farming. Theoretical evidence showing the area can be available for general land use is irrelevant because of the problem of attracting land users who might fear that unforeseen contamination issues could subsequently be found. Also, there is the high likelihood of social protests and substantial decommissioning costs.

Medium and high level nuclear waste disposal is another problem of decommissioning process. Medium and high level wastes—spent fuel and the byproducts of fuel reprocessing—must be removed from the plant before decommissioning can proceed. At present, not a single country has a permanent disposal facility for medium and high level waste and no such facilities are likely to be in operation before the turn of the century (Pollock, 1986: 13). In the case of the U.S., there are no states allowing storage of nuclear waste within their own state territory, as Davis captures:

The Carter administration sought to resolve the problems of radioactive waste through establishing federal government interim storage sites in South Carolina, Illinois, and New York. Critics objected to this government subsidy of the utility companies. Congress also sought a comprehensive solution of the disposal problem (Davis, 1982: 227).

While all agree that a nuclear country needs safe disposal sites in remote areas, no countries want them within their boundaries. Nuclear waste provokes the "not in my backyard" (NIMBY) attitude (Davis, 1982: 227).

The South Korean nuclear plan, as developed by KEPCO, calls for a doubling of the size of its nuclear system over the next decade. This plan, however, is confronting serious challenges from environmentalists, politicians and academics who cite the following issues: 1) the costs have proven to be very high; 2) it takes eight years to build a plant; and 3) there is growing opposition to siting nuclear plants. Some analysts do not believe that South Korea can meet the target, given the high cost and the short (ten-year) planning period. Further, strong opposition exists among the public, and greater democratic pressure in the country is going to make it more difficult to build nuclear plants (Holzman, 1990: 48).

South Korea is confronting a nuclear waste management problem, as well. The government is currently facing strong, and even violent, protest against a proposed nuclear waste disposal facility. This new waste disposal facility, on a small residential island in southern Yellow Sea of South Korea, Ahn-Myun Do (Island), was planned and being constructed without any notice or discussion with the residents of the island. This project was recently halted in the wake of an open riot by residents. The islanders attacked and detained police officers who were sent to suppress the demonstration, and they insisted that there must be an immediate withdrawal of the plan and facility under construction. This conflict between the residents and the South Korean nuclear authority was caused, in part, by the government's secretive and deceptive administration of the facility, ignoring public concerns (Joong-Ang Ilbo, November 9-13, 1990). This illustrates what can be expected as a typical conflict of nuclear waste management in the nuclear developing countries. The nuclear waste disposal problem is expected to get more serious in small countries like South Korea.

The burial of nuclear waste near the Kori power plant in December 1988 is another example of poor waste-disposal management in South Korea. Fifty four drums of radioactive waste, unearthed by citizen activists, were said by the activists to be giving off at least four times as much radioactivity as the permissible limit. Such an unsafe governmental performance in nuclear waste disposal without any long-term perspective is boosting the public's fear of nuclear power (Nuclear News, November 1989: 75). The South Korean government was supposed to announce a permanent waste disposal site by the end of 1989, and residents in the area which was expected to be chosen had already begun their protests (Clifford, 1989: 55).[10]

According to a survey by the Korea Atomic Energy Forum with the assistance of Korea Gallup Poll, in October 1986, the public gave a general endorsement to the construction of nuclear power stations—74.4 percent responded with approval, while 25.6 percent did not. To the question of whether the public would support construction of a nuclear station within 10 kilometers of their homes, the opposition was 73.5 percent, while a sum of approval and "undecided" was 26.5 percent (Kwak, 1989: 333). This indicates that even though large numbers of the public seem to agree with the necessity of nuclear technology to meet the nation's energy needs, an equally large number express their unwillingness to take risk for the benefit of others. Without question, public opposition to construction of nuclear plants and waste disposal facilities will continue and local struggles are likely to become more increasingly tense.

The highly favorable public response to the necessity for nuclear power is mainly due to nuclear campaigns delivered by governmental administrations which portrayed nuclear generation as safe, non-polluting and less expensive than alternatives. An imperative for nuclear energy has been stressed to the South Korean public not only by highlighting future energy problems without the employment of the nuclear power, but also by releasing information about the advantages of nuclear energy since nuclear development began in South Korea. An executive summary of a proposal for nuclear development in South Korea, prepared by KEPCO, admitted that only "one-sided information" on nuclear energy was given to the South Korean public (KEPCO, 1989: 146). As the South Korean people are permitted to learn about nuclear dangers and problems experienced in and out of the country, anti-nuclear sentiments are likely to grow.

IV. The Energy Future of South Korea: Challenges to Nuclear Power

A. Implications of Nuclear Power for the Future of South Korean Society

As discussed earlier, South Korean political, military, technocratic, and economic interests are all joined in the support of nuclear power. Few domestic energy alternatives are mobilized, while "centralized power" (Messing, 1979) is persistently sustained in South Korean society. This creates an institutional commitment to nuclear power in South Korea that, by the 1980s, is strikingly similar to the U.S. case of national promotion of nuclear power in the 1960-1978 period.

A recent proposal put forward by KEPCO indicates that institutional support remains strong. KEPCO's proposal is for nuclear generation capacity to increase substantially over the coming years; 7,616 MWe (1993), 12,316 MWe (2001), and 15,450 MWe (2011), while its share among all sources of electricity generation will be greater than 30 percent (32.5 percent, 34.5 percent, and 31.0 percent, respectively[11]—see KEPCO, 1989: 69). But this proposal can be challenged in terms of capital cost and environmental improvement. Keepin and Kats point out that under either the medium or the high emission energy scenario,[12] nuclear power can not solve the global warming problems originated by carbon dioxide and other gases (Keepin and Kats, 1988: 538). KEPCO's proposal expects a high increase of coal-fired electricity generation along with increased nuclear generation (indeed, coal-fired power is projected to grow faster than nuclear—see KEPCO, 1989: 69). Thus, KEPCO anticipates a medium to high emission scenario. Capital costs for the construction of nuclear power plants is a heavy burden, as Keepin and Kats capture, especially for the developing countries. Moreover, the increasing cost of construction and operation of nuclear power plants makes further nuclear development difficult for these countries.

Yet, South Korea remains firmly committed to nuclear energy. As of 1990, the country has no other major domestic energy policy but the continued promotion of nuclear power. Halting the advance of the nuclear technostructure is portrayed by the national government as exposing the country to an energy crisis. The decision to do without this energy source is compared to South Korea in a pre-industrial age, similar to life at the beginning of the 20th century. To go this route would mean great change in the political, social and economic structure; change which, according to South Korean nuclear advocates, would throw the country back to an earlier age of agricultural simplicity. Society could no longer exist in its contemporary economic form (KEPCO, 1989).

South Korean nuclear power is assumed by government, industry and the scientific community to be sustainable for the future with no significant obstacles critically affecting the trend. The only reason for halting the progress of South Korean nuclear development is in the currently increasing economic burden both in construction and operation. But this situation is not yet so serious that growth in the current nuclear system would be in danger of slowing down. The nuclear system is too strong to be affected by single-dimensional problems like economics.

The institutional basis of South Korea's nuclear energy system essentially precludes change from within. The alliance of the government, the military, conglomerates and advanced science and technology institutes commits the society to a centralized, technocratic energy orientation. There is also the dangerous possibility that the society may arm itself with nuclear weapons. While the prospect for change seems poor in this context, there are signs that it is possible nevertheless. Anti-nuclear sentiment is spreading throughout the society and groups are forming rapidly to bring political pressure. The recent peasants' strike in Ahn-Myun Do indicates that nuclear policy can be resisted. Also, there is reason to believe that the society's growing demands for political decentralization may bring challenges to the centralized politics of nuclear power. The next section speculates on these sources of change.

B. A Sustainable Energy Alternative: *The Soft Energy Path*

Nuclear fission is one of several technologies that Amory Lovins defines as *"hard energy paths,"* which also include coal-based electrification, oil-based electrification, and synthetic fuels. Contrastingly, energy conservation is typical of *"soft energy paths"* (Lovins, 1977: 25). Lovins captures the nature of the *hard path*:

> The list is impressive: the hard path, it was argued, demands strongly interventionist central control, bypasses traditional market mechanisms, concentrates political and economic power, encourages urbanization, persistently distorts political structures and social priorities, increases bureaucratization and alienation, compromises professional ethics, is probably inimical to greater distributional equity within and among nations, inequitably divorces costs from benefits, enhances vulnerability and the paramilitarization of civil life, introduces major economic and social risks, reinforces current trends toward centrifugal politics and the decline of federalism, and nurtures—even requires—elitist technocracy whose exercise erodes the legitimacy of democratic government (Lovins, 1977: 148).

He contrasts this path with the *soft energy path*:

> In a soft energy path, the technological measure to be achieved can be readily separated from the policy instrument used to encourage it. The former—cogeneration, bioconversion, insulation—is in itself relatively neutral; the latter—taxes, standards, exhortations—may be politically charged. It is only the latter that is likely to irritate us if ill-conceived. But the ends sought are so fine grained, locally tailored, dispersed, and small scale, and the means—the policy tools—can be chosen, according to practical and ideological convenience, from such an enormous array of options, that the choice can fully respect pluralism and voluntarism. Indeed, so diverse are our societies, and hence the local conditions to which soft path innovations must adapt, that a centralized management approach to a soft path simply would not work (Lovins, 1977: 149).

The above distinctions suggest that choice of energy systems involves choice of political, social and economic approaches as well. Under the *hard energy path*, as Lovins argues, the society depends on huge generation systems financed by huge outlays of capital. Only a few experts can govern the high technology and society is exposed to unimaginable risks. These phenomena can be expected to cause public distrust and alienation, even opposition, while the *hard path* system denies public participation (Lovins, 1977: 150).

In contrast, the *soft energy path* is pertinent to everyday life because it can be "locally tailored," as Lovins suggests, both technically and socially. Efficient use of energy often makes more sense to communities than building a nuclear power plant and a corresponding large electricity grid, and risking health and public safety.

South Korea is currently in the early stages of developing a local autonomy system. It is generally expected that the new governmental system will encourage decentralization and democratization. But the expansion of centralized nuclear development conflicts with this emerging political climate. As noted earlier, nuclear energy systems tend to centralize, monopolize, and greatly increase the size of electrical facilities. The combination of *"Big Science, Big Industry and Big Government to achieve big results,"* is characteristic of nuclear power (Byrne, Hoffman, and Martinez, 1989: 589). As the society implements local autonomy, the alternative of energy decentralization and democratization is likely to become more widely appreciated.

In this regard, a positive sign is the recent Workshop held in Seoul, South Korea on energy efficiency and environmental protection in four East and Southeast Asian countries—Indonesia, Malaysia, South Korea and Thailand. South Korean representatives included government, university and business leaders who discussed the importance of improving energy efficiency to promote national development and environmental quality. The preliminary report for this Workshop suggests that energy efficiency policies should be given the highest institutional priority in each country. The report recommends that the existing energy-related institutions should be strengthened to promote energy efficiency programs and new institutions be systematically organized to encourage the development of energy-efficient, environmentally sensitive technologies (Byrne, *et al.*, 1990: 26).

The conventional approach to economic growth has assured high level of energy use. The national (even international) energy system searches for abundant, low-cost energy sources and vulnerability-free energy strategies. Energy efficiency, however, can meet the requirement for expected economic development, while it gives, in addition, appropriate amounts of energy for self-reliance and environmental protection (Byrne, *et al.*, 1990: 23-24). The World Bank's commitment to an "Alternative Energy Path"—the Workshop was held a part of this new project—is also encouraging. In the past, the World Bank helped developing countries purchase nuclear technology; now, it will help them invest in energy conservation.

Until recently, the *soft energy path* approach of conservation, renewable energy, and environmental sustainability gained only a small amount of popular support. The people were told that it was not realistic for the country's development needs. But doubts about KEPCO's and other elites' exclusive focus on nuclear power have arisen; there are safety concerns and distrust that the government is not revealing the full story about the country's plants; and there is very strong desire for much greater community participation in shaping the future. The environmental and anti-nuclear movements have jointly focused and have begun to stress conservation and renewable energy. For many South Korean people whose lives are hard and economically fragile, the practicalness of the *soft path* can be very convincing. Why must the society spend so much on a nuclear plant instead of on better housing, better buses, better schools? These different interests or perspectives, when looked at together, can possibly bring change from outside the institutional web of the nuclear political economy. After the happenings in Eastern Europe, "centralized power' should not be assumed to be invincible!

NOTES

1. South Korea, hereafter, refers to the Republic of Korea (ROK), while North Korea refers to the Democratic People's Republic of Korea (DPRK).

2. Most of the peninsula's electric generation by 1950 was hydropower and the largest facilities were in North Korea.

3. Kori-1 is located in a farming village in southeastern South Korea.

4. In 1959, OAE was established under the direct authority of the president for the purpose of the management of research and promotion of nuclear generation.

5. TCe refers to tons of coal equivalent.

6. Korea Electric Company (KECO) was founded, for the purpose of expansion of electricity generation which was expected to be largely wanted by the economy, by merging three private electric utilities, Choseon Electrical Industry Company, Gyunggi Electric Company and Namseon Electric Company in 1961 (Ministry of Power and Resources, 1988: 11). KECO changed its name and function as a corporation to Korea Electric Power Corporation (KEPCO) in January 1, 1982 after the submission of a "Proposal for the incorporation of Korea Electric Company" by the Ministry of Power and Resources in December 2, 1980, and a congressional promulgation of "Laws of Korea Electric Power Corporation" in December 31 (Ministry of Power and Resources, 1988: 296).

7. The Korea Atomic Energy Research Institute (KAERI) and the Korea Nuclear Fuel Development Institute (KNFDI) were merged into the Korea Advanced Energy Research Institute in 1981, of which abbreviation is also KAERI (Ha, 1982: 228).

8. Due to less progress than expected and excessive military expenditures, the original seven-year economic development plan (1961-1967) was extended by three years (Ha, 1978: 1136).

9. In my opinion, the nuclear "arms race" between North and South Korea, which was stressed during President Park's regime, could never guarantee national security for either side. The pursuit of nuclear weaponry could only thwart hopes for reunification as North and South Korea created a "balance of terror." Such a balance would increase fears of a second Korean War. Further, nuclear weapons development threatened the stability of neighboring countries and, given the super-power alliances on the peninsula, even worldwide conflict.

10. The announcement has been delayed indefinitely. The national government has proposed to decide where the waste disposal sites will be based upon auction bidding by local governments. A local autonomy system is only now being introduced into the country and nuclear waste siting will place great pressure on these fledgling governments.

11. The decline in the relative share of nuclear power by 2011 is due an even more rapid building projected for coal-fired facilities.

12. Keepin and Kats' medium emission scenario is defined as follows: 75.4 percent of global primary energy consumption is supplied by fossil fuel, while the rest is supplied by nuclear as of 2025; 43 percent of the fossil contribution is coal; and CO_2 emissions reach 8.29 Gigaton/year by 2025. The high emission scenario is defined as follows: 80 percent of global primary energy is by fossil fuels of which coal is 55 percent among the fossil fuels; 3.2 percent of global primary energy consumption is supplied by nuclear power; and 10.3 Gigaton/year of CO_2 emissions are projected by 2025. (Keepin and Kats, 1988)

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TECHNOLOGY ADOPTION AND SUB-SAHARA AFRICAN AGRICULTURE: THE SUSTAINABLE DEVELOPMENT OPTION

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I. Introduction

The focus of this paper is on the institutional requirements for sustainable agricultural development in Sub-Saharan Africa (SSA). It examines SSA's situation from the perspective of both the recipient and the donor of aid, and identifies the institutional conditions under which Official Development Assistance (ODA)-- a major source of funding for agricultural development in SSA-- can become more effective in promoting sustainable development.

Agriculture represents the major employment sector in the region (as high as 75 to 80 percent in some countries). However, this high labor force contribution has not been translated into productivity for the sector. Also, bilateral and multilateral development agencies represent a major source of capital and technology for SSA development. **Table 1** summarizes ODA flows from developed countries to the Third World for selected years between 1983 and 1989. As the table indicates, SSA is the largest recipient of ODA in the world. This assistance constitutes a major sourc f capital investment in the region, higher on a percentage and per capita basis than any other Third World region. Yet, SSA has made only modest progress socio-economically, compared to other developing regions. In fact, "thirteen Sub-Saharan countries, accounting for a third of the region's population, are actually poorer in per capita terms today than they were at independence" (World Bank, 1989: 18) and the region is now more dependent on food aid than ever. This raises an issue as to whether conventional technology transfer schemes are adequate in meeting the development needs of the region.

Certainly, ODA could be an important source of support for redirecting SSA development. The issue is to identify the institutional conditions in which ODA can be an effective instrument for SSA to achieve sustainable development. Consequently, this study argues the following: that the present framework informing agricultural technology transfer to the region has been ineffective because **environmental sustainability**, **energy efficiency**, **agricultural self-reliance** (including domestic **food security**), and **social equity** have seldom been the central goals of programs.

Sustainability as used in this paper derives from the World Commission on Environment and Development's (WCED's) definition of sustainable development as "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs" (WCED, 1987: 9). Sustainability in agriculture refers to the "successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources" (FAO, 1989: xi). To respond to the several crises overtaking the region, the application of technological innovations that advance the aims of sustainability should be given high priority on the region's agricultural development agenda. The technology must not only be technically understood and economically affordable to small farmers, but must also be "feasible environmentally, socially, economically, and institutionally to maintain the technologies over the long term" (OTA, 1988: 16). Approached in this manner, technology adoption can indeed be a positive force in transforming SSA's agriculture and in promoting sustainable development in the region. International development agencies (IDAs) are seen as having a crucial role to play in that regard.

Table 1

OFFICIAL DEVELOPMENT ASSISTANCE (ODA) TO THIRD WORLD REGIONS
(Millions of Dollars)

	1983	1985	1987	1989	Per Capita
Sub-Saharan Africa	7,716	9,006	12,492	13,148	27.7
East Asia	3,428	3,577	5,548	6,357	4.1
South Asia	4,623	4,655	5,630	6,090	5.4
L. A. & Caribbean	2,818	3,328	4,146	3,697	8.8
TOTALS (Avg)	18,585	20,566	27,816	29,292	(11.5)

Note: Per Capita data are in units of dollars and for 1989 only
L. A. = Latin America
Source: World Bank, World Development Report 1991 (p. 243).

Overview of SSA's Development Crisis

Sub-Saharan Africa, arguably the most agrarian and agriculturally-dependent region in the world is unable to feed its people. During the past 30 years, total agricultural production in SSA has risen by only about 2 percent a year while agricultural exports have declined and food imports have risen at approximately 7 percent annually (World Bank, 1989: 89). In 1965, agriculture's contribution to Gross Domestic Product (GDP) in SSA was 41 percent. By 1989, the figure had fallen to 32 percent. Also, per capita grain production (a good measure of food production) which peaked at 180 kilograms in 1967 fell by more than 33 percent to 120 kilograms in 1984 (Brown & Wolf, 1985: 8). Between 1980 and 1989, the region experienced an unprecedented population increase, growing at a phenomenal rate of 3.2 percent annually against an agricultural production growth rate of 2 percent. Against this background, SSA finds itself having to rely more on food importation and food aid to bridge the gap between domestic supply and demand. Between 1974 and 1989, the food aid component of its total food imports nearly tripled from 0.9 million metric tons of grain to 2.6 million metric tons (World Bank, 1991: 211).

However, the crisis in SSA goes beyond weak agricultural performance or food dependency. It is multidimensional. The region is experiencing a plethora of environmental problems ranging from soil erosion in Burundi, Ethiopia, Kenya and Uganda, to deforestation in the Ivory Coast, Nigeria and Zaire, to desert encroachment and drought in the Sahel. Additional dimensions of the crisis include declining industrial output, poor export performance, rising external indebtedness, declining per capita income, deteriorating social indicators (including the lowest per capita caloric intake and life expectancy at birth, the highest infant mortality rate of any Third World region-- see **Table 2**), and deteriorating infrastructure and institutions (World Bank, 1989: 2).

Several factors have been cited to explain this negative trend. Some are internal, others external. These include a high population growth rate, biological and physical constraints, unsupportive macroeconomic policies, infrastructural and institutional weakness, political instability, unequal terms of trade, backward technology, and inappropriate development strategies (Lele, 1981; Eicher, 1982; Adedeji and Shaw, Ghai and Smith, 1987; U.S Congress Office of Technology Assessment (OTA), 1988; World Bank, 1989; Economic Commission for Africa, 1991). Regardless of whether the sources of the crisis are internal, external or a mix of both, there is increasing recognition that the solution to SSA's food/agricultural crisis in particular and its development crisis in general, lies in the creation of institutions for sustainable development (WCED, 1987).

Table 2

SELECTED SOCIO-ECONOMIC INDICATORS FOR SUB-SAHARAN AFRICA AND OTHER THIRD WORLD REGIONS (1989)

	Population mid-1989 (1 Mil)	Per Capita GNP (1989) (US$)	Total External Debt as percent of GNP	Per Capita Energy Consumption (KOE)	Avg. Index of Per Capita Food Production* (1987-89)	Per Capita Caloric intake	Life Expectancy at Birth (yrs)	Infant Mortality per 1000 Live Births	Average Annual Growth Rate (%) (1980-89)	
									Population	Per Capita GNP
SSA	480.4	340	96.9	73	95	2011	51	107	3.2	-1.2
E. Asia	1552.2	540	23.7	487	123	2596	68	35	1.6	6.3
S. Asia	1130.8	320	29.6	197	112	2116	58	95	2.3	2.9
LA & C	421.2	1950	45.8	1010	105	2724	67	50	2.1	-0.5

Notes:
(1) LA & C= Latin America and Caribbean
(2) KOE= Kilograms of Oil Equivalent
(3) * (1979-81 = 100)

Source: World Bank, World Development Report 1991 (pp. 181-182, 205-259)

II. SSA's Development Strategy since 1960: The Conventional Growth Model

During the colonial era, paths of economic development were imposed on SSA which were extraordinarily resource-intensive and which so disrupted the existing agricultural economy as to bring a region heretofore able to feed its people into a persistent state of hunger. After independence, the majority of member countries adopted a conventional growth orientation that mimicked development in the industrialized West (**Table 3**). While some effort was made to reverse the entrenched inequalities and poverty created under colonialism, post-independence development resembled its antecedent in its environmental impacts and neglect of modes of agriculture that would meet domestic food needs.

In its most rudimentary form, the adopted growth model is resource-intensive, consumption-driven and commodity-oriented. Because of its resource-intensiveness, the environment is treated as an infinite source of raw materials that can be continuously exploited for economic purposes to meet the increasing demands of an expanding population and at the same time generate revenues for the government. Environmental impact assessments, resource planning and management are external to development planning under this development regime. Wealth accumulation is emphasized through profit maximization, with social and environmental considerations assigned secondary status.

Technology choice in most sectors, and especially in the energy sector, is urban-industrial driven, emphasizing large-scale, capital intensiveness and, for the most part, is fossil fuel-based. Similarly, agricultural technology is energy- and capital-intensive and is intended for use primarily on large commercial-type farms (plantations) that are dedicated to the production of cash crops such as cotton, rubber, cocoa, coffee, and groundnut (peanuts). The pursuit of this multiple set of goals in the economic, energy, agriculture, technology and environment areas can explain why Sub-Saharan Africa is in its present predicament of unsustainable development. The conditions of economic stagnation, environmental degradation, debt crisis, and food dependency, among others can be linked to the region's commitment to an industrial model of development and technology adoption. This commitment also explains the highly skewed patterns of growth, resource, and income distribution between the rural-agricultural and the urban-industrial sectors. The resulting social and political tensions created in the process make promoting development a difficult enterprise.

Equally important, because of its technical/economic bias, the conventional growth model has ignored the social costs of resource use including pollution and externalities arising from production and consumption activities. Under current national income accounting procedures, resource depletion and environmental degradation are unaccounted for, and as such are treated as incomes or assets, rather than as losses or net depreciation in national wealth (El Serafy & Lutz, 1989: 23-38). For example, a nation experiencing an unprecedented increase in its agricultural outputs will, under this accounting system-- United Nations System of National Accounts (SNA)-- add the production gains to its GDP, regardless of whether the increase was due to the adoption of unsustainable farming practices such as overuse of chemical fertilizers and cultivation of marginally unproductive lands. In the end, as more lands are retired from farming due to further degradation, the nation loses part of its stock of natural assets and, in the process, its capacity for sustainable and productive farming. In this sense, a distorted idea of national wealth is promoted under the conventional growth model and nations are lulled into a false understanding of what constitutes prosperity.

TABLE 3

CONVENTIONAL GROWTH MODEL

ECONOMY

- Goal is short-term profit maximization
- Commodity-oriented
- Consumption-driven
- Resource-intensive and governed by economic priorities
- Resources are seen as "factors of production"
- Investment strategy skewed heavily toward the urban/industrial sector

AGRICULTURE

- Technical-economic considerations
- Emphasis on producing one or two cash crops for export
- Energy- and input-intensive
- Capital-intensive technology
- Factors of production owned by a small number of privileged class (elites)
- Fosters food dependency

ENERGY

- Fossil fuel-based
- Goal is to secure abundant, low cost supply
- Reduces vulnerability by having more than one supplier
- Energy-technology focused
- Efficiency in economic production: scale economies and technical efficiency

ENVIRONMENT

- Ecological assumption is that humans dominate the environment
- Environment is seen as an infinite source of commodities
- Environmental impacts external to economic choices
- Use-strategy is intensive and governed by economic profitability

TECHNOLOGY

- Large-scale
- Central/international system
- Technology choice driven primarily by urban/industrial infrastructure needs
- Technical decisions governed by production/economic costs
- Limited Technology options

Source: Center for Energy and Urban Policy Research, University of Delaware (1991).

SSA's Agricultural Development Model

The current framework for promoting agricultural development in Sub-Saharan Africa and more specifically for transferring agricultural technology to the region has followed exactly this conventional development orientation and, to that extent, is far from being sustainable. It is an export-based, capital-intensive strategy in which preference is given to cash crop production and emphasis placed on building large-scale infrastructure in support of agriculture. Christopher Gerrard succinctly points out this problem:

> The major Western donors concentrated their development assistance on physical infrastructure like roads, railways, dams, and electrification. They viewed the role of government (and donors) as providing physical infrastructure to support private investment in directly productive activities. They preferred to finance specific projects like infrastructure with a definite beginning and ending rather than open-ended programs. They prefer monumental investments that had low administrative costs to themselves relative to the quantities of capital transferred, and that appealed to politicians in the recipient countries. Between 1948 and 1963, the World Bank allocated almost three-quarters of its lending to LDCs to infrastructure (Gerrard, 1987: 3).

This mode of agricultural development draws its primary intellectual inspiration from the works of modern development economists such as W.W. Rostow (stages of growth) and Arthur W. Lewis (dual sector model). The theoretical orientation represented by these writers was also influential in shaping the agricultural development strategy of IDAs. Technical and institutional change in agriculture is defined in the conventional growth model as exogenous to the economic system, that is, as a product of autonomous advances in scientific and technical advances (Hayami & Ruttan, 1985: 84). Yet it is now recognized that agricultural technology is "highly location-specific and that techniques developed in advanced countries are not in most cases, directly transferrable to less developed countries with different climates and different resource endowments" (Hayami & Ruttan, 1985: 59). Nonetheless, local adaptability and environmental sustainability have seldom been a major concern of IDAs in their promotion of Western agricultural techniques and technologies in LDCs.

The failure of IDAs to consider social and environmental factors in agricultural technology transfer is evident in the manner in which transfer programs were organized and administered. Ruttan has identified three agricultural technology transfer models utilized by IDAs and donor countries: the **counterpart** (expert-adviser) **model**, the **university contract model**, and the **international research and training institute model** (Ruttan, 1978). Under the counterpart model of technology transfer, an IDA retained experts on specific agricultural issues as consultants to work on agricultural projects that were being funded and/or implemented by the agency in a developing country. The expert or consultant functioned in an advisory capacity relative to his or her counterpart in the developing country. Because of the limited applicability of agricultural knowledge in temperate to tropical regions, this model of technology transfer eventually was found to be inappropriate for solving the agricultural problems of Third World countries. Nevertheless, the counterpart model still enjoys wide patronage from bilateral and multilateral donors. The university contract model, fashioned after the United States land-grant model of agricultural development, emerged in the mid-1960s. This model emphasized the establishment of a collaborative relationship between a university in a developed country and a university in a developing country (e.g., the Michigan State University-University of Nigeria partnership). As Ruttan points out, this model was frequently utilized where training and institution-building at the local level were prime objectives of technical assistance activity. Although the university model produced a large number of trained agricultural scientists at the post-graduate level in most Third World countries, it failed to generate significant new knowledge or technologies that were appropriate to the conditions and circumstances of many Third World countries.

In response to this challenge, a third model, the international research institute (IRI), emerged in the late 1960s and early 1970s to organize scientific knowledge to bring about technological innovation in Third World agriculture. In SSA, the IRIs established include the International Institute for Tropical Agriculture in Ibadan, Nigeria in 1967; the International Laboratory for Research on Animal Diseases (ILRAD) in Nairobi, Kenya in 1973; the International Center for Insect Physiology and Ecology (ICIPE), also in Nairobi, Kenya; the International Livestock Center for Africa (ILCA) in Addis Ababa, Ethiopia in 1974; and a major ICRISAT regional research center in Niamey, Niger in 1981.

The establishment of these research facilities in SSA drew heavily from the experience of Asia and Latin America under the Green Revolution in which the International Center for the Improvement of Maize and Wheat (CIMMYT) in El Batan, Mexico and its predecessor (the Rockefeller-Ford Foundation alliance) gave Mexico and the rest of the world the Mexican dwarf variety that is capable of doubling its yield given the right amount of inputs and management. Similarly, the International Rice Research Institute (IRRI) in Los Banos, Philippines, was a major player in helping the Asian countries of India and Pakistan to become almost self sufficient in rice production. However, when the Green Revolution eventually reached the African sub-continent in the mid-1960s, the outcome was markedly different from the outcomes in Asia and Latin America. Today, the region is far from attaining the same level of self sufficiency in food production that Mexico, India, and Pakistan attained in the 1960s and 1970s. Given the same model of technology transfer, why was the outcome in SSA different from the outcomes in Asia and Latin America?

In SSA, institutional linkages between the developers and users of agricultural technologies have either been missing or underdeveloped, resulting in a non-transfer of technology. The United States Congress Office of Technology Assessment assesses the linkage problem thus:

> Extension systems in African countries..... generally lack staff, supplies, and technical support, and inadequate communication exists between researchers, extensionists, and farmers. They also suffer from a lack of appropriate and profitable technologies to transfer....Another problem with most extension services is that they focus on providing information and inputs for export crops rather than food crops. In addition, the approaches used are generally "top-down", with the information flow in one direction-- from the researcher through the extension agent to the male farmer. Women, the major food producers in many regions, often are not provided with relevant services (OTA, 1988: 68).

Other observers have analyzed this problem in terms of the insensitivity of researchers to the unique Sub-Saharan environment. Unlike Asia and Latin America, the sub-continent's harsh climate, distinct pest species, and crop and livestock diseases pose a major obstacle to research and successful transfer of technologies generated elsewhere. Paul Harrison observes that:

> The way research was organized worked against success... conditions on the research stations where new varieties were bred were far removed from the realities of the African peasant. Stations were sited on good soils, with easy access to water even in the dry season. Their new varieties were usually selected and tested with fertilizer levels that the farmers could not afford, and with high standards of ploughing, thinning and weeding that overworked peasants, mostly women, could not manage. Lo and behold, when new varieties and methods came to be tested under farmers' conditions, the results were 40 to 60 percent worse than had been achieved on station (Harrison, 1987: 100).

He asserts further: "[R]esearchers have largely failed to halt the fatal progression-- and in many ways have intensified it. This has come about partly by neglect, partly by exploitation, and partly by misguided attempts to introduce Western approaches that were unsuited to Africa's very different conditions" (Harrison, 1987: 27). Thus, it is not difficult to conceptualize why the Green Revolution and other conventional models of agricultural technology transfer succeeded elsewhere but failed in SSA. What then must be done to reverse this adverse trend? There is increasing recognition in the development community that regardless of what the sources of the problem are, the solution to SSA's development crisis lies in the creation of institutions of sustainable development (WCED, 1987).

III. Toward a New Framework for Promoting Sustainable Agricultural Development and Technology Adoption in SSA

A sustainable development framework is needed for SSA which seeks to achieve four basic objectives: **agricultural self-reliance** (including **domestic food security**); **environmental sustainability**; **energy efficiency** in production; and greater **equity** in the distribution of national resources between the urban/industrial and rural/agricultural sectors. Both national and international policy reforms will be crucial for realizing these objectives.

At the national level, the thrust of government policy "must be to redress disadvantages imposed by past development strategies" (Alexandratos, 1988: 16) by creating a supportive environment in which domestic agriculture could function successfully alongside industry. As a first step, **investments in human capital** in agriculture should receive high priority in the national development agenda. The lack of indigenous skills in much of Sub-Saharan Africa has been a major constraint on agricultural development as well as development assistance effectiveness (OTA, 1988: 102). As a result, the tendency has been to rely on foreign experts whose knowledge about the continent's unique environment and conditions are derived primarily from stereotypes and second-hand information rather than from first-hand knowledge. To correct this problem, new institutions will need to be created that are capable of training new agricultural scientists, economists, extension agents, technicians and engineers, anthropologists, nutritionists and policy analysts who are capable of generating and disseminating knowledge and information to farmers about country-specific, agroecological, socio-economic, and cultural conditions, and also capable of identifying constraints to technology diffusion. An integrated and multi-disciplinary approach to curricular reforms in the educational system is needed that emphasizes the linkage between agriculture, the environment and the rest of the economy. The aim of research and extension work in SSA must be to devise a most effective way of communicating scientific principles and practices to farmers. Without this, "tasks which seem simple to the extension officer who has mastered them may appear to be very difficult, and perhaps not worth attempting, to illiterate farmers who have not had the opportunity of understanding them thoroughly" (La-Anyane, 1985: 55).

By the same token, the transfer of knowledge and ideas should not be seen as a uni-directional process, from researchers to peasant farmers. Peasant farmers, although lacking in scientific principles and practices, possess a vast knowledge of local conditions. By incorporating these farmers early into the development process, planners and policy makers in SSA can avail themselves of the invaluable ideas and different perspectives which these farmers can bring. "What is often forgotten by development experts is that much of the agricultural innovation in the West, particularly during the so-called agricultural revolution of the eighteenth century, came from the farmers themselves" (Conway and Babier, 1990: 130). In its first review of the sustainability of its agricultural projects worldwide, the World Bank argued that a key factor for success was some prior familiarity in the project area with elements of the technology to be employed and a history of farmer involvement. The 1985 report stated further that "there were no instances among the agricultural projects which sustained their benefits where a proposed technology was completely rejected, in part probably because none of them attempted to transfer entirely new technologies" (World Bank, 1985: 16). The implications for SSA and other Third World regions are two-fold: that some of the ingredients (ideas and know-how) needed to transform domestic agriculture into a productive and sustainable sector are, to some extent, already available locally; and that technological innovations in agriculture must come gradually-- "if the changes are fast and the innovations differ significantly from previous technologies, then the customs and traditions of local resource management may become outmoded, leading to resource problems" (World Bank, 1983: 3). In this regard, a good starting point for reform might be the adoption of a **bottom-up** or **participatory approach to decision-making** in which farmers' inputs are actively sought in the development process. Also, the trend towards sensitizing non-indigenous policy actors to local customs and values through cultural sensitivity training should receive further reinforcement.

The provision of trained scientists, policy analysts, literate farmers and the involvement of farmers in the development process will not by itself generate a sustainable, indigenous technological capacity or assure sustainable agricultural development in SSA. National governments need to place greater emphasis on **creating an enabling environment** (World Bank, 1989) that fosters institutions which allow agriculture to function unimpairedly. At the heart of this policy reform is the need to sensitize public officials to environmental issues and promoting greater environmental awareness among the public, particularly among resource-poor farmers. This will require devising new and innovative environmental training programs for policy makers, researchers, extension agents, and farmers regarding resource management, energy efficiency and environmentally-sound farming practices. The long-standing project-by-project approach to development planning needs to be replaced by a more forward-looking and integrated approach which looks beyond individual projects to the broader issues of development. In particular, there needs to be an explicit recognition of the intersectoral links and intergenerational implications of different agricultural development strategies.

Project environmental impact assessments (EIAs) should be conducted within a more comprehensive, national environmental action plan-- EAP (World Bank, 1989: 45); resource depletion and environmental degradation should be accounted for in national income accounting (El Serafy & Lutz, 1989); neither environmental degradation nor resource use should be planned to exceed the assimilative and regenerative capacities of the natural resource base (Daly, 1990); and a mix of economic incentives and disincentives should be adopted that protect the environment and encourage resource conservation while fostering agricultural development. Without these changes in the institutional content of SSA development, food security will continue to be neglected as a significant development objective and a self-reinforcing cycle of environmental degradation will be maintained as disenchanted peasant farmers and national governments saddled with huge external debt payments look to a rapidly deteriorating environment for sustenance and revenues.

Beyond these national policy reforms, international development strategies must undergo changes so that indigenous technological capacity and sustainability in agriculture are emphasized. IDAs being a major supplier of agricultural capital to the region, technology choice is significantly influenced by them. SSA's emphasis on cash crops since independence, for example, is significantly a result of the policies and programs of IDAs providing ODA. Similarly, technology choice in the energy sector is influenced by donor programs and policies, where emphasis is placed on large-scale, capital-intensive projects such as irrigation and hydro-power which provide market opportunities for the industrial goods of donor countries (Lubeck, 1987: 176). How ODA influences technology choice can also be seen in the promotion of fossil fuel-based technologies by the providers of ODA in Third World countries. For SSA, the adoption of fossil fuel-based agricultural technologies can be bad for the region economically and environmentally. First, the majority of member countries rely on external markets for their commercial energy needs, particularly oil, and any shortages on the international market will almost certainly have a negative impact on the balance of payments of these countries. Second, the cost of high-yield, energy-intensive farming and the prices of food are tied to the prices of fossil fuels. This suggests that as the prices of fossil fuels rise, so too will the costs of fossil fuel-based agricultural production system and subsequently, the prices of food. Thus, the region becomes dependent on an external food market largely controlled by the demands of a few wealthy industrial nations. Third, the experience of industrialized countries has shown that energy-intensive, fossil fuel-based agriculture is limited in its economic potential (Pirages, 1989: 95). As more energy is applied to the land, a point is eventually reached where further application becomes economically inefficient because the increase in yield begins to slow or decline (Brown, 1990). For example, in the United States, it took 1 calorie of fossil fuel to produce 3.7 calories of food in 1945. In 1970, the same amount of fossil fuel yielded only 2.8 calories of food. Worldwide, 0.44 barrels of oil was required to produce 1 ton of grain in 1950, but in 1985, it required approximately 1.14 barrels to produce the same quantity of grain (Pirages, 1989: 98-99).

But more important than these economic implications of a fossil fuel-based agricultural production system are the environmental effects. Experience has shown that the use of chemical inputs such as fertilizers can cause soil contamination, a reduction in soil fertility, and can pose a significant pollution threat to both underground and surface water supply systems (Alexandratos, 1988: 254). Pesticides such as DDT with all their associated health risks have been banned in many industrialized countries, but are still being widely used in many developing countries. Dams and large irrigation schemes can lead to sedimentation and siltation of rivers and lakes, causing the sea level to rise. They can also cause flooding problems for downstream settlements and drying up of agriculturally productive flood plains and wetlands (Brown, et al. 1976; Stout, 1979; Fletcher, 1989).

One way IDAs and donor countries can help foster sustainable agricultural technologies in SSA is by making sustainable development a central goal of their lending activities and technical assistance programs. Projects that explicitly call for environmental protection and energy efficiency should be given the highest priority in loan approval. The initiatives by some non-governmental organizations (NGOs) under the "debt-for-nature" swap (World Bank, 1988 & 1990) also represent an innovative way of promoting greater environmental awareness and resource transfer to developing countries. IDAs and lenders can essentially act as facilitators or catalysts in this process, by working closely with the NGOs.

Equally important, the providers of aid can also help promote sustainable agricultural development in SSA by assisting member countries in **building an environmental management capacity.** This will require the establishment of institutions that are capable of monitoring environmental trends, collecting, analyzing, collating, and interpreting environmental data in relation to agricultural development as a basis for effective and timely decision-making by policy makers. Building such a capacity to conduct environmental audits is an essential requisite for promoting sustainable agricultural development.

The focus of aid and the criteria used by some donors in its allocation have not always been equitable or development-oriented. Rondinelli has observed that 62 percent of the $4.2 billion dollars earmarked by the U.S. for development and economic support in 1984 went to nine countries (all are political and military allies of the United States). Among these, four countries (Egypt, Israel, Pakistan and El Salvador) alone received nearly 50 percent (Rondinelli, 1987: 78). He suggests further that "the United States Agency for International Development is politically obliged to show how foreign assistance benefits the U.S. economy. Thus about 70 percent of U.S. development assistance and economic support funds is now spent in the United States on purchases of U.S. goods and services" (Rondinelli, 1988: 151). This tendency to link foreign aid, especially assistance provided under bilateral arrangements, with the foreign policy objectives of donor countries (economic, military, or political), has been a major impediment for developing countries wishing to remain neutral in international politics and to initiate policies that promote self-reliance and meet their own development objectives. In the current context, the acceptance of aid often means that recipient countries increasingly shape their policies and development plans according to aid criteria favoring donor country goals. In place of this system, an international development strategy is needed which enables developing countries to critically assess the social, economic and environmental implications of development options. Aid originating from bilateral sources should be delinked from narrow economic, political, and military motivations of donor countries and replaced with a more equitable and need-oriented allocation formula.

Finally, IDAs and donor countries can help promote food security as a development objective in SSA by redefining the role that **food aid** ought to play in national development. The tendency by donors to treat food aid as "surplus disposal" rather than as a development tool has had a counter-productive effect on many SSA countries. The lack of effective administration of food aid to avoid starvation or malnutrition among the most vulnerable groups (women, children and the poor), and the absence of an efficient internal transport and distribution system together have diminished the value of food aid in development (Singer, 1990). Similarly, the dumping of surplus grain by donor countries either on the world commodity market or in food-deficit countries as food aid has resulted in a depressed world grain market and in lower domestic food prices in recipient countries. This threatens the ability of peasant farmers to sustain themselves economically through food production.

Instead, they are forced to confine their production efforts to meeting immediate consumption needs. Too often, food aid has also been used by elites in recipient countries as an effective political tool to consolidate their position and hold on to power by keeping food prices low for urban consumers. Except for humanitarian purposes, food aid programs should be subjected to the same evaluation criteria to which financial and technical assistance programs are subjected (Gerrard, 1987). In this manner, food aid can become a catalyst for promoting domestic policy reforms in the agricultural sectors of member countries.

In sum, food aid policies need to be fundamentally refocused to promote the goals of sustainable development including:

- Domestic policy reforms that give priority to the support of peasant farmers as food producers (**self-reliance, food security, and equity goals**);
- Lower energy requirements in agriculture (**energy efficiency goal**); and
- Resource uses that are within the assimilative and regenerative capacities of the environment (**environmental sustainability goal**).

IV. Summary and Conclusions

In **Table 4**, I summarize the key concepts of a sustainable development framework as they relate to SSA agriculture. This framework emphasizes the institutional conditions that must be met in order to move away from the present unsustainable, conventional growth orientation. The emphasis is on policy reforms and institutional changes at the national and international levels. In each case, the objective is to remove the institutional barriers which hitherto have stood in the way of promoting sustainable agricultural development and food security. An integral part of this objective is the enhancement of the capacity of resource-poor farmers, including women, to engage in productive, energy-efficient and sustainable agriculture by emphasizing their needs as opposed to focusing exclusively on the needs of large estate holders and the urban-industrial sector. But more important, the sustainable agriculture framework seeks to reconcile economic growth with ecological considerations by recognizing the finiteness of the earth's non-renewable natural resources and the limited capacity of the renewable resource base to renew or regenerate itself. Economic growth strategies which tend to adopt a commodity-oriented view of the environment are always in conflict with these considerations.

These institutional reforms can offer hope for developing countries wishing to promote agricultural development on a sustainable basis. However, the guidelines should not be construed as a panacea for all the agricultural/food problems of SSA. They are basically a means for achieving a greater end-- a mode of development that establishes food security, promotes economic and technological self-reliance, and social equity while adhering to the principles of environmental balance. Each member country will need to examine its own peculiar conditions and circumstances, define its development objectives, and modify such guidelines to address country-specific problems.

In the final analysis, sustainable development requires finding common ground between economic growth, social equity, and environmental preservation in SSA. Too often, countries have settled for solutions that are attractive economically or technically but not socially and environmentally. A major test of national and international development institutions in the coming years will be the scope they permit for pursuing better integrated responses to rising environment-equity-economic conflicts.

TABLE 4

AGRICULTURAL INSTITUTION MODELS

CONVENTIONAL INSTITUTION MODEL	SUSTAINABLE INSTITUTION MODEL
SYSTEM GOALS	
■ Sector growth or value defined mainly in terms of contributions to GNP or GDP	■ Growth defined in terms of sustainability as well as contributions to GNP or GDP
■ Seen as a prelude to industrialization	■ Goes hand-in-hand with industrialization
■ Export-oriented production system	■ Food security-oriented production system
■ Urban-industrial biased	■ Balanced urban-rural incentive
■ Resource use is intensive and often exceeds the assimilative and regenerative capacities of the environment	■ Resource use is in harmony with the assimilative and regenerative capacities of the environment
INSTITUTIONAL GOALS	
National Policy	
■ Consumer-oriented incentive policy	■ Producer-oriented incentive policy
■ Focus on the interests of commercial farmers or large estate holders	■ Focus on small holders' interests
■ Promotes external dependency	■ Promotes individual and collective self-reliance
■ Centralized, bureaucratic centers of control	■ Decentralized, participatory centers of control
■ Preservation of existing property rights	■ Property rights reform
Technology System	
■ Complex, large-scale, capital-intensive technology	■ Simple, affordable, small- to moderate-scale technology appropriate to small producers' needs
■ Limited technology options	■ Wide variety of technologies to choose from
■ Urban/industrial and commercial-driven technology choice	■ Intelligent and selective technology choice based on end users' needs
■ Engineering based on production/economic costs	■ Engineering based on social/environmental costs

Table 4 cont'd

Technology Transfer/International Aid	
■ Emphasis on maximizing exports of donor country	■ Emphasis on helping recipient country build local technological capacity (self-reliance)
■ Transfer of proven or obsolete technologies of developed countries	■ Development of technology suitable to local needs and conditions, or transfer of proven technologies from elsewhere in the region
■ Priority given to cash crop production	■ Priority given to food crop production
■ Projects and technologies selected on the basis of economic profitability and technical efficiency	■ Selection made on the basis of social/environmental sustainability in addition to technical/economic considerations
Education, Research and Training	
■ Emphasis on cash crop research	■ Emphasis on food crop research
■ One solution fits all approach (e.g., Green Revolution)	■ Recognizes that conditions and circumstances vary from country to country and within country
■ Farmers seen as external to the research process	■ Farmers seen as an integral part of the research process (two-way communication essential)
■ Emphasis on importing expensive research personnel from abroad	■ Emphasis on building indigenous research capacity
■ Research and related activities (e.g., extension services) are seen as separate and therefore uncoordinated	■ Research is seen as inseparable from extension services and other related activities
Landholding Arrangements	
■ Lack of ownership or short-term tenure	■ Ownership or long-term tenure
■ Emphasis on large tracts of land	■ Emphasis on small- to moderate size plots
■ Emphasizes only economic and technical costs of land use (e.g., production maximization)	■ Social and environmental costs of land use are emphasized (e g. deforestation and desertification)

Source: Center for Energy and Urban Policy Research, University of Delaware (1991). Adapted from Table ES-1 (Energy Institution Models).

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ENVIRONMENTAL COMMODIFICATION AND THE INDUSTRIALIZATION OF NATIVE AMERICAN LANDS

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INTRODUCTION

The understanding of nature and society as autonomous structures is a distinctive idea of industrialization. It represents a paradigm shift that has utterly altered social relations and, as we are now learning, natural order as well. One writer has summarized the shift in the following manner: "the idea of nature as animate and living, where species seek to realize their own natural ends, has been replaced by the idea of a cold and mechanical nature . . . The modern mind has come to view nature as nothing more than matter-in-motion, whether planets, projectiles, or even animals" (Oelschlaeger, 1991: 77). In this construction, society is portrayed as standing outside of, rather than within, nature with its values reduced to the material resources exploitable for commodity production by the techniques of modern society.

The indigenous cultures of North America offer a point of departure for an analysis of the contradictions inherent in the industrial conception of social and ecological relations. A common view promulgated by European cultures is that Native peoples wandered "perpetually in scattered bands, grubbing out marginal subsistence from hunting and gathering without developing serious appreciation of art, science, mathematics, governance, and so on" (Churchill, 1986: 15). In this view, it was the obligation of European culture to civilize the Indians and their relation to the land. This racial stereotype set in motion European efforts, to, on the one hand, force Indian assimilation of non-Indian culture; and, on the other, to educate Native American communities in the principles and practices of self-determination. The various policies of removal and relocation to reservations, allotment, and reorganization and self-government are taken to represent variations on one or the other theme.

While this interpretation of Indian/non-Indian conflicts accurately underscores the racism characterizing the relationship, it fails to examine the influence of industrialization and its attendant ideology of commodification in shaping the nature and direction of European exploitation of Native American communities. Our analysis seeks to demonstrate that needs and requirements of a machine culture and a surplus based political economy during particular stages of its maturation were highly influential. Far from vacillating between concepts of self-determination and assimilation the policies of the last two hundred years represent, by our analysis, a consistent, and continuing, attempt by an evolving technological civilization to continue the logic of its expansion. It is our conclusion that the exploitation of Native Americans and their lands over the last two hundred years is an expected and necessary outcome of American industrial strategy.

THREE PHASES OF COMMODIFICATION

Two hundred years of industrialization in the U.S. have rendered social and ecological relations largely commodity-based. Human existence transpires within a reality of production and consumption of commodities which together release into the air and water and deposit on plants and the soil pollutants more numerous than we probably know and, certainly, more complex in their effects than we understand. This reality is structured and motivated by the logics of technology and capital. We depend for our lives and our experience of life upon the capacity to produce goods and services, as though nature was incidental to the human drama. In the technological milieu, natural experience has all but evaporated except as an emotional longing for a simpler, Arcadian time or as the context for modern recreational enjoyment.

This history has institutionalized a development orientation in which the physical environment is valued either for its raw materials or for its ability to absorb industrial wastes. Value derives from the "efficiencies" gained for commodity production and use through the transformation of the free gifts of nature into items of market exchange. The institutionalization of this development orientation is referred to here as a process of *commodification* (see Byrne, Hoffman and Martinez, 1991, for an elaboration of this concept). This process is neither socially nor ecologically neutral, instead producing environmental degradation and social inequality as functional elements of the technological order.

Three phases of commodification are identified in this paper: an era of *carboniferous capitalism* which traces its beginnings to the spread of what Lewis Mumford has called the "machine culture"; a second era of *technological authoritarianism*; and a third phase, *Big Science*, the character of which is only now becoming apparent. These phases are not intended to be interpreted as historically discreet eras. Rather, they represent overlapping periods defined by transitions in the resource and technological pollution regimes that govern social and ecological relations.

The combustive power of carbon-based fuels, harnessed by a rapidly expanding industrial system of production, set in motion the first era of commodification. The full realization of this era's transformative power was expressed in its facility for exploitation of human and natural resources. To maximize this facility, it was necessary to permanently alter the relationship of human beings to their natural economy. Where before social development depended upon observing and accommodating nature's conditions of productivity, the era of *carboniferous capitalism* secured progress through appropriation of nature's materials. In the case of Native American peoples, this meant their dispossession from the land of their ancestors. Those forms of nature which stood in the way of industrial expansion, but sustained Native American communities, including "wild" nature, were necessarily sacrificed for industrial success. The long history of broken treaties, forced removals, and termination and other policies on the one hand, and appropriation of Indian lands for minerals and energy resources on the other, is argued to have been impelled by the logic of *carboniferous capitalism*.

A second phase of the commodification process can be demarcated by a shift in the source of environmental degradation from the relatively unsophisticated practice of resource extraction to elaborate technological threats associated with advanced industrial production. One indication of this shift is environmental damage that is no longer localized or restricted to particular geographic areas. Instead, whole regions are contaminated as natural spaces are displaced by a unique sort of "technological space" created by the wastes associated with modern industrial processes. Such spaces and the technological systems that created the need for them assume that highly dangerous wastes will accompany "normal" operations and will require technological vigilance to keep them from harm's way.

The authoritarian character of modern technological society is powerfully expressed in the dictated social structure and operation of nuclear energy systems. The commercialization of this technology has required an extraordinary level of military involvement in the U.S. energy system and the establishment of social institutions that can garrison the technology and its wastes from general social oversight and criticism (Byrne and Hoffman, 1988). While many groups in society have been deeply affected by the commercialization of nuclear energy, Native American communities have borne the worst risks and realities. As will be shown below, many of these communities have suffered a second wave of colonialism with the arrival and spread of this technology.

While the consequences of technological authoritarianism have been severe, there is significant evidence that an even more far-reaching phase of commodification is underway. In this latest phase, the impacts of technological civilization are no longer constrained to particular regions. Instead, nature's structures and processes are affected. Phenomena such as global climate change and the thinning of stratospheric ozone signal a new era of commodity relations and the extension of cost-bearing to many populations around the globe who, to this point, have contributed little or nothing to the problem. In this respect, the exploitation of Native American communities and their lands serves to illustrate the impacts of commodification which will likely spread as the globalizing of environmental degradation ensues.

CARBONIFEROUS CAPITALISM

In his analysis of industrial development, Lewis Mumford argued that modern society has lost all semblance of balance with the natural order while reducing the focus of life to the mere production of things. According to Mumford, a machine culture rooted in European tradition and transplanted to the "New World" became the foundation for a uniquely modern world view. Mechanization, capitalism and a carbon power base combined to form a pattern of developmental relations which equated improvement of the human condition with the expanding production and consumption of goods (Mumford, 1934:105):

> Happiness was the true end of man, and it consisted in achieving the greatest good for the greatest number . . . The quantity of happiness, and ultimately the perfection of human institutions, could be reckoned roughly by the amount of goods a society was capable of producing: expanding wants: expanding markets: or expanding body of consumers. The machine made this possible and guaranteed its success. To cry enough or to call a limit was treason. Happiness and expanding production were one.

In the transformation of the "good life into the **goods** life," both human institutions and the natural environment were reorganized in accordance with the pervasive principle of quantification and the goals of material production. The new social order was indeed able to produce goods at an unsurpassed rate, but this surplus production exacted a price for its result: a pattern of unequal development accompanied by widespread environmental degradation. In the new social order, society and nature were simultaneously drawn into a commodification process in which the ultimate end in all aspects of life was to produce, produce, produce. In this first phase of commodification. the environment offered a seemingly endless supply of natural resources for growth: land, timber, minerals, metals and a variety of energy sources all valued for their ability to increase industrial production. As the machine culture spread, the world was divided in two parts, machine areas and non-machine areas, areas of production and areas of supply. "Advanced" societies were those which organized in compliance with the quantification principle, exploiting nature's endowments and transforming them into industrial products. But this political economy depended upon the expansion and reproduction of unequal development, such that no place or culture was immune to its central imperative: exploitation.

The first phase of industrial commodification was dominated by the products and operations of the mine. The establishment of territorial colonialism over Native Americans was an essential step in preparing the way for mining the natural resources of the U.S. Initially, the U.S. government sought to resolve conflicts through formal treaties with tribes. The aim was to secure greater parcels of land and resources in exchange for both money and social services (education, health, welfare, etc.) The land left in Indian hands as part of the treaty agreements were designated as tribal reservations to be held in trusteeship by the federal government. The establishment of reservations served dual purposes during this period. On the one hand, Indian tribes were effectively removed from the possibility of controlling any of the land's vast resources. At the same time, reservations provided the means for managing and educating Indians in the habits of technological society. As Takaki notes, a central feature of Indian policy during this period was the establishment of reservations as an institution to enforce assimilation: "(Indians) would be *required* to learn and practice the arts of industry until at least one generation had been placed on a course of *self-improvement*" (1979: 187).

The needs of industrial society soon outgrew this form of Indian/non-Indian relations. Population and economic growth in the 19th century occurred on an unprecedented scale, creating an insatiable demand for exploitable resources. Complementary trends such as the burgeoning settlements in eastern urban areas expansion of the railroad across the continent and the opening of canals and waterways and new developments in agricultural technology which enabled the cultivation of greater farm acreage also served to heighten non-Indian demands for land. As well, the industrializing economy required ever greater amounts of timber as both fuel and building material, and access to minerals and energy for increased industrial production. All of these conditions translated into a heightened conflict between the needs of the surplus economy and Indian sovereignty. The result was the Indian Removal Act of 1830 and the forced migration of eastern Indian tribes into areas west of the Mississippi River (Deloria and Lytle, 1983). By 1840, 420 million acres of land, or 22 percent of the continental area was secured from Indian tribes for an average of 7.4 cents an acre (Barsh, 1988: 819).

With the Indian treaties having served their purpose, it was now possible to turn to new strategies of commodification. The era of treaty-making ended in 1871, but the westward expansion of the industrial political economy did not. In response, the U.S. government instituted an aggressive land and minerals acquisition policy. The General Allotment Act of 1887, also known as the Dawes Act after its sponsor Senator Henry Dawes, furthered the assimilation strategy by dividing sections of communal tribal lands into individual parcels of 160 acres and distributing them as private property to tribal members. Significant parts of the communal lands which remained after allocation to tribal members were sold by the federal government. The Dawes Act was publicly justified as an effort to further the Indian cause by instituting a system of private property and individual initiative. As Commissioner of Indian Affairs T. Hartley Crawford stated (quoted in Takaki, 1979: 189):

> Unless some system is marked out by which there shall be a separate allotment of land to each individual . . . you will look in vain for any general casting off of savagism. Common property and civilization cannot co-exist.

While civility served as the official explanation for the Dawes Act, the result of this policy was to transfer 90 million acres of Indian land and its resources to non-Indian holdings for development. By the end of the 19th century, Native Americans had lost half of their lands by U.S. policy design (Kelley, 1979: 32).

As industrial society and its demands for coal, oil, and other minerals continued to grow, policies regarding the disposition of Native Americans lands changed. Mineral leasing was inaugurated and presidential executive orders were used to remove certain lands from Indian control (Kelley, 1979: 31-33). The mineral abundance that lay on Indian lands was known since the 19th century and knowledge of that existence influenced the character of subsequent Indian policies. In 1891, "[b]ecause the minerals were going to waste from the dominant society's perspective, Congress authorized mineral leasing of tribal and allotted lands" (Ambler, 1990: 37). The authorizing or leasing agent was not the tribe itself, but rather responsibility was placed within the federal government in fulfillment of its trusteeship role. This policy unleashed a flurry of mining activity in Indian country and set the course for energy and mineral development on Indian land. As early as 1894, the Oklahoma Territory was producing approximately 130 billion barrels of oil per year, and 39 corporations were extracting an average of 1.5 million tons of coal per year in the Choctaw Nation alone (Ambler, 1990: 35). Indeed, the wealth of minerals and energy resources which lay underneath much of existing Indian reservations, and the battle for control of them, became the foundation for what eventually resulted in the separation of land surface rights and mineral rights. The stakes of this conflict did not escape the tribes or the U.S. government: as Interior Secretary Carl Schurz suggested in 1881 that "there is nothing more dangerous to an Indian reservation than a rich mine" (quoted in Ambler, 1990: 32).

The Indian Reorganization Act of 1934 formally ended the period of allotment and assimilation. Section I of the Act stipulated that "no land on any Indian reservation . . . shall be allotted in severally to any Indian" (quoted in Deloria and Lytle, 1983: 14). A principal component of the Act was the reorganization of tribal governments, which hereafter were to be the only "officially" recognized governing bodies of Native American communities. These newly formed tribal councils were responsible for "economic planning, mineral lease negotiating and approval and other governmental commitments" (LaDuke, 1983: 10). The organizational form of these tribal governments was drawn, not from tribal tradition or custom, but by Congressional directive. A primary accomplishment of this reorganization was to standardize Native American governance structures and specifically as Churchill notes, to "replicate corporate directorates" (Churchill, 1986: 16). As if this wasn't enough, the U.S. Department of Interior retained ultimate authority over Indian development policies, ensuring that tribal governments would not interfere with industrial exploitation of shrinking Native lands. The announced commitment to self-determination of U.S. policy would cause no anxiety for those seeking reassurance that the momentum of commodification would be sustained.

The supposed policy balance between assimilation and self-determination shifted yet again as reorganization gave way to the "termination of many of the tribes' official status" during the 1950s (Allen, 1989: 864). This continued through the 1960s when termination as a formal policy was ended. The end of termination did not, however, put a halt to the acquisition of Indian resources. The new form of exploitation involved "royalty agreements" negotiated by trustee agents of the U.S. government on behalf of the tribe and approved by the tribal councils created under the 1934 Act. The grossly deficient level of compensation realized under these agreements is well-documented. Between 1959 and 1975, for example, the Navajo nation received approximately 15 cents per ton on coal sales of approximately 2.6 billion tons. During the same period, more than 300 million barrels of oil were taken out of Navajo land and sold for $2 billion as crude oil and $100 billion as refined products. For this, the Navajo Nation received approximately $700 million in royalties, bonuses, and rents from the energy companies (Steiner, 1983: 35). The pattern of abusive agreements has changed little since the 1950s. As of 1984, Indians were receiving 3.4 percent of market value for their uranium, 6 percent for oil, 11.3 percent for natural gas, and about 2 percent for coal. These royalty amounts ran as much as 85% under the royalty rates paid to non-Indians for the same items (Churchill, 1986: 16).

Despite the numerous policy reversals on assimilation vs. self-determination throughout the twentieth century, a consistent pattern of exploitation predicated on the needs of industrial culture prevailed. Native Americans and their lands were recognized almost entirely in terms of their commodity value. Policy shifts typically designated changes in national policies to realize this commodity value for industrial progress. In the next section, the transformative power of "high" technology is shown to have instigated a new phase of the commodification process that has not only stolen Indian land, but made it uninhabitable.

TECHNOLOGICAL AUTHORITARIANISM

The formative event for the second phase of Native American commodification was the U.S. government's decision originally to pursue the development of a nuclear weapon and later, to demonstrate a peaceful nuclear alternative for the supply of electricity. With this decision, a large segment of the Indian population was inextricably involved with a technology capable of disrupting and restructuring social and ecological relations on an unprecedented scale. As with the era of carbon power, Indian involvement was not a matter of choice but the result of political geology: they stood atop the mineral seams of the nuclear fuel needed to power the new technology and, therefore, were, in a literal sense, in the way of progress. Over 60 percent of all known U.S. domestic deposits of uranium are on Native lands. (Churchill, 1986: 16). Most of these deposits are located on the southern edge of the Colorado Plateau, an area encompassing significant portions of Arizona, Colorado, New Mexico, Utah and Wyoming. Nearly one in four of all Native Americans and the majority of the remaining reservation lands are found in this area. Since 1948, the mines of the Colorado Plateau have produced over 95% of the nation's uranium, first exclusively for nuclear weapons, and after 1954 for the "Atoms for Peace" commercialization program (Gilles, et al., 1990: 2). Until nuclear plant orders ceased in the late 1970s, 80% of the uranium mining and 100% of uranium processing was taking place on Indian lands (Allen, 1989: 887).

The advent of uranium mining, milling and enrichment on Indian lands ushered in an era of what Churchill and LaDuke have called "radioactive colonialism" (1986). Whereas the "old colonialism" had used territorial conquest and clearance to accomplish the goal of economic appropriation, the new colonial era seeks dominion over Indian people to facilitate technological advance. The aim of radioactive colonialism has less to do with maximizing the economic value of uranium *per se* than with establishing a technological system of exploitation. In this stage, the assimilative and regenerative properties of the nuclear system become paramount and are promoted over those of communities and natural environments. Technological reality supersedes social and natural reality: society reproduces what Jacques Ellul has described as the value of technique "in itself" (1964). A condition of technological authoritarianism is reached when the maintenance of communities and natural environments originally drawn into the operations of the nuclear system comes to depend upon the elaboration of that very system for their safety and viability.

The first Native American experience with the disruptive effects of nuclear technology involved its waste products. The mining and fabrication of nuclear fuels in the Colorado Plateau region produced a variety of hazardous by-products to which Indian miners and workers in fuel processing plants were exposed, as were Indian communities adjacent to these operations. These materials include both residual ores and liquid waste, such as radioactive wastewater, which accumulate and must be stored in mill tailing ponds. Large-scale accidents involving these wastes began to occur in the 1960s and continue to the present threatening human and biotic life on Indian lands.

On June 11, 1962, 200 tons of radioactive mill tailings washed into the Cheyenne River, an indirect source of potable water for the Pine Ridge Reservation. Eighteen years later, the Indian Health Service announced that as a result of this accident the well water at the reservation community of Slim Buttes contained gross alpha levels at least three times the national safety standard. A new well proposed to replace the old one tested at 14 times the national standard. While federal aid was given to secure replacement water supplies, the BIA stipulated that the replacement water "could only be used for consumption by cattle" (Churchill and LaDuke, 1986: 59).

In July 1979 a far more serious accident occurred when a United Nuclear uranium mill tailing pond located at Church Rock, New Mexico broke under pressure and released more than 100 million gallons of highly radioactive water into the Rio Puerco River. According to Churchill and LaDuke, "although United Nuclear had known of cracks within the dam at least two months prior to the break, no repairs were made (or attempted). 1,700 Navajo people were immediately affected, "their single water source contaminated beyond any conceivable limit" (1986: 58). The Church Rock spill is the largest leak of radioactive liquid in U.S. history (Gilles et al., 1990: 3).

In 1980, over 140 miles of normally dry washes in the Grants Uranium District of northern New Mexico flowed year-round with radioactive mine wastewater. The wastewater was discharged from the District's mines and milling operations (over 100 of the former and five of the latter) directly into the washes because the water table was located above the operations. Concentrations in this water of radioactivity, uranium, selenium, cadmium, lead, and other toxic materials often exceeded natural levels by 100 times. Drainage from uranium mine waste rock piles in the District included concentrations of these hazardous substances often 200 times greater than natural levels (Gilles et al., 1990: 3).

The accidents endured by these communities were only one legacy of radioactive colonialism. As Native Americans have learned, contamination is a necessary and functional part of the ordinary operation of nuclear fuel production. The Kerr-McGee mine at Church Rock, for instance, routinely discharged 80,000 gallons of radioactive water from its primary shaft per day, contamination which was introduced directly into local and downstream potable water supplies (Churchill and LaDuke, 1986: 58). Even after operations cease at specific sites, the radioactive threat often continues. Thus, the Lost Orphan Mine in the Grand Canyon, which closed in 1969 and which reverted to the National Park Service in 1987, continues to emit 26,280 millirems of radiation per year. This compares with normal background emissions for the area of 150 millirems per year, which is itself somewhat higher than national average (Gilles et al., 1990: 4). The nuclear industry has also left in its wake thousands of abandoned mines, tons of unprotected and unsecured mine waste and millions of gallons of waste liquid in largely untreated mill tailing ponds.

The health effects of uranium-related activity on local communities have been substantial, affecting both those who directly participated in the extractive and milling process and those who did not. According to Taylor, "numerous epidemiological studies conducted in the 1960s, '70s and '80s on underground uranium miners who worked during the 1940s, '50s and '60s . . . have linked exposure to radioactive radon gas and its short-lived decay products to a severalfold excess incidence of lung cancer among several thousand former uranium miners. The studies have also noted large increases over expected rates of noncancerous respiratory diseases in the same groups of former miners" (1983:192). For example, 38 of the 150 Navajo miners who worked the Ship Rock shaft between 1952 and 1970 had died of radiation induced lung cancer by 1980. Another 95 had contracted serious respiratory ailments and cancers by that year (Churchill, 1986: 27-28). In 1991, the U.S. Congress recognized, belatedly, the extraordinary threat to Native American miners' lives caused by the pursuit of nuclear technology. It declared (Gilles, et al., 1990: 4):

> Radiation released in underground uranium mines that were providing uranium for the sole use and benefit of the nuclear weapons program of the United States Government exposed miners to massive doses of radiation that produced an epidemic of lung cancer and respiratory diseases among the miners . . . Congress recognizes that the lives and the health of uranium miners and of innocent citizens . . . were sacrificed to the national

security interests of the United States, and Congress apologizes to these citizens and their families on behalf of the Nation.

The 1991 Radiation Exposure Compensation Act addresses the loss of miners' lives but not the harmful effects suffered by their children. Yet, the children in uranium-based Indian communities are experiencing some of the highest levels of birth defects and physical traumas in the U.S. In a study conducted for the period 1969-70, the Navajo communities of Cameron and Grey, had rates for several defects and traumas that were five times the national average. A 1981 study indicated that children growing up near the uranium mining towns of Shiprock, Farmington, and the Grants Uranium Belt had developed ovarian and testicular cancers at 15 times the national average and bone cancers at five times the national average (Gilles, 1991: 6).

While Native Americans have been long-standing victims of uranium mining and milling operations, evidence is accumulating that adverse health effects from these industrial activities have migrated to populations and areas distant from the immediate extraction or production sites. Thus, Arizona's statewide birth defect rate between 1969 and 1990 was one-third higher than the national average (Gilles, 1991: 5). Regional water supplies have also been adversely affected due to radioactive contamination of the Colorado River. Many of the beaches in the Grand Canyon are now contaminated with radioactive sand as a result of unregulated dumping into the Colorado River's tributaries, including the Animus, the Dolores, and the San Juan. Farther to the north, the U.S. Department of Interior has concluded that contamination in the Madison aquifer, the principal regional water supply for the Dakotas, "is well beyond the safe limit for animals. Escape by infiltration into the water table or by breakout to stream drainages could cause contamination by dangerous levels of radioactivity" (quoted in Churchill and LaDuke, 1986: 60).

The degradation of Native lands, and increasingly the contamination of adjacent regions, have led to the characterization of radioactive colonialism as the "underside of an industrialism that has no regard for people or the earth" (Johansen and Maestas, 1979: 146). In fact, the national policy debate on this issue has assured that environmental and human casualties are the necessary price for nuclear progress. In 1972, in conjunction with studies of the national energy situation performed by the Trilateral Commission, the U.S. government sought to designate certain parts of the Dakotas, Montana and Wyoming as "National Sacrifice Areas". These areas were to be formally declared uninhabitable as a consequence of uranium mining and processing and the attendant waste produced. Other areas which had not yet been rendered a threat to life were also to be designated as sacrifice areas in the recognition that continuing efficient uranium mining and milling would eventually lead to uninhabitability (Churchill and LaDuke, 1986: 62; Johansen and Maestas, 1979: 141-166). The loss of such lands to the demands of nuclear technology system were to be treated as a normal cost of doing business. While in law no National Sacrifice Areas have been designated, there is little doubt that Indian lands, after being subjected to 30-40 years of uranium mining and milling have been transformed *de facto* into largely uninhabitable places. The recently proposed National Energy Strategy, in calling for a doubling of nuclear power capacity by 2030, can only inspire fear for the Navajo, Havasupai, Utes, Hualapai, Hopi, and other tribes whose lands hold significant uranium deposits.

The creation of spaces that can only be occupied without risk by technological "inhabitants" and the ability of technological systems to drive out life affirming uses of natural environments gives new meaning to what Ellul has termed "technological invasion" (1964). His description of the collapse of nontechnical cultures in the face of technical challengers and his claim that "technique can leave nothing untouched in a civilization...[E]verything is its concern . . . [I]t is a whole civilization in itself" (1964: 125-126) conventionally has been taken to refer to the plight of non-industrial societies and communities.

Certainly, Native American cultures have been threatened in this manner. Thus, the Havasupai Tribe of northern Arizona has seen one of their most sacred sites turned into a new uranium mine operated by United Nuclear Corporation (Gilles, 1991: 9). In the same manner, the Mother Mountain of the Navajo Spirit is now being systematically strip-mined for coal to feed the country's dirtiest power plant (Johansen and Maestas, 1979: 146). That land could be understood as sacred, and that such an understanding might prohibit further technological development is simply inconceivable, Ellul argues, in an advanced stage of industrial society. But it would appear that Ellul's warning needs to be expanded in its application to encompass, as well, the dissolution of natural environments and the living communities supporting them. Nontechnical human *and* natural cultures are being subjected to technical invasion in the nuclear era.

BIG SCIENCE

Industrial societies are on the threshold of a third phase of commodification. In this new era, nature will no longer be exploited for its particular attributes but will be transformed and reshaped to meet the needs and interests of technological civilization. Whether this transformation is intentional is largely beside the point. Industrial societies now, or in the near future will, possess the capacity to alter the very structure of nature regardless of intent. The manufacture of acid rain and holes in the upper ozone, the extinction of plant and animal species (and the engineering of new ones), the reduction of the planet's capacity to breathe (due to deforestation, among other things), the manufacture of highly toxic, long-lived poisons which are so dangerous that they require 1000 year security zones, and the creation and satisfaction of consumptive appetites which in their aggregate portend a change in global climate - all are uniquely industrial in their origin. They represent a legacy that only industrial societies in all of human history could have bestowed to the future have become rational and efficient. As Nicholas Shackleton, a climatologist at Cambridge University, has suggested, "we are going outside what nature has experienced in the recent past 500,000 years" (*New York Times*, January 16, 1990: C1).

Indisputably structural in character, these social interventions into the natural order are serious enough in their own right. The most vivid means of illustrating the scale of the modern restructuring of natural environments is to consider, for example, the process by which global temperature change is effected in an exclusively natural structure. Climatic history over the last several hundred thousand years is thought to have been determined by the confluence of three astronomical cycles which regulate the earth's orbital ellipse, axial tilt and wobble. The orbit cycle, which fixes the earth's travel within the solar system takes approximately 100,000 years to complete the series of elliptical modifications involved; the tilt cycle lasts about 41,000 years to accomplish a series of axial corrections; and the elapse of the wobble cycle is nearly 23,000 years in duration. Together, these cycles control the timing of global warming and cooling by altering the angles and distance from which solar energy reaches the earth. These very long-lived cycles must be placed alongside the few hundred years of industrialization (with the last 100 years representing, by far, the most carbon-intensive), which are cumulatively believed to have begun a social process of temperature change, to appreciate the magnitude of industrial interference. The time disjuncture in the industrial and natural terms of reference points to the immense capacity assembling in the world political economy to threaten natural order. Even skeptics of the present status of knowledge about the greenhouse effect should be awed by the potential for social engineering to change the natural structure, which, if not available presently, almost certainly will soon be.

Embedded in conflict between Indian and non-Indian cultures over the past two centuries has been the struggle to realize nature as a commodity. The *Big Science* era merely pushes the idealization of environmental commodification to its logical conclusion. In so doing, its threat to Native Americans is no longer unique. Indeed, the globalization of the threat is the defining feature of this phase of commodification. In just the past thirty five years, for instance, efforts by Northern societies to internationalize industrial development patterns have led to a reduction in forest cover from one-fourth to one-fifth of the world's land surface (Goldemberg, et al., 1988: 39). The South has been particularly hard hit during this period where it can be estimated that 17 percent of tropic forests have been lost (Fletcher, 1989: 3). If deforestation continues at present rates, tropical forests will be eliminated in 85 years and the only remaining tropical forests will be those engineered in technology systems dedicated to this objective (Goldemberg, et al., 1988: 39).

In the third phase of commodification we are committed to a form of world political economy in which disruption of natural order is the necessary risk of progress. Whereas the initial stages of commodification tested the statics of nature, namely, the capacities of land, water and air, to absorb industrial pollution, the advanced technological order of global capital and markets challenges the dynamics of nature, in particular, the seasons, the tides, the breathing of the planet, and even the reproductive cycle of the atmosphere. While the emblems of advanced industrialism remain waste and pollution, there has been a fundamental breach of the nature-society relation. Advanced industrial life transpires not simply outside the constraints of nature, but relegates all of nature to commodity status, to be purchased and sold in the world political economy along with other products and services. The contemporary world political economy presumes that sustainability is a technological and economic matter. Although this presumption is typically manifested in economic terms and thus continues to be most concretely presented in discussions of trade-offs between environmental protection and material progress, its deeper implication is the demise of any idea of the inviolability of nature. There is *nothing* in advanced industrial logic beyond technological manipulation; not the climate, not the atmosphere, not species diversity. Nature is stripped altogether of autonomous status. Industrial society as the master of nature fulfills the Western dream of science: science replaces nature as the basis of life.

CONCLUSION

The environmental degradation of Native American lands and the exploitation of the people over the last 200 years are best understood as the common functional requirements of U.S. industrial progress. As the ideas and institutions of technological civilization achieve worldwide hegemony, the history of Native American peoples will be reproduced on a global scale. As Churchill and LaDuke have observed (1986: 73):

> Ultimately, the Lagunas, the Shiprocks, Churchrocks, Tuba Cities, Edgemonts and Pine Ridges which litter the American landscape are not primarily a moral concern for non-Indian movements (although they should be). Rather, they are pragmatic examples, precursors of situations and conditions which, within the not-so-distant future, will engulf other [U.S.] population sectors.

This prospect concerns the fate not only of poor and minority communities in the U.S., but Native and other peoples generally. Exploitive development and natural disorder are the distinctive attributes of mature commodification.

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A STRUCTURAL APPROACH TO THE ENVIRONMENTAL CRISIS: ENERGY, ENVIRONMENT AND UNDERDEVELOPMENT

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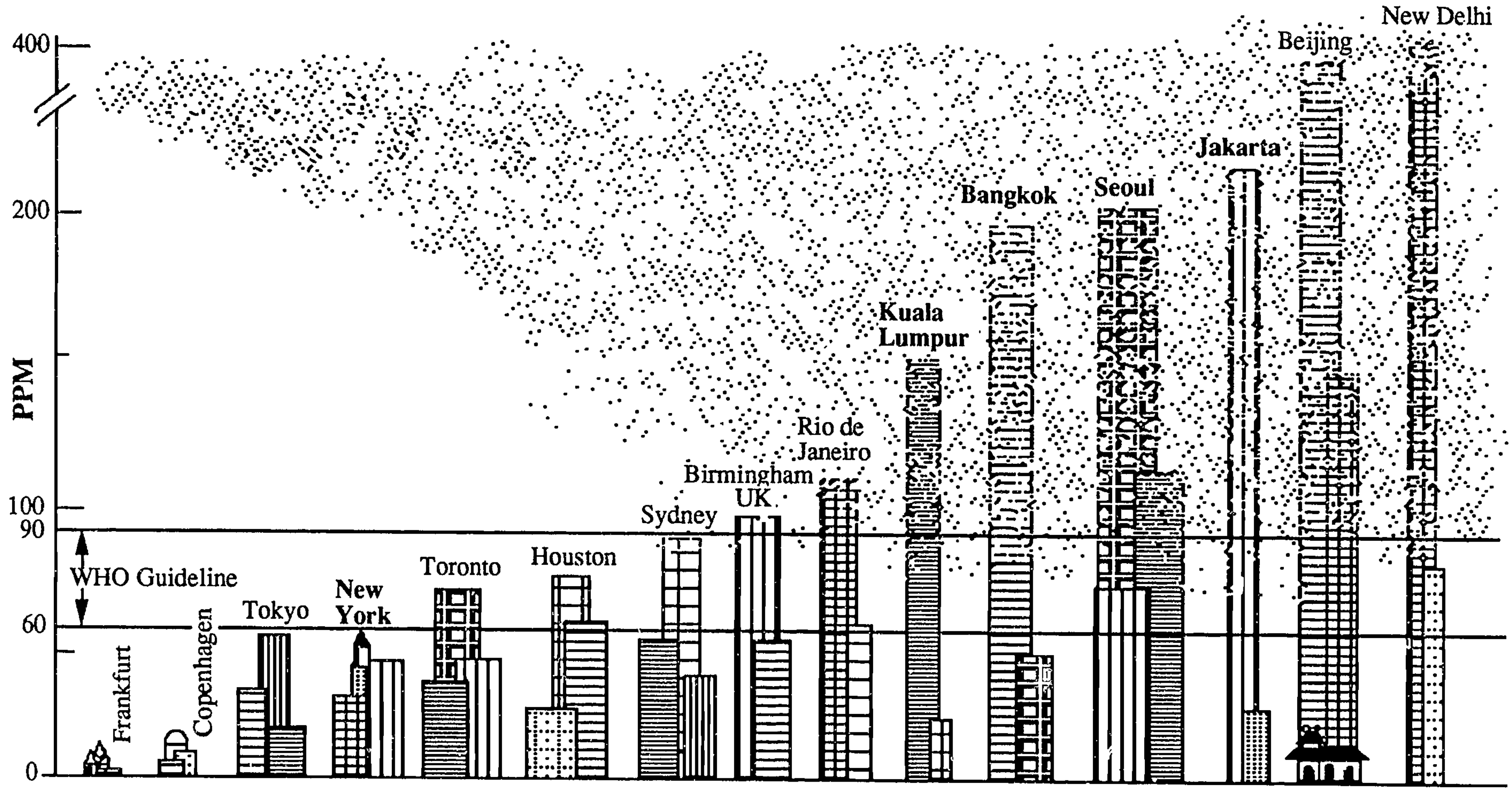
INTRODUCTION

The environmental crisis confronting the world today is inextricably intertwined with issues of development. In most cases, the principle causes which have compromised environmental quality and are endangering environmental viability are directly attributable to industrial growth. The dimensions of this crisis include deforestation, pollution, and global warming. Over a three-decade period, from the mid-1950s to the mid-1980s, the proportion of total global land surface covered by forests diminished from one-fourth to one-fifth (Goldemberg et al., 1988: 39). Air pollution has currently reached levels such that over 70% of the world's urban population breathes air that exceeds the World Health Organization's suspended particulate matter standard for healthy respiratory and heart function (World Health Organization, 1987: 7) (see Figure 1). The prospect of global warming represents the cumulative impact of two centuries of industrial growth, due primarily to energy production and use, which currently constitutes 57% of the activity generating greenhouse gas emissions, and processes of industrialization and urbanization, which account for 29% (Lashof and Tirpak, 1989: 55).

The lack of regard for the environmental impacts of human activities can be traced to an ideology of progress which values wealth creation as its supreme goal. This ideology, promoted by Western industrial societies, embraces technological productivity and economic growth as the criteria by which progress is to be measured. In the present context, as more and more peoples of the Third World seek to compete, or are forced to participate, in the global marketplace, the fragility of environmental systems becomes increasingly exposed.

The interdependent nature of world economic, technological and political order necessitates a global response to the environmental repercussions of the development process. Both developed and developing countries must face this challenge, and must cooperate in its confrontation and resolution. In order to do so, however, the structural relationships among nations and the development process must be examined and understood. This paper will relate the current environmental crisis to the prevailing ideology of progress adopted by industrialized countries, the energy and environmental implications of industrial development, and the structural relationship between industrialized and industrializing countries in the pursuit of economic growth. The structural nature of the environmental crisis manifested in developing countries will be identified as a part of the larger problem of uneven development.

Figure 1
Annual Suspended Particulate Matter Averages in Selected Cities: 1980 - 1984



Sources: World Health Organization (WHO) and United Nations Environmental Programme (UNEP). 1987. ***Global Pollution and Health***; Center for Energy and Urban Policy Research, University of Delaware.

ABUNDANCE AS THE KEYSTONE OF PROGRESS

At least since the rise of industrialization, the prevailing view in capitalistic industrial societies has been that progress entails increasing productivity. Growth of material goods has been understood to address the basic needs of society and to provide increasing levels of comfort and potential well-being. Theories of social development have been predicated upon the concept that progress will be evidenced as needs are met and members of society experience the elevation of their life circumstances such that concern regarding basic needs will be eliminated. Growth in productivity and the expansion of technological capability have been assumed to mean, eventually, growth in social welfare. This theory of social development through technological advance is future-oriented, optimistic and unilinear: given enough time and enough advance in technological systems, society will continue to move along the path of progress.

This idea of progress, which by the eighteenth century had attained the significance of a "cardinal doctrine", found its rationalization in the promise for social betterment allowed by material accumulation and its justification in increasing the distance between current conditions and those of the past.

> Man ... was climbing steadily out of the mire of superstition, ignorance, savagery, into a world that was to become ever more polished, humane and rational ... In the nature of progress, the world would go on forever and forever in the same direction, becoming more humane, more comfortable, more peaceful, more smooth to travel in, and above all, much more rich (Mumford, 1934: 182).

In time, this concept gained a momentum of its own, eliminating all considerations other than its own perpetuation.

> Unlike the organic patterns of movement through space and time ... progress was motion toward infinity, motion without completion or end, motion for motion's sake. One could not have too much progress; it could not come too rapidly; it could not spread too widely; and it could not destroy the "unprogressive" elements in society too swiftly and ruthlessly: for progress was a good in itself independent of direction or end (Mumford, 1934: 184).

As social development was tied to material accumulation, abundance and the "progress" which it signified became identified and determined by quantitative measures. Quantitative production became an imperative, defining increases in scale, volume, and activity as fundamental.

> Progress was possible only through increased production: production grew in volume only through larger sales: these in turn were an incentive to mechanical improvements and fresh inventions which ministered to new desires and made people conscious of new necessities. So the struggle for the market became the dominant motive in a progressive existence (Mumford, 1934: 185).

Industrial pursuits for "bigger" and "more" served ultimately to lead civilization to a worship of numbers, for "numbers begot numbers; concentration, once well started, tended to pile up in ever-increasing ratios" (Mumford, 1938: 160).

Within this techno-economic framework of abundance, the process of social development was easily reducible to mathematical formulation. In straightforward terms, Leslie White (1943) described the process of cultural development as the product of energy utilized and the technological means by which it is consumed, encapsulated by the formula "E x T = P" (*Energy* utilized per capita times *Technological* means for expending energy equals *Productivity*, or the production of goods and services). Cultural development is predicated upon the increase in energy, the improvement in efficiency of the mechanical or technical means, or both. Only increasing quantities of productive energy foster cultural advance, and civilization is enabled to flourish provided that new and increasing sources and per capita levels of productive energy can be harnessed and utilized.

The ideology of abundance presupposes that the progress of society is marked by decreasing dependence upon nature as a means of security and comfort. Civilization, measured by material growth, relies upon institutional adaptation to prevailing technological capabilities and the search for new and increasing energy sources with which to expand the margin between the natural and the technological environments.

ENERGY AND ENVIRONMENTAL IMPLICATIONS OF INDUSTRIAL DEVELOPMENT

As function of technological and economic dynamics, several implications of the prevailing view of progress and social development can be derived. The environment, energy and labor assume the characteristics of commodities, seen in terms of market exchange values. As factors of production, these resources are utilized to economic advantage. When competitive economic potential is not realized through additional inputs of natural resources, energy and labor, these commodities lose value until they are technologically revived as useful production factors in the economy.

New opportunities for the use of labor, capital and resources are defined in terms of their economic and technological "fit" in the existing order. Only those that can elaborate, expand, or complement current structures will be incorporated, and those that do not are ignored or replaced by technological substitutes, rendering them obsolete. The functions of labor may be assumed by mechanical substitutes or new competitive labor markets may be found in the international arena. The environment, beyond providing sites for mining and extraction, largely serves as a receptacle for the by-products of productivity. Indeed, pollution has become an accepted fact of life, and early in the industrial era was interpreted as a sign of economic health.

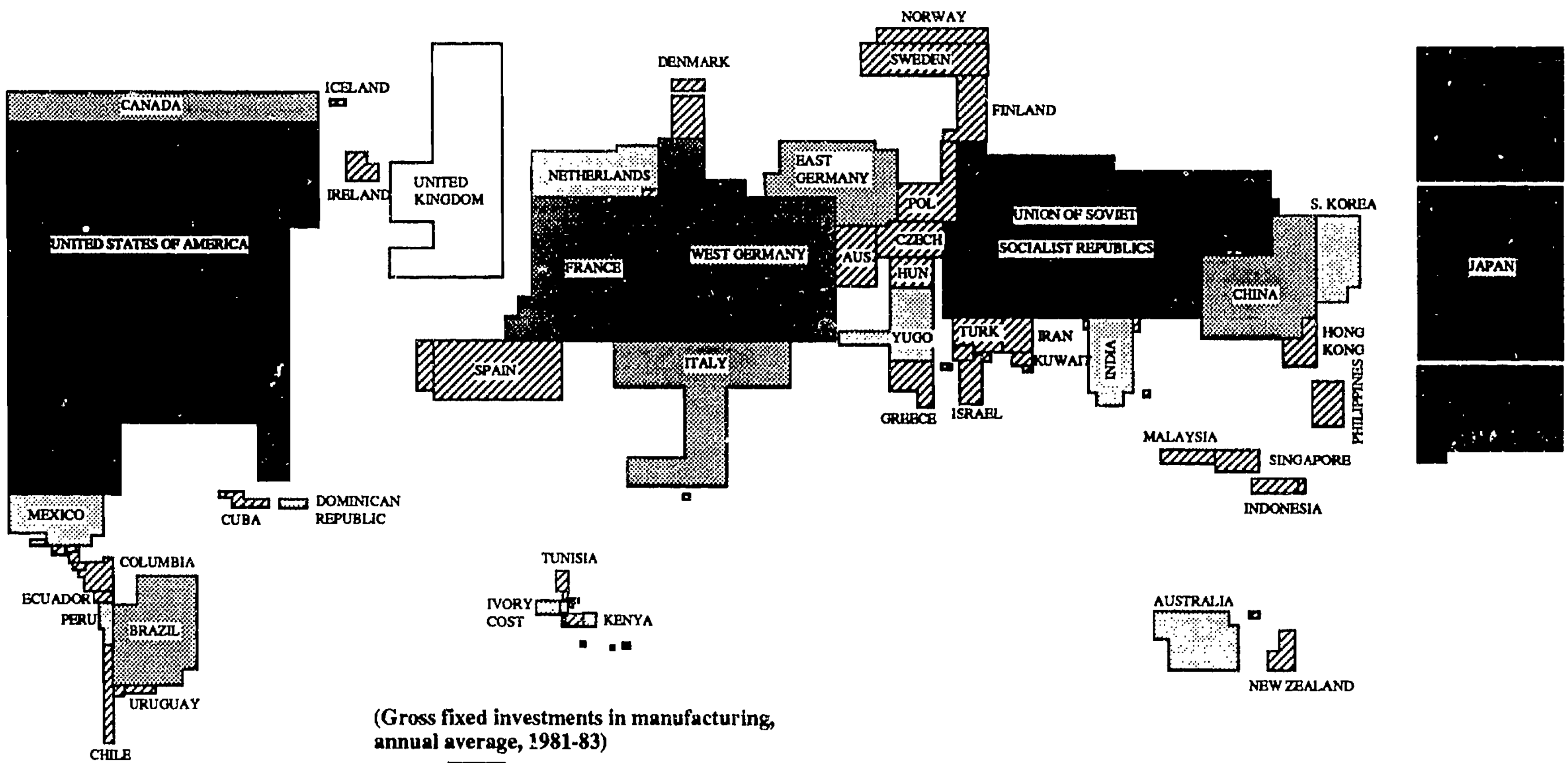
> The smoking factory chimney, which polluted the air and wasted energy, whose pall of smoke increased the number and thickness of natural fogs and shut off still sunlight - this emblem of a crude, imperfect technics became the boasted symbol of prosperity . . . (and) the reek of coal was the very incense of the new industrialism (Mumford, 1934: 168, 169).

This industrial culture, which denounced all but economic growth, precipitated the environmental problems which are assuming crisis dimensions today. The energy-intensity of industrial, commercial and consumer regimes, the scale of these activities, and the reality that the major pollutants are industrially manufactured, place responsibility squarely on the shoulders of industrialized countries (Figure 2). Examination of global patterns of commercial energy consumption, greenhouse gas emissions, and carbon emissions support this conclusion.

Figure 2

International Distribution of Industrial Power: 1981 - 83

(value of gross manufacturing output)



(Gross fixed investments in manufacturing, annual average, 1981-83)

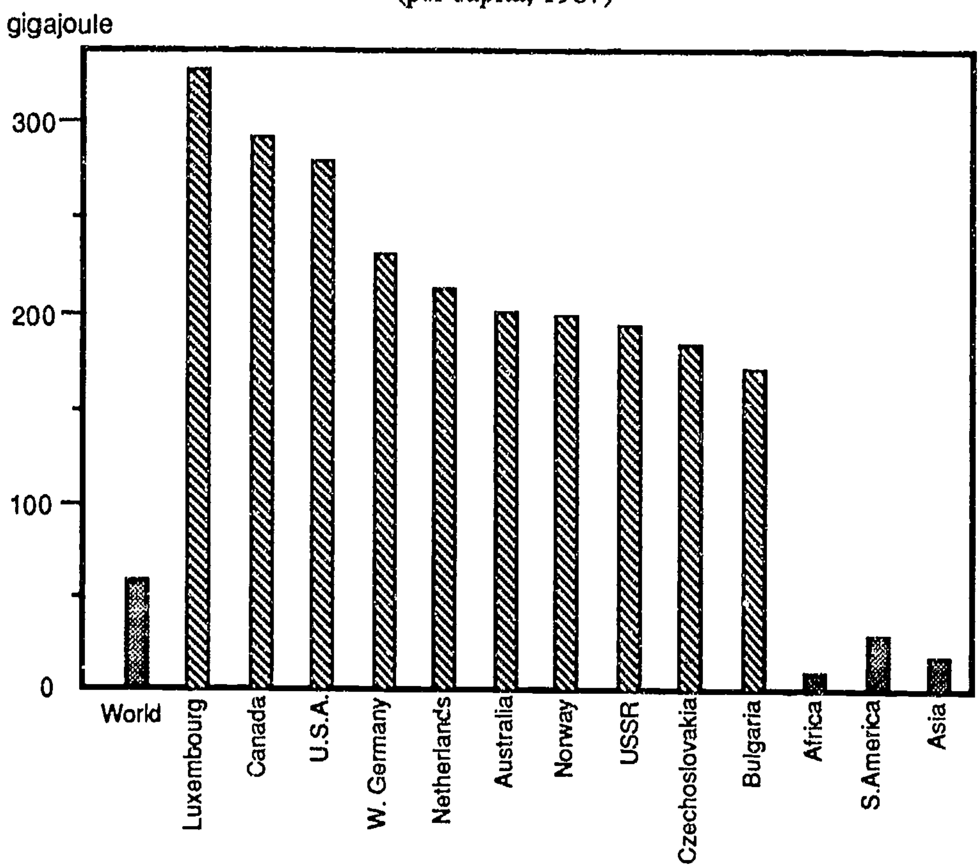
- quarter UK
- half UK
- UK
- twice UK
- 4 times UK

(62 countries compared with UK investment of US$13.1 billion)

* Sources: UN, ***Industrial Statistics Yearbooks*** ; IMF, ***International Financial Statistics*** ; UN, ***Monthly Bulletin of Statistics*** (as produced in ***The New State of the World Atlas,*** 1987)

Intensive fossil-fuel-based energy production and use, by far the largest contributor to greenhouse gases and a major source of carbon emissions, is concentrated in industrialized countries. With the 1987 world average commercial energy consumption of 56 gigajoules per capita, the most intensive per capita usages occurred in: Luxembourg, Canada, United States, West Germany, Netherlands, Australia, Norway, USSR, Czechoslovakia, and Bulgaria ranging from 326 to 173 gigajoules.[1] In contrast, the average per capita consumption was 12 gigajoules in the African nations, 30 in the South American countries, and 21 (including the Middle East region) throughout Asia (Figure 3). Carbon emissions are, for the most part, a function of industrialization, urbanization, and corresponding energy use. World carbon emissions per capita totalled 1.08 tons in 1987. As would be expected, carbon emissions also unequally distributed, with the United States contributing 5.03 tons per capita, Canada 4.24, Australia 4.00, and USSR 3.60 (Table 1). An index which combines carbon dioxide, methane, and CFCs, identifies two-fifths (40.1%) of net greenhouse gas emissions as attributable to the activities of three countries: United States (17.6%), USSR (12.0%), and Brazil (10.5%). Following these countries in volume of emissions are China, India, Japan, West Germany, United Kingdom, Indonesia, and France/Italy with percentage ranging from 6.6% to 2.1% (World Resources Institute, 1990: 15).

Figure 3. Commercial Energy Consumption, Selected Countries and Regions (per capita, 1987)



Source: World Resources Institute. 1990. *World Resources, 1990-1991*. pp.316-317

Table 1
Carbon Emissions from Fossil Fuels, Selected Countries 1960 and 1987

Country	Carbon 1960	Carbon 1987	Carbon per Dollar GNP 1960	Carbon per Dollar GNP 1987	Carbon per Capita 1960	Carbon per Capita 1987
	(million tons)		(grams)		(tons)	
United States	791	1,224	420	276	4.38	5.03
Canada	52	110	373	247	2.89	4.24
Australia	24	65	334	320	2.33	4.00
U.S.S.R.	396	1,035	416	436	1.85	3.68
Saudi Arabia	1	45	41	565	0.18	3.60
Poland	55	128	470	492	1.86	3.38
West Germany	149	182	410	223	2.68	2.98
United Kingdom	161	156	430	224	3.05	2.73
Japan	64	251	219	156	0.69	2.12
Italy	30	102	118	147	0.60	1.78
France	75	95	290	133	1.64	1.70
South Korea	3	44	274	374	0.14	1.14
Mexico	15	80	446	609	0.39	0.96
China	215	594	—	2,024	0.33	0.56
Egypt	4	21	688	801	0.17	0.41
Brazil	13	53	228	170	0.17	0.38
India	33	151	388	655	0.08	0.19
Indonesia	6	28	337	403	0.06	0.16
Nigeria	1	9	78	359	0.02	0.09
Zaire	1	1	—	183	0.04	0.03
WORLD	2,547	5,599	411	327	0.82	1.08

Source: C. Flavin. 1989. *Slowing Global Warming: A Worldwide Strategy*. p. 26.

There is obviously strong disparity in regard to the distribution of the responsibility for environmental damage. However, energy, environment and development can be considered neither separately nor locally, but must be viewed as interrelated, interdependent, and global in scope. Although historically concerns have been raised regarding the impact of development upon the environment, the present situation also requires assessment of the reverse: that environmental stress may impede or restrict development. Ecological interdependence, as well as economic dependence, has become a reality, and the plight of the poor and vulnerable throughout the world affects the security of those more fortunate.

ENVIRONMENTAL CRISIS IN DEVELOPING COUNTRIES

During the past couple of decades, the environment issues, first seen as mainly a problem of the industrialized countries, drew the international attention as a problem of industrializing nations; first, focusing on the issues of population growth and resource depletion, and later on the environment and the absorptive capacity of the earth. Recently, a series of events, such as the global disasters from severe droughts and flooding, global economic crisis and the discovery of the global nature of environment impacts - global warming and ozone depletion - spurred shifting the focus of studies to the needs of global responses from both the industrialized and the industrializing countries.

Conventional thinking on resource depletion and carrying capacity is the primary problem. On the basis of the status quo, the notion of carrying capacity is so often attempted to apply to poor countries only, and leads to the social-Darwinist rationalization of social inequality, as the so-called "lifeboat ethics" indicates. For example, when people are criticizing the Third World for its burgeoning population, it is totally neglected that "fifteen children in India are not going to deplete the world's supply of vital resources any more in the future than one child born in America" (Carter, 1991: 129). Fundamentally, it fails to address the possibility that "nature is undergoing a process of social capture which eventually may make it in effect a social subsystem" (Byrne et al., 1991: 67). Traditional views fail to address the social and economic forces behind resource depletion and carrying capacity which have been built on a logic of nature as an inexhaustible resource mine. In this context, the recent boom of studies on the ties between poverty and environmental degradation, especially in the industrializing countries, and the vague, limited, and technocratic diagnoses and suggestions, are not surprising.

The introduction of the technological strategies of the industrialized countries into nations undergoing development draws those nations into the exploitive and destructive arena of current energy and environmental usage patterns. The export of those strategies reproduces the relationship between energy, environment and development evidenced in the developed world. Countries seeking development are largely unable to do so independently, relying upon industrialized nations for technology and capital. Further, much of the energy-intensive and environmentally-damaging activity has been relocated from developed and developing nations, exacerbating environmental issues in those countries.

We argue that environmental degradation is integrally related to economic production, technology, social equity and the politics. It is true the industrializing countries' contribution to the global environmental degradation is rapidly rising, and also true that the poor pollute the environment, if we seek explanations at a micro level. However, the environment is being socially shaped and reconstituted by political and economic forces. Environmental change also has both a contemporary and historical dimension, with roots in social institutions and economic relationships. Thus, in order to correctly understand the environmental crisis in the industrializing countries, it should be examined in the social, historical and structural contexts. The structural constraints faced by those countries, the existing political economic relationship between North and South, and the global distributive issues are essential concepts for this understanding.

GLOBAL STRUCTURAL RELATIONSHIPS

The industrialized countries' commitment to growth and the domination of nature have deprived the developing countries of their right to choose alternative development paths and a different relationship between society and nature. The structure of their social system and development paths were shaped by colonialism, and maintained by the international political economy through the transfer of capital, labor, technology and natural resources. Global development must be regarded as a historical process which links the exploitation of resources in the South with that of the more industrialized countries. Recently, the target of exploitation has shifted toward cheap labor and environmental commodities, termed "the new international division of labor." Under the structural guidance of industrial capital, the North exported technologies, which are often obsolete, capital-intensive, centralized, large-scale, hierarchically organized, and energy-intensive. Consequently, these technological systems are pollution-prone, blind to the needs and capacities of the receiving society, and usually tied with the transfer of technology and capital, thus deepening the structural dependence on the North. Technology is not simply a means to harness nature in industrial society; it is also the instrument through which people are becoming alienated from nature in rural areas of the South (Redclift, 1987).

Debt burdens and trading relations induce the South to specialize in cash crops and commodity production which can be easily liquidated. Such alteration of the economic base necessarily destroys indigenous economies based on self-reliance and simple exchange, which are adaptive to the ecological system and give sustained yields. One hundred and ten million acres of the Third World land grow crops to export to rich countries; for the cultivation of coffee, tea and cocoa alone, about 40 million acres. In Latin America per capita production of subsistence crops decreased 10% between 1964 and 1974 while per capita production of export crops increased by 27% (Trainer, 1985: 142, 144). In terms of economic criteria, it may be a rational choice to devote a lot of land to cash crop production and ranches for cattle, while importing food grain. It may also be a rational choice for poor and powerless individuals to utilize the environment for their own subsistence, irrespective of the consequences of environmental degradation. It is not surprising to find a positive relationship between the amount of debt and the extent of deforestation (Table 2). Though the rapid growth of population is imposing a serious problem in many respects, large families are also one of the strategies for survival.

Modernized agriculture recommended as a way out of famine is a very expensive consumer of energy, requiring most developing countries to spend desperately needed foreign exchange monies on the import of fuel. It also accompanies the increase of pesticides use. It is not surprising that the Third World is assuming much of world pesticides consumption since the mid-1970's. What is worse, the use of some of these pesticides is barred or restricted in the countries that export them. For example, the United States annually exports about 500 million pounds of pesticides that are banned, restricted or not licensed for domestic use (Simons, 1991: 228). Another aspect of the introduction of modern agricultural technologies is the sharp rise in landlessness among rural people, because only the richer farmers can afford to utilize them. In the late 1970s, 30 - 60% of rural populations in Third World countries were landless and in many countries the proportion exceeds 80% (Trainer, 1985: 140).

Furthermore, the earnings from their products are beyond their control due to demand and production fluctuations, so often with disadvantageous consequences. What is worse, most of the income from these export crops goes into the pockets of a few rich plantation owners, often foreign corporations. In this sense, the Green Revolution of the 60s and 70s is not green at all, rather just the revolution of "farming with oil and capital." Under the present industrial order, these phenomena are inevitable because those decisions satisfy economic criteria and the systemic goal of the maximization of productivity and wealth. The creation of degraded environments cannot be seen as simply an unfortunate by-product of the development process. It is an inherent part of the process.

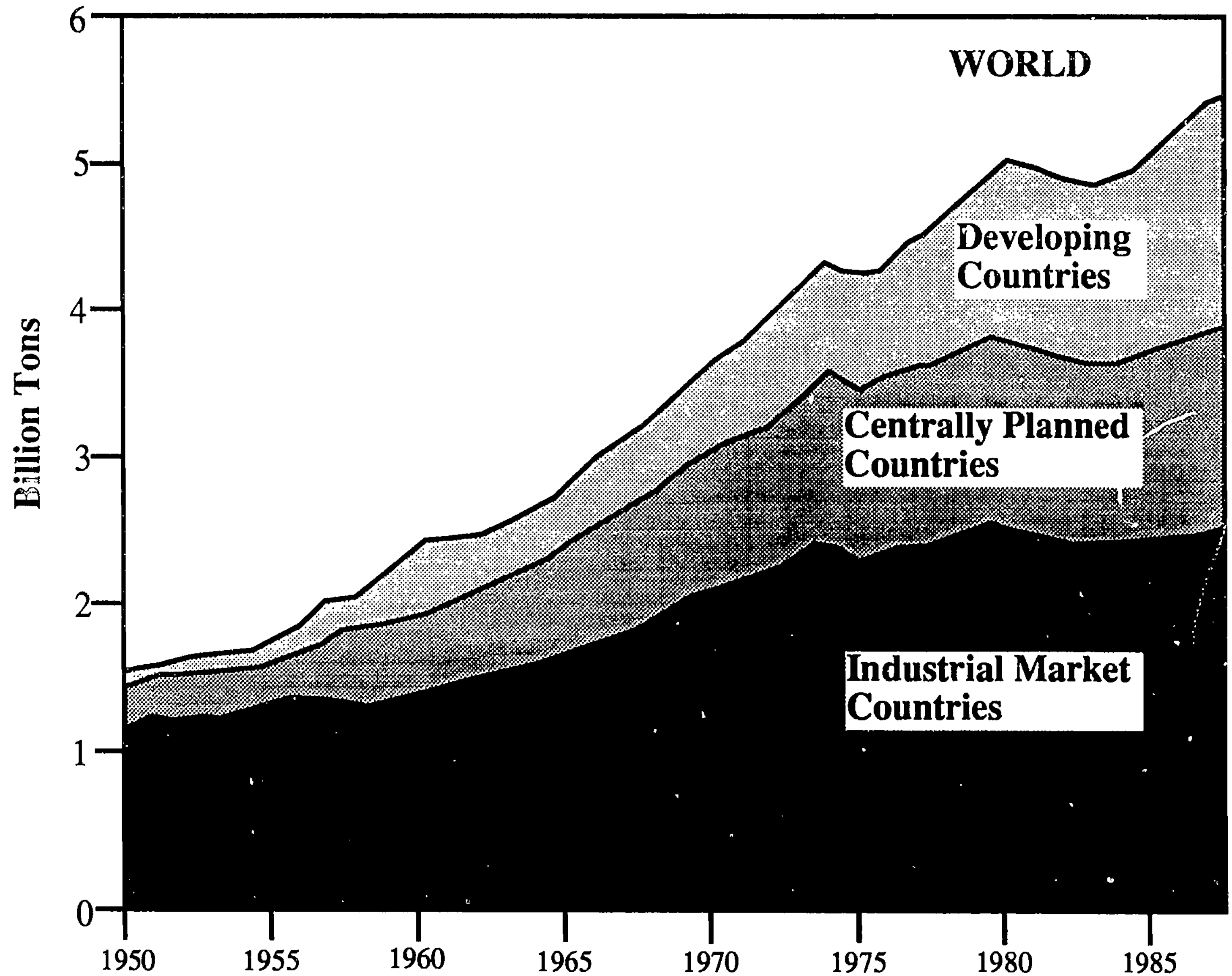
The result of capital transfer is almost the same. The aid story is one of the more unsavory elements in the relations between North and South. About half the aid given takes the form of loans that have to be repaid with interest, which seeds the debt crisis in advance. In addition, it is often given on the condition that the recipient spends the money on buying goods from the donor at higher prices than the market price, or that recipient governments adopt policies favorable to the operations of transnational corporations. Claims have been made to the effect that when all factors are combined, the functioning of the global economy drains $50 - 100 billion from the Third World to the rich world each year (Tinbergen, 1976: 16, referenced in Trainer, 1985: 165). Finally, most aid is an instrument of foreign policy, rather than a charitable device. The truth of this can be discovered by looking into the form of aid - military and food aid - and the information of the major recipients and the amounts. As for food aid, this is used both to dump food surpluses for the purpose of stabilizing domestic food prices and of encouraging a new dependence of taste. The global institutions, such as IMF and World Bank, function in order to make the world safe and predictable for private capital and free trade, not to support radical egalitarian policies of the Third World. (Corbridge, 1986: 203 - 211).

Table 2. The Debtor-Deforestation Connection

	Average Annual Deforestation 1980s Thousands Hectares	Total Debt (1987) US$ (billion)
Brazil	2,323	$ 109.5
Colombia	890	15.5
Mexico	615	82.8
Ecuador	340	10.4
Peru	270	16.6
Venezuela	245	29.0
Ivory Cost	510	10.3
Nigeria	400	28.4
Zaire	347	8.6
Indonesia	620	48.5
Thailand	379	17.6
Malaysia	255	21.1
India	147	42.9
Philippines	92	28.4

Sources: Food and Agriculture Organization (FAO) and World Bank (referenced in J.G. Speth. 1990. p.16)

Figure 4. Carbon Emissions from Fossil Fuels: 1955-88



Source: C. Flavin. 1989. *Slowing Global Warming: A Worldwide Strategy*. p.25.

The debt burden in the developing countries makes an international trade of waste possible. Basic waste-trade schemes are either arranged covertly or accompanied by "cash payments" large enough to entice countries to accept dangerous cargoes, such as radioactive wastes, toxic wastes, municipal solid wastes, incinerator ash, asbestos wastes, sewage sludge and so on. In 1989, Guinea-Bissau canceled a contract to accept more than 3.5 million tons of dangerous waste, which meant the loss of annual income of $140 million, greater than its gross national product (Dufour and Demis, 1991: 216). Between 1986 and 1988 alone, over 3.1 million tons of wastes were shipped from industrialized to developing countries. Another scheme is to build incinerators, which can produce electricity, and to supply fuels, in the form of various waste. The combined capacity of the proposed incinerators in several countries - Bangladesh, Paraguay, Haiti, Angola, Tunisia, Sierra Leone, Honduras and so on - is over one million tons per year; currently China imports tens of thousands of tons of waste each year to fuel an incinerator (Leonard and Vallette, 1990). Once again, only economic criteria are relevant, and the others such as social and environmental considerations are irrelevant to these decisions.

In the case of semi-industrialized countries, rapid economic growth has meant that they have inherited many of the environmental problems of the North in the spatio-temporarily condensed form. As Table 2 and Figure 4 illustrate, whether a country links to East or West, the result is not different, because "the capitalist societies of the West and the State socialist societies of the East are two varieties of a common corporate industrial culture based on the values of competitive individualism, rationality, growth efficiency, specialization, centralization and big scale" (Friberg and Hettne, 1985: 231). The misuse of land, the destruction of local forests for fuel wood and the inability to develop and implement appropriate and sustainable technologies are not the fault of inadequate people, but of the structural relationship between North and South (Redclift, 1987).

REPRODUCTION OF THE INDUSTRIAL REGIME

The North does not export just technology and capital. Along with them, it reproduced the energy-environment-development regime in the developing world. As a matter of fact, "to the extent that Left and Right agree on anything developmental, it is that industrialization is a precondition for successful economic development" (Corbridge, 1986: 129). In the institutional setting of an industrial market economy only economic and market laws are relevant. All factors involved must be on sale. They must be available in the needed quantities to anybody who is willing to purchase them at the market price. In other words, all of the natural and human substance of society is converted into commodities. To include labor and nature in the market mechanism through commodification means to subordinate the substance of society itself to the laws of market and economy. It implies the principle that no behavior or arrangement should be allowed to exist that might prevent the well-functioning of the economy (Polanyi, 1944: 72 - 73). It urges the institutionalization of economic criteria as determinants of choice and decisions, to the exclusion of non-economic criteria. The introduction of self-regulation market mechanism in the developing countries requires that they be accompanied by a change in the organization of society itself. The result is the breakdown of the fabric of community cohesion. Henderson describes the crises of industrial development:

> ... it begins to suck all such informal, use-value production and consumption into the monetized economies, drawing populations into the cities, denuding rural agricultural areas, dissolving the cultural glue of village life and reciprocal community systems of food-sharing, care of the young and elderly, and the folk medicine, and destroying inherited cultural wisdom

learned in coping with diverse ecological conditions. Thus, industrialism and the economic logic underpinning it tacitly view the industrialization process as also one of monetization of all production and consumption and the accumulation of investment "capital" or "surplus." (1981: 25 - 26)

Milbrath (1989: 44 - 46) points out as a prominent feature of Western civilization the "dominator culture" - nature and certain human beings, especially women, are viewed as commodities to be exploited for one's own welfare and comfort. In fact, as Adams (1990) argues, the trauma of development lies in the alien nature of those norms and values, inherent in the modernist attributes of Western notions of development. The existing political economy of inequality and its corresponding development regime of commodified nature and humanity is expected to be reproduced in the developing countries, along with the belief in the scientific, quantitative, reductionist world view and the cornucopian view. Whether following the model offered by the Western market-oriented societies or the Eastern centrally planned societies, the set of problems and symptoms faced by the developing countries have no difference: "catastrophic urbanization, unsustainably resource-intensive production methods, costly centralized technologies requiring huge bureaucracies, unattainable levels of specialization, technological dependence, lost food self-sufficiency, and disruption of their own cultures" (Henderson, 1981: 22 - 24).

Indeed many Third World governments have shared the view that peasants are expected to contribute to development by providing the resources for others to develop the urban industrial economy. Consequently, marginalized people and countries lose a meaningful function in the "megamachine" and the environment is rapidly getting worse as researches on the trap of poverty and environmental degradation indicate. In effect, the roots of the environmental crisis are to be found in the values of modern industrial society with its commitment to growth and the domination of nature (Cotgrove, 1982). More important in the survival equation than population growth, resource and food scarcity, or the pollution is the tendency in both the capitalist and the socialist block to increase industrial development as rapidly as possible.

ENVIRONMENTAL DEGRADATION AS A FUNCTIONAL ELEMENT OF INDUSTRIALISM

The present industrial order is structured and motivated by the logics of technology and capital. Though conventional development thoughts imply that development consists of the three combined processes of modernization, economic growth and nation state building, Neo-Marxist thoughts argue that all these processes are integral parts of the world capitalist system's prescribed norms and laws. In other words, those processes mean the steady penetration of capital into all spheres of social life, the dictates of the movement of capital and the creation of an internationally dependent and subservient state machinery respectively. Within this system, it is a logical result that so-called "interdependence" is characterized by unequal exchange, uneven development and relationships of domination and dependence between the center and the periphery. Marxists and Neo-Marxists have traditionally looked upon environmental problems as a necessary, but unfortunate, consequence of the development of capitalism. Thus, according to them, the best way for developing countries to enhance the environment and economy is to disengage them from the international capitalist economic system and to assume the socialist mode of production.

However, Marxism and capitalism are basically systems of industrialism, dedicated to maximizing material production and narrowly conceived technological progress (Henderson, 1981: 22). They are the only options for an industrial society. Both the conventional and the socialist approach rely upon a fundamental assumption that the historical evolution of humanity leads to progressively higher stages, and these higher stages are measured primarily in terms of human technological capability and man's capacity to dominate nature and to transform natural resources for his own material uses. Though the Marxist approach concerns structural change in light of the distributive issue, the main goal of structural change is the transformation of the productive and distributive system. Thus, techno-economic efficiency, productivity and growth emerge as the dominant values in the socialist societies as well as in their capitalist counterparts. It is their common participation in the methods and structures of industrialism that determines the extensive similarities between the two system (Daly and Cobb, Jr., 1989: 12).

The theoretical side of socialism appears to give better protection at least to the human environment, since labor is seen as more than simply the means to economic ends. In practice, the tendency to turn both labor and nature into commodities has been quite as forceful in socialism as in capitalism (Miller, 1991: 95). As Redclift (1989: 177 - 78) points out, Marxism envisages labor, capital and technology, rather than environment, as the essential elements of society. Marx himself expected socialism to bring social mastery over nature, through the rational use of advanced technology. Environmental consequences are, at best, a residual concern even in Marxist theory. It has failed to regard the environment as a system in which human productive activities are constrained as well as realised. The environment is constantly evolving in concert with the social system in ways which alter its character. In reality, both capitalist and socialist economic orders have structured their ideologies around "the myth of abundance and ecological plenty" (Miller, 1991: 82). They are exploiting nonrenewable resources and waste absorption capacities at unsustainable rates.

As long as both systems attempt to maximize productivity and wealth under the cornucopian view, it does not make any difference whether the ownership of the means of production belongs to the private sector or to society as a whole. Though it is true that markets are very poor in providing foresight to deal with future and environmental problems, there is no reason to believe in better functioning by planning mechanisms. Rather, criticism from socialist society is being heard:

> "The crisis now being experienced by the socialist countries springs from a planning illusion. It was assumed that nationalization of the economy would clear the way to central control of the flow of capital goods and human behavior for the good of society as a whole. It turned out, however, that interests within society are conflicting, that extreme centralization of decision-making not only does not reduce, but actually encourage, deviant behavior, that there is no algorithm for guiding complicated economic and social processes, and that bureaucratic control is none too effective (B. Jalowiecki quoted in Redclift, 1989).

As Redclift argues, "the more technological innovations incorporate environmental consideration, the more necessary it becomes for environmental policy to be subjected to greater democratic control" (1989: 182).

Whatever options - capitalism or socialism at present - might be taken, industrialism has geared traditional societies, both past and present, "toward larger scale and greater specialization, with the consequences of increasing integration and interdependence and of increasing vulnerability to systemic failure" (Daly and Cobb, Jr., 1989: 12). It becomes obvious that the political frameworks of socialism and capitalism have not served to greatly differentiate the environmental repercussions from their respective production regimes. Rather than pursuing questions of the locus of decision-making power, understanding the environmental crisis requires examination of the economic common denominator: the ideology of abundance and its attendant industrial regime.

CONCLUSION

The environmental crisis in industrializing countries cannot be disassociated from the structural relationships which have tied them to the regimes of industrialized nations. Unable to establish economic independence due to a lack of capital or technology, or the difficulties encountered in entry into an existing world market, developing countries must succumb to some level of dependence upon those controlling the existing order. What has occurred is the transfer of not only capital and technology, but the energy-environment-development nexus born of the ideology of abundance. Developing nations are reproducing the energy and environmentally-intensive patterns of their sponsors, exacerbating rather than addressing the global dimensions of the crisis.

Industrializing nations have been incorporated structurally into the economic arena, playing a role as significant as all the others. This role, however, is defined as a resource mine, which is fundamental to fueling the "megamachine" of industrial civilization. Industrialized countries have conceived the Third World as a commodity pool which represents a new frontier to be exploited. Environmental degradation will continue as long as developing countries assume the definition of progress incorporated into current development practices.

As Daly (1990) points out, what is certain is that the present mode of development is **unsustainable** in every aspect - energy system, environment and resources. "We are living by an ideology of death and accordingly we are destroying our own humanity and killing the planet" (Daly and Cobb, Jr., 1989: 21). Entire economies must be shifted toward a system that combines more people with less capital, energy and, material. As the recent idea of sustainable development indicates, we should break with the prevailing linear model of economic growth and accumulation that ultimately serves to undermine the planet's life supporting system. Only by breaking the bond of industrial ideology can developing countries begin to consider methods by which to instill meaning and viability into their environmental reality.

Foot Note

1 Consumption in six countries in the Middle East (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia. and the United Arab Emirates) exceeded that of those listed, but have been excluded from the ranking due to unusual economic circumstances in the region during the 1980s. These countries are, however, included in the global average.

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Religion and Ethics

AFTER EVE: VARIOUS WOMEN'S APPROACHES TO RELIGION, VALUES AND SCIENCE

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Feminists in religion have come rather late to a focused concern on science. I just did my first academic paper on the topic "If Biology Is Not Destiny, What Is?" looking at how notions of sin shift with scientific advancements. As the religion and science conversations heat up we notice that women's voices are few and far between on both sides. We are only now bringing some of the insights that feminists have brought to religious studies to our concern for science and values. Let me mention four such concerns:

First, feminist work is primarily an analysis of power, with the clear affirmation that women and other marginalized people, as well as the earth and animals, have been excluded from serious consideration when religious ethics have been developed. Terms like "dominion over" and "subdue the earth and all things in it" have given religious justification to the same power dynamics which have kept women dependent and subservient, and resulted in degradation of animals and abuse of the earth.

Forthcoming work by feminist theologians Rosemary Radford Ruether (Gaia and God) and Carol Adams (Eco-Feminism and the Sacred) bring these matters to the fore. Dr. Ruether critiques images of the divine which encourage such behavior. Carol Adams suggests that women, like the earth, are used as natural resources in reproduction, an insightful image for dealing with the current abortion debate, a debate which is largely fueled by religious ideology. In short, religious feminism is a major shaper of cultural values. In order to shift the power equation we cannot ignore religion.

Feminist work is having an impact on churches/synagogues despite mighty resistance in many corners. The impact is on questions of power as much as questions of content: who says who/what the divine is, who says that something is right/wrong, whose perspective is taken into account, and, in line with the many other liberation theologies, how can those who/which have been marginalized be empowered? It is these feminist religious questions that I bring to the dialogue with science.

A second area of inquiry is what is referred to as "womanist theology." It is a close cousin of feminist efforts. Alice Walker said "womanism is to feminism as purple is to lavender"-- meaning that womanism is the particular work of African-American women who are concerned as women with their survival and the survival of their dependent children. It is akin to feminism as well as to black theology done by black men. Both feminist efforts by white women and black theological efforts by black men fail to articulate what a womanist approach does, namely, the specific nexus of oppression that comes with being both black and a woman.

The key womanist insight is that survival is communal. As Alice Walker put it, a womanist is "committed to survival and wholeness of entire people, male **and** female." To which I would add, to the whole ecosystem. The point is that survival can no longer be read in a private, individualistic way after the fashion of those religious writers who spoke of individual salvation. Rather, it is a communal goal with "communal" having a far wider extent than previously imagined: humans, animals, the earth and even the cosmos. One begins to see the usefulness of this approach in religion, also the challenge that womanists offer when taken seriously, a challenge to individualism and a demand for solidarity. When coupled with ecological concerns, issues like life after death take a profound shift.

A third insight from feminist work in religion which is relevant for the conversation with science and ethics is the degree to which we have embraced an international perspective perforce. Religious organizations are finally transnational corporations with international subsidiaries, no less so feminist work in religion and science.

My favorite example of the moment is the exciting if difficult conversation on RU 486/PG, the French abortion procedure which is an alternative to surgical abortion. There is currently an import ban on it in the U.S., but there is much to be learned from French women, tens of thousands of whom have used it already, and from women in Bangladesh, some of whom argue that this will not be appropriate technology in their settings.

Religious feminists who are pro-choice in this country must find a way to steer a course between the hearty affirmation from France and the cautionary tale from Bangladesh, between the enthusiasm of activists rightly insulted by the import ban and the capitulation of drug companies and governments to the right-wing, and the strong warnings of those feminists who argue against any invasive and uncertain technologies.

This is the complexity we face, but it is important to locate the source of this uncertainty as a shared feminist commitment to women's well being with varying strategies for making that happen. Religious feminists are providing the framework for such ethical challenges, and some of the concrete linkages with women in other countries.

A fourth aspect of a contemporary religious feminist approach to issues of values and science is explicit talk about eco-feminist theology and the sacred. Frankly, here I think we are balancing between two poles: on the one hand, the stereotypic notion that women approximate the sacred more than men or at least that feminist values of inclusivity and mutuality are more promising as we move in that direction, and on the other hand, the resistance some of us feel toward making such a claim for fear of falling for the woman and nature trap.

Here one begins to see how Goddess imageries of various sorts, rituals related to the earth, the seasons, our interaction with plants and animals, all take on increased centrality as feminist/womanist perspectives get woven into the larger religious fabric. I reiterate my personal nervousness about some of this, but underscore the exciting possibilities that are emerging. I would not hazard a definition but I can say that concern for and acknowledgement of the sacred dimensions of human experience are essential elements of any discussion on values.

Scientists may wonder why theologians consider these matters central. For my part, as a theologian I cannot imagine another way that gets more quickly and viscerally to the heart of massive cultural shifts in the late twentieth century. In this sense, to say "Goddess-we" and to work, pray and strategize toward the achievement of "right relation" with all of creation is a feminist/womanist challenge and contribution to both theology and science.

A MEDITATION ON FATE AND DESTINY IN A TECHNOLOGICAL AGE

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To claim that one can simultaneously meditate on fate, destiny, and technology must seem odd. We usually associate technology with rational planning and design rather than strange forces beyond our control. Yet, our reluctance to consider the prospects of fate and destiny in a technological age partly accounts for our ambivalent, and at times disquieting, relationship with modern technology. The purpose of this brief essay is to sketch some rough contours of such pondering. To accomplish this I begin with the customary definition of terms.

By "fate" I mean a future state or condition that is beyond our ability to avoid or prevent. We may be able to delay a fate, but eventually it will have its way. Death, for instance, is a fate we all share.

"Destiny" is closely related to fate, but is subject to our manipulation. A particular destiny is formed by a combination of circumstances both within and beyond our control. Although we all share the fate of death, how and when we die is also partly a matter of the destinies we shape; e.g., if we choose to smoke, decide not to exercise, or how we respond to dangerous situations.

A "technological age" provides the dominant modern context for pondering our fate and destiny. We are, as George Grant observed, in "each lived moment of our waking and sleeping" a "technological civilisation" (Grant, 1986: 11). Unlike previous generations, capricious natural forces no longer command our attention; the wilderness is not a threat but something we must protect. We live within intricate webs of industrial, transportation, communication, and medical technologies; they are the primary tools with which we forge our destinies and delay our fates. A good death, for instance, now means something far different than it did to our ancestors.

I have chosen the word "meditation" because of its religious implications. To meditate on a particular set of circumstances requires both knowledge and faith; it combines what we believe is true as well as what we trust. In our growing fascination with and dependence upon modern technology, we catch a glimpse of, in Martin Luther's words, what our "heart clings to. . .and relies upon" (Niebuhr, 1960: 119). Jacques Ellul is correct when he claims that we have wagered our well-being on technique (Ellul, 1990: 1-31). Such a high stake forces us to consider questions of fate and destiny. As is true with any great gamble, we need to consider with a religious, if not reverent, attitude what we may lose or win in the process. With these preliminary observations in mind, we can move-on with this brief meditation.

Our love-affair with technology reflects a desire to displace our natural fates with a technological destiny. This desire in turn stems from a belief that if we can better manage or master our present circumstances, the prospects for our future will be much improved. A destiny shaped in our image of rational control and management is preferable to a fate formed by capricious natural forces. A scientific knowledge of the world can be used to manipulate it to our perceived benefit.

Consequently, the advent of modern technology was accompanied with great optimism. A utopian age had been born. Despite his profound reservations, even Ralph Waldo Emerson was captured by this vision. A few excerpts from his essay on "Fate" reveal a popular and pervasive belief that humanity was on the verge of controlling its own destiny. He wrote: "If Fate follows and limits power, power tends and antagonizes Fate" (Gilman, 1965: 388). Later, we are more simply assured that "intellect annuls Fate" (Gilman, 1965: 389). Indeed, fate is only a debilitating fantasy for it is nothing but "a name for facts not yet passed under the fire of thought;--for causes which are unpenetrated" (Gilman, 1965: 393). With this penetration we learn that the "first and worst races are dead," the "second and imperfect races are dying out," leaving the future to a "maturing" or "higher" humanity (Gilman, 1965: 395).

Emerson personifies, I believe, the dominant common-sense notion of our present age. Although his words echo from the nineteenth century, they still express our principal assumptions and values. We are a people who have been shaped in an image of inevitable progress. Modern technology is simply the most concrete example of a comprehensive wave of improvement which includes intellectual, political, social, moral, and spiritual progress. What is "contemporary" is always synonymous with what is "best." Technology is also the collection of tools we have chosen to create and control our destiny--malleable instruments subject to our progressive knowledge, skill, and virtue. If fate has not been eliminated, it has at least been pushed so far aside that it casts but a tiny and insignificant shadow on our present circumstances. Our destiny is now literally in our own minds and hands.

Yet, the means we choose alters the ends. We deceive ourselves when we assume that technology is infinitely malleable and inevitably progressive. Technology brings with it a particular destiny. Again, as Grant observed:

> To put the matter crudely: when we represent technology to ourselves through its own common sense we think of ourselves as picking and choosing in a supermarket, rather than within the analogy of the package deal. We have bought a package deal of far more fundamental novelness than simply a set of instruments under our control. It is a destiny which enfolds us in its own conceptions of instrumentality, neutrality and purposiveness (Grant, 1986: 32)

In short, we increasingly define our identities and sense of purpose in technological terms.

After a while a technological destiny begins to look very much like a fate. Modern industrial, transportation, communication, and medical technologies have been introduced with the promise that we would enjoy increased freedom, leisure, mobility, and autonomy.

To use contemporary jargon, the bottom-line is that we would gain greater control over our lives.

To a limited degree this promise has been honored, but one must surely pause to wonder if "control" is the best word we should use to describe our life in a technological age. We certainly have a growing range of options available to us regarding consumer goods and services, but the decisions that most affect our daily lives are increasingly far-removed from our direct control. The use of modern technology requires a great deal of management and expertise; consequently, our lives are increasingly shaped by impersonal institutions, complex policies, and omnipresent bureaucracies. For the sake of greater control over our lives we are sacrificing personal judgment in favor of prescribed procedures and protocols; in the name of a humanly created destiny we are inheriting a fate of increasingly sophisticated technologies which are largely beyond our understanding, much less control.

A technological fate offers only an illusion of control. This is most often depicted as fabricated options which we consume to express our unique identities, or that curious term "lifestyles." Cable television, for instance, was hailed as a great benefit to education, the arts, and even the democratic process. Yet, the proliferation of channels primarily offers us a greater range of banalities to occupy, or better kill, our spare time. A technological age also has no future, only an endless process of planning and management. We have purged ourselves of utopian dreams, much less hope for a new Jerusalem, and replaced them with a vague presumption that our rational knowledge and skill will somehow always lead to longer, healthier, and happier lives because of our growing mastery over capricious natural forces. Yet, are the prospects of toxic waste or persistent vegetative states more reassuring or comforting than those faced by our ancestors?

It is our reluctance to address the possibility that our efforts to construct a technological destiny is leading to the birth of a new fate that accounts for much of our contemporary ambivalence and anxiety. It is difficult to live at peace in a world of control, yet no-control, of a future with no-future. Modern technology is molding us in its image, and we are not entirely pleased with the results but lack the vocabulary to challenge such a fate. For modern technology does not solve but only exacerbates perennial moral and spiritual longings. There are two brief examples which illustrate the problem I have in mind.

The first example is the practice of modern medicine. We have come to expect, almost as a right, that physicians will give us a long and healthy life. This is accomplished through routine interventions from birth to death--and even beyond. We can now conceive children in the laboratory and take living organs from those who are dead to place them in others who need replacement parts. The accomplishments of modern medical technologies are breathtaking, but they have not eliminated the dreaded evil that makes them necessary. As Stanley Hauerwas has observed:

> Sickness should not exist because we think of it as something in which we can intervene and which we can ultimately eliminate. Sickness challenges our most cherished presumption that we are or at least can be in control of our existence (Hauerwas, 1990: 62).

In the face of sickness, particularly terminal illness, modern medicine cannot provide what we really need, for again as Hauerwas ironically reminded us: "We do not need a community capable of caring for the ill; all we need is an instrumental rationality made powerful by technological sophistication" (Hauerwas, 1990: 62). When we are sick we grow dependent upon human caring, yet we increasingly place our trust and confidence in techniques that work against this quality. For technology can only reinforce our autonomy and mobility, forces which prevent the formation of covenanted communities that provide the caring we require. Hence our paradoxical attitude toward medicine in which we invest heavily in instruments to extend our lives and yet also fear that they will keep us technically alive for too long.

The second example is the prospect of human genetic engineering. Medical science has failed to conquer disease because the raw material it works with is of inferior quality. Our next great hope in our war with sickness is to improve the genetic profile of our species. The Human Genome Project, for instance, is partly justified by the promise that when complete, the physical and mental health of the nation will be significantly improved. Genetic maps can be used to screen fetal development in order to identify abnormalities, and then either therapeutically correct them or prevent them from coming to fruition.

I have no doubt that our growing ability to intervene in human genetics will improve the quality of life for individuals who face a variety of debilitating and life-threatening conditions. Yet, our efforts reveal a startling presumption: There is, perhaps, such a creature as a normative human being that can be identified and determined by genetic criteria. The moral and spiritual dilemma is what will be the fate of those who fail to meet implicit minimal standards? In the past, when parents gave birth to a child with genetic abnormalities it presented an opportunity to exhibit compassion and at the very least the parents were not blamed for this "mistake of nature." I suspect, however, that in the future parents will be held accountable for these "mistakes" as the means for identifying, correcting, or preventing them become increasingly available. A calling for compassion will be transformed into a moment of assigning moral blame.

I freely confess that I have committed the sins of overgeneralizing and hyperbole in this meditation. The task was more daunting than I first imagined, for it requires a transcendence over the spirit that has shaped our present circumstances, and I am very much a child of a technological age. I have no desire to give-up my personal computer or cable television, and I suspect I will gladly accept any medical procedure that might improve or prolong my life. Yet, I also have this vague feeling that all is not right with our world that prides itself on its progress.

To fall back upon generalization and hyperbole means that I have no obvious religious or theological answer for the spiritual and moral unrest of our present age. I can only conclude with an attempt to offer some questions.

With all our technological skill and potential, are we losing our ability to wonder? To wonder invokes a desire to understand and search for meaning in the face of, in James Gustafson's words, "a power that bears down upon us," and "sustains us" (Gustafson, 1981: 264). Increasingly, these forces are of our own design or manipulation. What does "understanding" now signify, and what is the context of our search for meaning? What do such simple values as truth or beauty become as they are reshaped and redefined in a technological image? Which communities and virtues do we use to form our character in a world obsessed with autonomy and mobility? What becomes of caring and compassion when our attention is directed toward identifying, correcting, and preventing mistakes? Does our trust in planning and management reflect a maturing sense of responsibility, or "our impoverished idea of what it means to lead a good life"? (Lasch, 1989: 9)

A few simple anecdotes will illustrate what is at stake in these questions. Last summer I took my eight-year old daughter to her first major league baseball game. Most of the time she watched the giant screen television rather than the playing field. At one point a player hit a homerun. "Did you see that?" I asked her. "Wait a minute," she replied as she continued to stare at the huge TV. After the replay she exclaimed, "He *really* did hit a homerun!" What type of world, in what reality, is my daughter pursing her wonderment?

A few weeks ago some students in my class informed me that they had spent the previous evening "listening to music together." As they talked, it became clear to me that none of them were referring to a common tune. I was told they could not agree on the music, so they broke out their walkmans and listened to different tapes. What does it mean in a technological age to share a common experience or practice?

Within the last year I have met two women, with Down syndrome children, who on two separate occasions were shopping in our local grocery store. In each instance, a stranger approached them and asked, in no uncertain terms, why they had allowed these unnecessary persons to be born. What becomes of compassion with our growing ability to prevent "mistakes of nature?"

These questions are not as random as they might first appear, for what links them are the larger issues of fate and destiny. If we are unwilling to religiously consider or ponder the possibility that our technological destiny is becoming our fate, then we are literally left to our own devices. That prospect is not as cheerful an idea as when we first embarked upon the construction of our modern destiny.

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ETHICS FROM A SCIENTIFIC BASIS

by

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1.0 Normally morals are based on religions, while ethics are established by philosophers and custom. We are now proposing ethics based on the scientific method in general and specifically the Science of Evolution.

1.1 The scientific method consists of objective experiments and observations, confirmation by others and the development of a self-consistent body of knowledge which grows by accepting refinements, additions, and occasional deletions. This method has proven to be a more accurate process for explaining reality than supernatural phenomena, religion or a philosophy rooted in the era of its author. Theories and hypotheses, expressed mathematically, lend themselves to predictions which can be independently tested by others world-wide. Thus we propose to use a scientific approach to develop ethics.

2.0 The prime assumption of the proposed scientific basis for ethics, as shown in Fig. 1, is that:

The most precious thing in our life is life itself.

Later, some apparent exceptions, which really are illusory, will be covered.

2.1 The scientific basis presented here is the biological and social evolution of mankind. The formal fields are biology especially molecular biology, genetics, anthropology, sociology, chemistry, physics, mathematics: all now integrated in a new discipline called sociobiology.

2.2 The basic concept utilized, as shown in Fig. 2, is that,

Those physical and mental traits common to most humans, preferentially selected by natural and societal forces in the evolutionary process are positive guides to purposeful actions. These guides are considered to be the scientific basis of ethics because they gave us our most precious human possession,

namely, life itself.

Natural forces selected those physical and mental characteristics which proved to be more effective at accommodating mankind to the then existing environment and to subsequent changes in the environment. Currently societal forces are apparently also selective.

3.0 On this basis any predecessor of humans must have had at least the following characteristics which will be called "Primordial Laws" or PLs.

3.1 A strong will to stay alive. This is evident in the struggles of a drowning person and the frantic speed of a prey fleeing a predator. This is called PL 1.

3.2 Once successful in staying alive, any living specimen must leave progeny. There must be a strong urge to copulate which we now call the sex drive. This is designated as PL 2.

3.3 Copulation and the subsequent birth are a necessary but not sufficient condition for propagation of our specie. Human off-springs must be fed, nurtured, protected and taught skills for many years before they are capable of self-support and procreation themselves. This is PL 3.

3.4 Cooperation with the kin or group it lived with, to protect and promote their well being as well as his/her own. Such altruistic actions is in reality selfish as it increases the probability of success in propagating one's own genes. This is due in part to the following mechanisms:

a. Reciprocity. If I help you now, you will help me later.

b. "The strength in numbers." The result of a group can be greater than the sum of the results of the individual efforts. In addition the group is able to accomplish feats that no number of individuals could.

c. Increase in productivity by the division of labor.

d The tribal environment permits the development and utilization of rare and special skills. One has the time to become a shaman, a tool maker or an artist if and only if others will provide food and shelter in return.

e A biological advantage for self-sacrifice. As each offspring gets 1/2 of its genes from each parent, saving 2 offspring preserves a "set of one's genes". Saving 4 offsprings saves two sets of genes. As your siblings share with you your parents genes, they and your cousins and nephews and nieces in lesser degree do the same. Saving large numbers of your group acts to preserve your genes and gene pool. Thus an apparent exception to PL 1 is really not an exception.

Returning to the tribal instinct, to cooperate and act in groups is designated as PL 4. . Many sub-ethics remain to be formulated. The environment of the tribe provides a complex mixture of rights and responsibilities sometimes called "The Social Contract". This will be expanded upon at another time.

3.5 As there are many ways to adapt to any change, the ability of individuals to pick different ways provides nature and society with alternatives from which the best ones can be selected. Thus the freedom of an individual to take whatever action he/she thinks best is safest from an evolutionary process and becomes

PL 5. Philosophically this is akin to freedom for the "Pursuit of Happiness"

3.6 There were many significant biological changes during our evolution:

a The height went from 4 ft to about 6 ft or a 50% increase..

b The weight about doubled.

c The limbs rotated so that height and visibility increased but more importantly hands became free to hold things like extra food and weapons.

d The receptivity of the female to copulation went from a few days a month, when in estrus, to almost the entire month. This ensured that the male hung around and helped feed her during pregnancy and during the long period of child care. This is the basis of the "Marriage Contract" and the family. These and other physical and mental changes led to the growth of love rather than the conventual "bang-bang thank you mam" copulation common to most mammals.

e But the most significant change of all was the increase in the size of the brain. This went from about 400 cc to about 1500 cc, a 3-4 fold increase. It is this increase in intelligence which allowed mankind to conquer the beasts that were stronger, faster, had bigger teeth and sharper claws. P' ing a high value on intelligence is PL No. 6.

3.7 The ability to communicate abstract thoughts became a significant factor in group activity. Those that could do more than grunt were selected and the larynx and vocal cords grew. The ability to give complex instructions, pass on bits of knowledge, experience and feelings of love all lead to more efficient operations. We call this "freedom to speak" PL 7.

3.8 Sometime during the growth of intelligence, man began to ask the question, "WHY?". To satisfy this curiosity when no answer was apparent, an answer was invented. This initially led to the personified gods and nubile spirits assumed to cause all observable natural phenomena. However this concept was not supported by experience. The number of gods decreased to one, an ethereal God who started it all and is responsible for everything. Religion apparently provided solutions to many of life's great problems and paradoxes and became and still is, very supportive and popular. Some of the reasons for this will be expanded upon later. Now, science provides a better and confirmable explanation of natural phenomena. Many of the great advances of mankind occurred because of the effort to answer the question, WHY? Thus curiosity and its satisfaction is PL No. 8.

3.9 An investment of time and effort in order to fashion tools, weapons and clothing paid off but only if the benefits accrued to the person who had made these investments of time and effort so that he could help himself, his family and kinfolk.

The philosophic ethic, "From each according to their ability and to each according to their needs" sounded very attractive in principle to much of mankind in the last century. But the failure of the 70 year communist experiment has, in part, proven that this philosophic ethic goes against human nature and is not effective. Of course there were some other reasons as well.

The passion for ownership in whatever one has made (or now in its equivalent money) becomes PL No. 9.

3.10 As insurance against extinction, it was better that mankind spread out and be in as many different places as possible. No natural catastrophe like an Ice Age or a social calamity like a war or a genocide would wipe him out. Thus the wanderlust is an instinct that had survival value. This is PL No 10. It is the basis of our inalienable right to "go where the grass is greener."

4.0 If the above characteristics, summarized in Fig. 3, did not exist in the human race, we would not be here in our present form. Thus we have the axiom :

Those physical and mental traits common to most humans, preferentially selected by natural and social forces in a process called evolution, are positive guides to purposeful actions. These guides are considered to be the basis of scientific ethics. There are many sub-ethics under each of them that need to be defined and proven.

4.1 There are some problems however in the application of these SciEthics. Human traits are not uniform throughout mankind. That they are statistically distributed must be accepted and utilized. There will be many deviants from average or median behavior but these do not negate statements about the general behavior.

4.2 There is another problem in the application of SciEthics. Today societal forces have mostly replaced natural forces, but our genetic make-up still reflects largely the selections based on the natural forces that existed over the last few million years. Thus we have to accommodate that old genetic behavior to a radically new social environment made by man over perhaps the last fifty thousand years. This provides a feedback loop that may be unstable.

4.3 Science however is now offering mankind a solution to this mismatch by the emerging ability to alter homo's DNA. This is an awesome gift. Nuclear energy, was a gift of science used both constructively and destructively; for energy and for bombs. And like nuclear energy, we will certainly use the gift of genetic engineering. However will it be used for mankind or for a specific tribe? Do we have the ability and the social structure to use genetic engineering wisely? First, we would have to ask, what is meant by "wisely"?

4.4 In spite of the above problems, there are several features that help in the application of SciEthics. First there is a hierarchical system of importance from 1 to 10. This number will probably increase and be rearranged. Second there is a context within the science of evolution by which the situation and consequences can be evaluated. In addition there are simple rational rules:

1. The situation must be described.
2. There must be a logical analysis.
3. A course of action must be defined.

4 The consequences must be anticipated.

If the consequences are not compatible with SciEthics, we have to review the process and probably change our thinking. How do we formulate ethics that accommodate the deep seated, old genetic instincts to the new societal environment? Also we must remember that there are no absolutes; thus there may be exceptions.

5.0 Now let's try to apply these SciEthics to a few ethical medical problems

5.1 Problem 1 Euthanasia

Situation: Your elderly patient is incurably ill, is in pain and will soon die. He knows this and requests euthanasia.

Analysis: Since he can do nothing to propagate the specie, directly or indirectly, PLs 1,2,3,4, are inapplicable and thus PL 5 applies.

Course of Action: Do as he asks. What appears to be a violation of PL 1 is really not because the resources to keep him alive could be better spent to enhance PL 3 and PL 4 which would act to propagate his genes.

Consequences: The chances of a medical miracle that could cure him, being discovered, before he would die normally, is vanishing small. His pain will end. His children will, secretly, be relieved. His funeral will be earlier. One can live with all these possibilities.

5.2 Problem 2 Early Sex

Situation: A 15 yr old girl, a child you have delivered and doctored all these years has discovered sex and wants to experiment with an eager boy friend and seeks your help.

Analysis: PL 2 applies and statements like, "Don't do it, take a cold shower or go ask your parents" will not be followed. But PL 3 and 4 also apply.

Course of Action: Education. Give her condoms in case the boyfriend forgets. Also give her a pill. Advise discretion. Check both for transmissible diseases.

Consequences: If there is a pregnancy you can abort it. If the parents learn of the sexual activity and come to you in anger, you will have to educate them as well. None of these consequences are disastrous.

5.3 Problem 3 Abortion

Situation: A 3 month pregnant woman had her fetus genetically tested and found it would have Down Syndrome. She wants an abortion.

Analysis: Her two prior children are normal. The extra care of an abnormal child would burden the family so that they and the other children would suffer. The parents are both college graduates, have professional careers and are reluctant to acknowledge that they have a child who is an "idiot". There is a certain amount of ego damage involved. Both are in agreement on an abortion.

Course Of Action: Enact a promise to try again and perform an abortion.

Consequences: If the abortion causes loss of the ability to conceive, they already have two children. Death from a medical abortion is so remote as to be only mentioned but not emphasized. No other consequence appears to be significantly disastrous in the evolutionary sense.

Problem 4 What problem bothers you? Would the use of SciEthics help in resolving them? Feel free to write to me about it. Also about any other aspect of this scientific approach to ethics.

Basic Assumption

The most precious thing in our human life

Is life itself.

Fig. 1

AXIOM

Those physical and mental traits
common to most humans,

Preferentially selected by
natural and societal forces in the
evolutionary process

Are positive guides to purposeful
actions.

These guides are considered to be
the scientific basis of ethics.

Because they gave us our most
precious human possession,

Life itself.

Fig. 2

SUMMARY OF SCIETHICS

1 Do what is necessary to stay alive.

2 Consenting sexual activity is necessary and healthy, but

3 Any progeny must be nurtured until they are able to be self supporting.

4 Cooperate with and do no harm to others in your tribe.

5 Do your own thing but remember 4 above.

6 Value intelligence above strength and speed.

7 Speak up and give others the benefit of your thoughts.

8 Value curiosity and try to answer WHY? scientifically.

9 The things you make by your own efforts are yours.

10 You are free to go where the "Grass Is Greener"

Fig. 3

HOW SHOULD NON-TECHNOLOGICAL SOLUTIONS BE JUDGED?

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This paper consists of a case to be discussed by students, a section full of questions which students might debate or discuss, and a few comments.

It has been persuasively argued in recent issues of NASTS News that merely lecturing to students or their teachers will not achieve STS literacy. One way to actively involve the learner is through the discussion of case studies. What is offered here is a rich case study that raises questions about what it means to be a scientifically literate society and what rights minorities should have in a technological society. What I propose is that case studies, like the one in this paper, be discussed by students as part of the STS component of classes.

Please note that in the title of this paper, and below, I assume that some proposed solutions to society's problems deserve to be called "non-technological." For example, I would call sexual abstinence a non-technological solution to teen pregnancy. I am aware, however, that not all would agree with this distinction.

A CASE FOR STUDY. This case involves two sets of parents and how they handled the problem of health care for their sick child. One set of parents turned to modern medicine -- the high-tech solution to health care preferred by most of Western society. The other set turned to what I call a non-technological solution preferred by the minority to which they belong.

In 1986, the parents of Robyn Twitchell turned to Christian Science prayer exclusively to heal their child. This mode of treatment had been used in the families of both parents for generations and they had seen it work consistently for their own children. During their child's illness, they report having seen ups and downs until finally, on the fifth day, he appeared to be improving. Then, suddenly, the child died. An autopsy showed that Robyn died of a rare congenital condition called Meckel's diverticulum -- more generally referred to as a bowel obstruction.

Also in 1986, the parents of Poltergeist movie star Heather O'Rourke were faced with a sick child. They took their child to a physician. The child was given the best medical care available, but she died -- just as had Robyn Twitchell -- of an undiagnosed bowel obstruction.

The parents of Robyn Twitchell were prosecuted for manslaughter and, after a jury found them guilty, were sentenced to use medical technology for their surviving children. (To a Christian Scientist, this was like sentencing observant Jewish parents to feed their children pork or sentencing Roman Catholic parents to allow their daughters the option of having an abortion.)

When their tradition failed, no one even suggested prosecuting the parents of Heather O'Rourke. Even had they been prosecuted for choosing a system that failed, they would never have been sentenced to turn to prayer-based treatment for the care of their surviving children.

The aspect of this and other prosecutions of Christian Science parents that raises the most danger signals for society is that, when these cases have come to trial, evidence of the effectiveness of Christian Science care for children has not been allowed in court.

Christian Science is not an anti-technology culture. Christian Scientists say that they normally forego medical therapies much as an environmentalist might reject a particular technology such as chlorofluorocarbon aerosol sprays. Christian Scientists do not find medical therapies to be the best solution to the problem of maintaining health, given their particular values. They feel they are choosing the approach to health care that is most likely to keep them alive and healthy and believe they have a good enough overall record to deserve to practice this approach.

Many Christian Scientists who were raised in the medical tradition and came later in life to this denomination will tell you that they believe Christian Science works better for them than the medical tradition they left behind. Members of this denomination would not, however, be comfortable with a simplistic comparison of their holistic approach with the very different approach to health offered by modern medicine. They would not, for example, feel that their way of life could be fairly or appropriately judged using the kind of double-blind test that is used to assess a drug or a surgical procedure.

QUESTIONS FOR DISCUSSION. In the case just described, the state is faced with two different solutions to the problem of health care. One solution is highly technological in nature.

This is the solution preferred by the majority. The other solution is non-technological and is preferred by a minority.

Let's work up to the discussion of this case by considering first a series of simpler hypotheticals.

(1) Let us say that two competing medical procedures are under review -- one well established and one new. Would it be scientific or rational to consider the overall record of the established procedure but to judge the newer procedure only on its failures?

(2) Consider a proposal to administer a drug to children who have certain criminal tendencies. Against this, consider an alternative proposal to treat these children by putting them in extremely supportive foster families. Would it be scientific or rational to allow into evidence the overall record of the drug but to consider only the pitfalls of time spent in foster homes?

(3) Let's assume that, in the future, using a particular drug to treat children with criminal tendencies becomes an established and accepted remedy. Consider then, a minority group of parents who want the right to raise such children without the drug but in a particularly supportive family setting. Let's assume, further, that both solutions yield some successes and some failures. We want to examine these alternatives in a scientific and rational way.

The most appropriate way to assess the chemically-based solution may be a double-blind test. Is this also the best way to assess the non-technological solution? Double-blind testing would involve placing children with and without criminal tendencies in some families which are and some families which are not loving and supportive. Is it appropriate to randomly place normal children, or children with criminal tendencies, in families known to be unsupportive?

(4) Let us suppose that, in the future, technology is developed for identifying individuals with criminal tendencies before birth. Let's further say that experts become convinced that fetuses with these characteristics should be aborted and a majority of society concurs. How, then, should public policy deal with a minority that believes in bringing all such children to term and raising them in a nurturing environment?

Should these minority parents be prosecuted every time such an unaborted child becomes anti-social? What if this minority has a good overall record of raising these children to be law-abiding citizens? If the model illustrated by the Twitchell prosecution is followed, this good record will be ruled irrelevant, and parents who refuse the abortion will be prosecuted for every failure of their alternate approach. Parents who agree to the approach preferred by the state, however, will not be prosecuted even should their surviving children for some reason become anti-social.

What constitutes a scientifically literate approach to public policy? Is it scientific and rational to judge the solution to a problem by considering only its successes? Or only its failures? When considering alternative solutions, is it scientific to refuse to consider the overall record of any one of them? If this is unscientific and irrational, what are the implications of the state acting in this way?

Let's now turn from hypotheticals to consider the contrast between the actual treatment of the parents of Heather O'Rourke and of Robyn Twitchell.

What does this contrast say about the state's possible approach to other technologies? Might the state establish nuclear power and refuse to consider the advantages of alternatives? Might the state develop a preference for genetic engineering and then judge alternatives only on their failures? Should we expect the state to act in a scientific and rational way in deciding which alternative solutions to allow and which to outlaw? How much irrationality and prejudice must we tolerate in public policy and government decision-making?

When the state refuses even to consider alternatives to modern medicine, is this evidence of a blind faith in a particular technology? Might public officials develop a blind faith in other technologies, such as the automobile? Have they already done so? Might public officials then refuse to give rational consideration to alternatives such as public transportation? How much scientific literacy should we expect from public officials? What amount of factual and conceptual knowledge? What degree of skill in thinking scientifically?

So far in the prosecution of Christian Scientists we have seen experts and vested interests show a predetermined preference for one technology -- medical drugs and procedures. Then, in cases like the Twitchell prosecution, elected officials have proceeded to criminalize those who prefer an alternative to this technology without considering countervailing evidence. When a technology becomes preferred by experts and state-sponsored -- like medicine or nuclear power -- should this end the toleration for and consideration of alternatives? What are the advantages of state-sponsored technologies? What are the dangers?

(Recall that when Lester Brown of Worldwatch addressed one of our conference sessions, he remarked that it might take an environmental Pearl Harbor to overcome special interests in the battle to save our planet. Students who have been thinking about special interests and environmental problems might enjoy discussing the above questions.)

If the approach being taken in the Christian Science cases becomes widespread, might we see similar phenomena with other technologies? When experts develop a preference for other complex, high-tech solutions to society's problems, could this lead prosecutors to then criminalize those who prefer other solutions?

In a free society, will citizens make their own choices or will they have technologies forced upon them by authorities and vested interests? This is a question that STS has been dealing with for a long time. STS professionals have argued eloquently for the rational consideration of alternatives -- including alternatives not among those preferred by experts. But here is a further question: After the choosing is done, will minorities be free to pursue alternatives not sponsored by the state and not chosen by the majority?

Do we want a society that makes room for pluralism -- for a multiplicity of views and choices? Or do we want a society that only responds to the will of the majority? Does making room for diversity strengthen or weaken our society? Should our society sanction only one solution to each complex problem we face and criminalize those who pursue other responsible solutions?

(In one of our conference sessions, Clifford Matthews argued that technological and scientific progress stopped in China when it closed itself off from other cultures and a pluralism of ideas. Students who have been studying the historical relation between culture and technology might be especially interested in the above questions.)

In 1971 Massachusetts passed a law stating that children will not be considered neglected or lacking proper physical care if they are afforded remedial treatment by an accredited practitioner of a recognized religion. In 1975 the Attorney General of Massachusetts rendered the opinion that this law would preclude criminal liability for parents of these children. Some observers of the Twitchell prosecution believe this trial was an attempt to change public policy previously worked out in the legislature. Might elected officials, frustrated by the democratic process, use criminal prosecution to change or make public policy in other areas? Is the courtroom the best and most appropriate place to sort out public policy questions? Is criminal prosecution the proper way to force minority groups to give up alternatives and accept technology? Does the state violate due process when it attempts to change public policy through criminal prosecution?

What arguments might be made for and against permitting many alternate approaches to health care? What arguments might be made for and against allowing technological and non-technological approaches to exist side-by-side? When the will of the majority encroaches on minority practices, how should Constitutional rights be taken into account? Are modern interpretations of the First Amendment true to the intent of its authors? Is there any evidence of an anti-religious bias in these interpretations? Is there a bias in our society today in favor of technological and against non-technological solutions to human problems?

To what extent should government intrude into family decisions made in private? Should parents be subject to criminal prosecution if their children are injured while not wearing seat belts? Should a mother be prosecuted if her fetus is harmed by her smoking or drinking during pregnancy? When family choices are religious in nature, what protection should they enjoy under the First Amendment? What role should children have in making health care decisions that affect them? What role should parents have? What should be the role of the state in making health care decisions?

We know from history that imposing technology on a culture can alter or destroy it. What then is our responsibility towards minority cultures that wish to be exempted from some aspect of technology? The Amish prefer to farm with horses. Some environmentalists prefer solar and wind energy and reject nuclear and coal-generated electricity. Immigrant groups such as the Hmong rely on certain traditional tribal healing practices rather than modern medicine. Native Americans engage in cultural practices that are sometimes at odds with the majority. Many Catholics reject abortion as well as birth control technologies which have become common to our Western culture. As more and more new technologies are established, additional groups, because of their values, may want to stand apart.

(The questions immediately below may be of special interest to students who know something about the debate over Paul Feyerabend's recent books. See, for example, the discussion of his Farewell to Reason by Harvey Siegel and Alfred Nordmann in the journal Inquiry, volume 32, page 343 and volume 33, page 317, respectively.)

The suppression of the practices of minority cultures -- even those with a good record of success and laudable values -- could be the result of the direction taken in the Twitchell case. Is elimination of cultural diversity a necessary side effect of technological advance? Are there ways to have both technology and pluralism in our society? If we agree that minority cultures should be allowed to exist, what criteria will decide which minorities can be tolerated and which cannot? We must be careful here, because if we choose an inappropriate criterion for judging a minority tradition, that criterion may itself be the imposition that destroys the minority culture.

We know quite a bit about how to pass judgment on technological aspects of modern life. A drug is certified if it passes a double-blind experiment and produces no unbearable side effects. But how should we judge the non-technological aspects of life? To reduce everything in life to good and bad technology would be narrow, biased, and inhumane. To avoid such an inappropriate reduction, is there a way to expand our concept of data without abandoning logic and rationality?

When are double-blind experiments appropriate? When are they inappropriate? What other measures are available and when are they appropriate? Should "thick descriptions" of the quality of life experienced by the Amish or the Hmong be considered in judging the choices they have made? Would "unobtrusive measures" such as life insurance statistics be appropriate data to judge the effectiveness of non-traditional choices of health care? What is an appropriate measure of the overall record and quality of a way of life? When both technological and non-technological solutions to problems are under consideration, how should the non-technological solutions be judged?

COMMENTS. One way to use this case study would be to ask students to provide written answers to a number of questions that it raises. You might pick a few of the questions I've listed or you may have questions of your own. An even more active involvement of students might result from a group discussion -- either student- or teacher-led. As background to any use of this case with students, I would like to share a few additional comments.

The death of a child is without question one of the deepest of human tragedies. If we are going to look clearly at the issues raised by this case, we will somehow have to move beyond human emotions and put the action of the state under the light of reason.

One possible approach to public policy on such an issue would be to allow a broad range of solutions to exist in society, ruling out only those that do not have a good overall record of success. This would seem to be the approach most consistent with a commitment to pluralism, freedom of choice, and the welfare of children.

To me, scientific literacy involves more than knowledge of facts and theories -- as important as scientific facts and theories are to an informed citizenry. Scientific literacy must also include a working knowledge of scientific reason. Citizens and public officials should have at least enough scientific knowledge to see that considering the evidence for only one side of an issue is not enough.

Beyond this, scientific literacy should include an awareness of the fact that not all solutions to a given problem can be assessed by the same procedures. A scientific and rational judgment requires the use of measures that are appropriate to each proposed solution.

The Twitchell model, which judges the accepted, technological approach on its overall record but judges non-technological alternatives only on their failures, clearly brings into question the scientific literacy of the state. Perhaps the most ironic aspect of this kind of state-sponsored prosecution is that it is being done in the name of science and technology. Yet the state's refusal to consider the good record of the alternative does little to support scientific methodology or the true spirit of scientific inquiry.

Part of the problem is the decision to take this public policy question into the criminal courtroom where the state is in the role of defending the technology it prefers and proving wrong the minority approach. Despite its demands, the legislative process has proved to be a better forum in which to consider fully and fairly whether a minority should be allowed to practice an alternative to an accepted technology.

Mary E. Hunt writes in the October issue of NASTS News that "the myth of value-free research that prizes double-blind experiments and increasingly complex solutions has been put to rest." As true as this may be among the most scientifically literate, it is hardly true among public officials, in many professional groups, or in society generally. This highlights the importance of the work we are doing at this conference.

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Special Symposium: Women in Science

WOMEN IN SCIENCE: 5000 YEARS OF OBSTACLES AND ACHIEVEMENTS

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When elementary school children were asked to draw a picture of a scientist in a recent study, 820 girls and 699 boys drew male scientists. Only 129 girls and just 6 boys drew female scientists (Fort & Varney, 1989). It is not just children who think of science as a male endeavor. In my 1972 edition of Asimov's Biographical Encyclopedia of Science and Technology, I found listings for five women out of 1195 biographies. (I had to go through the entire book page by page to count the women because there are no index entries for female, woman, or any other synonym.) Checking the 1982 edition at the library, I found 308 more men and 7 more women compared to the edition published a decade earlier.

This is not a trivial issue. In stories of individual lives and in conclusions of education research studies, role models have been shown to be of immense importance in girls' and women's decisions to learn science.

Evidence of women scientists comes from as long ago as 4000 B.C., when a carving of an unnamed Sumerian priestess-physician was made. Written records exist about Egyptian female physicians such as Merit Ptah from 2700 B.C. and Zipporah from 1500 B.C. Ancient Egyptian women could attend medical school with males or attend an exclusively female school at Sais. Tapputi-Belatikallim worked with chemicals used for perfume production in Mesopotamia around 1200 B.C.

At 600 B.C. due to the flowering of Greek science, the number of women recorded per century in historical documents increased about fifty fold to twenty per century. That ratio stayed relatively constant for the next twelve centuries (Herzenberg, 1987). Women were treated equal to men in the Pythagorean Community, Plato's Academy, and the Epicurean School. Theano probably married Pythagorus when he was an old man; she was the leader of his school after he died. Agnodice in 300 B.C. was a successful doctor dressed as a man. When she was to be tried for illegal practice, protests by the women she had healed resulted in changing the law so women could be physicians who treated only women.

In Rome, female physicians were numerous and were allowed to treat men. In the First or Second Century, Maria of Alexandria, also called Mary the Jewess, was an alchemist who invented the water bath, the three-armed still, and other chemical equipment. The last great scientist of antiquity was Hypatia, who was born in 370 A.D. Following the pattern set by her father, she lectured at the University of Alexandria in mathematics and astronomy. She invented the plane astrolabe for measuring positions of stars and planets, an apparatus for distilling water, and the hydrometer for determining the density of liquids. She was murdered in 415 A.D. by a Christian mob trying to stamp out Platonism.

In the Seventh through the Tenth Centuries, as in the beginnings of recorded history, there were few women scientists in the Western World and most were physicians or alchemists. In the Byzantine Empire, the dark ages were not as bleak for women scientists because royal women studied medicine and natural sciences with scholars in their courts. At this time, there were also women engineers in China.

From 1000 to 1400, opportunities for women scientists in Europe reached a new peak, one that was not surpassed until the present century. The rapid growth of monastic life can be credited with most of this increase in intellectual freedom for women. The majority of scientists, male and female, belonged to religious orders. Hildegard of Bingen, a Benedictine Abbess born in 1098, was the most influential of women scientists of this era. She is also the earliest women scientist whose major works are still intact; she wrote about cosmology, medicine, botany, zoology, and geology. (Her versatility is shown by the fact her music for the mass is the oldest such music known to be composed by a woman.) In spite of being periodically ill, perhaps with migraines or epilepsy, she lived to the age of 81.

The medical school of Salerno, Italy, was the first one not affiliated with the Church. Tortula was a professor there, and she wrote several treatises widely used for five hundred years. "At times Trotula's advice seems uncannily modern, emphasizing the importance of cleanliness, a balanced diet and exercise, and warning against the effects of anxiety and stress" (Alic, 1986, p. 51). Little is known about Tortula's life except that she had a husband and two sons who were also physicians and faculty at Salerno. Most likely, she died in 1097. The number and importance of European universities increased greatly beginning in the Twelfth Century, but everywhere outside of Italy they were closed to women.

Contrary to popular impressions of the Renaissance as a period of great resurgence in intellectual activity in Europe, it was a time of decreased participation of women in science (particularly in the 1500s). There were a number of factors causing this decline. Numerous abbeys were closed following the Protestant Reformation, and often their property was given to universities. For other abbeys, their control was transferred from an abbess to an abbot. As universities grew, female physicians who had been trained by other women lost the right to their profession even if they had passed an examination. Not only were women with scientific knowledge called charlatans, with more serious consequences they were called witches. Estimates for the number of people (nearly all of whom were female) executed for witchcraft between 1400 and 1700 have ranged from 100,000 to 9,000,000.

The Seventeenth Century saw the beginning of a rise in the numbers of women scientists. Botany, including the use of the newly invented microscope, was considered a particularly appropriate subject for them to study. Entomology was also a popular subject explored through the microscope. Similarly, the telescope fueled interest in astronomy. Manufacturers of these instruments promoted women's interest through lectures and books. The first English periodical for women interested in science was published from 1690-1697. Most women studied at home, sometimes developing impressive natural history collections.

A few unusual women traveled far like Maria Merian and her daughter Dorothea, who went in 1698 from Holland to Surinam to collect and paint specimens of insects and plants. Both Maria's father (who died when she was an infant) and her step-father had been botanical illustrators. She married her teacher, but she left him in 1685 after 17 years of marriage.

During the Eighteenth Century Age of Enlightenment, women's role in scientific discoveries continued to be limited by the extent they had education and encouragement at home. For example, Antoine Lavoisier is called the "Father of Modern Chemistry" for his ideas like the conservation of matter, but his wife Marie's contributions are difficult to assess. She was married to him at age thirteen when he was already a chemist elected to the French Academy of Sciences. Marie assisted with experiments, kept laboratory records, translated scientific works from English to French, carried on scientific correspondence, and illustrated her husband's numerous publications. After he was guillotined in 1794 by French revolutionaries, she edited his works. Then Marie married another scientist Benjamin Thompson, also known as Count Rumford.

Unlike Marie Lavoisier, Jane Colden Farquahar ended rather than began her scientific work upon getting married. Colden, born in 1724, is the first well-known American female scientist. She was taught by her father, and like him she corresponded with the great botanists of the day including Carolus Linnaeus in Sweden She described and sketched 300 local plants, being the first to identify the gardenia.

The number of women scientists working with their husbands increased in the Nineteenth Century. Notable examples are Mary Lyell, a conchologist; Marie Pasteur, a biologist; Mary Buckland, a geologist; Elizabeth Britton, a botanist; Amalie Dietrich, an entomologist; Margaret Huggins, an astronomer; Eliza Sullivant, a botanist; and Hertha Ayrton, a physicist. Despite the accomplishments of these women, a commonly held belief was that developing a woman's intellectual capacity would always diminish her reproductive capacity.

A momentous--and controversial--change occurred in that century: higher education was opened to women. In the United States, it started with the charter of Georgia Female College in 1836. By contrast, the first institution for males (Harvard) was begun 200 years earlier. An era of commitment to excellence in women's education began when Vassar was founded in 1865, followed by Smith and Wellesley within the next decade.

Education for women was justified so they could be better wives and raise better sons. Even women like botanist Almira Phelps, who had an influential teaching and writing career in seven states between husbands and after the last husband's retirement, believed men and women were meant to have separate spheres. Phelps wrote, "She [woman] was created to be the companion of man, to cheer his solitude and to assist him in his duties...A companion or assistant fills a secondary position" (Slack, 1987, p. 91). In 1859, Phelps was elected the second woman member of the American Association for the Advancement of Science. By the end of the century, nearly four hundred thousand copies of her Familiar Lectures on Botany had been sold.

Women's colleges were not only places for women to learn, but also institutions that employed women scientists. The first edition of American Men of Science, published in 1906, listed 4,131 persons including 149 women. Over two-thirds of the 52 women employed at the faculty rank of assistant professor or higher were at women's colleges. That group included the most important American female scientist of the century--the astronomer Maria Mitchell. However, this employment had a stringent condition: they had to remain single. Harriet Brooks, who had already published two major articles on radioactivity with Ernest Rutherford, told her employers at Barnard in 1906 that she was engaged, but wished to continue teaching in the physics department. The trustees decided that a married woman should "dignify her home-making into a profession, and not assume that she can carry on two full professions at a time" (Rossiter, 1982, p. 16). Brooks resigned, broke off her engagement, and never did any more physics research.

Similarly, education for women was expanding in Europe. Six women's colleges were opened at Oxford and Cambridge from 1869 through 1893. Italian universities, which had ceased admitting women around 1800, began letting them in again during the 1870s. France, Switzerland, Sweden, and Denmark all started accepting female university students during the second half of the century. However, in Russia, following the government's rejection of an 1867 petition to allow women into universities, women had to be content with an informal combination of public lectures and private discussions led by cooperative professors.

One of these Russian women was Sonya Kovalevsky. She married to sidestep getting her father's permission to continue her studies in Germany. She earned her Ph.D. in 1874 through private tutoring because women were not allowed at university lectures there either. After her husband's suicide, she joined the faculty of the newly opened University of Stockholm, becoming the first woman professor in Europe since the Italian universities were closed to females. When Kovalevsky won in 1888 a prize from the French Academy of Sciences for her paper about the rotation of solids, her former professor Karl Weierstrass wrote that "I have particularly experienced a real satisfaction; competent judges have now given their verdict that my faithful pupil, my 'weakness,' is not a frivolous marionette" (Ogilvie, 1986, p. 116). The judging process was done with each manuscript lacking the author's name, but identified by a motto. Kovalevsky's motto was "Say what you know, do what you must, come what may" (Osen, 1974, p. 132).

Another woman who left her native country to continue her education was Marie Curie, who moved from Poland (then under Russian domination) to France. Marie was the first person to win two Nobel prizes: a 1903 prize in physics and a 1911 prize in chemistry. The former was awarded for her doctoral dissertation work on radioactivity. It was she who first used that terminology. The latter prize was for establishing the existence of the elements radium and polonium. She had come far from her start as a governess in Poland from 1885 to 1890. Discouraged by the restraints of her situation, she wrote in an 1886 letter, "My plans for the future? I have none, or rather they are so commonplace and simple that they are not worth talking about. I mean to get through as well as I can, and when I can do no more, say farewell to this base world. The loss will be small, and regret for me will be short--as short as for so many others" (Pycior, 1987, p. 195). Even though she wrote that she had no plans, she continued to study alone until she had financial resources enough to return to school.

Besides her own determination and intelligence, the other great asset

Marie Curie had was support from an extended family that included her parents, sisters, husband, and father-in-law. The last, Dr. Eugene Curie, assumed much of the responsibility for caring for Marie and Pierre's two daughters until his death in 1910, when they were ages five and twelve. Pierre abandoned his own research in piezoelectricity to work with Marie on isolating radioactive substances, for which he shared in the 1903 Nobel prize. After Pierre's death in 1906, Marie declined a widow's pension and instead got her husband's job; thus she became the first woman professor at the Sorbonne.

Even with all her accomplishments, male scientists of international statue did not always treat her with openness and respect. For example, she was never elected to the French Academy of Sciences, even though Pierre was elected in 1905. In 1911, she lost by one vote on the first ballot and by two votes on the second. No woman was elected until 1979. Writers in the public press questioned whether or not Marie Curie's scientific accomplishments should be credited first to Pierre and later to Paul Langevin (with whom she was accused of having sexual intimacy) in attempts to show that women were not capable of independent, creative thought.

Madame Curie had a powerful influence as a role model. Her daughter Irene Joliot-Curie discovered artificial radioactivity in 1934 with her husband Frederic, and they were rewarded with a Nobel prize in 1935. Their children, Helene and Pierre, continued the tradition of being distinguished scientists working with spouses.

After thirty years of rapidly expanding opportunities, rigidity set in concerning women's roles in science after 1910. Women were generally low-paid laboratory assistants assigned tasks of painstaking, tedious detail. Women were forbidden to enter mines because they might cause bad luck, and women were not allowed to use astronomical observatories because they might be unsafe away from home at night. Even if females did the work usually assigned to males, the females received substanially less pay. Women's colleges replaced female faculty with male. Fearing the loss of their prestige, most male researchers refused to collaborate with women. This practice obviously reduced women's chances to gain prestige. Women were often unable to obtain their own grant funds or the reduced teaching loads that would enable them to independently make significant contributions to research.

An exception to this pattern was Lise Meitner, another woman inspired by Marie Curie. By 1910, she had published important papers as sole author and in collaboration with Otto Hahn. She wrote with her nephew in 1939 the first paper about nuclear fission after she became convinced that uranium atoms could be split. In 1966, she became the first woman to win a Fermi Award from the Atomic Energy Commission. Just as Curie before her, Meitner experienced more than the glory, such as when she worked for one Nobel laureate in Berlin who made her promise to stay out of any laboratory where males were conducting research. Because there are so many female scientists in the Twentieth Century, I will continue mentioning only those who, like Marie Curie, studied radioactivity.

For decades, women aspiring to scientific careers were expected to use the "Madame Curie strategy" of deliberate overqualification modestly acquired. Especially during the depression, women were often advised not to overcome stereotypes, but to adapt to them, being grateful for any job remotely related to science.

In the United States, antinepotism rules became more widely applied in the 1920s, depriving numerous women of faculty positions at the universities that employed their husbands. Through World War II, these rules were not weakened even though there was a great demand for trained scientists. In 1970, three-quarters of the land-grant universities still had written policies restricting the employment of relatives.

Maria Goeppert-Mayer, born in 1906, came from a family of six continuous generations of German university professors. Like Kovalevsky, Goeppert received her doctorate from the University of Gottingen. She was only 24 years old at the time. The same year, she married the chemist Joseph Mayer and became subject to antinepotism rules. Her next step was becoming a volunteer research associate--a euphemism for an unemployed person--in Baltimore and then in Chicago. As such, she formulated in 1948 a shell model for atomic nuclei. The 1963 Nobel Prize in physics was given to her for this work. She was elected to the National Academy of Science in 1956, but she was not employed full-time as a professor, and paid accordingly, until 1960.

The second half of the Twentieth Century has been a time of positive changes for women in many realms. Women assumed more leadership roles, working against the stereotypes that had blocked them for so long.

Chein-Shiung Wu was elected the first woman president of the American Physical Society. In 1958, she became the seventh woman ever elected to the National Academy of Science. A physics professor for more than thirty years at Columbia University, Wu is famous for her experiment demonstrating the lack of parity conservation when cobalt decays. "She is reputed to be very smart, and very fierce--she has fought hard to control her turf and to defend her position" (Jones, 1990, p. 208). When Wu retired, the physics faculty at Columbia became entirely male.

Even at the lower ranks, equity has not been achieved yet. In the United States, bachelor's degrees in physics awarded to females were estimated by the National Science Foundation to be 21% of the total in 1930. They reached a high of 23% in 1945, coming up from 14% in 1940. From 1950 through 1970 when the National Science Foundation provided more accurate values, the proportion stood at 4% to 6% By 1980, that number had risen to 13% and was leveling off (Garmon, 1983, p. 115)

Women are still bound by meeting traditionally male criteria for professional success, especially in science, while being expected to fit traditionally female modes of personal behavior. The result is that many girls choose to avoid this conflict by avoiding scientific careers.

We have seen that for at least 5000 years, women have made contributions to science. Details of a few women's lives have been presented to illuminate the pattern of female participation in science. All the women selected made professional contributions, but they were not chosen on the basis of the significance of their work. Instead, they were chosen to broaden understanding of overt and covert discrimination as well as commitment to equity. Opportunities for women in science have expanded, but progress has not been continuous.

Although some women scientists have been remembered through the ages, countless more have been forgotten. It is difficult to trace their authorship due to women changing their names upon marriage. Copiers of manuscripts sometimes substituted masculine forms of names for feminine forms. Some women published under male pseudonyms to avoid persecution or loss of social position. Other women did likewise to increase the probability that their work would be taken seriously.

Until recent times, few women had access to formal education. Because their education was provided by fathers, brothers, husbands, and male colleagues, women's discoveries were easily appropriated by or attributed to those men in their lives. Some women had low self-esteem and underestimated the importance of their own original ideas, reflecting the values of society in general. Other women, for reasons of propriety, did not seek or want credit for their work.

For all these reasons, the value of women's scientific work has been underestimated by most people. From ignorance of women's contributions, people for centuries have concluded that women are by nature less capable than men in scientific endeavors. Then when women like Curie or Mitchell demonstrated undeniable ability in science, it was labeled an exception to the rule. With this false logic, women could never "prove" their equal aptitude.

Despite the lack of the support or rewards given to men, thousands of women have observed nature, experimented in laboratories, and constructed abstract scientific ideas. This speaks powerfully to the inherent appeal of science.

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WOMEN IN SCIENCE; 5000 YEARS OF OBSTACLES AND ACHIEVEMENTS

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Early Astronomers

In the sixteen and seventeen hundreds, women in astronomy in Europe were part of what is called the craft tradition. People learned occupations through apprenticeships or assistantships. The role of the guild wife, sister, or daughter was as an assistant, but was considered to be so useful that every guild master was required by law to have one (Schiebinger, 1989).

The astronomer's observatory was usually in the home so this allowed the female to play a more comprehensive role than if it were outside the home. It was not considered proper for women to engage in scientific activities in public, such as at universities (Schiebinger, 1989).

The universities of this era spent their time in astronomy in debates over the nature of the universe while the practice of astronomy, that is actual observations, was conducted at private observatories run by the master guild astronomers. Therefore, women's exclusion from the universities did not exclude them entirely from the practice of astronomy. With universities closed to them, women had to rely on family members for a tie to the scientific community (Schiebinger,1989).

In Germany during this period about 14% of the astronomers were women. They included Elizabetha Koopman Hevelius, Maria Winkelmann Kirch, and Caroline Lucretia Herschel (Schiebinger, 1989). Elizabetha was a well educated daughter of a wealthy merchant. She married an astronomer who was 36 years her senior. She aided him, as his chief assistant, in running the observatory in Danzig. She succeeded other wives and assistants and is said to have been the best of them all. After his death, she published many of his writings, for example Prodromius Astronomiae, which is a catalog of almost 2,000 stars (Ogilvie, 1986).

Maria Winkelmann was the daughter of a Lutheran minister and educated privately by her father and uncle. She married Gottfried Kirch, 30 years her senior, who was Germany's leading astronomer. In 1702, she discovered a comet (Alic, 1986). The announcement bore his name, but he acknowledged her discovery. She published three tracts, but because she lacked training in Latin, the language of science, they were rejected by the only scientific publication in Germany. She and her husband worked as a team on many problems. They obtained money to operate the observatory by the compilation and sale of calendars and farmer's almanacs (Schiebinger, 1989).

When Marin's husband died in 1710, the Berlin Academy of Science did not even consider her to succeed him, even though there were few possible replacements. Both she and her husband had discovered comets, prepared ephemeridas and calendars, and recorded numerous observations, but she did not hold a university degree. Some guilds had permitted the widow the right to run the family business after the death of the husband, but she was denied.

The Academy was concerned with setting a precedent, and so it appointed a man. He quickly showed himself to be incompetent (Schiebinger, 1989).

A few years later Maria and her newly university graduated son were asked to resume as appointed observer and assistant. She fell into disfavor again when she ignored the Academy's censor for talking to visitors at the observatory. She was forced to move out and conduct her private observations behind closed doors. This hampered the progress she might have made in astronomy. After his mother's departure, Christfried used his sisters to do the calculations for him. They, having observed the problems encountered by their mother, asked for no compensation or official recognition and became invisible helpers. After her brother's death, Christine Kirch continued to prepare the Academy's calendar and observe the heavens for another 40 years. She eventually was paid a small pension but never recognized (Schiebinger, 1989).

There were no other women who worked for the Academy for the next 150 years. The first election of a female to the Academy for her scientific merit, and even this one was as a corresponding member, occurred in 1949. The physicist Lise Meitner was followed a year later by the daughter of Marie Curie. Since its founding in 1700, only 14 of its 2900 members have been women (Schiebinger, 1989).

Caroline Lucretia Herschel was born in Germany and was taught reading, writing, and music by her father over the objection of her mother. She was told by her father that she probably would never marry because of her lack of physical beauty or fortune (Olsen, 1974).

After the death of her father, the spinster Caroline was taken to England by her brother William. She was to keep house for him. He was a musician and amateur astronomer. After the discovery of the planet Uranus in 1781, William and Caroline were appointed by the King of England as an astronomer and assistant. She was the first woman in England to be honored with a government service position (Olsen, 1974).

She did all the calculations, reductions, record keeping, and some of the actual observations. She added 14 nebulae to those already cataloged and discovered eight comets. She cataloged and made calculations for 2500 nebulae. She accepted no praise but attributed everything to her brother. She considered herself as a tool for her brother, calling herself a well trained puppy dog (Schiebinger, 1989).

After his death, Caroline returned to Germany but continued to work on Flamsteed's catalog, on organizing an eight volume work of her brother's, and on a catalog of the 1500 nebulae and star clusters discovered by the Herschel family. At the age of 85 she was elected as an honorary member of the Royal Astronomical Society and the Royal Irish Academy and at 96 was awarded a gold medal of science by the King of Prussia. Full membership in the Royal Astronomical Society was not given to a female until 1945 (Ogilvie, 1986).

Later Astronomers

Much of the astronomical research shifted from Europe to the United States in the nineteenth century. A division of gender specific labor again occurred. It determined who observed, collected data, analyzed, and published as per the mores of the American culture. In 1859, Maria Mitchell was the lone female astronomer. By the end of the century females made up 18% of the profession (Lankford, 1990).

Women found university appointments open to them only after the opening of women's colleges. Female professors rarely published because they typically had heavy teaching loads and often outdated or inferior equipment. They relied on males at nearby institutions to escort them to meetings, to help pick equipment, and to advise on professional matters. They did not form ties with other female astronomers. One of the important activities for these first generation women scientists was the selection of bright protegees to succeed them on the faculty. The second generation had greater opportunities and were more oriented to research and keeping up in the field (Rossiter, 1982).

The division of responsibilities at men's schools and at observatories found men doing the observing and women reducing and analyzing the data. The men would carry out the final discussion of the data (Lankford, 1990). Edward Pickering, director at Harvard's Observatory, became so upset with his male assistants that he declared his maid could do a better job. He hired her, and she became one of the best known astronomers of her generation (Rossiter, 1982). They assembled a female team to aid her. He called them computers and others called them "Pickering's Harem" (Rubin, 1986). This pattern of female assistants spread to other observatories in the United States. Records indicate that over 150 women worked as assistants at observatories between 1875 and 1920. The practice proliferated because the field had a rapid expansion, and the male assistants were quickly hired elsewhere to higher positions. The females were not promoted into the male jobs and were paid less. They became trapped into these low level, low paying jobs (Rossiter, 1990). Maria Mitchell, the first American female astronomer, also believed in the cultural value of gender roles. She stated, "The eye that directs a needle in the delicate meshes of embroidery will equally well bisect a star with the spiderweb of a micrometer. Routine observations... dull as they are, are less dull than the endless repetition of the same pattern in crochet-work." (Lankford, 1990). Men described women as physically unable to perform some tasks, citing emotional and nervous problems and bouts with ill health (Lankford, 1990).

Men also feared that women would marry and leave the field. Indeed many did. Only 12% had careers longer than twenty five years. Honors and awards usually do not begin to accrue until about the fourteenth year of a career (Lankford, 1990).

Equal pay was not even considered. Mitchell received $800 while her male colleagues were paid $2500. She fought the administration but had little success (Lankford, 1990).

Maria Mitchell is considered the most important woman scientist in America in the nineteenth century. Her election to a professorship at Vassar College began a new era. Born in Nantucket, MA, she helped her father make navigational observations for the fishermen. First educated by her father she then attended an elementary school and a girl's school. She became a teacher and a librarian. After the discovery of a comet in 1847, she was given a gold medal by the king of Denmark. It was the first awarded to an American and a female. She was also the first female awarded membership in the American Academy of Arts and Sciences (Ogilvie, 1986).

While at Vassar, Maria encouraged females to be curious, to be speculative, and to question. She held small classes so she could give individual attention. She almost never lectured. She was committed to teaching and to observational astronomy rather than to research (Abir-Am, 1987). She stated,"The scientist should be free to pursue his investigations. He can not be a scientist and a schoolmaster. If he pursues his science in all his intervals from his class-work, his classes will suffer on account of his engrossments; if he devotes himself to his students science suffers; and yet we all go on, year after year, trying to work the two fields together, and they need different cultures and different implements"(Ogilvie, 1986).

She helped found the Association for the Advancement of Women. Her successors at Vassar were students and grand-students of hers through 1932. The first male was hired in her position in 1958 (Rossiter, 1982).

Williamina Stevens Fleming was born in Scotland, married and moved to Boston. Separated and pregnant, she found work as a maid for the Director of the Harvard Observatory, Edward Pickering. Later, he offered her part-time work doing clerical and computing tasks at the Observatory. In 1881, she became a permanent member of the staff, and five years later she was put in charge of the women in astronomy and was the first woman to receive a corporation appointment at Harvard. In 1906, she was elected to the Royal Astronomical Society (Ogilvie, 1986).

The women at the observatory examined, classified and indexed photographic plates of stellar spectras. They organized the stars into a useful classification scheme. Over 10,000 stars were classified and a publication created by 1890. Williamina was editor of the Observatory's publications. She also complained of low pay, reminding others that she had to run a household just as the males did (Rossiter, 1982).

Annie Jump Cannon succeeded Williamina as curator for the Observatory's astronomical photographs. Born in Delaware, the daughter of a state senator, she was educated in the public schools. She attended Wellesley and Radcliffe. She received an M.A. and was the first woman to receive an honorary doctorate from Oxford (Kidwell, 1984). She simplified and perfected the basic sequence of stellar spectra and classified 350,000 stars. This is what is today called the seven spectral classes of stars- O,B,A,F,G,K,M. Every new student to astronomy learns the mnemonic,"Oh, Be, A Fine Girl, Kiss Me." She observed and found 300 long-period spectroscopic binaries. Annie said patience was a major component of her success (Rossiter 1982).

Ms. Cannon persuaded Maria Mitchell's cousin, Lydia Hichman, to establish a fellowship for young women to do research at Harvard Observatory. It was called the E.C. Pickering Fellowship. It was the first fellowship which aided women scientists (Kidwell, 1982). After being given an award in 1932, Ms. Cannon donated the money to start an award to be given by the American Astronomical Society for distinguished contributions to astronomy by a woman (Rossiter, 1982).

Henretta Swan Leavitt was born in Massachusetts, daughter of a minister. Although she had a serious hearing problem, she attended public schools, Oberlin College and Radcliffe College. She was a volunteer on the Harvard staff for seven years and then became a permanent staff member. Chief of the photographic photometry department, she made accurate measurements of the brightnesses (magnitude) of stars (Ogilvie, 1986).

In 1917, she established what is now called the Period-Luminosity Relation of Cepheid variable stars. It permits the calculation of distances to star clusters and other galaxies. There was no method for distance calculation before this. It is still a valuable tool in astronomy today. "Pickering relieved Miss Leavitt of her discovery and sent her back to collecting and cataloguing other variables, explaining that it was a "computer's duty to collect information - not to formulate scientific theories" (Spangenburg, 1979). She remained on the staff the rest of her life (Ogilvie, 1986).

Recent Women in Astronomy

The twentieth century has shown evidence of some increased opportunities for women, but many obstacles continue to exist. Membership in the American Astronomical Society reflects the representation of women in the field. In 1900, women comprised 10%, while a peak of 17% occurred in the late 1930's. In the 1950's, the number of women enrolled in graduate astronomy programs declined while at the same time the number of men increased significantly. During the next two decades, only 10% of the doctorates in astronomy were granted to females (Warner, 1979).

Throughout most of the century, females "couldn't" be hired at Mount Wilson Observatory, one of the major installations in the US, because there was only a men's toilet (Rubin, 1986)! If a female married, questions were asked if she planned to quit soon. Many females were given assistants jobs and/or teaching jobs; only a few were able to obtain research positions. (Warner, 1979). In the past two decades many of these barriers have crumbled. Most of the female astronomers today are married. They have been able to secure some research positions. The introduction of mechanical computers has broken the bondage chains and freed the female astronomers to pursue investigative astronomy (Warner, 1979).

Cecilia Payne-Gaposchkin was born in England. Her father was a musician and her mother a painter. Educated at Cambridge University, she was the first female to complete a research paper in astronomy. She saw no future in England except teaching, which she described as a fate worse than death, so she accepted Harlow Shapley's invitation to join the staff at Harvard Observatory (Whitney, 1980). She was the first female to complete a doctorate in astronomy from Harvard even though females had such a great research record there (Rubin, 1986). Her dissertation was described as the most brilliant ever written in astronomy (Kidwell, 1984). It was published as the fist book from Harvard College Observatory. She also authored its' second book. Her early work was about stellar atmospheres, but later she also conducted research on high luminosity stars and then on variable stars (Whitney, 1980).

In 1934, she married a new staff member, Sergei Gaposchkin, and had three children. He was an expert in eclipsing binaries, and they researched and published both together and individually (Whitney, 1980).

An early promoter of careers for women, she stated "Women have rested under (a) cloud of inferiority because too long they have accepted the traditional idea that their place was centered and small, their duties limited...I say that a career and homemaking and motherhood may be thoroughly compatible through the exercise of commonsense and making intelligent adjustments... (Whitney, 1980)."

She was, in 1956, the first woman to be promoted to the rank of full professor at Harvard, and became the first female department chairman there (Whitney, 1980). She still received a lower salary than male astronomers of comparable standing (Kidwell, 1984).

E. Margaret Peachy Burbidge, daughter of a chemist, was born in England in the 1920's. She and her astrophysicist husband, Geoffrey, moved to the U.S. because of the cloudy skies of Britian. He received a Carnegie Fellowship to work at Mount Wilson, but these awards were not available to females. She could get observing time at Mt. Wilsom only by having her husband apply, and she act as his assistant. "It was my first exposure to the discouragement women scientists encounter in the U.S. (Time, 1972)." She again suffered when they moved to Chicago. Her husband was named a fully paid associate professor, but because of old nepotism rules at the University of Chicago, she settled for an unsalaried appointment (Rubin, 1981).

In 1972, she returned to England after being named the first female director of Britain's famed Royal Greenwich Observatory. He took a leave of absence to return with her (Time, 1972). Both are now professors at University of California at San Diego. She has been honored by many professional memberships, including the presidency of AAAS in 1981 (Rubin, 1981).

In 1967, Jocelyn Bell was a graduate student at Cambridge University. She had helped to construct the radio telescope, then began to operate it and analyze data from it so she could get enough data for a thesis. While searching through the thousands of feet of chart data, she discovered the first pulsar. The news was given to Nature, but she was listed as second author, after Anthony Hewish, her supervisor (Wade, 1975).

Hewish and his superior Martin Ryle, the leader of the Cambridge radio-astronomy team, were awarded the Nobel Prize for physics in 1974 for their role in the discovery. No mention of Bell was given. Some have called it a scandal. The discovery was not from a preset routine, but a feat of unaided memory and observation, and many feel that it should have gone to her. The Franklin Institute of Philadelphia awarded its Albert A. Michelson medal to Hewish and Burnell jointly in 1973 (Wade, 1975).

Ms. Burnell works part-time for London University on a team which is analyzing data from a British x-ray satellite and is raising a family. She has steadfastly remained out of the controversy (Wade, 1975).

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WOMEN IN SCIENCE: 5000 YEARS OF OBSTACLES AND ACHIEVEMENTS

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A. Late 1700s to early 1800s

In Europe in the late 1700s to early 1800s society placed obstacles toward further learning by scientifically-minded women. The following two stories illustrate some of these barriers.

Sophie Germain (1776-1831) and Mary Fairfax Somerville (1780-1872) were contemporaries (Ogilvie, 1986; Osen, 1974; Alic, 1986; Russett, 1989; Schiebinger, 1989). They shared much in common--both were educated haphazardly (Mary was barely literate at age 10), but both "discovered" mathematics at the age of 15. In France Sophie "disappeared" into her family's library during the turmoil of the French Revolution. There she taught herself mathematics, Greek, and Latin. Sophie's parents were so distressed by her interest in scholarly subjects that they took away her books, clothes, firewood, and candles so she could not study at night. They relented when they discovered her one morning wrapped in blankets reading scraps of paper by stolen candlelight and unable to write because her ink had frozen.

In Britain, Mary discovered algebra while reading a fashion magazine (the equivalent I expect of today's "Seventeen"). She taught herself algebra, but kept her efforts from her parents who thought that learning higher mathematics would drive her mad. Her father knew a woman in an insane asylum who was obsessed with longitude. Mary's painting teacher introduced her to geometry when they tackled perspective. Mary memorized Euclid's "Elements of Geometry," which she obtained from her younger brother's tutor, because her parents confiscated her books so she would not study as much. At night, Mary mentally reviewed the memorized pages of Euclid's geometry before she slept.

Then their life stories diverge, although both became well-known within their lifetimes and praised for their mathematical knowledge.

Mary's second husband encouraged her interests in mathematics and science. Mary accompanied him, an army surgeon, on his many trips to Europe. She and her husband knew, corresponded, and entertained most of the great scientists of Europe. When she was 50 the Society for the Diffusion of Knowledge asked her to translate, explain, and comment upon Laplace's "Mecanique Celeste." Her explanation of the mathematics necessary to understand this important work became the preface to "Mechanics of the Heavens" published in 1831. The preface was published separately from Laplace's work and was used as a college textbook for nearly 100 years. Laplace considered her one of the few who understood his work and said that she was one of only two women who had sufficient mathematical background to understand his work--the other was a Mrs. Grieg. Laplace did not know that Mrs. Grieg and Mrs. Somerville were the same person. Mary was denounced both by the House of Commons and the Church of England as being a "godless woman" for writing "Mechanics of the Heavens" (Osen, 1974).

Mary wrote three more treatises which made physical laws familiar and understandable to laypeople, but which were of sufficient depth and authority to be of interest to the scientist. She was well-honored within her lifetime, but no one noticed the irony of some of the accolades bestowed upon her. As examples, her bust was placed in the Great Hall of the Royal Society--a place where she, as a woman, could not step. Societies on both sides of the Atlantic which did not permit women as members or even in the audience gave her numerous awards. Praise for her was particularly strong in scientific societies at that time because she was a "womanly woman:" wife, mother, society matron as well as scientific author.

At age 18 Sophie arranged to collect and read the lecture notes in mathematics and physics at the Ecole Polytechnique in Paris. No females were permitted to study there. Using a male pseudonym she submitted mathematical solutions and physics problem solving to Lagrange, one of the leading mathematicians in Europe. Lagrange wanted to meet with this talented student and determinedly sought her out. He praised her as a kind of mathematical phenomenon--brilliant, intuitive, but lacking in some formal mathematical skills. No matter how talented she was, neither he nor any other mathematical professor considered her as a possible student.

Her early work dealt with number theory and her later work with applied mathematics--she has been called one of the founders of mathematical physics (Ogilvie, 1986). On her third try in 1816 she won the prestigious grand prize from the French Academy of Science for a mathematical explanation of experimental data dealing with elasticity and acoustics. This work was necessary to design the Eiffel Tower and other tall structures. Her work suffered from lack of formal training in mathematics: she had to recreate some mathematics and there were gaps in her knowledge so that the mathematical explanation for which she won the grant prize was incomplete. This lack of formal training in math worked somewhat to her advantage, however, because she did not have the preconceived notions of her mathematical contemporaries as to what was possible. She worked with such illustrious mathematicians as Poisson, Fourier, and Navier. Breast cancer in 1829 necessarily curtailed her work.

B. 1800s to 1900s early American women geologists and a British botanist

In the late 19th and early 20th centuries American women's colleges were important as both employers of women scientists and as training sites for future women scientists. In 1906, for example, two-thirds of women scientists in academia worked at 14 women's colleges (Rossiter, 1982). In some fields, for example physics, 100% of the women physicists taught at women's colleges. Also in 1906, 23% of women college graduates came from five eastern women's colleges. Rossiter's (1982) data include 1821 women at 291 different institutions so that it is even more impressive than at first glance that the five eastern women's colleges produced so many women graduates. One woman geoscientist trained a long line of "descendants" at her woman's college: Florence Bascom (1862-1945).

Florence earned her PhD in structural geology in 1893 at Johns Hopkins. Women students were not permitted to officially register at Hopkins until 1907 and then only with the proviso each instructor gave his permission for the woman to attend his class (Rossiter, 1982). Hopkins did not list women among its graduates until 1913. Florence was given special permission to matriculate at Hopkins because the trustees felt she was a "safe candidate"--they knew her father, a college president, who had assured them that Florence would be employed at Bryn Mawr. Florence had to sit behind a screen to attend her university lectures.

Florence initiated the geology program at Bryn Mawr in 1895 and trained women geologists for more than 40 years (Rossiter, 1982). She was the first woman to work with the United States Geological Survey and she mapped much of the Piedmont and Coastal Plain provinces of the Mid-Atlantic states. She emphasized field work for herself and her students. This emphasis was revolutionary because previously women geologists had worked mainly in the laboratory or the drafting room.

She was well-honored within her lifetime; for example, she was the first woman fellow of the Geological Society of America. She trained most of the second generation of women geologists who worked primarily in academia (Coates, 1986). Even today approximately 50% of women geologists are teachers at secondary schools or universities (Coates, 1986).

Other noteworthy women in the history of women in geology include Mary Emilee Holmes who, in 1887, was the first woman to receive a PhD in geology in the United States (from the University of Michigan) (Coates, 1986). She taught for three years at university, then became a missionary. Esther Richards Applin is historic because she changed methods of showing equivalence of rock units underground by using microfossils. This is the modern method of stratigraphic correlation.

Beatrix Potter (1866-1943) illustrates another common story of this period--the lack of attention paid to contributions by women scientists. Beatrix studied fungi and lichen. She was the first to prove what a Swiss botanist had proposed in 1867: the symbiotic relationship of alga and fungus to produce the dual organism lichen (Gilpatrick, 1972). Her microscopic work with lichen showed that the fungal partner is not a parasite, but that the alga and the fungus are equal partners. The alga conducts photosynthesis using water which is provided by the fungus. At the age of 30 she accompanied her uncle, Sir Henry Roscoe, a well-known chemist, to the Royal Botanic Gardens at Kew. She wanted to discuss her research findings with the botanists there, but she felt that they dismissed her work because she was too young and had not been formally trained in botany (Gilpatrick, 1972). The following year her uncle arranged for her research to be presented at the Linnean Society of London, the most prestigious scientific group at that time. Her paper was read by a male lichenologist, for no women were permitted to give papers or to be in the audience. Although she was the first botanist to be continually successful at germination of spores, and despite the fact that her research on lichen was innovative and important, her work was not accorded respect or attention. Later, she was proved to be correct in her deductions. As we all know, she discontinued her research on lichens and wrote and illustrated children's books.

C. 20th century women scientists

Rosalind Franklin (1920-1958), Rachel Carson (1907-1964) and Barbara McClintock (1902-) were similar in how they wanted to be regarded by history: they wanted to be assessed as scientists, judged by their abilities and accomplishments and not by their sex. But their critics recreated them as unfeminine, disorderly women who did not fit into either the scientific niches or social frameworks to which they should have belonged. Carson was vilified as a "socially irrelevant spinster" who should not concern herself about genetics (Hynes, 1989); Franklin was called "contentious, quarrelsome, contradictory" even though she was later proved correct (Sayre, 1975); McClintock was regarded as "mad, obscure, and mystical" in how she approached science, although other such notable scientists as Einstein were praised for their intuition (Keller, 1983). The first paragraph of the "New York Times" article announcing McClintock's winning of the Nobel Prize described McClintock as a woman who likes to bake with black walnuts (Janice Koch, personal communication, Feb. 1992). One can hardly imagine the "Times" describing a male scientist's cooking abilities in the lead paragraph announcing his winning a major scientific honor. Although these women had made significant and breakthrough contributions to science, their accomplishments were little recognized, trivialized or denigrated as "mystical."

Rosalind Franklin earned her PhD in physical chemistry at Cambridge University. She was an expert in x-ray crystallography which deduces the atomic structure (in three dimensions) of compounds by the two-dimensional photograph of how x-rays are diffracted by the crystal lattice. The earliest work in x-ray diffraction dealt with minerals; later work encompassed the larger molecular structures of organic molecules. Franklin began her earliest work in x-ray diffraction with poorly crystalline coal; this work required extreme care, analytical precision, and higher level mathematics to analyze the structures. Her most famous work applied these x-ray techniques to very large organic molecules. At King's College (London) she worked with Maurice Wilkins on DNA. For various reasons (see Watson, 1968; Sayre, 1975; Gribbin, 1985) she and Wilkins did not get along so that they were competitive rather than cooperative. Because of this adversarial relationship and the fact that the King's College lunchroom was for men only, Franklin felt isolated at King's College (Sayre, 1975). This lack of informal camaraderie and opportunities for brainstorming increased her struggles and unhappiness at London. Her relationship with Wilkins deteriorated so much that Wilkins showed one of her x-ray patterns of DNA to Crick and Watson ("competitors" at Cambridge) without her permission or knowledge.

After less than one year at King's (including eight months to set up her laboratory equipment), Franklin recognized that the DNA molecule was helical with the phosphate-sugar compounds forming the backbone on the outside. Her x-ray work with its complicated mathematics and complex patterns constrained the models of DNA built by Crick and Watson. Wilkins, Crick, and Watson won the Nobel prize for deciphering DNA. It is difficult to second guess the Nobel Committee, but both Sayre (1975) and Gibbin (1985) argue ably that Franklin would have won the Nobel Prize for deciphering the atomic structure of DNA had she lived. Watson's (1968) portrayal of Franklin (he called her "Rosie") in his widely read "Double Helix" has been refuted by Sayre (1975) and Gribbin (1985) as false in terms of her person as well as her scientific contributions. Franklin was a woman scientist who was early criticized because of her appearance and social behavior rather than any shortcoming in her research.

Because of her luminous writing, we tend to remember Rachel Carson (1907-1964) as a best selling nature writer rather than as a marine biologist. She earned her master's degree in marine biology at the John Hopkins University and worked for 17 years as a biologist for Fish and Wildlife Services (Bonta, 1991). She is most renown for "Silent Spring" published in 1962. As Patricia Hynes wrote (1989): "'Silent Spring' altered the balance of power in the world--no one would sell pollution as the necessary underside of progress so easily or uncritically again." With data she accumulated over four years and with the authority of 17 years with Fish and Wildlife, she changed the direction and priorities of the scientific, governmental, and industrial communities in the United States. Her work energized various Presidential and Congressional committees which studied the uses of pesticides. They supported Carson's conclusions on the negative effects of pesticides on ecology. The Environmental Protection Agency was founded in 1970 partially as a consequence of Carson and her best seller. Her detractors, as with Franklin, denigrated her as a woman (spinster, not a scientist) rather than on her scientific arguments and conclusions. As Hynes (1989) points out Carson's "Silent Spring" still speaks out to us today. We continue to be concerned about recurring "silent springs" as Lester Brown reminded us in the plenary session at TLC VII concerning environmental disasters in eastern Europe and the former Soviet Union.

Barbara McClintock (1902-) won numerous honors and awards including the Nobel Prize. She is the originator of such complex genetic theories that they are "dimly understood" by her fellow microbiologists (Keller, 1983). She did most of her work alone without technical assistance and without much university or grant support. Her life's work is the study of corn which she began at Cornell University where she earned her PhD in 1927. By the microscopic examination of the characteristics of chromosomes, she deduced transposition by which the DNA of a cell can rearrange itself sometimes in response to environmental challenges. Her close observations and ability to recognize individual ears of corn enabled her to make these scientific deductions.

Throughout most of her professional life, McClintock worked in a setting where women were not granted the same opportunities as men. Despite early recognition of the significance of her work in corn genetics, despite her educational credentials, and despite her influential backers, she knew she would not be offered a professorship at Cornell. It was not until 1947 that Cornell did hire a woman professor who was not a home economist (Keller, 1985). After several years in other people's labs, she established her own lab (even though it was peripheral to others' work in genetics) in 1941 at Cold Spring Harbor which was supported by the Carnegie Institution. She was considered an outsider because her ideas of transposition were at odds with the then prevalent beliefs on how cells can change. Her work is accepted today and has convinced scientists that the gene is much more complex than earlier thought. Her research exemplifies a lifetime of experience in carefully looking at plants. Her scientific method has been called "mystical" because she said "as you look at these things, they become part of you and you forget yourself" (Keller, 1985). This involvement in her objects of study permitted her to clearly see how the gene can change--changes which were not perceptible to others.

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STS EDUCATION

IN

K-12 SCHOOLS

SCIENCE AND TECHNOLOGY AS A BASIS FOR AN INTEGRATED CURRICULUM

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This paper describes several units, developed for middle school instruction, that combine science and technology with language arts, social studies, and art. The units were developed as part of a larger school reform project that emphasizes instruction-based assessment, hands-on science and technology, and an integrated curriculum motivated by environmental and social problems evident in the student's world. Support for this work has come from the Educational Testing Service and the Dwight D. Eisenhower Fund for Improvement of Science and Mathematics Instruction. In the discussion that follows, three of the experimental units are described: Artifacts, Water Resources, and Control Systems. Each of the first two is taught over an 8-14 week period; the third was originally designed for three weeks of instruction but will eventually be expanded to cover eight weeks.

ArtiFacts

This unit focuses on tools, machines, and technologies viewed as the result of human problem solving and design activities aimed at satisfying specific needs.The knowledge and skills addressed by the instruction are grouped around two main processes: ***Functional analysis process*** of technological solutions, and ***Design*** of technological solutions.

Through the functional analysis activities the students learn to identify functional aspects of a given tool or machine (e.g., its main purpose or the network of necessary sub-functions), its structural components, materials, and mechanisms, and the contextual reasons (e.g., social, cultural, technological, or economical) that affected how the particular object came to be designed.

Through the design activities the students acquire the knowledge and skills required to carry out a methodological and systematic process of designing and implementing a technological solution. The students are involved in stating a problem, doing research to define the specifications for its required solution (e.g., competitive analysis, user survey), doing research and experimentation on alternative solutions for the problem, implementing the solution, and evaluating the extent to which it satisfies the stated problem requirements and specifications.

The students work in small groups with each group assigned a different technological field (e.g., communications, textiles, transportation). Their role is defined as being the design department of their company, in charge of preparing the company's exhibits for a coming trade show. The first set of exhibits they have to produce focuses on past technological developments in the group's field. The activities in this part are centered on a particular tool or machine, representative of technologies in use in the past. The students perform a functional analysis of their artifact, and learn about the social, cultural, and technological context within which it was created. The second set of products focuses on future developments of their company. These activities are centered on the design process of a new artifact (or the redesign of an existing artifact), including the building of a working model and the writing of the appropriate documentation.

Different types of materials were developed for the instruction of the unit. The main reading materials, instructions for the activities, and worksheets are part of the student booklet. A series of computer databases, as well as printed resource packets were developed for supporting the research activities. The Lego-Logo building and programming kit is the main tool used by the students for the model design and building activities. Appropriate guides and exercise worksheets were developed, along with supporting materials for the language arts and the arts (design a logo).

Outline of the unit

Start up: *About Human Needs and Technological Solutions*
The introductory chapter presents the main questions guiding the work through the whole unit, focusing on human needs and the technological solutions created to solve them.

Chapter 1: *Mapping an Artifact*
This chapter centers on the functional analysis of technological solutions. The students are assigned a technological field and start working on the analysis of a tool or device from the recent past. They learn systematic ways to identify and name parts and sub-parts, recognize main and secondary functions, materials, mechanisms, and sources of energy.

Chapter 2: *The Artifact in Context*
Through an extensive research process using computer databases and resource packs containing many different kinds of documents (e.g., articles, trade catalogs, patent information, time-lines), the students deal with questions related to the scientific, technological, and social context within which the given artifact was created.

Chapter 3: *The Design Specifications*
This chapter focuses on the creation of the design document for a new artifact. A competitive analysis of existent artifacts and a user survey about desired or preferred features are conducted to gather the required background information. At the end of the chapter a functional design specification report is produced by each group.

Chapter 4: *About Bricks and Bits*
The design and building tool for this unit is the Lego-Logo building and programming kit. In this chapter the students learn about the kit's features, building techniques, and ways to create computer programs to control the activation of the Lego models.

Chapter 5: ***Explorations and Decisions***
The first activities of this chapter are aimed at generating alternative solutions to the problems stated in the design specifications document. The alternatives are explored and refined in successive cycles, until the best solution is selected. At the end of the chapter a model of the artifact (or of a particular section of it), a corresponding computer program, and written documentation (e.g., user's manual) are produced by each group.

Chapter 6: ***Let's Think About It***
This is the evaluation stage. It is aimed at reflecting on the whole design process and identifying where differences between the initial design specifications and the actual products have resulted and why.

Chapter 7: ***It's My Pleasure to Introduce... (The Trade Show)***
This is a final presentation of each group's work. The presentations are followed by a class discussion, both about the content and the process of the work the groups did. This discussion is also meant to close the unit, re-considering the issues raised in the introductory chapter about technology and human needs.

Water Resources

This unit deals with the issues of quality and distribution of water and the role of technology in managing our water supply. The whole unit is designed as an evolving problem solving process: To supply the people in a new settlement with water of different qualities for their different needs and uses.

The large problem is divided into five sub-problems: finding an appropriate source of drinking water, designing a satisfactory water transportation and distribution scheme, using water as a resource to generate power, etc. Solving each one of the problems requires the performing of laboratory experiments (chemistry, physics), model building activities (technological solutions), information retrieval from different sources, and communication activities (letter and research report writing, project presentation).

The character and specifications of each of the sub-problems is defined on the basis of various social, historical, or technological contexts and constraints, such as the availability of given technologies in different historical periods, or economical considerations affecting the choice among alternative solutions.

The learning is carried out in small groups. A particular geographic area is assigned to each group, each area representing a different set of constraints and problems in relation to water quality and supply (e.g., Buffalo, NY; Saudi Arabia; Mexico City).

At the end of the unit each group will have completed a 3-D maquette containing models and devices built and accumulated through their work on the solution of the different problems (e.g., stating the quality of the water in their area, using water for energy generation or esthetic purposes).

Outline of the unit

Start up : The introductory activities present the main questions the unit is aimed at answering, namely, what makes water such an important resource and how to solve the problems related to the water's quality and supply.

Chapter 1: ***Your New Home***
Each group adopts a home in one of several world locations, each one presenting a particular water supply problem. The first activity focuses on research on the characteristics (geographical, economical, social) of the assigned area, the identification of its water related problems, and the building of a three-dimensional model for the area.

Chapter 2: ***What Makes Water Water?***
This chapter contains laboratory experiments and an information search on the unique properties of water that make it critical for our survival on this planet. The students gradually move from doing well structured lab experiments to the design of their own experiments about some of water's physical properties.

Chapter 3: ***What's "Unwater" in Your Water?***
In the first part of this chapter the students learn about water pollution and purification technologies. In the second part each group focuses on a particular technology relevant to the problem and constraints in their geographic area. They finally build a working model of the purification device or process selected as the most appropriate to their problem.

Chapter 4: ***Moving Water Around***
This chapter centers on the physical and technological aspects of water transportation and distribution. First, the students do a set of experiments about liquid pressure (e.g., the pressure exerted by a column of water, communicating vases), and about water "moving" devices (pumps, syphons). Then, each group builds a model of their water distribution network on their three-dimensional model.

Chapter 5: ***Water at Work***
Laboratory experiments, library research, and model building about the use of water for energy production (e.g., waterwheels), transportation (e.g., canals), and esthetic purposes (e.g., fountains). Once again a working model is incorporated into the geographic area model.

Chapter 6: ***The Water's Delicate Equilibrium***
The supply of water is related not only to scientific and technological decision making, but also to social, economical and political decisions as well. Problems related to water allocation, costs, planning, and responsible decision making are addressed in this chapter. The activity is based on research on various kinds of documents and on a spreadsheet-based simulation where decisions made can be tested.

Chapter 8: ***Then, What's the Water With You?***
This is the closing activity, where each group presents the complete set of reports and models produced during the unit. Self evaluations as well as evaluations by other groups are conducted.

Control Concepts

This unit is aimed at teaching control concepts and models, today considered central components of our technology related knowledge base. Control models were adopted by researchers and practitioners from a wide range of disciplines as a conceptual framework for the understanding and description of natural and social phenomena. Countless examples of control mechanisms can be found all over the natural, social and artificial environments we are part of, from feedback mechanisms in our body through control mechanisms in devices and machines, to regulatory, adaptive and evolutionary processes in nature.

The unit is organized around a core track dealing with increasing complexity in control procedures of a mechanical device. Through six differentiated stages, the student deals with the problem of controlling a two-motor car operation, from a basic stage of simple on/off activation, to the final stage of implementing a feedback loop by which the car's functioning adapts to changing features in the environment. The core track is expanded at each stage, through examples from the artificial world, the natural world, and the social environment that hold similar (control related) characteristics to those so far discussed for the Lego-Logo system. For example, the consideration about how information detected by a sensor triggers an immediate response by the system is carried out both by working on the programmed Lego car and by studying touch-response plants (e.g., Mimosa pudica).

One of the main objectives of the instruction is the teaching of systematic conceptual tools for the analysis and the design of control systems. One of these tools is a symbol system for the representation of the different components of a system and their functions. This symbolic representation of the system is part of the analysis or design worksheet used by the students to describe each system they work on. The worksheet is organized in three main parts. The first is a prose description of the system. The second is the symbolic representation (with appropriate explanations where needed), and the third is the description of the control plan. At the stages where the control component reaches a higher degree of complexity, formalisms to describe the control plan are introduced (e.g., "If...Then..." sentences, state space diagrams, truth tables).

Outline of the unit

Stage	**Control pattern**	**Activity**	Parallel examples
1a	Simple on/off activation	Two-motor car activated by switches forward/backward	
1b	Complex on/off activation	Two-motor car activated by two switches in combinations: forward, left, right.	The epiglotis: the movement of food and air in the throat
2	Programmed fixed paths	Programs combining six primitives [f,b,l,r,w,repeat] to activate the car	Automatic door designed by Hero 2000 years ago.
3	Simple use of incoming information	Using sensor information to modify the car's functioning	Mimosa pudica: touch-response plants.
4a	Feedback loop - fixed environment	Car following the line	
4b	Feedback loop - changing environment	Car looking for light	Immigrants/Nationals relationships at the beginning of the century

The table shows a description of the core track, built around the Lego-Logo car. Parallel activities in the unit's plan deal with examples from the artificial, natural, and social environment relevant to each stage. Some examples appear in the table.

Computer Tools

A variety of computer-based tools have been adopted or developed for the various units, including the programming language Logo, databases, a weather simulator, and a banking program.

Logo

Logo is a list processing and control language originally developed at MIT for teaching programming concepts. In the units presented here, Logo is used to drive various components of a Lego building kit, including motors, lights, sensors, and switches. Students are taught only a subset of the Logo language, built around commands for developing control programs for Lego models. A special interface for an Apple II computer provides a power supply and control panel for the Lego components. The Logo programs allow students to turn motors and lights on and off, sense the conditions of switches and sensors, and access a computer clock and internal programming registers. Thus, a student could activate a fan motor for a fixed period of time or until a set number of revolutions occurred. Students can also develop complex control programs based upon multiple sensors and switches. No attempt is made to teach general programming concepts and in most cases functions for primitive operations (e.g., turn on a motor for a specified period of time) are provided for the students. A two-week introduction to the Lego-Logo system has been developed and pilot tested in conjunction with several of the units.

The Weather Machine

The Weather Machine is a HyperCard/HyperTalk system, running on a Macintosh computer, for teaching and assessing weather prediction concepts. Students can set weather conditions, based upon temperature, barometric pressure, wind speed and direction, and cloud type and percentage of coverage, and then make predictions about forthcoming weather. The simulator, which is an expert system, evaluates the student's weather settings to ensure they are within appropriate ranges and are internally consistent. It then makes its own prediction, based upon the student settings, and compares this to the student's prediction. Differences are then communicated to the student through an interactive dialogue.

The student might also be asked to justify his or her prediction by explaining which weather conditions were considered important for each component of the prediction. Various types of help are available to the student at each stage in the development of a prediction. Alternatively, the student can construct questions for the weather machine by selecting sentence components from menus (e.g., Can a northwest wind and falling barometer be causes of snow?). The system then responds to the questions, drawing upon its internal knowledge base. The weather machine also creates a log of each student interaction so that data are available to teachers and others who might want to review a student's on-line work.

This system might be used in a variety of formats. In one, an advanced student is introduced to the machine's operation and allowed to explore weather prediction without a fixed sequence of problems to solve.

Alternatively, the student might be given worksheets with problems specified. As each is worked on the Weather Machine, results are transferred to the worksheets and the work eventually turned in for grading. In another mode, the Weather Machine could be programmed to present a series of problems to a student and to provide feedback on the student's responses. In assessment mode, however, no feedback would be given.

Databases

For two of the units described above, Artifacts and Water Resources, HyperCard databases have been developed for student use. For both, a special student interface has been written in HyperTalk to facilitate access and searching. This interface provides menus for all of the available (and relevant) databases, simple search capabilities (AND, OR), a print facility for either a card or for a specified reference, and expanded help.

For Artifacts, eight HyperCard files (stacks) have been created, one for each technology area assigned in the unit: textiles, food processing, time, medicine, lighting, communications, wood and metal working (hand tools), plus one for general history. For each of the technology files, information is provided on the history of the technology, including materials on manufacturing and social impact. Reference cards, containing tables of contents for each area, are also stored in the files. For Water Resources, a single file has been created, containing geographic and demographic information on the various areas around the world for which water supply and purification systems are to be designed.

Bank-It

Bank-It is a HyperCard/HyperTalk system for maintaining individual bank accounts. Accounts are initially established for each student in a class and personalized checks generated. As funds are deposited or withdrawn, accounts are updated. Monthly statements are then generated. One teacher uses the system both to teach basic mathematics and money concepts and to track a behavior point system. Points are given to students each day for attendance, homework completion, special work, and other performances. These points are entered as money in the student accounts and then used to purchase materials for projects, treats, and gifts for special occasions.

Assessment

Four types of instructional assessments have been identified and built into the units.

Entry level

Entry level assessment appears at first to be nothing more than a traditional pretest; however, it differs from pretests in both composition and use. A typical entry level assessment examines not only facts and concepts, but also attitudes towards the subject being taught and prior experiences related to the topic. Teachers are taught to use this information in introducing the unit and in deciding what types of motivation to incorporate.

Diagnostic

Diagnostic assessments examine a single skill, often in isolation. They are used to make decisions about reteaching or review and may be used as much for showing students how well they are learning as they are for teacher decisions.

Benchmark

A benchmark assessment probes how well students can integrate skills, as in a design project or in problem solving. For projects, grading schemes are developed to encourage students to take an interest in their own learning.

Reflective

A reflective assessment is most often a class discussion wherein students talk about a science unit they have just finished. The object of the assessment is for the students to give sufficient feedback to the teacher so that needed changes in the teaching of the unit can be made before it is taught again.

Conclusions

The various units described here, along with the computer tools, printed resources, and teacher training, are part of a school reform effort based upon science and technology. The long-range goal of this project is to create an integrated curriculum for children, motivated by the need to solve pressing environmental and social problems, plus a professional environment for teachers, wherein they have control over and support for instruction and learning. For the units to work effectively, the typical school infrastructure needs to change. Teachers need to work in pairs or teams, with control over time allocation. A laboratory experiment, for example, needs more than 50 minutes at one time to be properly performed. A rigid sequence of time slots for instruction does not allow lesson content and student interest to influence the duration of instruction. Similarly, skills such as information location and report writing need to be taught when needed rather than as abstractions, divorced from real needs to communicate.

Science and technology form a flexible base for an integrated school curriculum. They allow easy integration of language arts, social studies, expressive arts, and mathematics. What is critical in this integration process, however, is to ensure that the full range of contents and skills of these other areas are represented in the curriculum, rather than simply using these areas to reinforce science and technology. These other subjects cannot become adjuncts of science and technology, no matter how important or interesting we may feel these latter subjects might be. And the teachers of language arts, social studies, expressive arts, and mathematics must have an equal role in the design of the integrated curriculum.

ELEMENTS OF TECHNOLOGY

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Introduction:

Many of the educational reform studies have called for a study of technology in the public schools. To implement a study of technology it would be helpful to analyze technology and identify the individual elements that are commonly associated with technology. This listing would be valuable to curriculum developers who are interested in developing introductory programs and teachers who are interested in evaluating the comprehensiveness of existing educational curricula related to the study of technology. The following items represent a consensus listing of the elements of technology that I have identified from a review of current literature related to the philosophy of technology. The purpose of this listing is to encourage a multi-disciplinary dialogue among the various groups who are interested in promoting public school programs that include the study of technology for all students.

Summary listing of elements:

1. Technology is developed in response to the needs of society. Technology originates with a need, a perceived need, or a want and is adopted, rejected, or modified over time according to the values of a particular society.

The idea that "necessity is the mother of invention" is a common expression of this element. Cultures have different needs and values. These differences contribute to the variation among the chosen technologies that support life throughout the world.

2. Technology is practical. Technology is pragmatic and the efforts of technology are toward something that is workable.

Science is theoretical and technology is applied. Know-how is an example of practical knowledge. Technology is application-oriented and involves doing. The emphasis is on implementation. The concept of the technological imperative suggests that if a particular technology is available, it will be utilized.

3. Technology is problem-oriented. The impetus for technology is a problem derived from the needs of society.

Technology develops as a response to a problem. The definition of the problem is critical to the quality of the solution. A definite process can be used to obtain results. Finding problems, defining problems, and organizing knowledge to solve problems is intrinsic to technology.

4. Technology is future-oriented. The focus is on what is to be, what could be, and what should be.

Education about technology must include information about the future. Technology is being developed that will impact the future. As citizens we must be knowledgeable about technology and be able to influence its development. The techniques of technology assessment are useful to anticipate and evaluate the positive and negative consequences of a particular technology.

5. Technology is cumulative and evolutionary.

There is a body of knowledge that has been evolved and developed that comes to be known as a technology. The technology we have today is the result of the contributions of many individuals. Our quality of life is a function of the achievements and failures of past generations. Technology has proceeded from the mechanical and directly observable to the abstract, math and science based technology of today. To understand technology, we must understand its history.

6. Technology is multi-disciplinary. Knowledge from several diverse disciplines are brought together in the study of technology.

Technology borrows from science and other disciplines. It is eclectic and pragmatic. If useful knowledge is not available, it must be found or developed. The study of technology should be at the core of education because of its multi-disciplinary characteristic. Technology breaks down academic barriers and facilitates the integration of knowledge.

7. Technology creates new realities and possibilities. It determines what is to be.

The technology that is available today is the result of much creative achievement and human ingenuity. Technological breakthroughs have revolutionized the world, and changed the way we view the world. Technology is a creative venture and provides the opportunity for a better future.

8. Technology multiplies and extends human abilities and impacts.

The scale, power, and impact of technology today, is without precedent.

9. Technology creates an artificial environment that insulates and separates us from the realities of nature.

Sun City Arizona with its air conditioning, swimming pools, and lush vegetation has been created in the middle of a desert. There are many examples of the unintended secondary and tertiary effects of technology--DDT, the Aswan Dam, acid rain, and the destruction of the ozone layer. There are also many powerful benefits of technology associated with agriculture, medicine, communication, etc..

10. Technology has certain governing values.

Skill, craftsmanship, ingenuity, simplicity, functionality, appropriateness, optimization, efficiency, effectiveness, conservation, control, precision, etc..

11. Technology is an organized, coordinated system.

Technology can be studied as a system using the universal systems model. Technological systems can also be studied in conjunction with the sociological, ideological, ecological systems. Technology should be studied in context, this is why STS is so important for implementation in our public schools.

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DEVELOPING INTELLECTUAL PROCESSES THROUGH TECHNOLOGY EDUCATION

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Improving the thinking abilities of youth has become a major goal of American education. This goal has received increasing emphasis in the past five years as a result of widely publicized recommendations from a variety of professional and government sponsored task forces. For example, the Education Commission of the States (Task Force on Education for Economic Growth, 1983) included evaluation and analysis, synthesis, application, problem solving, decision-making, and critical thinking in its recommended "basics for tomorrow." The National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology (National Science Board Commission on Pre-College Education in Mathematics, 1983) has focused on the basics of the 21st century by including thinking as a key component of scientific and technological literacy. Improving student thinking abilities has also become the primary thrust of professional associations such as the National Council of Teachers of Mathematics (1989), the American Association for the Advancement of Science (1989), and the Carnegie Council on Adolescent Development (1989). These groups have joined others in stressing that the development of intellectual capacities for problem solving and decision making across all subject areas should be the fundamental goal of education. In essence, these abilities represent the intellectual tools which enable us to comprehend and adapt to the complex technological world we live in.

One curricular area which offers unique opportunities to develop and foster the intellectual processes of students is called technology education. Through a curriculum laden with technological concepts, processes, and applications, technology education teachers are able to provide a motivating and experiential learning environment which supports cognitive development. Technology education students are confronted with technological problems and become immersed in technological issues concerning our society and the protection and promotion of our physical environment. Students are given the opportunity to develop a variety of intellectual abilities by examining real world problems, posing actual solutions, and then testing out those solutions.

Technology education is not just a new name for industrial arts; there are significant philosophical, curricular, and methodological differences as well. While traditional industrial arts programs have the potential to develop student's intellectual processes, they typically focus on motor skill development through individualized project work. Often these projects involve nothing more than replicating a design or solution shown by the instructor. Over the years the field of industrial arts has evolved from a curriculum which focused on materials and technical processes and was dominated by specific craft activities to a technology-based curriculum which emphasizes concepts, generalizable skills, and thinking processes.

As the field of technology education evolves, its unique mission to provide relevant and expansive learning opportunities for students is becoming clear. Through well developed curricula, technology education programs are able to reinforce academic content, enhance higher order thinking skills, and promote active involvement with technology (Johnson, 1991). The development of curricula which addresses such goals is both difficult and complex. Current curriculum perspectives provide some guidance for technology education curriculum developers although elaboration of those curriculum theories is needed. The purpose of this paper is to examine current approaches to curriculum development and identify distinguishing characteristics of curricula which enhance intellectual processes.

Major Orientations to Curriculum Practice

A variety of philosophical orientations influence the purpose, methods, and outcomes of the curriculum. Miller and Seller (1985) denote three primary orientations that support diversity in curriculum development. Descriptions of these three orientations provide a foundation for a more detailed analysis of the various conceptions of curriculum theory.

Curriculum as Transmission

The transmission approach to curriculum development is the most predominate of the three orientations. This approach views the primary function of education as the one-way transmission of facts, skills, and values to students. Metaphorically, this orientation views education as a process of transmitting information from teacher to student in much the same way as water flows through a conduit (Royer, 1986). This orientation characterizes students' minds as "empty vessels" which teachers must fill by pouring information into their heads.

Curriculum developers who adopt the transmission philosophy must embrace a mechanistic view of human behavior which is based in the behavioral psychology work of Thorndike and Skinner. With a focus on behaviorism which advocates breaking human activity into specific responses, curriculum planning emphasizes the development of skills through specific instructional strategies. Curriculum developed under this orientation typically stresses mastery of traditional school subjects through routine teaching methods with a great emphasis on textbook learning. The current competency-based education movement is an operational example of the transmission orientation.

Curriculum as Transaction

The transaction orientation views students as rational individuals who are capable of intelligent problem solving. This approach goes beyond education's traditional role as a conveyor of rote learning by promoting a two-way dialogue between teacher and student in which ideas, processes, and values are freely exchanged.

The central element of the transaction curriculum is an emphasis on curricular strategies that facilitate problem solving, application of problem solving skills in social contexts and democratic processes, and the development of cognitive skills in academic disciplines. In other words, the transaction orientation emphasizes the learning of cognitive processes which empower students with the skills needed to continuously learn and adapt to the changing world.

The transaction orientation can be traced back to the enlightenment era where noteworthy American thinkers such as Benjamin Franklin and Thomas Jefferson called for a curriculum that developed students' intellectual abilities instead of concentrating on rote learning. The progressive education movement of Dewey provided the philosophical foundation for this orientation and the cognitive development theories of Piaget and Kohlberg provided the psychological roots (Miller & Seller, 1985).

Curriculum as Transformation

The final curriculum orientation proposed by Miller and Seller (1985) focuses on personal and social change. By emphasizing each student as a unique individual, this orientation seeks to provide the skills that promote personal and social transformation. Ultimately, the goal of this orientation is to promote social change through individual development.

Approaches to Curriculum Design

While Miller and Seller (1985) advocate a broad view of curricular orientations, other curriculum theorists favor a finer level of categorization (Eisner & Vallance, 1974; Zuga, 1989). Zuga (1989), for example, examined the models of eight curriculum theorists and identified five major categories. Table 1 identifies those five categories and denotes their distinguishing characteristics:

Table 1

Categories of Curriculum Designs

Curriculum Designs	Major Curricular Goal	Major Curricular Question
Academic	Improve students' knowledge of subject matter.	What needs to be learned?
Technical	Improve students' ability to perform various tasks.	How is it done?
Intellectual Processes	Develop students' cognitive process skills.	How is knowledge acquired and used?
Social	Help students acquire the skills needed to change society (social reconstruction) or prepare students to adapt to current society.	What do students need in order to adapt to current society or assume the role of social change agent?
Personal	Allow students to determine what is learned based on their individual needs and interests.	What do students want to learn?

There is a clear relationship between the five curriculum categories described above and the three orientations posited by Miller and Seller (1985). Both the academic and technical curriculum design categories correspond to the transmission orientation. When the goals of instruction are to master subject matter content or develop skills, the standard instructional approach is to transmit information to students through lectures and demonstrations. In this way, the information is passed on to students much as water flows through a conduit. As the receptors of the information, students can either absorb the information or let it flow past. The intellectual processes category, with its major emphasis on cognitive processes, is identical to the transaction orientation. Because they focus on individual growth and social change, the social and personal categories closely align with the transformation orientation. While a more thorough explanation of the various curriculum design theories can be found in other sources (Eisner, 1985; Eisner & Vallance, 1974; Miller & Seller, 1985; Zuga, 1989), the above discussion serves as an advanced organizer for the following discussion of an intellectual processes curriculum.

A careful analysis of the various curriculum perspectives reveals the strengths and weaknesses of each approach. While each perspective provides bits and pieces for a well-rounded education, this paper is based on the assumption that the development of intellectual processes, while neglected in the past, should be the primary goal of education. Therefore, the purposes of this paper are to establish a rationale for curricula which emphasizes the development of intellectual processes and to lay the foundation for an intellectual processes curriculum framework.

Importance of Intellectual Skills in Future Workforce

There is little doubt that intellectual processes are becoming more important each day. Tremendous changes have occurred and will continue to occur in the workplace. Equipment and processes are becoming more sophisticated. This sophistication has resulted in fundamental changes in the skills needed by workers. Increased levels of skills are required to maintain complex equipment. There has been a switch from concrete (hands-on) tasks to abstract (minds-on) tasks which require mental skills such as symbolic and abstract thinking (Grubb, 1984). Management strategies have also changed in recent years. Just-in-time manufacturing, participative management techniques, statistical process control, and an increased emphasis on teamwork are just a few examples of the changing nature of the workplace.

As a result of these advances in technology and the organizational changes to the industrial infrastructure, job expectations for workers have changed. Rather than simply performing repetitive tasks, workers are now expected to be skilled in many jobs. While technical skills are still needed, they are not enough. Workers need to have a broader understanding of their role in the organization, to be able to work in teams, and they must possess higher levels of communication and computational skills. Consequently, business and industry needs a workforce that possesses a broad general education with heavy emphasis on math and science. While these changes suggest the need for a greater emphasis on academic skills, the most important job skills may be the ability to think creatively, solve problems, and make decisions. In actuality, the workforce must have the ability to learn in order to keep pace with the constantly changing world.

While technological and organizational changes are impacting the workforce, similar challenges face the general public. The impacts of technology on our society, culture, environment, and political systems need to be analyzed and evaluated by citizens. Without well developed intellectual skills and an understanding of technology, it is doubtful that the general public will be willing nor able to make critical decisions regarding technological issues.

Given the fact that the skills needed by the workforce are changing and the increased need for all citizens to have high level thinking skills, are students being provided with the opportunity to acquire those skills? The answer to that question is a disappointing NO! These skills are not being taught in the majority of the schools — students are left to discover them on their own. School curricula has traditionally been developed based on behavioral psychology foundations and traditional task analysis methods which lead to a focus on rote learning and physical and basic skill development.

Because contemporary curriculum needs to emphasize understanding rather than rote memorization and heighten higher level cognitive skills in addition to physical and basic skills, curriculum development is more complex than it has been in the past. Part of the difficulty in developing curriculum that emphasizes intellectual processes is the fact that these processes occur only in the mind and are therefore not directly observable to the curriculum developer. In addition, good thinkers and problem solvers do not know how they think and solve problems because intellectual processes become so automated that they occur instinctively (Ericsson & Simon, 1984). Because the intellectual processes are not directly observable, teachers often neglect these processes in their instruction.

Zuga (1985) acknowledges that there have been few attempts to design and operationalize a thinking skills curriculum; partly because there is a lack of a coherent framework. However, recent research in cognitive psychology has provided conceptions and techniques for identifying intellectual processes.

What are Intellectual Processes?

What are these intellectual processes that are becoming so important? They are the higher order abilities that enable us to acquire new knowledge, to apply that knowledge in both familiar and unique situations, and to control our own thinking. Without a doubt, the term "thinking" has different meanings to different people. In an attempt to clarify the term, a recent gathering of educators from around the country developed a framework for describing intellectual processes (Marzano, Brandt, Hughes, Jones, Presseisen, Rankin, & Suthor, 1988). This framework emphasized several dimensions of thinking including thinking processes and skills, critical and creative thinking, and metacognition.

Intellectual processes and skills are the mental operations we use to learn, solve problems, think creatively and critically, and make decisions. These include broad intellectual processes such as concept formation, comprehension, problem solving, decision making, and inquiry and the more specific thinking skills such as goal setting, comparing, classifying, and restructuring.

Critical and creative thinking is another major dimension of thinking. While many people equate critical and creative thinking with intellectual processes such as problem solving and decision making, they are really unique aspects of those processes. People can engage in varying degrees of creative and critical thinking while solving problems, making decisions, and conducting research. For example, when attempting to design a more efficient solar energy collector, one engineer may develop a very creative solution while another engineer may choose a traditional design. During the same design process, the engineers may also differ in the degree of critical thought they use to create a solution to the problem.

The final dimension of thinking is often called metacognition or strategic thinking. Metacognition refers to our awareness of our own thinking processes and involves the planning that takes place before engaging in a thinking activity, regulation of our thinking during the activity, and an evaluation of the appropriateness of the thought processes used to complete the activity.

In response to the need to increase the emphasis on thinking in the school curriculum, many educators are reevaluating what is being taught in the schools. As a result, a number of instructional programs designed to teach thinking have been developed to fill the void in this area. Many of these programs are being offered to students as separate thinking courses while others have been infused into the regular subject matter of the disciplines. The key to effectively developing and fostering intellectual abilities in students, however, is to immerse them in thinking oriented activities within every unit throughout the entire school curriculum.

What are the Characteristics of an Intellectual Processes Curriculum?

Given the importance of intellectual processes in this world of constant change, what are the characteristics of an intellectual processes curriculum? Intellectual processes curricula should build on the current cognitive theories of learning. These theories view learning as a process of constructing one's own understanding through active involvement in the learning process. Under this learning theory, teachers design instruction in a way which allows students to develop understanding rather than simply memorizing new content. To develop good thinkers and problem solvers, the cognitive theories of learning suggest that we teach through an "apprenticeship" model of instruction, emphasize learning through experiences that are situated in real-life contexts, integrate rather than isolate the content areas, and use authentic methods of assessment. Each of these approaches to instruction are being effectively used in many technology education programs throughout the world.

Uses Apprenticeship in the Classroom

Cognitive apprenticeship uses many of the instructional strategies of traditional apprenticeship but emphasizes cognitive skills rather than physical skills. Traditional apprenticeship typically involves an expert who models good performance for novices, coaches them through a task, and gives the novices more autonomy as their skills develop. For example, in a traditional craft guild, the master will model expert behavior by demonstrating to the apprentice how to do a task while explaining what is being done and why it is done that way. By observing the master perform, the apprentice learns the correct actions and procedures and then attempts to copy them on a similar task. The master then coaches the apprentice through the task by providing hints and corrective feedback if needed. As the apprentice becomes more skilled, the master gives the apprentice more control over the task by "fading" into the background. Another important aspect of apprenticeship is the emphasis on "real world" activities which are appropriately sequenced by the master to fit the apprentice's current level of ability.

Cognitive apprenticeship uses the same "modeling, coaching, fading" approach to enhance students' cognitive abilities. During the modeling phase of cognitive apprenticeship, the teacher shows students how to complete a task or solve a problem while describing what is being done, why it is done that way, and when the approach is most appropriate. However, in contrast to typical instruction, the activity is modeled within the context of real world situations. For example, if a lesson deals with the concept of flight and involves the creation of a lighter than air transportation device, the teacher would attempt to solve a similar problem with the class in order to model the intellectual processes that are used in creative problem solving. By modeling the desired intellectual processes, students will discover that there are many ways to solve problems, that experts make mistakes, and that seemingly simple problems are very complex in the real world.

Following the modeling of the desired processes, teachers become coaches by observing students while they carry out a task, analyzing their performance, and providing hints and assistance if needed. Through this instructional approach, proper thinking techniques are nurtured by the teacher through explicit modeling, support, and guidance. In addition, teachers need to pay close attention to the developmental nature of thinking. Students need to be given problems that build on their prior learning and provide a scaffolding to help them become increasingly complex, abstract, and sophisticated thinkers. As students' intellectual processes become more accomplished they will be able to perform with less and less instructor intervention. This fading aspect of cognitive apprenticeship results in the gradual transfer of responsibility for learning from teacher to student.

Because technology education content is often taught through a problem solving method, the cognitive apprenticeship approach to instruction is easily adapted to the technology education classroom. Technology teachers act like technologists in their classrooms. They solve unfamiliar technological problems for students and are not afraid to make errors or have difficulty finding solutions in front of the class. By serving as a role model in this capacity, technology teachers show students how to collect and use information to solve technological problems and help them realize that not all problems have straightforward and simple solutions.

Uses Situated Contexts for Understanding and Transfer

Instruction typically promotes an understanding that the teacher is the all knowing authority, that problems are simple and straightforward, that problems can be solved by applying the methods or formulas just covered in class, and that there is usually only one right answer to a problem. In contrast, instruction that occurs within real world contexts promotes a much different type of understanding. Much of the success of the cognitive apprenticeship model of instruction lies in the fact that intellectual processes are best developed through experiential learning activities that occur in realistic contexts. In addition, the knowledge that is gained through realistic contexts is more likely to transfer to new situations.

In technology education, learning activities are designed to address the interests of students and relate to current problems in the local community. These experiential learning activities may involve the development of a community recycling program, designing alternative energy sources for the home, or creating a manufacturing enterprise to produce a product desired by local consumers. These types of experiential learning activities present students with real world problems and challenge them to define the problem, collect data through research methods, design and test potential solutions, and evaluate the results.

Learning within real-world contexts does not mean that instruction must take place outside the school classroom to be effective. Many technology education programs have demonstrated that real problems can be simulated in the classroom. An excellent example of a situated learning activity can be found at McCullough High School in The Woodlands, Texas (McHaney & Bernhardt, 1989). Larry McHaney and Jerry Bernhardt are technology education teachers who have developed a space simulation project that began as an activity in one class and quickly expanded into a project which involved virtually every program in the school. This project began when several students in a drafting class expressed an interest in doing something more interesting and relevant than simple drafting exercises. In response to this request the students were given an ill-defined assignment of designing a space station. The students were expected to conduct research on the requirements of design in weightless conditions and develop a drawing and physical model of the space station. As other technology education classes heard about this activity they also became involved. For example, the construction class decided to take the space station design from the drafting class and actually build the components of the space station. This required the students to examine the requirements of construction in space and raised questions about the appropriateness of common construction materials, effective ways to transport materials, and innovative methods of construction. As the activity became known throughout the school, it was decided that the entire space station concept should be carried out as a simulation. This meant that an actual (simulated) space launch would take place. As a result, virtually every content area in the school became involved. For example, the food sciences classes researched space food and precooked and packaged the meals for the astronauts, the math classes helped with water volume, air replacement, and weight calculations, the art department contributed to the decoration of the space station, and the science classes helped build robotic arms and designed experiments that would be conducted during the simulated space voyage. As explained by the two instructors who coordinated the simulation, the motivation and excitement generated by the realism of the activity could not be replicated through conventional educational methods.

Integrated With Other Content Areas

Organizing the school curriculum around isolated subject areas is a result of the need for efficiency rather than for quality learning. Segmenting the school day into isolated lessons in subjects such as literature, mathematics, science, social studies, fine arts, and foreign language promotes a view that there is little relationship among these fields. The compartmentalized curriculum and the segmentation of the school day into isolated content areas prevents students from seeing the relationships among the content areas and reduces their chances of developing the cohesive breadth of understanding they will need in the 21st century.

When dealing with real problems, people need to use all of their available resources and knowledge to find solutions. This includes scientific and technological understanding as well as an awareness of social, political, and economic issues. When dealing with technological advances and their impacts on society and the environment, an integrated understanding of mathematics, science, and technology is, without question, needed to make quality decisions. Without an explicit attempt to integrate these fields in school, it is doubtful that students will recognize their importance and be able to integrate the subject matter on their own.

Attempts to promote the integration of school subjects rather than dealing with them as isolated areas of study are currently underway. The move toward integration of subject matter is evident in technology education, particularly at the elementary school level. For example, at Dranesville Elementary School in Fairfax County, Virginia, technology education is woven into all areas of the curriculum. It is not treated as a separate curriculum area, rather it is approached as a method for applying concepts of math, language arts, science, and social studies to real problems and situations (Forman & Etchison, 1991). One teacher at Dranesville incorporated technology education into a language arts class after the students read the novel, The Secret of NIMH, by Robert C. O'Brien. Upon completing the book, students launched a study of the environmental needs of rodents. They formed teams to design houses for the 'clients' using resource materials from the American Institute of Architects. Math skills of measurement, scale, calculation of area, and estimation were reinforced in the students through this experience. Classroom discussions centered on the selection of appropriate materials, and how these choices would affect the social and physical environment. Later, groups were asked to write scripts to sell the homes and videotape advertisements for them. The teacher included lessons on speaking and persuasion during this portion. What might have been a routine language arts reading assignment became an integrated activity, forcing students to draw upon the knowledge they possessed in a number of subject areas, think critically about the situation, and apply this information by creating and designing solutions to a given problem.

This example represents an exceptional program, yet many regular elementary teachers incorporate technology education problem solving activities into their regular schedule as enrichment, to reinforce basic subject area knowledge and to allow students to apply this information in a realistic situation. Teachers at Oak Grove Intermediate School in Bloomington, Minnesota regularly infuse technology education into the regular curriculum through technological problem solving activities. Students attack problems which challenge them to design and build towers using spaghetti sticks and marshmallows, towers which will hold the most weight using note cards and paper clips, or bridges using straws and paper clips. Students become involved in designing the structure, exchanging and evaluating ideas, purchasing building supplies from a simulated supply store, and then actually constructing the structure. The students must manage a limited budget, write checks to pay for building materials, and consider the limitations of the materials when devising problem solutions. They draw upon math skills in calculating the cost of materials, maintaining their budget, and calculating their final score based on a sophisticated point system. Language arts abilities are strengthened as students write final reports and present design ideas in written and oral form. By working in cooperative groups, communication and expressive abilities become vital for the eventual success of each design team. Students build higher order thinking abilities through the brainstorming of creative design solutions to the given problem. Ideas are critically evaluated before a final design is selected, based on student-devised sets of evaluation criteria. Through technology education activities such as these, the integrated curriculum becomes a reality. Intellectual abilities are fostered in the learners concurrently as they are forced to draw upon knowledge from all of the subject areas to design, construct, and test creative solutions to multi-faceted problems.

Uses Authentic Assessment Methods

Assessment is a central topic of professional debate in education. A current trend is toward the view of assessment as an occasion for learning rather than testing. Conventional testing and assessment, with its emphasis on recognition and recall tasks, often promotes memorization rather than understanding. Conventional assessment also has difficulty evaluating the higher order thinking skills students use for problem solving, reasoning, and decision making. While it is possible to develop multiple-choice items which assess higher order thinking, it is rarely done in practice (Linn, 1991).

Because most real-world problems are structured in ways that cannot be quantified on paper and pencil tests, assessment in courses that emphasize intellectual processes need to directly assess practical skill performance. In addition, increased attention should be given to assessing personal qualities such as honesty, judgment, work habits, and adaptive capabilities.

In technology education, where student learning is judged through exhibitions of invention, transfer, and inquiry, assessment methods emphasize depth of understanding and comprehension in addition to recognition and recall. When technology teachers give assignments to students that are ill-structured, problem-centered, and highly experiential, students complete these assignments by engaging in thoughtful problem solving and then testing their solutions through hands-on activity with tools, materials, and equipment. During the completion of these activities, technology teachers observe students in action, provide mentoring and coaching support, and continually assess student performance. Much of the subjective, naturalistic assessment that occurs through observations and interactions with students in lab settings provides technology teachers with a greater understanding of student learning that can be used to improve instruction and to assign grades. While these methods of assessment may not fit the psychometician's desire for statistical rigor, they are certainly capable of providing teachers with the information they need to make the ongoing judgments of student learning and performance on higher order thinking processes.

One alternative form of assessment of higher order thinking ability involves videotaping students as they solve technological problems. This approach has been used in a limited number of technology education classrooms has exhibited some exciting results (Glass, 1991). In this approach, students are asked to "think aloud" as they attempt to solve a technological problem. The problems range from building a bridge with straws and paper clips or toothpicks, to troubleshooting a faulty electronic device or gasoline engine, all within a set time limit. By thinking aloud, the students expose their thought processes and their overall approach to problem solving. The students' understanding and mental representation of the problem becomes exposed by the required verbalization as they attempt a solution.

Upon completing the activity, the students are invited to view the videotape of how they approached the problem and observe the solution path they followed. They are then able to see mistakes they might have made and are able to devise new ideas as alternatives to those that were unsuccessful. By viewing and hearing themselves as they attempted a solution, students develop abilities in devising and structuring appropriate solutions to problems. They continue to build and develop different solution strategies as they participate in other problem oriented activities, creating a network of information to draw upon when they face new problems. Over time, as students think aloud during their attempt at new problems, they become more aware of their approach to problem solving and are more likely to catch themselves before making trivial errors.

Assessing student performance using this method of videotaping is beneficial to teachers and students alike. By having an audiovisual record of how students approached a problem, the instructor easily determines the types of background knowledge that needs to be provided to students and key concepts are highlighted the next time the unit is taught. Students benefit by seeing their own errors as well as successful ideas and solutions, which helps them build a repertoire of problem solving strategies for the future.

Summary

Technology education has the potential to be a significant contributor to the development of student intellectual processes. This vital role in the development of intellectual abilities is currently being implemented in various technology education programs throughout the world. By bringing realistic technological problems into the classroom or laboratory and encouraging students to critically evaluate the situation, devise creative solutions, and apply appropriately learned problem solving strategies to overcome obstacles and solve the problems at hand, technology education is in the position of taking the lead in building on this message and applying it in classrooms at all grade levels.

The need to teach young people to think critically and creatively, to approach problems systematically and thoroughly, and to be able to monitor and direct their own thinking and learning is glaringly evident. Leaders in education and business have stressed that these abilities will be increasingly important assets for people to enable them to survive in the workplace and thrive in a technological world. Recent research is now beginning to show that higher order processes such as problem solving, critical thinking, creative thinking, decision making, and metacognition can be developed in learners. With careful attention to the development of appropriate curricula, technology education is one programmatic area that offers unique opportunities to develop and foster these types of abilities in learners.

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PROBLEM SOLVING IN SCIENCE, TECHNOLOGY AND SOCIETY EDUCATION WITHIN A MIDDLE-LEVEL SCIENCE CURRICULUM

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The New York Science, Technology and Society Education Project (NYSTEP) is a joint effort of the Atmospheric Sciences Research Center at the State University of New York at Albany (SUNY-A), the Bureau of Science Education of the New York State Education Department (NYSED), and the New York Power Pool.[1] These three organizations have worked in contractual partnership since 1982. The partnership has developed award-winning elementary and secondary school energy education curricula and STS curricula, and provides teacher enhancement activities for teachers across New York State. Previous TLC presentations have explained the history and evolving nature of the partnership (Valentine, 1989; Peruzzi, 1990, 1991).

NYSTEP has received awards from the National Association for Industry-Education Cooperation, the U.S. Department of Energy, the Office of the Governor (New York), and the Anderson Medal competition. NYSTEP seeks to enhance the scientific literacy of middle-level (grades 7-9) students and to assure appropriate participation of underrepresented minorities and females in science and science education.

Over a four-year period, twelve Science, Technology and Society (STS) modules are being developed, field-tested, and revised by NYSTEP using funds from both the National Science Foundation and the New York State Department of Environmental Conservation. The modules will be disseminated statewide by NYSTEP's forty Resource Agents who will perform staff development activities for middle-level science teachers using funds provided by the New York Power Pool and the New York State Education Department.

ACTIVITIES

The curricular materials under development emphasize problem-solving and decision-making through Science, Technology and Society (STS) issues. Each module is tied to the state Science Syllabus for Middle and Junior High Schools and the Regents Competency Test in Science administered annually across the State. This close connection to the state science framework and a statewide examination, increases the likelihood of appropriate use of each module by the approximately 5,000 middle-level science teachers and 600,000 middle-level students in New York State.

NYSTEP provides staff development for middle-level science teachers to whom the modules will be disseminated. This set of activities is funded by cost-sharing through sources other than the National Science Foundation (NSF). Interwoven staff development networks already in place bring appropriate awareness and training to science teachers and supervisors. This training is expected to result in major instructional style changes for science education as it takes place in middle-level science classrooms.

Two modules have been released statewide in final editions during the 1991-92 school year. Solid Waste: Is There a Solution? Problem-Solving Activities for Middle-Level Science moves students beyond a mere study of solid waste management problems to the design and implementation of effective local actions that contribute toward solutions. Through concrete experiences in the local community, students develop growing awareness of the interactions of science, technology and society with their daily lives. Science learning then becomes connected to real world experiences and the concepts and principles of science are seen as more relevant to student behavior and action.

The solid waste module is intended for use in middle-level science classrooms over a four-to-eight week period of time. Complex solid waste problems and issues are addressed in six units. The first unit motivates students to investigate the dimensions and personal relevance of solid waste problems in their local community. Unit two focuses on waste reduction. Reuse and recycling are the focus of Unit three. Waste-to-energy facilities are considered in Unit four. The fifth unit considers the destination of all solid waste not dealt with in any of the previous ways - the landfill. The final unit involves students in exploration and evaluation of existing long-range community plans for solid waste management. Students are encouraged to analyze and evaluate local plans based on the knowledge they have gained from research on solid waste management.

The second module which has been released statewide is titled Using Earth's Resources: What are the Tradeoffs? Problem-Solving Activities for Middle-Level Science. This module is intended for use in middle-level science classrooms over a three-to-four week period of time. The first unit helps students locate their school and local area on a map and assess the local tradeoffs involved in living where they do. The second unit looks more closely at soils and mineral resources. Students identify and explore various properties of soils, develop a soil profile, identify properties of minerals, and relate the raw materials from soils and mineral resources to manufactured goods, food products, and energy resources. The final unit focuses on issues involved in stewardship. The aim is to engage students in informed action regarding local soil erosion.

A three-part simulation within the module facilitates students' understanding of tradeoffs in using Earth's soils and mineral resources, including the sociopolitical nature of land use planning. Each time students return to the simulation, they encounter increasing complexity.

Living in the twenty-first century will present citizens with challenging issues and problems regarding science- and technology-related personal and social issues. Making informed personal and policy decisions about these STS issues will require the long-term collection of data from many sources, as well as new and improved methods. NYSTEP believes students need to experience the worth and challenges of long-term investigations that require the use of knowledge, concepts, and skills from several different discipline areas.

To help science teachers realize this important educational goal, NYSTEP modules provide in each activity within each module, a set of short-term interdisciplinary connections keyed to various areas of the curriculum. These connections can be assigned as individual or group projects to enrich student learning and to help students connect their experiences in science classes to other discipline areas.

Ideally, schools should also provide opportunities for longer-term interdisciplinary learning. To help teachers accomplish this goal, NYSTEP modules provide some long-term interdisciplinary connections for various school subjects at the beginning of each module. Teachers in situations where teaming is either the rule or a possibility can use these suggestions as they are, or they can adapt them to their particular needs. The suggestions are not exhaustive but are designed to stimulate thinking about long-term student activities that connect several school disciplines.

The following additional modules are in various stages of development:

- Bic'ogy and Adolescence
- Communication
- Energy in Biological Systems
- Energy in Physical Systems
- Epidemics
- Global Systems
- Natural Disasters
- Teacher Guide to the NYSTEP Modules
- Water Resources
- Wildlife

Classroom science teachers in New York State receive the modules free of charge with attendance at one of the NYSTEP dissemination workshops hosted by one or more of the NYSTEP Resource Agents working collaboratively with their local gas and electric utility. Teachers and other interested individuals and organizations outside New York State may purchase modules through the mail.

A statewide advisory committee guides the Project. The committee is composed of classroom teachers, district level supervisors, university researchers, and business and industry representatives. This activity is complimented by the use of a broad range of external curriculum review organizations that includes business and industry, education, research, and public interest sectors.

IMPACT

Five modules have been subjected to a statewide field test at this point, therefore, only limited data is available about the impact of project materials. The formative evaluation of the solid waste management module, for example, indicates that the NYSTEP modules have equal or greater student impact than the energy modules that the project earlier developed. The solid waste field test, to cite just one extended example, brought a return rate of over 85% for teacher and student evaluations and an enormous number of parent responses. This translates into over 250 teachers, 7,500 students, and over 1,000 parent responses. The high number of returned parent surveys indicates that the modules are succeeding in involving parents as key participants in the formal science education of children. Schools represented in the sample include those in the inner city, remote rural areas, suburban environs, the State School for the Deaf, and four schools in the juvenile prison system.

Overall teacher and student satisfaction with the field test materials is high. Teachers rated the following aspects of the solid waste module at a mean of 4.0 or better (out of a possible 5.0):

- promoting problem-solving skills
- helping students act responsibly concerning this issue
- improving attitudes toward science
- improving science process skills
- encouraging effective decision making
- improving solid waste knowledge base

Student ratings of the solid waste field test experience were also high, especially in regards to the following attributes (mean of 4.0 or better out of possible 5.0):

- amount of factual knowledge gained
- personal relevance of topic
- personal success with the activities
- amount of thinking they had to do
- amount of collaboration with fellow students on tasks

Qualitatively, results from the field tests of the five modules indicate that the Project is making a difference in the lives and learning of middle-level students. When asked to state in a sentence or two what they learned from the module on solid waste, for example, seventh and eighth grade student replies included:

- "Solid waste is a problem we must all be aware of."

- "Garbage is a problem and always will be. We can develop some solutions to problems but they will always raise new problems."

- "That there are no simple, easy answers to problems of trash."

- "That we can all make a difference in dealing with the problem of garbage."

- "That even though my trash looks like a little, it really adds up to a big problem."

- "That we can all recycle or reuse more things than we do."

Parents were asked to tell us in one or two paragraphs about any behavioral differences they saw on the part of their child during their study of a particular module. Project staff have been surprised by the large number of parental responses and the overwhelming evidence of changes in student behaviors within their homes and neighborhoods. For the field test module on solid waste management, these are a sample of the parental replies:

- "Mary and I separated the recyclable garbage items. She tore up boxes and cardboard to take up less space. Mary counted the number of bags of refuse taken from our home to the curb. She took back the recyclable cans. As always, I was encouraged by Mary to purchase recyclable items. Mary and I discussed the garbage problem in our city."

- "Nick talked constantly about his 'garbology' unit in science class. He brought home some 'paper' made from recycled newspaper. He scoured the house for a pound of garbage to bring to school . . . It is my impression that this topic in his science class has left a lasting impression on Nick."

- "Colleen has been very interested in reusing items we would have normally thrown away. She has designed a number of useful objects for use around the house."

- "As a direct result of her research project about the disposal of medical waste from the local hospital, my daughter has now decided she wants to pursue a career in medical waste disposal."

COLLABORATION

NYSTEP benefits from contributions of time, effort, and expertise from an enormous range of organizations and individuals. Some sample commitments of business and industry include:

- Aggregate contributions of over 1.7 million dollars from the New York Power Pool, its member gas and electric utilities, and National Fuel Gas Distribution Corporation. The level of their corporate contributions has risen steadily since the inception of the project.

- Contributed time (totalling thousands of hours) of utility company public relations personnel, engineers and scientists, and educational representatives to participate in teacher workshops and provide technical assistance to project staff in curriculum development and planning.

- Mr. William Balet, Executive Director of the New York Power Pool, has been an active corporate champion for the Project. He serves as co-principal investigator for the NSF grant and as lead person within the electric and gas companies on behalf of the Project. He is the liaison to other businesses and industries as we seek additional funds to expand the Project's impact.

- Hundreds of hours in contributed release time of private sector scientists and engineers to work on curriculum writing teams in the Big Five Cities or to react to drafts of Project materials. Scientists and engineers from the following companies, in addition to already mentioned utility companies, have worked on aspects of NYSTEP: Eastman Kodak Company, IBM, Brooklyn Union Gas Company, The Fleming Group, Calspan Corporation, Family Services Associates, The C.T. Male Company, Ryan-Biggs Associates, AT&T Bell Laboratories, Delta Laboratories, Greatbach Gen-Aid Inc., O'Brien and Gere Engineering, Inc., and the Medical Foundation of Buffalo.

The State Education Department provides the office space from which the Project operates, the services of the Project Director, Carolyn S. Graham (an Associate within the Bureau of Science Education), telephone and postal services, library and information retrieval services, and warehouse facilities as in-kind contributions to the Project. The State Education Department also provideds:

- Subject matter specialists to consult with Project staff regarding curricular and instructional matters

- Computer assistance in the form of configuration of systems and on-site training

The Atmospheric Sciences Research Center (ASRC) of the State University of New York is a statewide research organization headquartered at The University at Albany, SUNY. The Associate Director of ASRC advises the Project on a continual basis and arranges for additional university scientist and science educator participation in the Project as needs arise. Most recently, for example, ASRC arranged for technical experts on global climate change to meet with NYSTEP staff and the appropriate science teacher-writers to receive a mini-seminar on topics and issues related to global climatic change, acid deposition, ozone depletion, SMOG, and the greenhouse effect.

SUNY at Albany administers the NSF grant to NYSTEP. SUNY at Albany provides two members of the NYSTEP Advisory Committee, library borrowing privileges, joint appointments for three of the NYSTEP staff, the external evaluator for the Project, and access to a mainframe computer for data analysis and worldwide telecommunications.

Additional university participation in NYSTEP has come from faculty and staff at the following institutions:

- State University of New York campuses at Stony Brook, Syracuse, Brockport, Buffalo, Cortland, Oswego, Oneonta, Binghamton, and Purchase.
- Cornell University and its associated Cooperative Extension Services
- Syracuse University
- New York University
- City University of New York campuses of Lehman, Brooklyn, and Hunter Colleges
- Columbia University, including Teachers College
- Rennselaer Polytechnic Institute
- Community College of the Finger Lakes
- California State University at Long Beach
- National Technical Institute for the Deaf, Rochester Institute of Technology

The city school districts of Syracuse, Rochester, Buffalo, Yonkers and New York City have been an integral part of NYSTEP. The science supervisor for each of these districts selected teacher writers for the pilot modules and marshalled local resources for curriculum writing, editing, and pilot testing of Project materials during the past three summers and school years. Superintendents and building level administrators across the State are instrumental in helping the Project field test its materials in the full range of classroom environments present within the State by soliciting field test teachers, providing release time (totalling thousands of days to date) for participating teachers to attend all day workshops, and giving them additional support as needed. Strong encouragement for schools to participate in NYSTEP field test has also come from a number of Boards of Cooperative Educational Services (BOCES) and Teacher Centers across the State and the Science Technical Assistance Centers (STACs) within New York City. With field testing completed for only five of the twelve modules, more than 500 teachers from across the State have been involved.

The support from building level administrators and classroom teachers for student-led decision making and action taking has been heartening. This support has led to substantial and informed student action regarding a host of science-related societal issues both in the community and within the local school building. Two examples of such positive change are cited here:

- Students at Clarkstown South High School in West Nyack, New York developed a campaign to sensitize the entire town to additional recycling possibilities. Following carefully researched and planned student presentations within the local community, students saw the town council adopt a student proposal for a townwide "detinning" program feasability study. Within their own school, the student-designed source separation project was so successful that the district has now decided to replicate it at four other schools within the district.

- What began as a seventh-grade study of solid waste management at Notre Dame Bishop Gibbons School in Schenectady, New York burgeoned into a grades 7-12 interdisciplinary project. Seventh grade students convinced their parents and a significant proportion of the community, to bring returnable deposit bottles to school. Students formed a company to collect and return the bottles with high school business classes designing and implementing the necessary components of this fledgling business. Junior and senior high school art students developed the marketing components. This enterprise has developed into an important, ongoing fund-raiser for this small, economically strapped private school.

A large number of professional associations and nonprofit education organizations generously donate their time and talents - performing important curricular review and technical assistance functions. These associations and organizations include:

- Optical Society of America
- New York Academy of Sciences
- Association for Women in Science
- National Technical Association
- Society of Automotive Engineers
- New York Society of Professional Engineers
- Science Teachers Association of New York State
- Alliance for Environmental Education
- American Indian Science and Engineering Society
- New York State United Teachers
- Business Council of New York State
- New York State Congress of Parents and Teachers
- Environmental Education Advisory Council
- Science Council of New York City
- National Association of Business and Industry
- League of Woman Voters
- New York Science Supervisors Association

Finally, NYSTEP benefits from the specialized knowledge and expertise possessed by various federal and state employees in technical disciplines, who contribute time to review and/or directly contribute to the development of Project materials. Some agencies that provide free consulting time to the project include:

- Brookhaven National Laboratory, U. S. Department of Energy
- New York State Museum and Science Service
- New York State Department of Environmental Conservation
- New York State Health Department
- U.S. Geological Survey
- National Oceanic and Atmospheric Administration
- U.S. Environmental Protection Agency
- Federal and New York State Emergency Management Agencies

CONCLUSIONS

All NYSTEP modules emphasize instructional strategies that improve education for all students - including females and minorities. These strategies include cooperative learning ideas, teaching for conceptual change, and use of student-led planning and decision making. Students are encouraged throughout the modules to investigate relevant careers and to apply what they are learning in their home and community environment. By changing the teaching and learning of science at the middle level from memorization of science facts to application of scientific knowledge in the resolution of real world science- and technology-related societal issues, NYSTEP will make a lasting change in science education across New York State and in the lives of hundreds of thousands of students.

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1. Since 1987 additional funding has been provided from Columbia Gas of New York and National Fuel Gas Distribution Corporation. In 1990, Columbia Gas of New York was acquired by an existing partner of the New York Power Pool.

ROBOTICS: STS CURRICULUM STRANDS INTEGRATED WITH LANGUAGE ARTS AND SOCIAL STUDIES FOR MIDDLE/SECONDARY STUDENTS

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Introduction:

The character of R2D2 developed in the movie, "Star Wars" is a familiar one to the younger generation now in our classrooms. However, the benign, friendly persona of a helpful, non-threatening presence belies the serious role of robotics in the real world.

Through a study of the processes and applications of robotics, appropriate for middle and secondary areas, students could explore and discern the implications of robotics as a central force in new technology. At the same time, language arts/communications and social studies skills and attitudes would be strengthened - all within a framework that emphasizes research and critical thinking.

Curriculum Models:

Recent curriculum models have been proposed that focus on STS and student-centered curriculum strands (Liao, 1991; Ogawa, 1991; and Torda, 1991). Liao, teaching at the State University of New York at Stony Brook, designed a curriculum model for his technological literacy courses to include several concepts. These were: (1) the personal impact on the citizen and consumer and (2) the societal impact: environmental, economic and political (Liao, 1991). All of these components would form an appropriate base for concepts and objectives in an integrated unit on robotics (included as a supplement to this paper).

In a similar manner, T.P. Torda, chair of the Education Committee, Technology and Society Division of the American Society of Mechanical Engineers, made a recommendation that has implications for an STS curriculum. It should be based on "solving open-ended problems in teams" known also as "the project method." (Torda, 1991).

Finally, a third strand was outlined by Masakata Ogawa which included the development of "STS modules for various kinds of citizens" and an awareness of STS issues in a "student-centered framework." (Ogawa, 1991). All curriculum strands could enrich and enhance each other and could be considered appropriate for inclusion in an interdisciplinary unit.

The dilemma posed by technological advances can be studied as a microcosm of problems in the wider global community. One of the primary needs of society has been articulated as the formation of "scientifically literate citizens . . . capable of making humanitarian decisions about a whole host of social, economic, and technological problems." (Carin and Sund, 1980: 65).

The side effects of new technologies may be beneficial, benign, or harmful. When related to the employment sector, the jobs affected may present: (1) a resulting increase; (2) a decrease; (3) a positive benefit or (4) a detriment or deterrent to full-time employment. For those involved in the new technological processes, job opportunities may increase. On the other hand, jobs held by workers may decrease for those replaced or displaced by the new technology (Rutherford and Ahlgren, 1990). Unemployment may be the net result for the latter group of workers. This is an issue that has influenced the "nature of human society" and should be addressed by the work force of the new century, the students now in our classrooms. The effect on employment that results from the addition of robotic arms for handling all welding and painting on an automobile assembly line could be a case study involving the "open-ended problems" that Torda suggested should be questioned and debated. Our young, creative thinkers should be encouraged to propose multiple solutions.

Study of Robotics within an STS Framework:

Robotics(usually linked with computerization, of course) as a technological process has become an issue of expanding importance. Robotics has been considered by many as a major player in the automation of industry. Students in our middle and secondary classrooms need to become a part of this technological revolution by developing an awareness of the processes and applications of robotics.

At the same time, knowledge, skills, and attitudes can also be acquired and enhanced by activities that include the language arts and communications skills, integrated with social studies. Through infusion with other areas of the curriculum, students can sharpen language subskills such as defining, describing, and recording (Gega, 1986). A science curriculum can also be enhanced by a study of a technological area, such as robotics, as one that holds interest for students. However, robotics should also be considered as an instrument for social and economic change and presented as an augmented perspective within the purview of an STS framework.

Nevertheless, robotics, along with computerization and the resulting automation, has been implicated as one of many possible causes of the complex de-industrialization of American society that has been underway for several years. Of prime importance, therefore, would be an examination of the human dimension present, past, and future - especially as related to the social issue of the young, unemployed worker (Howland, 1988). Clearly, the technological revolution has common links that can be discerned through study of a new technology, and one that has relevance for students.

Robotics, a New Technology + Unemployment, a Social Issue in a Real World Setting:

When I returned to a public school to teach middle school language arts in 1988, the robot character of R2D2 was a common reference point for my students. They were also familiar with the processes and applications of robotics through their leisure time activities, such as electronic games and robot-like characters in fiction and film, such as "Robocop." These common experiences formed a base for prior knowledge and could serve as initial links for students at the pre-adolescent and adolescent stages of development. At this point, they are able to interpret and ponder multiple issues as well as pose thoughtful solutions.

It is within the realm of the human dimension that study of robotics and unemployment should be rooted. If indeed robotics and automation have been implicated as part of the complex causes of the de-industrialization of American society, young people need to engage in an exploration of the issues. Unemployment, viewed as a widespread social problem, resulting from decreased opportunities for the American workforce, will directly impact on millions of American families. The real world can also become a central focus of the classroom.

A growing body of statistics for student analysis already exists. Large employment losses in manufacturing added up to approximately 1.2 million jobs lost, with approximately 2.6 million manufacturing workers permanently laid off between 1982 and 1986 (Howland, 1988). Perhaps, as many as 3 million "out of 21 million manufacturing jobs" may have disappeared since 1979 (Dentzler, 1991: 40). Statistics from the fall of 1991, however, added even more: 6 million working part-time as "underemployed" workers with almost 1 million as "discouraged workers." Inadequate reporting has resulted in "undercounting the unemployed" and has disguised "the jobless problem." (McCarroll, 1991: 56).

Unemployment in the past has spawned social movements that reshaped history, as for example, the New Deal era of Franklin Delano Roosevelt. This historical perspective could also be explored in an integrated unit. Future jobs and economic security, the stability of political and social institutions - all fit into the pattern of a broader structure that could be examined by students through an integrated study of robotics. Certainly, the historical perspective lends itself to the interdisciplinary framework that undergirds the STS curriculum strands envisioned.

Teachers have embraced the integrated curriculum approach in recent years as they prepare students for the new century. The real world of science and technology should be a natural area for the classroom, especially with the expansion of the whole language approach with language used in situations that are "meaningful, functional, and genuine." (Hoskisson, 1987: 50). Furthermore, curriculum reform advocates for secondary school science and social studies have asked several vital questions: (1) "Is the material directly applicable to the lives of our learners now?" and (2) Is "theoretical material" linked with "concrete experience?" (Hickman, Patrick, and Bybee, 1987: 3). Robotics, with the social issue of unemployment as an added dimension, could bring the real world into the classroom in the nineties.

An Integrated Unit: **Robotics and Unemployment, the Human Dimension:**

Through the proposed integrated unit, the emphasis will be on learning ABOUT Robotics - the processes, applications, scientists-developers, creative projects, the persona of the robot in science fiction and film, the vocabulary, and career awareness - all as part of an activity-oriented science curriculum. Presently, robotics has been largely confined to the vocational education program at the secondary or postsecondary levels. (See Bibliography for applicable readings in these areas). Learning ABOUT robotics would help to fulfill one of the primary needs of society for "scientifically literate citizens."

At the same time, students whose families may already be involved in the cycle of job loss will read about other young people of the "Freeway" area in a sociological study of dropouts affected by a post-industrial society (Weis, 1990). They will experience the historical perspective by turning back in time to the voices of the Great Depression, reading the interviews based on oral histories from that era (Turkel, 1970). Special research skills will be honed as students learn to interpret the implications of social and economic change from charts, graphs, and statistical tables. Knowledge, skills, and attitudes can be the framework for an integrated unit based on inclusion of the human dimension.

A Caution Concerning Teaching Based On an Integrated, Issue-Centered Field of Study:

As a college educator preparing future social studies teachers, a special effort has been made to actively involve students in cooperative learning, simulations, reflective writing, interactive software and videodiscs, units integrated with the humanities, and other teaching strategies. Hopefully, our own students' future classrooms will one day reflect these attempts to transform passive students into active ones.

However, researchers in recent years have decried the turning away from the issue-centered field of study, also known as the societal-problems approach. The unhappy fate of the issue-centered approach was traced by Evans(1989) and Gross (1989). The decline was attributed to a variety of causes. In teacher education, especially, students have been exposed to possibly only one or two problem-oriented education courses, with chronological history courses named as "the largest academic influence in the background of social studies teachers." (Gross, 1989). Social studies courses since the sixties have been a part of the back-to-basics movement with the suggestion of perhaps " a cultural aversion to controversial questions . . . because they can be gut wrenching." (Evans, 1989).

The puzzle for the nineties may be in learning how to integrate or fit in the "multiple options" approach that could include participatory citizenship, a foundation of content knowledge such as history, geography and the other areas of social studies, along with decision making or social criticism in an honest examination of societal problems (Risinger, 1991).

For the past few years, the pages of social studies journals have reflected the struggle to resolve differences concerning relevant goals for the new century. Fred Risinger, Past-President (1991) for the National Council for the Social Studies (NCSS) outlined this dilemma:

> We must turn part . . . of our attention to how we teach . We know that teaching in-depth is more effective than trying to cover every topic in the textbook. We know that the more students write, the more they learn and the longer they retain it. (Risinger, 1991, p. 139).

Students in the nineties deserve to have the opportunity to examine, dissect, and debate issues that have caused problems in society rather than permit these events to wash over them, uncriticized and unexamined. An integrated unit that includes learning about robotics and the possible implications for society, is an example of an issue-centered study that could bring the real world once more back into the classroom.

Conclusion:

The basic structures within the American economy in 1992 are undergoing a drastic change, perhaps even a revolutionary one. Questions have even been raised as to whether or not the traditional American middle class will be able to survive. A clearer understanding of some of the factors involved in these changes should be translated into issues and problems for students to examine.

For instance, in 1989 when the transformation of Eastern Europe was underway, teachers reported that these events could not be adequately addressed because of time constraints or lack of background information. Clearly, the youth of America deserve to explore the implications for changes in their society and at the same time acquire the knowledge of a new technology, robotics, as one that may hold a key to their own future career paths and job security.

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Appendix A

AN INTEGRATED UNIT: LANGUAGE ARTS/COMMUNICATION SKILLS, SCIENCE (ROBOTICS) AND SOCIAL STUDIES

I. CONCEPTS

II. OBJECTIVES

III. LEARNING ACTIVITIES

IV. MATERIALS

V. EVALUATION

I. CONCEPTS:

ADAPTATION AND CULTURE:

1. The future of American society may be seriously affected by the increase in automation, computerization, and robotics in significant portions of the employment sector such as business management, manufacturing, and the service industry.

2. Future citizens may be deprived of jobs because of the impact of new technology (as one of many causes) on the American economy.

3. Unemployment has been a cyclical factor in past history and should be an area of serious study.

CHANGE:

4. The language arts/communications area can furnish motivation for writing persuasive letters to decision makers or to clarify thoughts and opinions.

5. The skills for finding out information will involve students in first-hand research as well as in ways to personalize learning.

6. Information acquired through research could affect personal motives and attitudes toward future employment, through an expanded career awareness involving new technology.

7. Specialized knowledge could reduce the barriers to full participation in science-based careers by females, minorities and the physically challenged.

II. OBJECTIVES:

1. Students will gather information through listening, observing, reading, and writing.

2. Students will use reference materials including maps, graphs, charts, and statistical tables.

3. Students will organize and evaluate information, research and written materials through maintenance of a personal portfolio.

4. Students will maintain a Learning Log with reflections on new knowledge and insights acquired.

5. Students will recognize the interests and viewpoints of multiple groups in society: Workers, management, government, etc.

6. Students will use oral language skills in cooperative group work, interviews, and discussion groups.

7. Students will show respect for the varying opinions of others and work in cooperative groups.

8. Students will use written language skills to communicate personal opinions and ideas to decision makers in the community, state or federal government.

9. Students will draw inferences from non-print materials such as political cartoons and drawings, oral histories, films, and videotapes.

10. Students will participate in special learning activities to enhance critical thinking, such as: Making inferences, evaluating a primary source(such as a letter or document), detecting bias in an article, interpreting a point of view, forming an opinion, determining a cause and effect relationship, making a decision or expressing a personal viewpoint.

III. LEARNING ACTIVITIES:

LANGUAGE ARTS/COMMUNICATIONS SKILL:

1. Read newspaper accounts or magazine articles from Library Vertical Files under the category of UNEMPLOYMENT OR JOB LOSS in student's home state. A library online search facility such as NEWSBANK and MAGAZINE INDEX may be used. S.I.R.S., another source, is on a CD-ROM. (See Resource Directory - Appendix B).

2. Discuss in cooperative groups the importance of a low unemployment rate for the state and the implications when a "jobs are scarce" situation prevails.

3. Develop a Class Vocabulary Book: Robotics containing a glossary of terms and definitions relating to the applications of robotics. (Lambert, 1985: 44-45 has a Word List of common terms - See Bibliography - Appendix C). Compile a second Class Vocabulary Book: Unemployment with a glossary of terms pertaining to unemployment, such as benefits, discouraged workers, GNP, GDP(Gross Domestic

Product), unemployment insurance, jobless rolls, downsizing, recession, slump, outplacement, etc. Use of word processing software, such as AppleWorks or WordPerfect whenever computers are available for student use, should be encouraged. Desktop publishing and use of graphics should also be en-uraged in ALL of the learning activities.

4. Arrange an interview with a resource person,e.g., worker in an automated plant or engineer/instructor to explain the use of a robotic arm. Tape record interview for playback in class. Students may also wish to create a videotape recording titled "Careers in Robotics" after gathering information from professional organizations and interest groups. (See Resource Directory - Appendix B).

5. Plan a simulated television panel of "experts" for a discussion on the ethical implications of robotics to include student-generated questions such as:

- Should robots be used only by industry?
- Should robots be used in situations hazardous to humans?
- Should robots be used as a military weapon?

Use videotape recorder for playback to class groups. ("Newscast," a simulation from Interact could be used. See Resource Directory - Appendix B).

6. Develop oral and written reports on the applications of Robotics, to include industry, science, engineering, medicine, space exploration, hobby-leisure pastime, among others. (See Bibliography - Appendix C).

7. Research the robot as a genre in literature,especially in science fiction or film.

8. Write letters to editors, representatives or government officials to express views on the social implications of robotics, advocacy for unemployment benefits, etc.

9. Design a robot on paper, to include at least one experiment that could be performed by the robot, using the scientific method model (National Student Research Center, 1991). This could be a project of several cooperative groups. Models could be from the Boys' Life competitions, 1987-1989 or of a more complicated nature (Radio-Electronics, 1989.) Written descriptions and abstracts should accompany diagrams. (See Resource Directory - Appendix B and Bibliography - Appendix C).

10. As a small group project, assemble short biographies of scientists involved in robotics research. (See Bibliography - Appendix C).

11. Develop a poster, transparency or other visual aid to illustrate how various technologies(in addition to robotics) influence societies and the citizenry - such as computers, lasers, nuclear energy, etc.

12. Read and report on the human hardships caused by job loss and recurrent unemployment, comparing accounts from the 1930s (Turkel, 1970) and personal stories from 1991 (Dentzler, 1991; McCarroll, 1991; Pomice and Hawkins, 1991 in Bibliography - Appendix C).

13. Write business letters to manufacturers and suppliers of equipment for information and product catalogs (See Resource Directory - Appendix B).

14. Create a science fiction or fantasy story involving a community of robots, or a similar theme involving a futuristic scenario.

15. Write an editorial based on information concerning unemployment rates in student's home community.

16. Develop a radio or television script concerning a future society where daily work is carried out by robots.

17. Using a computer-generated software program, develop a crossword puzzle based on robotics terms.

18. Give an oral book review on a significant application of robotics, such as a medical innovation or scientific advance to persuade others to also read the book.(Check Bibliography - Appendix C).

19. Design a question and answer column to appear in the school newspaper that centers around questions generated by the class concerning robotics.

20. Write several mathematics story problems that involve robotics.

SOCIAL STUDIES:

1. Design a timeline depicting the major financial crises that precipated unemployment (Kindelberger, 1989 has an outline dating from 1720-1987). (See Bibliography- Appendix C).

2. Develop a bar graph showing the rate of unemployment in student's home state from 1981-1991, if statistics are available. (NEWSBANK has state-by-state reports).

3. Construct graphs and charts to show eras of unemployment in the past century.

4. Interpret bar graph such as "GM's Idle Plants." (Levin, D. New G.M. Leadership. . . New York Times, 15 December 1991- See Bibliography - Appendix C). Students could bring in other charts or graphs from newspapers and magazines to discuss and interpret.

5. One or two cooperative groups could research the historical perspective, e.g., past social movements or revolutions also caused by the introduction of new technology, such as the Industrial Revolution.

6. Small group discussion on the "role of the citizen actor" - one who develops an awareness of the impact of new technology on society and takes an active role. Record viewpoints on chart paper, posterboard or chalkboard.

7.One or two peer groups could read and reflect on selections from an ethnographic study (Weis, 1990-References, p.6-Paper). Reflections should be made in their Learning Logs concerning their feelings toward the unemployed dropouts, former students in the Detroit community who were the subjects of the study.

8. Students can interpret several political cartoons relating to unemployment and job loss. (See Resource Directory - Appendix B - Gonick).

9. Students can research in their cooperative groups several areas from the post-1929 Great Depression, including responses of Presidents Herbert Hoover and Franklin D. Roosevelt: reform legislation to assist the recovering economy, and use of programs such as WPA and CCC to assist the unemployed. (See Resource Directory -Appendix B; Bibliography Appendix C).

10. Students could emphathize with feelings and emotions of the unemployed through participation in a simulation such as "Panic" or "American Letters" (Interact, 1990-See Resource Directory -Appendix B).

CULMINATING ACTIVITIES:

1. Final written reflections should be made by each student in individual Learning Logs to include their attitudes and opinions discerned from studying the positive and negative implications of robotics as a new technology in America.

2. Students will create a personal project to sum up their opinions on robotics as an impact on their personal futures. How will they be personally affected? Future job? Further study? A wide variety of media could be used, e.g., poem, essay, painting, cartoon, or collage.

3. Students can display their personal projects in an assembled Class Book for publication and dissemination to parents and others or as a school showcase exhibit. A follow-up article in a school newsletter or community newspaper would also be appropriate.

IV. MATERIALS: RESOURCE DIRECTORY - Appendix B and BIBLIOGRAPHY - APPENDIX C

V. EVALUATION:

Each student's personal portfolio and Learning Log would serve to determine the extent of knowledge, skills and attitudes that were acquired. The teacher may also wish to grade the student on a project such as the creation of a Semantic Web or Cluster in which student would depict multiple aspects or concepts concerning curriculum strands of robotics or unemployment.

Appendix B

RESOURCE DIRECTORY

I. ROBOTICS

II. TEACHING ABOUT THE GREAT DEPRESSION/NEW DEAL ERA

I. ROBOTICS:

(A) COMMERCIAL FIRMS (MANUFACTURERS OF ROBOTS-WRITE FOR INFO.)

General Robotics Corp., 14618 W. 6th Ave., Suite 150 Golden, CO 80401. Robots for instruction, including a K-12 Curriculum Guide, Teacher's Guide and Student Workbook. An Upper Level curriculum is also available for high school, vocational technical schools and universities. For 6th Grade: RB5X Robot.

GMF Robotics, Inc., 5600 New King St., Troy,MI 48098.

Thomas J. Watson Research Center, IBM, Old Orchard Rd. Armond, NY 10504.

(b) INSTRUCTIONAL KITS, EQUIPMENT AND SUPPLIES:

Boys' Life Robot, 1325 Walnut Hill Lane, P.O. Box 153079, Irving, TX 75015-2079. Plans for building the robot (Boys' Life, 1987-1990). Send self-addressed, stamped envelope.

Edmund Scientific Co., 101 E. Gloucester Pike, Barrington, NJ 07922. Instructional robots.

Feedback, Inc. 620 Springfield Ave., Berkeley Heights, NJ 07922. Instructional robots.

H & R Corp., 401 E. Erie Ave., Philadelphia, PA 19134. Motors for building Boys' Life GISMO2BL robots.

Heathkit Co., Dept. 025-078, Benton Harbor, MI 49022. Model building kits.

Teachers' Laboratory, Inc., The Robocar, kit for robotics applications controlled with a classroom computer (Apple IIe or IBM/PC. P.O. Box 6480, Brattleboro, VT 05302-6480.

Technical Solutions, Inc., P.O. Box 284, Damascus, MD 20872. Parts and equipment for building robots and programmable elements.

The Robot Shop, P.O. Box 582, El Toro, CA 92630. Parts, plans, and a handbook for robot building.

(c) **PROFESSIONAL ORGANIZATIONS AND EDUCATIONAL PROGRAMS:**

American Association for Artificial Intelligence, 445 Burgess Dr., Menlo Park, CA 94025.

Deep Submergence Laboratory, Woods Hole Oceanographic Institute, 98 Water St., Falmouth, MA 02543.

Institute of Electrical and Electronics Engineers, Inc. (IEEE) 345 E. 47th St., New York, NY 10017-2394.

Institute of Industrial Engineers, 25 Technology Park, Norcross, GA 30092.

National Service Robot Association, c/o Robotics Industries Association, 900 Victors Way, P.O. Box 3724, Ann Arbor, MI 48106. (Association devoted to "application of robot technology to health care, education, security, space and undersea exploration.")

National Student Research Center, (Dr. John I. Swang, Director), Mandeville Middle School, 2525 Soult St., Mandeville, LA 70448. Concept designed to assist students in research and publication of science projects.

NBS Automated Manufacturing Research Facility, National Bureau of Standards, Gaithersburg, MD 20899.

Oceanic Engineering Society (a part of IEEE).

Robots Industries **Association,** 900 Victors Way, Ann Arbor, MI 48106.

Robotics International of SME, P.O. Box 930, One SME Dr., Dearborn, MI 48121.

United Auto Workers Union, Skilled Trades Dept. Solidarity House, 8000 East Jefferson, Detroit, MI 48214.

United States Robotics Society, 616 University Ave., Palo Alto, CA 94301.

Virginia Sea Grant College Program, VA Institute of **Marine Science,** Gloucester Point, VA 23062.

Woods Hole Oceanographic Institution, Woods Hole, MA 02543. Deep Submergence Lab and the JASON PROJECT using robots and involving students.

(d) SPECIAL INTEREST GROUPS:

Homebrew Robotics Club, 91 Roosevelt Circle, Palo Alto, CA 94306.

Robotics Experimenters Amateur League (REAL), P.O.Box 3227, Seal Beach, CA 90740.

Robotics Interest Group (ROBIG), 3205 Sydenham St., Fairfax, VA 22030.

II. TEACHING ABOUT THE GREAT DEPRESSION/NEW DEAL ERA:

GENERAL SOURCES FOR SOCIAL STUDIES MATERIALS:

Interact, P.O. Box 977-S2-90, Lakeside, CA 92040. Catalog: High School/Middle School Social Studies, source for simulations in American History, Government, Economics, Social Issues, etc.

Jackdaw Publications, P.O. Box A03, Amawalk, NY 10511. Catalog of primary source documents in history and government.

Social Issues Resources Series, Inc. (S.I.R.S.), P.O. Box 2348, Boca Raton, FL 33427-2348. Critical issues in society, also available on CD-ROM.

Social Science Education Consortium, Inc., 855 Broadway, Boulder, CO 80302.

Social Studies School Service, 10,000 Culver Blvd., Dept. Y3, P.O. Box 802, Culver City, CA 90230.

The following materials are all from the Social Studies School Service, 10200 Jefferson Blvd., Rm. 18, P.O. Box 802, Culver City, CA 90232-0802:

(a) FILMSTRIPS:

The Great Depression: A Chronicle of the Lean Years. Educational Enrichment.

The Great Depression. Multi-Media Productions.

The Great Depression: 1929-1939. Guidance Associates.

The New Deal. Multi-Media Productions.

Where Historians Disagree Series: Evaluating the New Deal(1985). Random House Media.

(b) **INSTRUCTIONAL MATERIALS: BOOKS, GAMES, PHOTOS:**

American Timeline Series (1986). Grs. 7-10. Entering the 20th Century, 1901-1929: Great Depression, New Deal.

Galbraith, J.K. (1988). The Great Crash, 1929. Houghton Mifflin.

Games and Strategies for Teaching U.S. History, including "The Stock Market Crash." (1984).

Great Depression: 1929-1939. Photos and Political Cartoons). Documentary Photo Aids.

Industrializing America: A Game of American Industrial Development.(Computer Software for Apple). Perfection Form. (1987). Form. (1987).

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Responding: An approach to writing in the Social Studies using an organization 'notes on notes' student notebook, Grs. 7-12. Social Studies School Services.

Social Studies Writing Process Series (1988),including Comparing and Contrasting, Exploring Causes and Effects, Expression of Valid Opinions and The Position Paper, Grades 7-12. Social Studies School Services.

Steps: An essay writing program on three levels for Social Studies, also from Interact.

Gonick, L. (1988). The Cartoon Guide to U.S. History: Vol. II, 1865-Now. New York: Barnes and Noble. (including The Great Depression)

Rothstein, A. The Depression Years.(Photographs). Dover Press.

Schraff, A.E. (1990). The Great Depression and the New Deal: America's Economy Collapse and Recovery, Grs. 9-12. New York: Watts.

U.S. History Classroom Games, Grs. 7-12. The Great Crash Stock Market Games. H.M.S. Historical Games.

Zinn, H. (1980). A People's history of the United States, including the Depression as seen by "the man-on-the-street." New York: Harper & Row.

(c) SIMULATIONS

American Letters Series, Grades 7-12. American Letters (Depression, 1932 Election). Available from Social Studies School Service or Interact, Grs. 8-12.

The following are all available from Interact, P.O. Box 997-S2-91, Lakeside, CA 92040:

New Deal on Trial: Has FDR's New Deal helped or hurt America and its traditions?

Panic: A simulation of the Prosperity of the 1920s and the Depression of the 1930s.

Strike: A simulation of the history of American labor-management relations (including unemployed trying to get hired).

(d) VIDEOCASSETTES:

American Documents Series: Just Around the Corner, the years of the Great Depression.

American Heritage Media Collection Series: The 20s and 30s (Stock Market Crash, New Deal). Westport Media.

American History Video Series: Two Great Crusades (New Deal and World War II). Mastervision.

Brother Can You Spare a Dime: History in Action. Films for the Humanities.

Grapes of Wrath, based on the novel by John Steinbeck. Guidance Associates, 1987.

March of Time Series: The Great Depression, newsreels from the era.

Witness to History Series: The Great Depression: Witness to History. Guidance Associates, 1987.

Witness to History Series: The Roaring 20s: Witness to History. Grades 7-12. Guidance Associates, 1990.

Appendix C

BIBLIOGRAPHY -

I. ROBOTS: GENERAL INTEREST BOOKS
II. ROBOTS: JUVENILE BOOKS
III. IMPLICATIONS FOR SOCIETY: UNEMPLOYMENT, DE-INDUSTRIALIZATION, JOB LOSS, HISTORICAL PERSPECTIVE

Albus, J. (1981). Brains, behavior and robots. Peterborough, NH: BYTE Books.

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Geduld, H.M. and Gottesman, R. (1978). Robots, robots, robots. Boston: New York Graphics Society (Little, Brown and Co.)

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(Publications that focus on job loss and de-industrialization in the American economy in the past decade as well as in other eras of financial crisis).

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INTRODUCING DRAG FORCE TO HIGH SCHOOL STUDENTS

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Why are the automobiles of 1990 more streamlined than the cars of the 1950's or 1970's? What is the purpose of the deflector that sits on the top of the cab of an 18-wheel truck? Why do runners in a marathon often run in a bunch? Why do racing bikes have solid wheels? Why did jockeys replace the traditional loose-fitting silks with tight-fitting synthetic clothes? Why did some of the skiers in the 1992 Winter Olympics spread their skis to form a V rather than use the traditional straight-forward position? The answers to these questions center on the concept of drag force.

Drag force is a technical topic that should be introduced to high school students because it has important implications to society. The reduction of drag has been largely responsible for the savings in gasoline consumption by automobiles. This has reduced the potential for air pollution, improved aesthetics of our communities, possibly had a favorable impact on public health, and reduced consumption of a nonrenewable resource.

In addition to improving the student's understanding of the basis for technological advancement, knowledge of technological concepts can provide encouragement for students to enter a technical career path, such as engineering. However, the effectiveness in meeting this goal will depend on the way that technical subjects are introduced. Hands-on experiments can be an effective way of introducing technical subjects such as drag force. We have developed a hands-on experiment that can be used to demonstrate the basic principles of the subject and demonstrate the relative importance of factors, such as the cross-sectional area, that influence the magnitude of the drag force.

The hands-on experiment performed by the student cannot be an end in itself. The student should be made aware that it is a model and that the purpose of a model is to simulate a real-world prototype. Furthermore, the principle on which the model and prototype are based may apply to other technologies and the student needs to be able to extend the application of the basic principle to these other technologies. Pre-lab and post-lab questions provide a mechanism for extending the student's awareness to these other technologies. In addition to these questions, our lab includes a design problem for the student. The solution requires the student to apply the principle to solve an actual problem, thus demonstrating the engineering process of using scientific principles for the solution of our needs.

The hands-on experiment given as an appendix can be used at the senior high school level, possibly even in middle school, to demonstrate the principles behind pressure drag. The active-learning approach will teach the student the fundamentals of drag force and encourage students towards a career in a technical field. The design problem will hopefully get them to believe that they can be an engineer or scientist and that technology is not beyond their abilities.

Acknowledgment: This work was supported by the NSF-ECSEL program.

APPENDIX

♦ Materials

paper
cardboard
sewing thread
3 ping-pong balls
cellophane tape
meter stick
stopwatch
an assortment of small screws or nuts
paper clips
metric scale
scissors
knife

♦ Objectives

1. To demonstrate the effects of parachutes on the velocity of falling objects.

2. To introduce the concepts of drag force, the drag coefficient, and the Reynolds number.

3. To determine through experimentation the factors that affect the drag coefficient of a parachute.

♦ Pre-Lab Questions

1. Using the follwoing data, graph the relationships between the independent variable X and the dependent variable Y in cases A, B, C, and D. In each case, characterize the relationship, if one exists. Is it direct or inverse? What would be the form of an equation of the line? If there is no systematic relationship between the two variables, what does the consistency of the points tell you about the accuracy of the experiment?

X	A	B	C	D
1	50	20	3	25
2	40	20	12	25
3	30	20	27	5
4	20	20	48	40
5	10	20	75	15

2. You know that gravity causes falling objects to accelerate

toward earth at a rate of 9.81 m/s². Why is it, then, that we are not killed by raindrops as they fall from clouds over 1km above us? What determines the velocity of the raindrops when they reach the ground?

3. A marble is dropped into a jar that is 30cm high and contains water and another marble is simultaneously dropped into a second jar that is 30cm high and contains maple syrup. Which marble will hit the bottom first? Why?

♦ **Procedure**

Preparation

1. To construct the parachutes, begin by cutting the strips of cardboard that will serve as the frames of the parachutes. Cut strips of the following dimensions for each parachute:

   small flat parachute: 4 strips: 8cm x 2cm
   medium flat parachute: 4 strips: 18cm x 2cm
   large flat parachute: 4 strips: 28cm x 2cm
   canopy parachute: 4 strips: 18cm x 2cm

2. Cut the pieces of paper that will act as the "fabric" of the parachutes. Cut the pieces to the following dimensions:

   small flat parachute: 1 square 10cm x 10cm
   medium flat parachute: 1 square 20cm x 20cm
   large flat parachute: 1 square 30cm x 30cm
   canopy parachute: 4 equilateral triangles, 20cm on each side
   (Use a compass to draw the triangle)

3. Tape the pieces of each frame together as shown in Figure 1.

4. Tape the paper squares onto their frames to make the flat parachutes.

5. To assemble the canopy, tape the four triangles together to form a pyramid, as shown in Figure 2. Use tape to seal the seams so that there are no holes in the pyramid.

6. Tape the canopy parachute to its frame, as shown in Figure 3.

7. For each parachute cut four pieces of thread to be used as rigging lines. Cut the pieces to the following lengths:

   small parachute: 10cm
   medium parachute: 20cm
   large parachute: 30cm
   canopy parachute: 20cm

8. Use tape to attach one rigging line to each corner of each

parachute, as shown in Figure 4. When the lines of a parachute hang down, all of them should be the same length.

9. Weigh each of the parachutes and determine which of the four has the greatest mass. Record this value.

10. The other parachutes must be weighted so that all four will have the same mass. Add to the lighter parachutes an appropriate number of screws, nuts, or paperclips in order to make up the difference in mass. Tape the weights to the frame of the parachutes. Make sure that the weight is symmetrically distributed around the frame.

11. In order to prepare the ping-pong balls, use a razor blade to slice two of them halfway around the circumference (see Figure 5).

12. Fill one ping-pong ball with approximately 15g and the other with approximately 30g of metal screws and nuts.

13. Measure the weight of all three ping-pong balls and record these values on the Parachute Data Sheet.

14. Measure a point 2m above the ground and mark it with a line or with a piece of tape on the wall. This will be the height from which you will drop the parachutes.

15. Attach the four rigging lines of the small flat parachute to the top of the empty ping-pong ball using tape. When the ball hangs down, all strings should be equally taut and the ball should hang under the center of the parachute.

Testing

1. One student should hold the parachute in the air so that the bottom of the ball is at the 2m mark (he or she should stand on a chair to ensure accuracy).

2. The other student should operate the stopwatch. On this student's signal, the student holding the parachute will let it drop to the floor. The student with the stopwatch should watch the parachute as it falls and mark the time from the instant it leaves the other student's hand to the instant that it hits the floor.

3. The student with the stopwatch should record this reading on his or her data sheet. Repeat the measurement three more times.

4. The two students should switch tasks. The timer will now record his or her own data. Again, four trials should be made.

5. Remove the empty ping-pong ball and suspend the middle-

weight ping-pong ball from the small flat parachute.

6. Repeat the testing, making four trials for each timer. Each timer should record his or her own data.

7. Replace the middle-weight ping-pong ball with the heavyweight ping-pong ball. Run the trials again. Continue by testing all three weights on the medium flat parachute, the large flat parachute, and the canopy parachute. The procedure remains the same for all parachutes. Be sure that the ball is always dropped from the same height (2m), regardless of the length of the parachute rigging lines.

8. After collecting all of your data, complete Parachute Worksheets A and B to determine the drag coefficient and Reynolds number associated with each test.

♦ **Questions**

Using one sheet of log-log graph paper, plot the drag coefficient versus the Reynolds number for each of the ping-pong ball weights. Use the following symbols for the points: empty +; middle-weight O; heavy-weight *. Connect the points for each ball. Label which line represents which ball (empty, middle, or heavy). On each line indicate which point represents each parachute (s, m, l, or c).

1. Comparing the location of the lines and points, describe how the drag coefficient is affected by:

   a. the size of the parachute

   b. the shape of the parachute (compare the medium flat chute to the canopy chute)

   c. the weight of the load

2. How is the drag force (i.e., the force exerted by the entire parachute against the direction of motion) affected by: (Hint: Think about how drag force is related to velocity.)

   a. the size of the parachute?

   b. the shape of the parachute?

   c. the weight of the load?

♦ **Post-Lab Questions**

1. Based on your analysis, what was the most important factor in determining the drag coefficient -- size, shape, or load of the parachute? Justify your answer.

2. Make a plot of velocity vs. area of the parachute for the

small, medium, and large flat parachutes. Use different symbols for each ping-pong ball and connect the points for each ball. What can you say about the effect of area on the velocity? What would happen to the velocity as the area of the parachute became infinitely large? Infinitesimally small?

3. How long would it take a 10g marble attached to your medium flat parachute to fall 2m if the drag coefficient is 3.0? What is the Reynolds number in this case?

♦ **Design Problem**

The maximum velocity at which a paratrooper can land safely is approximately 5m/s. You are a design engineer hired by Department of Defense to design a flat parachute to be used by a 90kg paratrooper. Begin by guessing what area is necessary and calculating the corresponding Reynolds number. Refer to your logarithmic graph of Reynolds number versus area and determine the corresponding drag coefficient, based on the data you obtained for your medium flat parachute. Using the drag coefficient, calculate the velocity. From this result, decide if you need to make the area bigger or smaller, and recalculate the velocity. Continue this process until you reach a stable solution. Remember that a parachute that is too large will waste material and may slow the paratrooper down too much, but a parachute that is too small will allow the paratrooper to descend at too high of a velocity, which may cause the paratrooper to be injured. Show all of your calculations and justify your final design.

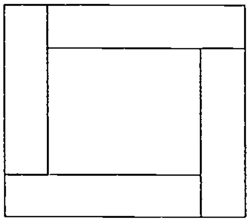

Figure 1:
Assembly of frame

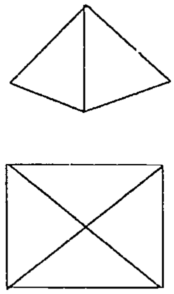

Figure 2:
Assembly of canopy

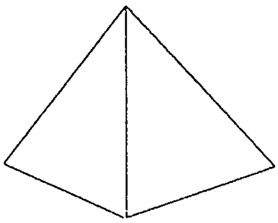

Figure 3:
Canopy and Frame

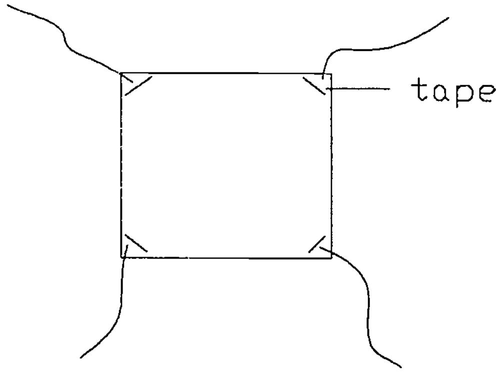

Figure 4:
Attaching rigging lines

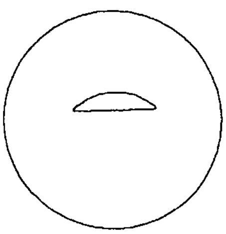

Figure 5:
Slit in ping-pong ball

THE SIEGE OF TYRE

AN INTEGRATED STS UNIT: THE TECHNOLOGY OF ANCIENT WAR

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An Introductory Scenario

In 322 B.C., Alexander the Great marched his armies along the coast of the eastern Mediterranean summarily subjugating everyone in his path. The only substantial fortress separating him from the bounty in Egypt was the city of Tyre situated on the coast of what we now call Lebanon. The city of Tyre was located on an island 1/2 mile off the shores of the coastal plain separated by shallow sea. The older part of the city was situated on the mainland. Tyre was noted for its active textile and trade economy and was particularly known for its purple fabrics. The highly valued purple dye was extracted from a sea snail (genus Murex) found in the Mediterranean Sea. Archaeologists have unearthed mountains of discarded snail shells mined by these early peoples to the extent that today, the snail is nearly extinct in the Mediterranean.

Although most cities resigned quickly to Alexander's demands for allegiance and subjugation, Tyre resisted. The city and its people had a long history of economic success and naval prowess. The city had been besieged before and had not willingly succumbed in over 1000 years to a conquering army. Alexander demanded entrance to the city, but the Tyrinians rejected his requests. The long siege began.

Without a navy, Alexander was faced with the most difficult, longest, and most costly challenge of his military career. He was faced with the imposing fortress of Tyre:

- An island separated by one-half mile of sea as deep as 20 feet near the island
- A 150 foot wall of stone and gypsum mortar protecting the shore side of the island.
- The wall defended by thousands of well equipped soldiers
- A formidable navy harbored on the lee(protected) side of the island with ships called triremes(oared boats without sails)
- Catapults and other devices capable of firing rocks and flaming missiles at anyone close to the island. Some of these had a capability of tossing 50 pound rocks up to 400 yards.

- Their own fresh water supply and access to trade from the sea

- Strong winds and rough seas in the separating channel (Williams, 1907)

Alexander was faced with an important decision, should he skip the city and allow his back to be left vulnerable from the sea? Should he besiege the city at a high cost and delay his eventual showdown with Darius, the Persian king at his flank? We know which way he thought about the problem because the Greek historian Arrian quotes Alexander in a speech to his officers:

> "Friends and allies, I see that an expedition to Egypt will not be safe for us, so long as the Persians retain the sovereignty of the sea; nor is it a safe course, both for other reasons, and especially looking at the state of matters in Greece, for us to pursue Darius, leaving in our rear the city of Tyre itself in doubtful allegiance, and Egypt and Cyprus in occupation of the Persians. ... But, if Tyre were captured, the whole of Phoenicia would be in our possession, and the fleet of Phoenicians, which is the most numerous and best in the Persian navy, would in all probability come over to us. " (Godolphin, Ed., 1942)

Alexander had a dream that night that confirmed his desire to take Tyre. He saw the god Heracles taking him by the hand and leading him into the city. Heracles was a god that employed labor in accomplishing his tasks so Alexander interpreted the dream to mean that the siege would be long and arduous. He would take the city by force. What force would that be?

What would you recommend to Alexander if you had been his chief engineer? How would you take the city? Remember that the defenses and geography very much favored the Tyrinians. Alexander had access to the old city of Tyre on the mainland, the 50,000 inhabitants, the forested mountains of Lebanon, and his army of more than 30,000. What methods might you use, given the resources available to Alexander's army, to conquer the city?

<u>The Integrated Unit</u>

Given this historical narrative a teacher challenges sixth grade students to discuss possible strategies. In cooperative groups they discuss the merits of bridges, catapults, ship construction, tunnels, flaming barges and every sort of secret weapon imaginable. These ideas are shared as though they were generals advising Alexander himself on which strategy makes the most sense. Each group is encouraged to examine and critique all possibilities.

In the discussions about siege tactics, the technology of catapults becomes an important focal point. Students usually are interested in the issues involved in the ancient weapons of hurling rocks long distances over and through fortifications and other implements of destruction. Since the Greeks were masters of this ancient technology, students can be challenged by such questions as: How accurate were they? How far could they hurl a rock? What size of stone could they toss?

Groups of students use popscicle sticks, sugar cubes, rubber bands, paper clips, string and a plastic strawberry container as metaphorical materials representing those things available to Alexander's engineers: cedars of Lebanon, rubble from the old city of Tyre, animal sinews, pieces of bronze and iron, rope, and the walled city of Tyre. From these materials the challenge is given to construct a machine capable of hurling a sugar cube as far and as accurate distance as possible. In demonstrations of their technological inventiveness, students compete to test their "engines of destruction."

Teaching adjuncts for this inventive construction may address content and concept in the physical sciences. Topics related to forces, simple machines, torsion, tension, potential energy, kinetic energy, motion in two dimensions, or momentum may be well served by this introductory problem. Mathematical skills such as measurement, data collection and manipulation, and graphing may be reinforced. This connectedness extends to questions surrounding the ethical issues of war and the proliferation of aggressive technologies.

Exploring catapults is only one of many areas of inquiry that can be used as a spark for further investigation. The story provides a backdrop or context for developing a series of integrated lessons. There are many other explorations of problems presented in this scenario that may require that we learn as much about the variables as possible. Guiding questions from the teacher can help shape further student explorations. Questions surrounding the geographic, economic, social, natural environmental, and physical attributes of the region may need to be explored. Cooperative groups might explore ancient and modern maps of the region relating conquests of Alexander to modern boundaries. The fate of the Murex snail and the cedars of Lebanon could help focus attention of ancient ecological disasters. The history of the Phoenicians and Greeks are obvious adjuncts to this problem as are reasons for reading Greek mythology. Why, for example, was Alexander strongly influenced by the vision of Heracles in the dream? Technological aspects of the problem are numerous. How did the ancients construct fortifications and engines of war?

Exploring Curricular Adjuncts

Students may wish to hear the rest of the story of the Siege of Tyre, not only to hear the compelling detail, but also to compare their solutions with Alexander's. In the balance of the story one can find a number of jumping-off points or intersections for discussion of real science, mathematics, or social questions. In completing the story below, possible questions for further exploration are noted and listed at the conclusion of the narrative.

> Alexander listened to the engineers that convinced him to build a mole or dike in the narrow channel separating the island from the mainland.[1] After all, there was plenty of rock and rubble from the old city of Tyre on the mainland that he had destroyed, so there was plenty of material to build a causeway to the island. They would build a road to

the island, scale the walls with ladders and towers and take the city.

At firr': the Tyrinians laughed at the prospect of building a land bridge across the strait. A half mile of ocean in rough waters that were 20 feet deep? How could Alexander do it? (Remember that he had 30,000 troops and all of the slave labor of the inhabitants of the mainland.)[2] At first the work went quickly. Great progress was made on the first section of the mole because the water was shallow and the muddy bottom allowed the rocks and logs to stick easily.

As the Tyrinians watched the progress they became nervous and started to devise ways that they could foil the building of the mole. They sailed their ships near the workers and hailed them with arrows and rocks. Alexander sent men into the forests to bring back lumber. He had large wooden walls constructed to shield the workers. These were tall towers covered in hides of animals that absorbed the shock of rock and arrow attack and repelled flaming missiles.[3] Work on the mole continued.

The Tyrinians devised a counter attack. They converted a barge they had used to transport horses to the mainland into a hugh tinder box. The loaded it with anything and everything that might burn including a highly volatile substance called naphtha, a mixture of brimstone and pitch.[4] Rigging sails on the vessel, they towed the barge with two triremes toward the mole and waited for a strong wind. As the wind carried the vessel toward the protected mole, the oarers catapulted the barge further. At the last minute they cut the tow ropes and lit the barge. As the vessel crashed into the mole it sent both solid and liquid burning materials everywhere. The towers became engulfed in flames and the workers fled. Meanwhile, other triremes had encircled the mole and began a hail of rocks and arrows on those trying to escape. The next day the mole looked like a pile of burnt rubble. The Tyrinians had temporarily thwarted the building of the mole.

Alexander now knew that he could not continue this tactic without the benefit of a navy. Over the next month he assembled a fleet of ships from all of the previously conquered Mediterranean peoples. Many of these navies were eager to see the Tyrinians defeated because of their long standing feuds. Alexander's new fleet of ships outnumbered the Tyrinians so that when they met outside the harbor to do battle, the Tyrinians became instantly aware of their underdog status and retreated to their harbor blocking the entrance with their ships. Although Alexander's fleet did not defeat the Tyrinian navy, they rendered it unusable. The work on the mole continued without the threat of the ships from Tyre.

Alexander slowly continued the work on the mole. As he had the base widened, the ocean seemed to swallow up all the stones that were dumped into the sea now that they were at the deepest part. The mole was also now in range of the catapults and archers from the wall.[5] A constant hail of rocks and fire bombs were tossed onto the workers.

To counter these assaults, Alexander had his largest ships anchor alongside the mole and hold up shields to protect the work. Tyre countered by sending divers down to cut the anchor ropes. The ships would drift off and the hail of missiles continued. Alexander then sent for chain. The ships now remained anchored.

Under the hail of burning naphtha, boiling sand, rocks, arrows, and all other sorts of flying objects, the mole was completed after 6 months of work. Now Alexander had a new task. How would the 150 foot walls be scaled? The Tyrinians had all sorts of defenses against attackers with ladders. They dropped rocks on them, they threw down weighted nets that would entangle climbers, they would shoot out burning sand, they would use hooks, beams swung down by ropes, spears, molten metal, and scythes on poles to cut ropes.

Alexander had siege towers built. Hugh wheeled buildings that were 150 foot tall. These were covered with hides and they repelled the hail of missiles fairly well. The towers were rolled up next to the walls, but the Tyrinians were still able to repel the attack.[6] Alexander had to try something else!

The greatest defenses were on the mainland side of the island. The wall was 150 foot high and probably at its widest there. Alexander decided to work on the side walls. He built special ships equipped with battering rams. As the ships were rowed to the shore they slammed into the walls.[7] The Tyrinians dropped rocks into the shallow banks to try to keep the boats from coming close. Alexander's men winched rocks from the bottom of the shallows and took them to deeper waters.[8]

After a month of battering on the side wall, a hole developed. The Tyrinians scurried frantically to seal-up the breach. They used skins and rocks and other materials to keep rocks and fire from entering the city. Alexander kept attacking the opening and finally decided to send a thrust of men into the breech. By attaching a ladder to his ships and then dropping the ladder onto shore, the men held up their shields and scrambled into the opening. The Tyrinians fought back courageously. Alexander's men would have taken the city that day except for a fierce storm that forced the attack to be called off.

After a couple of days when the storm had subsided, Alexander tried the breech one more time. This time, however, he sent his fleet around to the other side of the harbor to try to make a breech there. He also assigned all other battle groups to attack all of the Tyrinians on the walls so that they might be kept away from the main attacking force. This strategy finally worked. Alexander's troops finally gained a foothold in the opening and entered the city. Most of the defenders fell back and took up positions in houses and in the temple. It was too late for the people of Tyre, however. Alexander's battle-hardened troops quickly overpowered the men of Tyre and the battle was won. After seven months of siege, one of the world's most dramatic battles was over.

[1]How much material was needed to fill a 1/2 mile trench 20' deep on one end and only a few feet on the other?

[2]If he had access to 50,000 people, how many rocks

could he move? How much volume in a rock? How long would it take if the mole were 50' wide?

[3]If you throw a rock at something, won't it fall over? What kind of design did the towers need to be so that they wouldn't break or tip over?

[4]What kind of floating device can be constructed out of ice cream sticks that will float as much cargo as possible? What design features keep the vessel from tipping over?

[5]What kind of principles of catapulting rocks can you discover? For example, how could you design a catapult from a rubber band and stick that would toss a sugar pebble a certain distance? How far can it be shot? How do you control the direction?

[6]A 150 foot tower is about 20 stories tall. How could you design a rolling siege tower made of toothpicks and paper that might simulate Alexander's design?

[7]If you are going to use a battering ram, when will it have the most force? What if the barge carrying it were light and fast? What damage could it do? What if the barge were slow and heavy? What would the head of the battering ram need to look like? Big and flat or pointed?

[8]What are winches? How could they lift rocks under water? Are rocks in water heavier or lighter than in air?

This historical narrative is rich in drama, character and setting. It is a compelling story presenting the reader with conflict and challenge--a perfect launching point for a problem-solving curriculum. It is important at this point to mention why selecting a problem is important. Solving novel problems requires that we have knowledge, appropriate computational skill, conceptual understanding, ideas, verbal skills, analytical abilities and powers of synthesis.(Gagne, 1970) Real problems that have alternative solutions are ways in which we drive home meaning to our students. To solve a real problem means that we contribute to what is known by offering new knowledge. This means contributing to the common good--a rationale for participating in the endeavors of human society.

Meeting Curricular Goals

Although real problems introduced by such things as historical narratives are ideal ways to construct a meaningful integrated curriculum, important questions for teachers arise. Are all instructional goals served by this sort of curriculum organization? Are all content areas well served by an uncertain curricular spiral? How will the teacher select other appropriate problems for exploration?

Concept Goals

In this type of curriculum we use the problem to serve-up the required knowledge, skills, concepts and processes that help solve the problem. As teachers develop the problem with students and start listing the requirements for possible solution, they must be aware of certain developmental considerations that control the orientation and directions as well as outcome skills and responsibilities that are part of the goal structure of the school. Concepts often provide a framework for categorization and distribution of problem types. Concepts might be developmentally cued to primary, middle and upper grades by the type of concept.

For example, Oregon's Common Curricular goals for science list several concepts that may serve as broad organizers of curriculum.(Oregon Department of Education, 1988) Each of these concepts fits best with particular levels of learners because of cognitive, psychosocial and moral developmental considerations:

Primary Concepts: Change, Cause and Effect, Interaction, Symmetry, Cycle, Organism

Middle Grades: Systems, Energy-Matter, Force, Scale

Upper Grades: Models, Fundamental Entities, Order

These science concepts and other broad organizers like justice, economy, conflict, equality, diversity, equilibrium communicate more than a discipline-centered idea. Concepts in this sense are broad ways in which people or conditions are arranged. Certain problems subsume underlying concepts. In the case of the Siege of Tyre, and the problem of escalation of war, we might choose an appropriate developmental concept that organizes the type of problem. Since we need to explore the interactions found in social, political, economic, and mechanical systems that affect the technology of war, the broad organizer "interaction" may be an appropriate way in which to classify this problem. In this example we have "attached" this concept to the problem. In the development of a K-8 curriculum, concepts would need to be selected first as an organizer for the types of problems introduced.

Broad Goals

Besides the developmental consciousness or broad organizing concepts, schools also make statements about other broad goals for students. For example, a school may elect to set aside important goals for all students to be sought as outcomes of the elementary experience. Here is a typical example of broad goals stated by an elementary school expressing the widest rationale for schooling:

Aesthetic and Artistic Development
- appreciate the arts
- think, learn and communicate through the arts

Emotional and Social Development
- develop a positive, realistic self concept
- develop independence
- set appropriate goals and feel satisfaction in accomplishment and effort
- cope with change
- develop friendships
- learn from others
- enjoy living and learning

Intellectual Development
- sustain and extend natural curiosity
- develop thinking through meaningful learning

experiences
- use language to facilitate thinking and learning
- become an independent, lifelong learner

Physical Development and Well-Being
- learn and practice safety measures
- take care of and respect their bodies
- develop an awareness of good nutrition
- develop a wide variety of motor skills while maintaining physical fitness
- develop an appreciation and enjoyment of human movement
- learn social skills in physical activity setting

Social Responsibility
- value and respect individual contributions
- value, respect and appreciate cultural identity and heritage
- accept and demonstrate empathy
- become a responsible member of society
- respect and care for environment
- adapt to a changing world (Ackerman Laboratory School, 1992)

These are broad brushes that define the purpose of education and give reason for the curriculum. The "strands" developed above are just one sample of an elementary school's attempt to characterize the main rationale for the elementary experience.

Foundational skills

Coupled with the broad needs outlined above are often the more pragmatic, or skill-related goals of the elementary experience. The SCANS (U. S. Department of Labor, Secretary's Commission on Achieving Necessary Skills, 1991) report describes a three-part foundation for these basic skills or attributes:

Basic Skills:
A. Reading
B. Listening
C. Arithmetic/Mathematics
D. Speaking
E. Writing

Thinking Skills:
A. Creative Thinking
B. Decision Making
C. Problem Solving
D. Seeing things in the mind's eye
E. Knowing How to Learn
F. Reasoning
G. Ability to use tools

Personal Qualities:
A. Responsibility
B. Self-esteem
C. Sociability
D. Self-Management
E. Integrity/Honesty

Notice that this list might be best linked to action verbs. In attaining these skills children demonstrate abilities to perform at a particular level. These are requisite skills and traits that help one conceptualize, analyze and communicate aspects of the problem.

Content Goals

Besides the developmental organizers, broad goal responsibilities and the foundational skills, most schools accept the notion that there are facts, knowledge and minor concepts that students should acquire in the elementary grades. This set of "stuff", as some like to call it, is really the realm of the textbook.

Stuff, in this paradigm, has a place, but it is relegated as a subordinate role to the need of the problem. In the case of the Siege of Tyre, the stuff we need to know to solve the problem might be facts about who the Greeks and Tyrinians were; why they became enemies; how, when, and where they lived; and how they fortified and armed themselves. The facts and knowledge serve the problem and only are introduced to help bring more informed solutions to the problem. This inversion of the curriculum is a deep departure from typical textbook curricula. We might find the information in parts of several textbooks treated as separate and disarticulated facts. The challenge for teachers in adopting a problem approach is to de-emphasize the facts of the curriculum and to allow traditional "stuff" organization to take a back-seat to problem solving and higher order thinking skills.

Selecting Problems

Finding good problems and appropriate products that match developmental needs, broad goals, foundational skills, and a common cultural literacy may seem overly difficult. There are at least four resources in finding appropriate problems: temporal or media problems, conflicts found in literature, historical narratives, and applications found in existing content curriculum.

A temporal or media method is to examine the local, national and international newspaper for stories about people places and things that appear to have possible value as problems. Over a one week period, as an example, several articles were gleaned that may appear to have start-up value in generating problems in the classroom:

Garbage dumps and recycling of certain wastes
The proliferation of too many pets at the animal shelter

Nuclear waste	Wood stoves
Ozone layer and freon	Foam products
Land use	Spotted owl issue
Electric cars	The technology of war
Zoos	Homeless
Information technology	Nintendo, CD ROM
Sports medicine	HIV
Prosthesis	Extinct species

Each of these problems have a host of associated temporal information that must be researched by teacher and student to address the unit. Newspapers, magazines and supportive industries or interest groups become primary resources that provide the background for this sort of curriculum. Developing the skeleton of the curriculum by adding the broad goals, skills and knowledge to be addressed may require linking the problem to existing textbooks, library resources or adopted scope and sequence curricula approved by the school.

Literature may also provide a context for selecting problems. In the case of Alexander we might have first found a biographical book and then used it as the context and launching point of the curriculum. Any other book may also provide such a linkage. A real circumstance and drama provides the context for selecting a problem. Biographical sketches, case histories and anecdotes provide compelling narratives that hook the learner and develop a problem that begs resolution. With historical problems, however, the solutions are often given as the last chapter in the history, that is, we know the result of the crisis. What we do not know are alternative possibilities if the individuals in history had done something else. What might have happened it Alexander had...passed up Tyre?

Perhaps the most productive and indefinite way in which to generate problems is to search textbooks for problems that are hiding in the content. Since most textbooks are organized on a scope and sequence of "stuff" we can look at all of that stuff and see if there is any reason to teach that stuff. As one looks at any chapter in a science, mathematics, social studies or technology book, topics like cells, microorganisms, simple machines, polygons, fractions, probability, Egypt, waterways, the 100 Years War, welding, electrical circuits become problems to solve. With a little effort and help from the end of the chapter, appropriate problems can be brainstormed that will become very broad and perhaps worth exploration. Cells can be explored via topics and issues such as cloning, cancer, or aging. Microorganism could be reorganized around a problem of infectious disease, HIV, or food preservation. Simple machines can become the problem of how they built the pyramids, the technology of war, or handicapped access. Electricity can be shaped into the problem of fixing a flashlight how to tap energy from falling water. The danger in this sort of problem search is that it offers the possibility of developing trivial or synthetic problems that have no real purpose or meaning. The problem selected must be plausible and have a useable product or outcome.

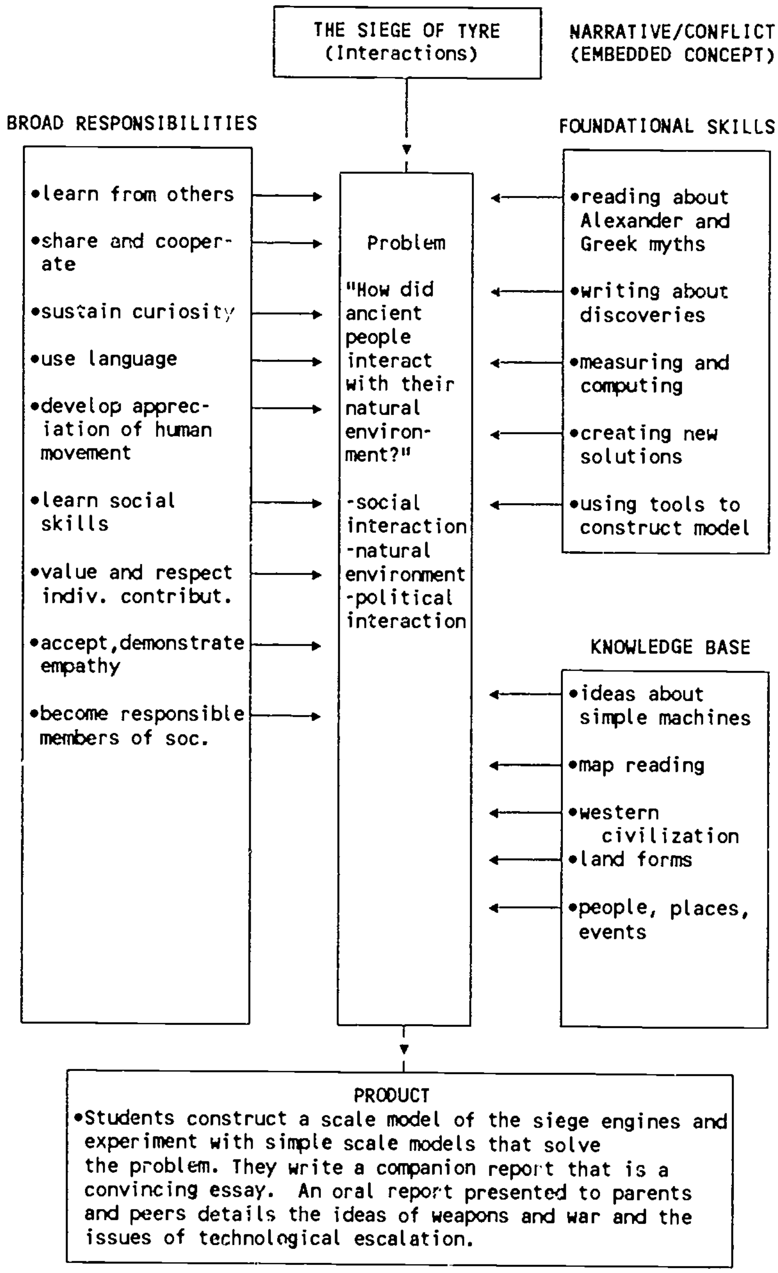
Figure 1

Schematic Representation of
Narrative Curriculum Construction

A Possible Curricular Model

Schematically, the model for this curriculum exampled by the Siege of Tyre unit can be diagrammed as major goals, outcomes, and expectations impacting on the selection, development, and assessment of the problem. Figure 1 depicts how the narrative problem shapes or, more accurately demands, the appropriate skills, knowledge and abilities required in order to seek resolution. In this way, a natural form of integration occurs. Basic skills, concepts, broad goals and sets of informational knowledge are called upon as necessary and connected adjuncts. There is no need to "crowbar" a discipline into the problem because the problem calls-out its own requirements.

Assessment of learning using this model is a matter of matching the product with the various expectations. The product, if carefully monitored and developed, becomes a portfolio/project demonstrating skills, knowledge, broad responsibilities and expectations. If a group of children build a working model they have demonstrated cooperation, hand skills, creativity, decision making skills and ownership of the problem itself. In solving the problem they have accessed broad concepts, ideas, hand skills, facts and social abilities in a meaningful context. If they write a convincing proposal they must have acquired the language arts skills required to research, organize and write the words on the paper. If they present the paper orally they have learned to communicate.



Summary

Although the concept of constructing an integrated curriculum is certainly not a new or revolutionary idea, finding an appropriate motivator or starter may be. The narrative framed problem combines the power of a good story in entreating the interest of the learner with the connectedness of context. (Egan, 1979) Learning facts, concepts, and skills become natural adjuncts of the problem. The learner is allowed to construct meaning for learning. This holistic or whole brain approach to teaching may allow learners better perspective to the ways information are connected. The meaning-making constructed in the process of solving the problem may best suit the way students think and learn.(Shoemaker, 1991) Seeking and producing a resolution or solution brings closure to the problem and allows students and teachers alike an alternative view of assessment.

The prospect of shifting curriculum to this paradigm transcends the enhanced motivation reaped in its delivery, or in the novelty and excitement created by the activities that it shapes. The long-term benefit in creating a problem-centered curriculum is that it allows children to invent or construct solutions to novel problems using every piece of knowledge and skill available. This problem solving practice offers us the brightest potential in that it creates citizens able to solve the real problems of the future--and that is the real rationale for school.

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WATER

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Note: This is adapted from "WATER - a Unified Science Supplement"

I. PROPERTIES

Water has some interesting and unique characteristics. Some suggested activities demonstrating this include:

1. Water's composition. Decompose water easily by putting a 9 volt battery into a beaker of salt water. Compare the difference in the bubbles coming from each electrode. Discuss the water molecule.

2. Surface tension. Compare the number of drops of pure water to soapy water that you can put on a penny's surface. Discuss how water striders can stay on the water's surface.

3. Heat capacity. Compare the temperature changes when comparable amounts of water and soil are heated and cooled. Discuss the influence of large bodies of water on climate.

4. Solvency. Compare the amounts of various substances (solutes) which will dissolve in the same amount of water. Discuss the implications of this with reference to salty oceans and water pollution.

5. Density. Compare the results of floating ice cubes in water and alcohol. Discuss the importance of the peculiar property of water that it is at its densest as a liquid. (Read "The Catalyst", by G. R. Yohe.)

II. SOURCES OF WATER

Of the Earth's water, approximately 97% comes from the oceans, 2% from the ice caps and glaciers. Of the remaining water, .62% is ground water and .0091% is found in freshwater lakes and streams.

THE WATER CYCLE - A continuous exchange of water between land, ocean and atmosphere.

Discuss the unequal distribution of water and its effects on society. (for example, drought in Ethiopia.)

SOURCES OF WATER FOR USE

1. Surface water. Examine the surface waters in your region. (streams, lakes, rivers, etc.)

Suggested activities: Measure certain properties, such as pH, velocities of streams. Examine the history of any human made reservoirs.

2. Ground water.

Suggested activities:

1. Crumple a piece of aluminum foil approximately 50 cm in length and then smooth it slightly. Sprinkle water on the surface of the aluminum foil. Observe and identify the drainage basins.

2. Examine a map of drainage basins of New York State in order to determine in which drainage basin you reside.

3. Investigate the permeability of water as it passes through differenct types of soil, by timing how long it takes for water to move through the different soils. Discuss the effects of soil composition on the rate at which ground water can be polluted by surface pollutants.

III. WATER USES - A COMBINATION OF TECHNOLOGY AND SOCIETAL ASPECTS

COMMON WATER USES - Water is used for a variety of activities, including biological functions, domestic activities, industry, agriculture, energy, recreation, and habitats.

Suggested activities:

1. Study a water habitat such as a salt marsh, oond, etc.

2. Study how water affected the history of your area (for example, the effects of the Erie Canal on the development of New York State.)

3. Examine how and how much water is used in industry and agriculture.

4. Study the development of technologies involved in water-related recreation.

5. Energy - Examine the potential hydroelectric power in your area. Examine the potential for other water-related alternative energy sources, such as ocean thermal energy conversion (OTECH), tides, waves.

6. Examine various technologies of desalinization.

7. If you have a water meter, read it every day for a month. Graph the data, and discuss activities which involve large amounts of water use.

WATER MANAGEMENT - Water quality and availability is important to people's health and well-being.

Suggested activities:

1. Compare individual water supplies (wells) to municipal systems.

2. Visit a water treatment plant and/or a sewage treatment plant.

3. Examine how a septic system works or how a municipal sewage treatment system works.

4. Examine various careers involved in water management.

WATER POLLUTION - Due to its properties and certain human activities, much water is no longer suitable for human use.

Suggested activites:

1. Examine the major sources of water pollution in New York State. Discuss how some of these could be eliminated.

2. Examine the condition of the water in your area.

3. Discuss ways to conserve water and the advantages of doing so.

4. Determine the amount of water wasted from a leaky faucet over a one year period.

5. Measure the amount of wasted water when brushing your teeth.

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NASTS CONFERENCE - February 6-9, 1992
ALEXANDRIA, VA.

SCIENCE FAIRS FOR YOUNG CHILDREN?

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It is apparent to all of us who are in the midst and/or in the forefront of new and controversial dialogues concerning science fairs, that there still seems to be a need for further investigations as to the philosophy, intent and approach vis a vis science fairs - especially science fairs which involve children as young as four years old.

In the context of this discussion, permit me to share the approach that the Walden Lincoln School utilized in holding its second annual science fair for children, Pre-Kindergarten through third grade.

- What the purpose of a science fair should be
- What should it reflect
- What should it encompass
- What are developmentally appropriate experiences re: Science for these young children
- Whether a science fair is a feasible and/or desirable venture for young people to engage in

Some faculty researched articles on these salient points and shared their findings with the rest of us. Several of our staff visited other schools and discussed the topic of science fairs with myriad other professionals.

We consulted with our parents and we surveyed our students for their opinions, views and comments regarding this venture. What emerged was definitely not the usual array of guiding principles. Instead, all of us were charged with creating a science fair which could be viewed as an enriching open-ended investigation/hands-on activity program, entitling everyone in these grades to partake in the event.

The goals agreed upon beforehand:

- Science is Life for young children, thus children will utilize such skills that will enable them to understand the world around them
- Provide an experience that will permit children equal opportunities and access to materials, etc.
- Make the experience age-appropriate
- Make the experience open-ended -- that the child need not be coerced to come to a right or wrong conclusion
- Make the experience one that would support individual projects, encourage cooperative experimentation, and facilitate community interaction.

The Science Fair would:

- Be a non-competitive event
- Reflect children's interests, progress, needs
- Involve every single student in the designated grades
- Offer certificates of participation (no rewards, prizes)
- Utilize recycled materials whenever possible (instead of buying cardboard displays, use refrigerator boxes, etc. - create our own display sets)

A memo was sent home to our parents describing the underpinnings of the venture and listing our collective goals. Invitations were printed by the Arts Department, announcements were mailed to all involved, and our whole school community was enlisted to assist us.

Because many of our students were young in age, both the classroom teachers and the science specialist took time to clarify the concept of this fair, how the children could participate, where it would be held, the format, when it would be held, and the kinds of activities suitable for a fair of this magnitude.

The outcome of this planning resulted in this sample venture. The Pre-Kindergarten children and their teacher settled on a collaborative project which involved:

- The demonstration and exhibition of all their plantings that the children had engaged in throughout the year -- apple plants - (our first apple tree), grapefruit plants, corn plants, carrot plants, etc.
- The changes that occur to foods left in the open, in a refrigerator, and/or exposed to the atmosphere over a long period of time (e.g., our grapes (October) slowly changed into recognizable raisins.)
- Display all of our experience charts, depicting our learnings during our science periods and sessions

Any and all photographs of our students engaging in projects - school-wide or community-wide - were included. Lab books, stories, paintings, exhibits, dioramas, logs, research papers, science riddles, biographies of scientists, collections, inventions and slides were included.

The older students were given a worksheet to fill out.

Sample:

Name Date

My project is ______________________________

I am working alone, or with ________________

I plan on starting my project in this format ______________________________

I will be ready by __________________________

I will need ________________________________

____

Copies of this worksheet were made; one was given to the student, one was sent home, and one was kept on file by the science specialist and/or the classroom teacher.

Specific science sessions were designated as work times - that is, students could utilize the period to work on their projects. Storage space was made available to the students as school projects were encouraged and given equal footing with those projects initiated and developed on the home site. Students were advised, assisted, and encouraged to plan their contributions. They were "cajoled" to keep track of their progress, and to work within a time frame.

What emerged was a science fair not only worthy and indicative of our school's philosophy, but a science fair reflective of our students' interests, progress, talents, skills. Every student became both a demonstrator/teacher and a learner. Every student was an active participant. The energy and enthusiasm were evident and contagious. The rewards, both inherent and overt, were manifested in subtle yet evident ways. Comments such as, "What are you going to do for next year's science fair?" were overheard repeatedly by visitors and non-visitors.

This was a fair that I personally relished, but more important was the fact that the entire school community gave credence and support to a celebration of our childrens' work in science.

I enclose a sample program from our last fair. We welcome comments and suggestions from other educators and interested parties.

WALDEN LINCOLN LOWER SCHOOL
SCIENCE FAIR * MAY 17, 1991

EXHIBITS AND DEMONSTRATIONS

GROUP A - 9:30 - 10:00

KINDERGARTEN CLASS

EASTERN BOX TURTLE EXHIBIT - Including group models, individual models, recorded research and observations, live turtle.

GARBAGE EXHIBIT - Including labeling, sorting and garbage, experiment in decomposition in water and in air, use of organic garbage to make compost, insects as "by-product" of composting process.

BOTH EXHIBITS BY:

Andrew Buchan
Gaspar Del Castillo
Douglas Drucker
Aron Gans
Stanislas Izerable
Jacob Kling
Max Martinelli
Eli Pincus
Abigail Robinson
Rebecca Serlin
Jessica Shaw
Nya-Quen Smith
Ruby Stardrum
Madeline Tzall
Theodora Wallace-Orr
Malcom-Adam West
Alexander Wyles
Alexander Wynn

SECOND GRADE

STAIN REMOVAL BY CHEMICAL PROCESS	Selina McMahon and Kate Adolph
STAIN COLOR CHANGE	Lily Florenz
WATER CLOCK	Chris Lake
SOUND VARIATION IN BOTTLES	Natalie Parker
LIQUID RACES: A VISCOCITY DEMONSTRATION	Nathan Churchill-Seder Carson Calvo
BUBBLES	Sheason Allen

GROUP A - 9:30 - 10:00

VIBRATIONS AT WORK	Zachary Goldstien
MAGNETIC FORCE THROUGH SOLID MATTER	Steven Lopez Ben White
ANTS	Allison Velez
MUSICAL INSTRUMENT: GUITAR	Kemal Gaspar
MOLECULES: HOT AND COLD	Ben Guller
WHICH ROAD WOULD YOU TAKE?	Billy Adelson

GROUP B - 10:00 - 10:30

FIRST GRADE

COMPARISONS OF STRENGTHS OF BUILDING MATERIALS: FURNITURE FOR THE THREE BEARS AND HOMES FOR THE THREE LITTLE PIGS

SOLAR-HEATED HOMES

COMPARISON OF PLANTING MEDIA - WATER, SOIL AND PAPER TOWELING

COLLECTIONS - ROCKS AND SHELLS

MODEL STRUCTURE OF ROADS AND BRIDGES

EXHIBITS BY:

Emily Allen
Reina Allen
Jonathan Baum-Tucillo
Aslan Chalom
Ahmed Elsayed
Vida Landron
Christopher LeGuillow
Christopher O'Bryan
Jillian Orenstein
Esteban Pulido
Jamie Schoffman
Benjamin Softness

THIRD GRADE

CRYSTALS	Andree Tzall
SLIME	Maryum Christie

GROUP B - 10:00 - 10:30

DISAPPEARING MONEY	Nathaniel Milner
CORK AS ROCKET SHIP	Josh Burgener Peter Katz
BIRD RESEARCH	Ilana Turoff
ELECTRICAL ALARM SYSTEM: A DEMONSTRATION	Noah Blumenfeld
GUMDROPS	Emily Purchia Sara Kravetz
DETERGENT	Ben Koenigsberg Chris Kallan
CAMERA AND MOTOR	Tariq Brown
FLAVORED PLAYDOUGH	Samantha Gorelick
COLOR SCREENS, DYEING, GLUE	Ariana Ayala-Woods
DIAMONDS AND CRYSTALS	Molly Clarke
BUTTERFLIES	Faith Wallace Gadsen
FOSSILS	Laura Wheater

TEN YEARS LATER: HAVE OPINIONS ABOUT THE ENVIRONMENT CHANGED? (A Survey of High School Students 1980 and 1990)

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(504) 448-4332

Introduction

A comparative study of the knowledge, attitudes and opinions about the environment was undertaken in spring of 1980 and followed-up in the spring of 1990. This study was undertaken to determine if changes in the knowledge, attitudes, and opinions of high school students about the environment had occurred and if these changes were significant. This paper will report only on the opinions of what the high school students perceived as the most serious domestic problems facing their community, state, and the nation; global problems facing the nation; and international problems. These data represent a portion of a larger study in which the knowledge and attitudes of high school students in 1980 were compared with those of high school students in 1990.

In order to assess this change, test data from the LEKAT (Louisiana Environmental Knowledge and Attitude Test) collected in 1980 from high school students enrolled in science classes (N=1412) were compared with test data from the LEKAT in 1990 from high school students enrolled in science classes (N=1335). Students assessed in 1990 had statistically higher mean knowledge scores and more positive attitudes about the environment. The opinions expressed indicated major changes in the perception of specific environmental and social problems.

Background of the Study

In 1980, a curriculum plan in environmental education for Louisiana was developed based on a needs-based survey of 1412 tenth grade students enrolled in biology (Barr, 1980). The instrument used in the survey was designed to assess the knowledge, attitudes and opinions of high school students about the environment. An analysis of the study produced a core of 60 objectives that later formed the foundation of the Louisiana Environmental Science Curriculum Guide, (Louisiana Department of Education, 1986).

Method

Subjects

The population for this study was defined as all of the tenth and eleventh grade students enrolled in public secondary schools taking a science course. The schools included in the study were selected as suggested by Chin (1971), Perkes (1973), Bohl (1976) and modified using a sample design developed by Bayless, Mills, and Barr (1985). This study involved a stratified-random sample (weighted by socioeconomic data and region of the state) of 53 public schools (53 classroo ,) in Louisiana in the Spring of 1980 and a stratified-random sample of 28 public schools (36 classrooms) in 1990 (figure 1).

Insert Figure 1 about here

Instrument Development

The LEKAT (Louisiana Environmental Knowledge and Attitudes Test) used in the study was developed by the researcher in 1979 (Barr, 1980). Items were developed from a review of state plans and legislation and piloted from 134 general objectives. A total of forty-three items were developed for the cognitive portion of the instrument. Fifteen questions developed from the objectives were aimed at measuring the students' attitudes about environmental issues. Six questions addressed students' opinions about serious problems within their community, state, nation (as viewed as domestic problems) nation (viewed within the context of global problems) and international problems. The LEKAT has a reported estimated reliability range of .82 to .96 based on KR-21 calculations.

Collection of Data

The 1980 data were collected from March 15, 1980 to June 15, 1980. The 1990 data collection began in January 20, 1990 and continued until June 4, 1990. All data were collected with the use of an NCS general purpose scan sheet. The data were optical ly scored and transferred to disk.

A total of 1412 students participated in the study in 1980 representi ıg 53 schools. A total of 1335 students participated in the 1990 study representing 28 schools. These responses represented a 98 percent return in 1980 and a 94 percent return in 1990.

Results

The purpose of this study was to determine what specific differences existed in the opinions of high school students in

1980 and 1990.

Figures 2 through 6 show the percent of students, sorted by year, responding to each of the questions aimed at identifying what were the most serious problems within their community, state, the nation and the world. The average number of respondents for each year is given. The 1990 students rated all of the issues within each category different than students from 1980.

When asked "what they perceived as the greatest problem in their community, 27 percent of the students from 1980 selected waste. However, 32 percent of the 1990 students selected air and water pollution. Crime (22%) land use (20%) and traffic (13%) were all rated higher by students in 1980 than in 1990. Even though waste was perceived by the 1980 students as the greatest problem, students from 1990 rated it 28 percent (figure 2).

Insert Figure 2 about here

Both groups of students responded identically (24%) by selecting "waste" as a serious problem within the state, however, the greatest problem perceived by the students in 1980 was crime. Thirty percent of the 1980 students selected crime, whereas 36 percent of the 1990 students selected air and water pollution. Only 8 percent of the 1990 students selected crime as a serious problem in the state (figure 3).

Insert Figure 3 about here

The students were asked what they perceived as the greatest national problem. This question was aimed at domestic issues. The 1980 students felt that crime (43%) was the greatest national domestic problem. Only 10 percent of the 1990 students selected crime. Air and water pollution was selected more often (36%) by the 1990 students followed by public health issues (26%). Land-use was not identified as a serious problem. Only 8 percent of the 1980 students and 11 percent of the 1990 students selected this issue (figure 4).

Insert Figure 4 about here

National problems viewed from a a global perspective brought similar reaction. Thirty-nine percent of the 1980 students and 37 percent of the 1990 selected resources as a major national-global issue. In 1980, the threat of war was great in the opinions of 25 percent of the 1980 students. Six percent of the 1990 students selected war as a major problem. Poverty (27%) and education (24%) were selected more often by 1990 students than by 1980 students (poverty = 6%). Energy was still in the minds of students in 1980, with 19 percent responding. Five percent of the 1990 students selected energy as one of the national global issues (figure 5).

Insert Figure 5 about here

The final question asked the students to select what they thought were the greatest international problems. Poverty and hunger were selected by both 1980 (43%) and 1990 (51%) students. War was perceived by the 1980 students as being a serious threat (19%), followed by energy problems (16%), and then population (15%). Students from 1980 rated pollution as the least serious international problem. In 1990, students rated population (19%) second to poverty and hunger. Pollution was selected 16 percent of the time by the 1990 students, followed by war (8%) and energy (6%) (figure 5).

Insert Figure 6 about here

Summary

These results do not indicate that the introduction of specific curriculum may improve the accuracy of how students perceive environmental problems. However, changes in the students perception do indicate that some phenomena has occurred. A time-series study is subject to historical validity issues. Students asked about the issue of war in 1980 were well aware of the Iranian hostage crisis and the threat of war. Rumors of wars throughout the world have created the perception that wars are always going on. In addition, the energy crisis of the 1970's produced an array of curriculum materials emphasizing conservation and energy-related issues. These materials have informed students of the issues and helped them understand how energy consumption is related to supply and demand.

The responses of the students to these questions indicates that students are learning about the environment and have developed a network of values consistent with knowledgable persons. Instruction from the curriculum or the hidden curriculum is improving students awareness of the environment.

The curriculum developed in the 1980's may have affected the students' opinions, however, direct evidence is unobtainable since the two sample populations are different.

Limitations

The use of a limited time series design in which two groups of students are separated by ten years raises questions of inter nal validity. Contemporary historical issues are a primary factor. In addition, this study is limited since there were only two testing periods. Further testing should take place to determine if periodic changes are due to temporary conditions or long term changes in behavior.

Prior the development of any new curriculum, especially in the area of science, technology and society, preliminary assessments should be made to assure accurate measures.

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Sampling Design

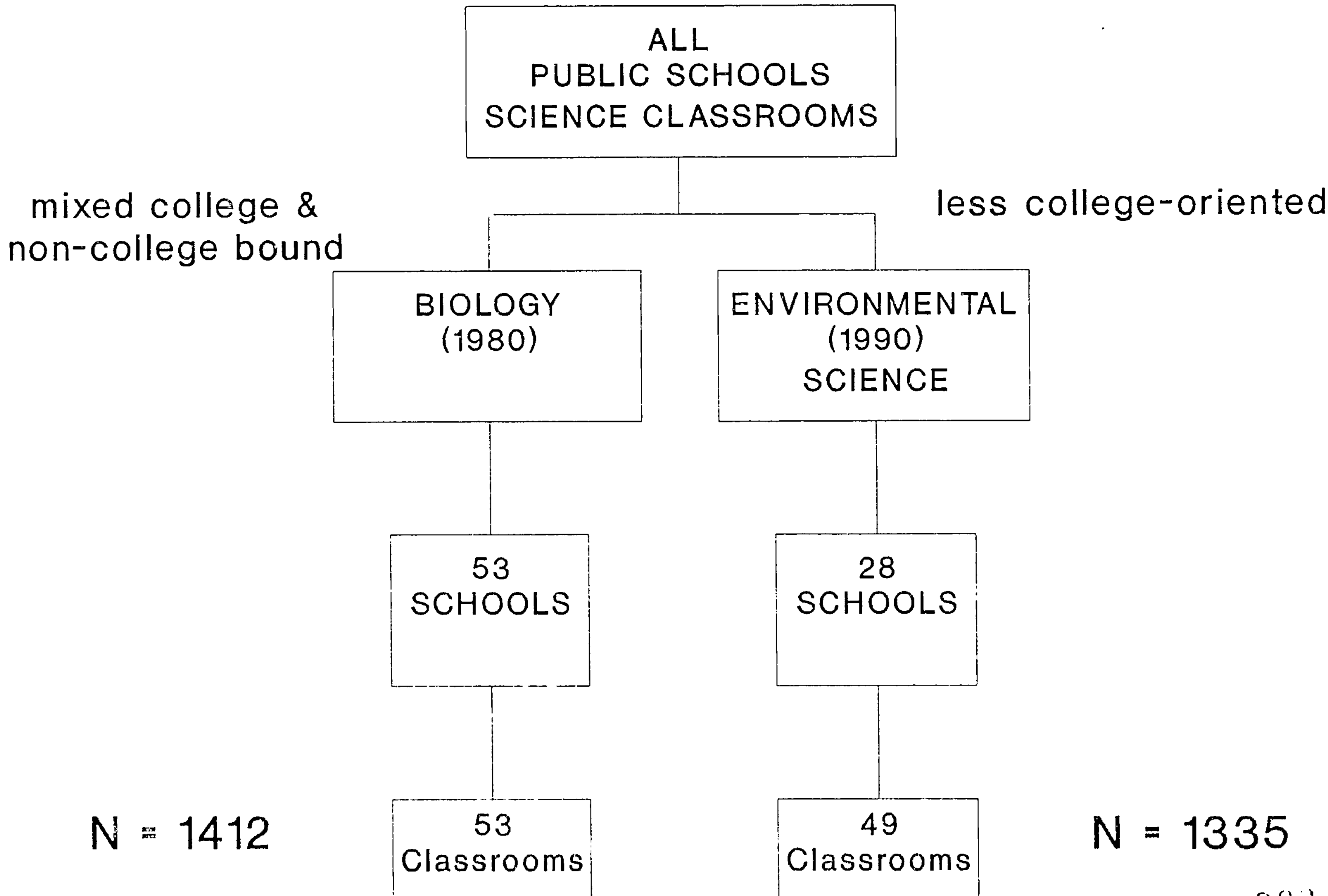

Figure 1. Sample design for selecting students.

Community Problems

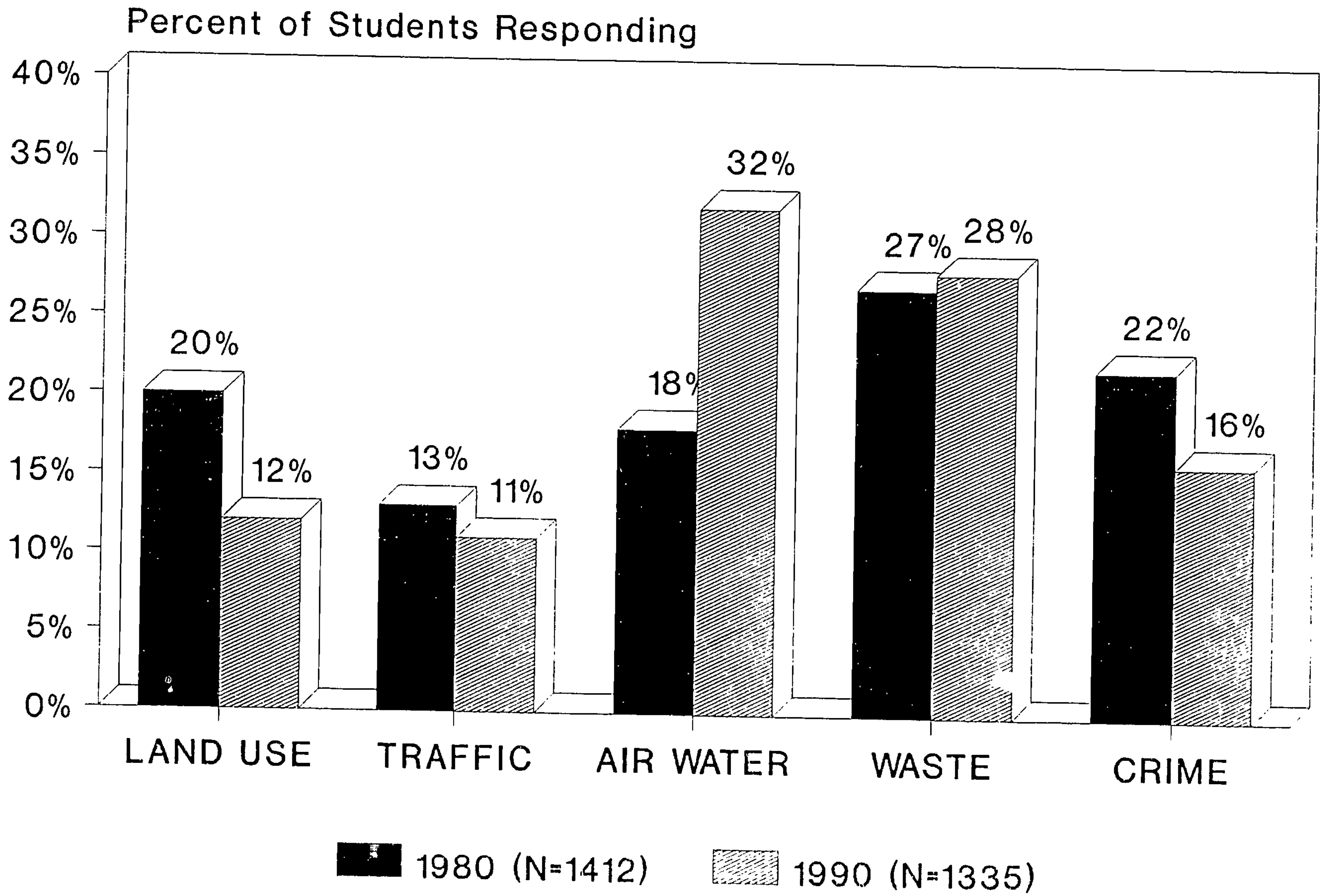

Figure 2. Serious community problems selected by high school students.

State Problems

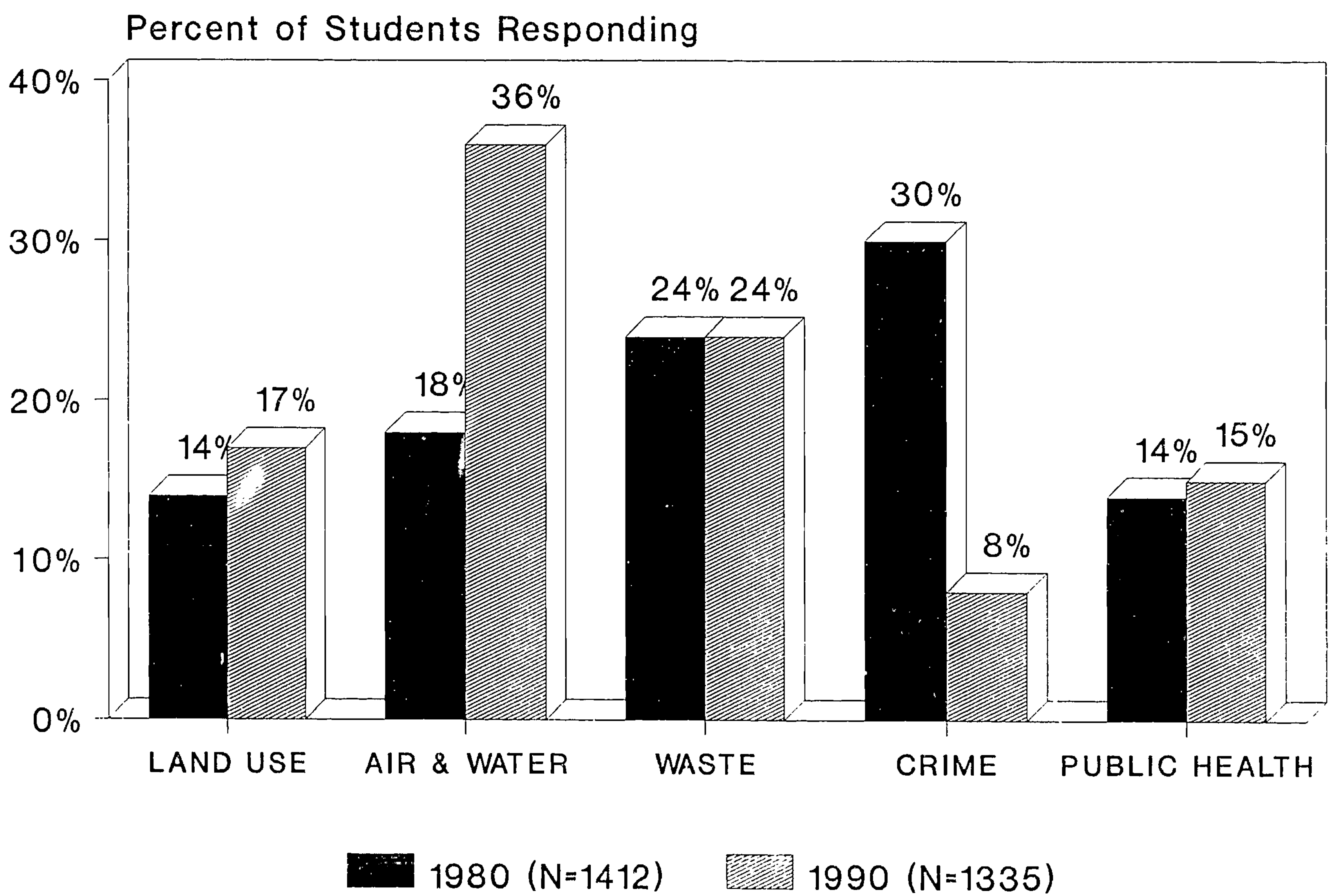

Figure 3. Serious state environmental problems selected by high school students.

National Domestic Problems

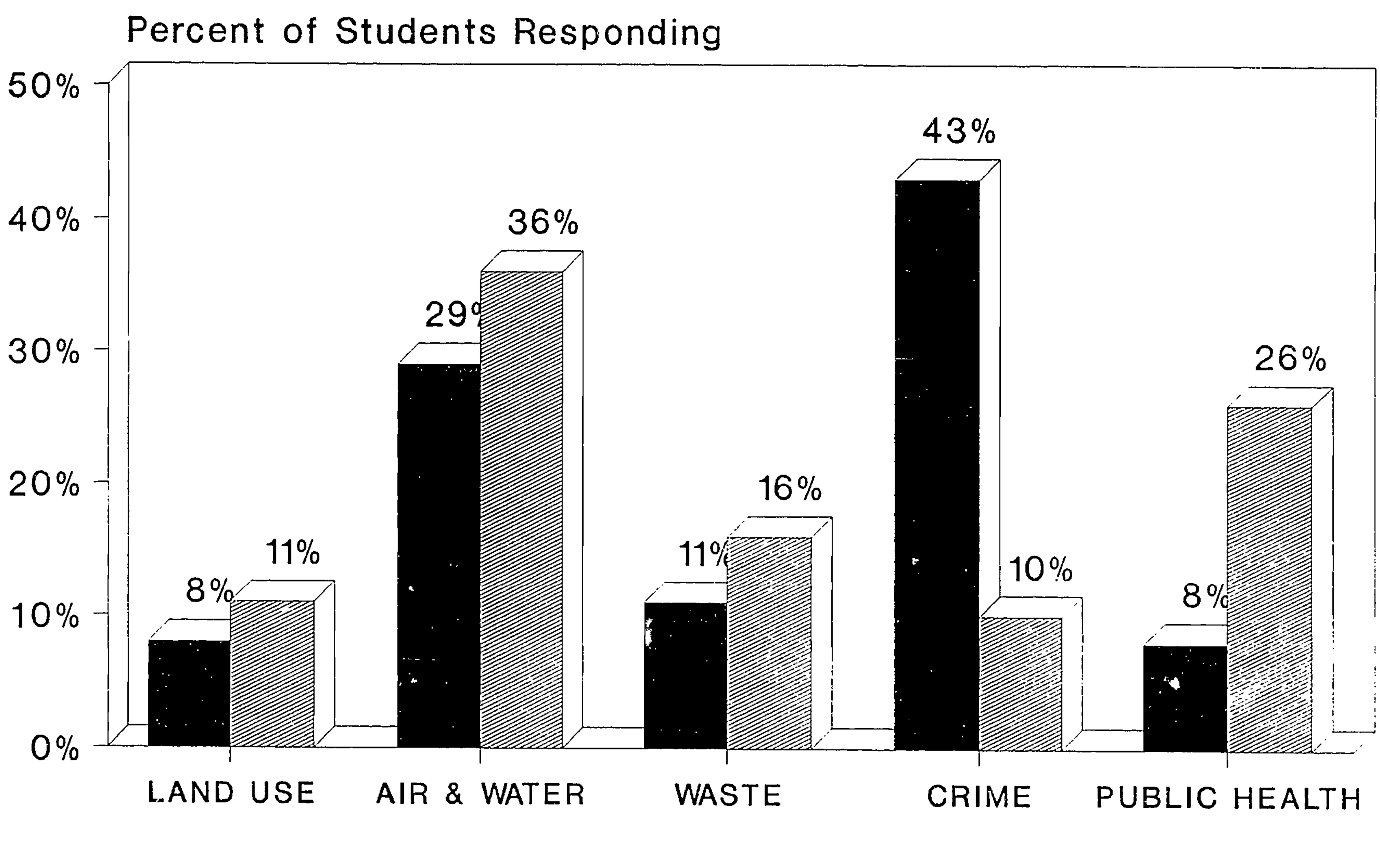

Figure 4. Serious domestic national problems selected by high school students.

Global National Problems

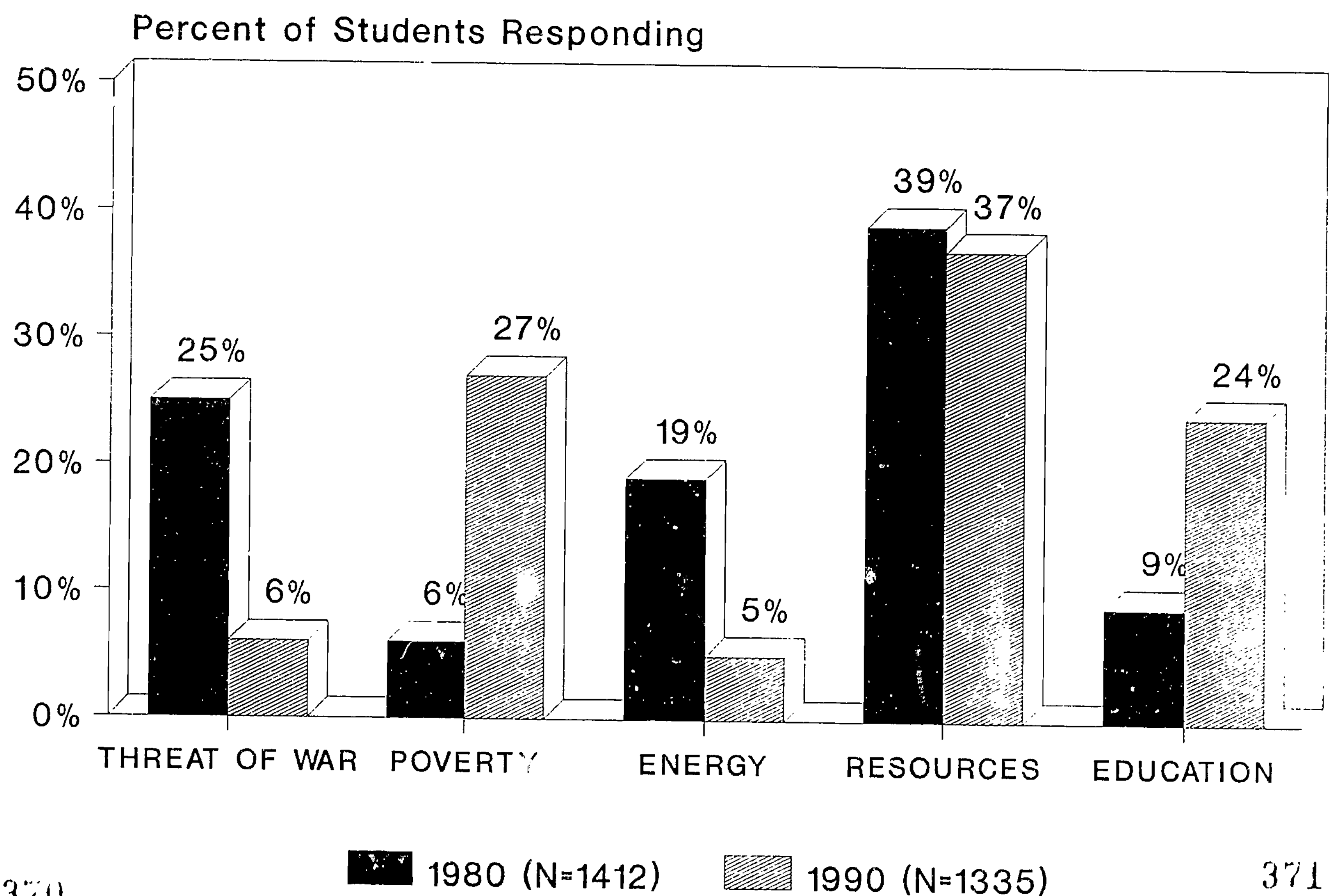

Figure 5. Serious foreign policy problems facing the nation selected by high students.

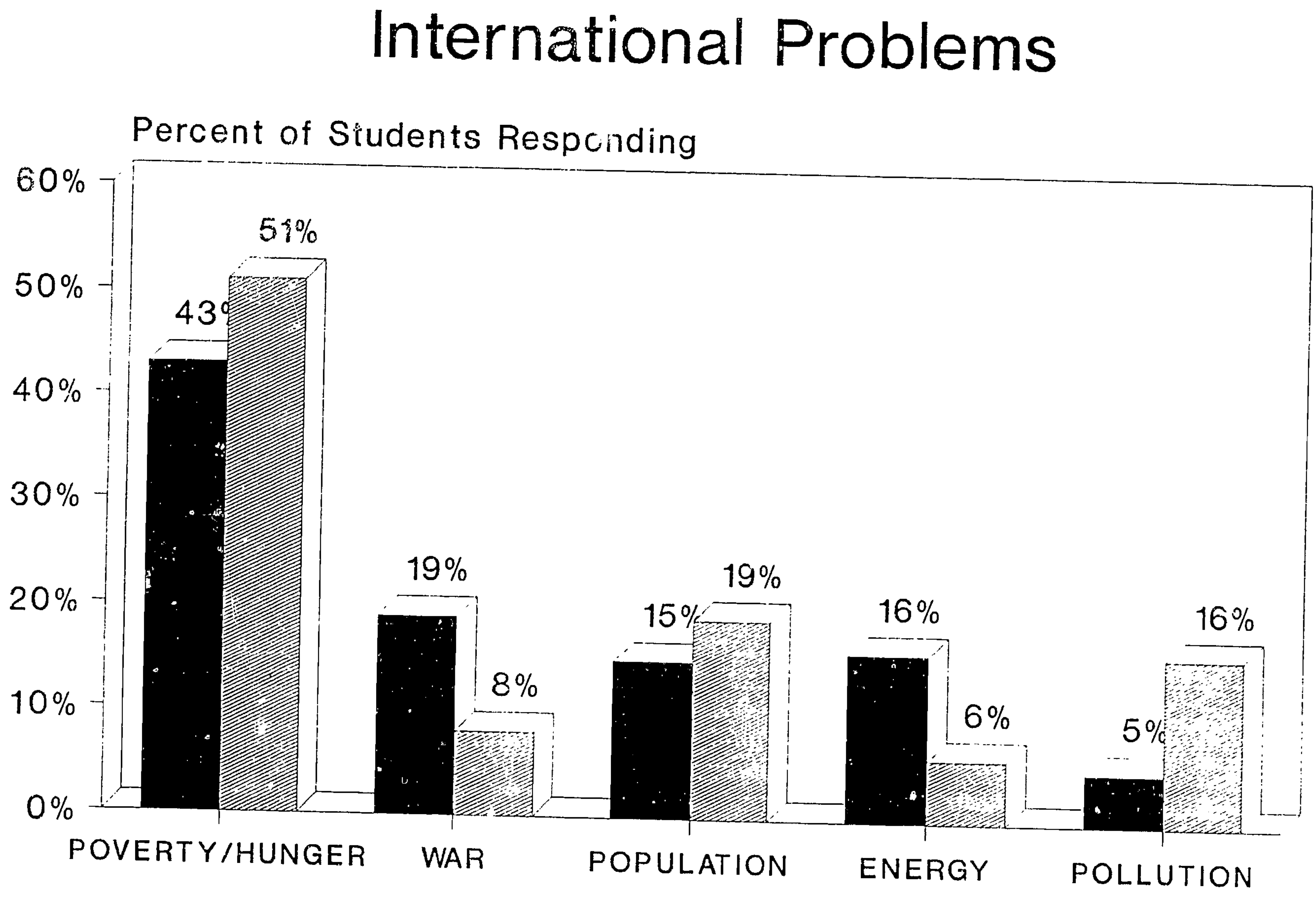

Figure 6. Serious global problems selected by high school students.

Research, Innovation, and Project Work for Students and Teachers in Secondary Schools in Slovenia

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The quality of educational and instructional work with young people on research, innovation and project work has become one of the fundamental orientations of modern school systems and society. This orientation is especially important for those countries which have based development on extensive business, high technology, ecotechnology, and tourism.

The basic idea of this kind of secondary school work lies in the fact that each student is more motivated, more interested in, and more gifted for a certain field. School work must be organized in such a way, that all of the students and their teachers have the opportunity to develop besides the standard school program their special interests and abilities.

Research, innovation, and project work must be incorporated in everyday pedagogical practice and become an integral part of regular or extra curricular activities. The research work is, to a certain extent, carried out in the framework of obligatory work practice.

Research and project work has influenced our whole system of laboratory and seminar work, the conception of extra curricular, out-of-school activities, holiday research campus, natural science days, optional and free choice subjects.

This work requires special organization and professional attitudes by those taking part in this program. Such activity demands the introduction of new, up-to-date methods, teaching materials and equipment. At the same time, this concept gives a lot of opportunities for teacher study and research work, leading to personal improvement. In this connection a good collaboration with university specialists is also achieved.

Research, innovation and project work is organized in 80% of Slovene secondary schools. In this paper, the work of the most successful grammar school in Ljubljana (Gimnazija Bežigrad) is presented. Students can choose among four different activities.

Optional Activities

Clubs for drama, literature, poetry, the arts, computers, math, chemistry, astronomy, geology, etc. are commonplace.

These activities are organized by school teachers, students and professionals.

Preparation of Students for Different Competitions

Among secondary school students there is great interest in various knowledge competitions. Over 25% of students are included in this program. These competitions are an integral part of students' theoretical preparation and form the basis for research and project work.

Preparations for competitions are organized by school teachers or external mentors for groups of 5 to 10 students comprising about 80 hours per year. In the period from May to June, we organize competitions on the school, city, republic and international levels.

Preparation for Projects Reports

Writing project reports are part of methodologically equipping students for active study. Project work is compulsory for all third grade students. They choose a problem they are interested in, and work on it on the basis of information they get from literature. Most of them have a interdisciplinary theme.

The introductory course (where students get the basic information on their later individual work) lasts 3 hours for all students. After 40 hours, students must prepare their own project report, which is an original product. Finally the student has to present his project in the classroom, in a school symposium, or a special science day, etc. Those students who have acquired more theoretical knowledge are usually invited to join in the preparation of experimental research work.

Preparation of Research Reports

Students who regularly take part in competitions, or have enough theoretical knowledge in a certain scientific branch of study can start on research work. We distinguish between the following levels of research work:

- Work carried out by students in research groups in industry, institutes, or in conjunction with university faculty
- Work which is prepared in the school with the purpose of direct applications for school programs

- Studies on very special problems carried out by the student. This is usually done by more creative students and we try to do our best to find the best conditions for their work.

When the students finish their work, they have to present it in their classroom, and later before city and republic meetings for young researchers. Some of the themes are featured in international summer schools and research campuses.

Besides different kinds of research and project work , the program of International Baccalaureate enables our secondary school students to incorporate the work in internationally recognized ways. This is very important for the achievement of a high quality of our secondary school system and the international criteria of knowledge.

Some private educational agencies, university and institute departments, and firms have developed a variety of research programs. These programs are of 2 - 3 weeks duration and cover the themes:

1. Education and training for the exact definition of problems, communication and the efficient exploration of scientific concepts and materials in problem solving

2. Education and training for the acquisition of new knowledge and for written and oral communication

3. Bases for research work

4. Computer-assisted learning

5. Information as a knowledge resource

6. From the traditional sources of information towards more advanced information systems

7. Observation as a method of research work

8. Formulating research questions

9. Making hypotheses

10. Methods of research work

11. Public address - communication and knowledge transmission

12. Preparation of reports and seminar works

13. Preparation, planning and implementation of research work

14. Computer as a tool

More than 1,000 pupils and their mentors follow a variety of research programs, organized and carried out by the great Slovene Institute Jozef Stefan. These cooperative programs are very important because gifted students can get excellent mentors outside school. In time it could be a good possibility for cadre policy.

All of these programs are an integral part of the complex social development program in Slovenia. This program has developed considerable research potential, capable of establishing a relatively close relationship with the contemporary cultural, political and economic trends in the developed world.

TEACHER PRESERVICE

AND

INSERVICE STS EDUCATION

COUPLING TEACHER INSERVICE AND STUDENT SCIENCE TRAINING PROGRAMS

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INTRODUCTION

In this paper, we describe the coupling of a teacher enhancement project and a student science training program. The teacher program is called TNT -- Teacher Networked Teams, and is funded by the National Science Foundation. The student program is called SOS -- Summer of Science, and is funded by the NSF Young Scholars Program. Both projects were developed in response to the needs of teachers and students and are consonant with the major policy studies on science and mathematics education (Loucks-Horsley 1990; Press 1989; Rutherford and Ahlgren 1990; NCTM 1989). Both projects were tested during the past five years. A pilot project during the summer of 1991 explored ways and means of coupling teacher and student programs. Based on this experience, we have planned a week of articulated activities for this coming summer.

Why Couple Programs?

There are both conceptual and logistical-social barriers to implementing new science teaching strategies. On the conceptual side, teachers' view of the nature of science may limit the development of their pedagogical strategies. Brickhouse (1990) examined teachers' beliefs about the nature of science and how these beliefs actually influenced their classroom practice and curriculum development. Teachers' knowledge of the history and philosophy of science likewise influences their understanding of the nature of science, and relates to their subsequent teaching strategies (Lederman and Zeidler 1987). However, we face the reality that teachers, as well as the majority of scientists, have not studied the history and philosophy of science in such a way that would influence their teaching strategies. The nature of science is not traditionally a part of the undergraduate curriculum in science departments or education schools so students, in general, are not exposed to this. Furthermore, neither do students, both pre-service or science majors, gain experience with the operational side of actually doing science. So in general, our universities prepare teachers who neither have the philosophical nor practical background to understand the nature of science as it relates to teaching.

On the logistical-social side, we found some reluctance among teachers to integrate materials and strategies from our inservice programs into their classes because they had not used these materials/strategies with students. Even among those teachers who readily adapted what they learned into class units, lessons, and activities, there was still concern about many of the logistical problems encountered in teaching new content, using new curricular materials, or adopting new pedagogical techniques. Of course, the scrutiny of parents and administrators makes changes in a classroom difficult under the best of circumstances, and there may be high expectations placed on teachers returning from inservice programs (particularly teachers who got release time at a school's expense).

In the following sections of this paper, we first describe the teacher program, then the student project, and close with a discussion of what was accomplished in our pilot and what we hope for during this coming summer.

Precursor for the Coupled Program Model

Our ideas for coupling student and teacher programs go back to work done at Kenyon College during the period 1985-1989. At that time, we had helped develop a program that served inner city Cleveland high school students. The student program evolved from work on the Kenyon School-College Articulation Program, an interesting project that involved a long-term educational partnership between Kenyon and Ohio high schools. The partnership brought together faculty from the college and high school faculty from schools around Ohio. Together the partnership faculty created college-level courses for high schools, which were taught at the schools for Kenyon College credit. In 1986, Kenyon faculty and faculty from selected Cleveland schools created an interdisciplinary summer program for high school students that helped these students prepare for taking the college-level courses offered at their high schools during the academic year.

From this model, a number of programs were developed and tested by staff now at Northern Arizona University. These included a diverse array of teacher enhancement projects and a number of student science training programs that offered summer research internships to high school students.

Summer 1991

With funding from the Eisenhower Mathematics and Science Education Act, we implemented two teacher inservice programs in the summer of 1991. One project, called Arizona Science and Environmental Education Development (ASEED), focused on the needs of middle school science teachers. The other project, Critical M.A.S.S. -- Math and Science Specialists, focused on high school and middle school mathematics teachers. We linked parts of both programs to our Summer of Science student program.

ASEED teachers accompanied SOS students on a research trip down a portion of the Colorado River. On this trip, students and teachers worked together to study water chemistry, biota, and human and river impact on beach characteristics. Critical M.A.S.S. and ASEED teachers were invited to observe SOS activities, meet with program students, and discuss program activities with SOS faculty and scientists. Teachers from both programs attended the student research conference at the SOS program. We had designed the SOS project as an exemplar of science and mathematics teaching strategies and materials, but had also included a major component of high quality research. Teachers were able to see that what we were discussing in the inservice programs had already been applied to a student program. Although a summer residential program and the kinds of students in the SOS project are atypical of most school settings, we at least provided teachers with a living laboratory and a focus for discussions about what would and would not work in their home schools.

Summer 1992

For this coming summer, we again plan to couple some of the activities of our teacher inservice and student science training programs. The third week of our TNT project overlaps with the first week of the SOS program. Teachers will be able to observe and work with students in SOS. The key point is that the first week of SOS is more typical of a high school classroom setting except that we use a research-based curricular model and a combination of pedagogical strategies not usually found in K-12 classes (e.g. writing to learn mathematics and science, interdisciplinary problem-solving, cooperative group research activities, technical writing, and original research in the classroom). Teachers will have completed workshops in the spring of 1992 and two weeks of their summer institute, and so will have had exposure to new strategies of pedagogy as well as a research experience. They will be able to observe the SOS project as a model of what they have learned in TNT.

We have designed the third week of TNT as a Curriculum Development phase in the program. It is important that teachers see real students and interact with them as they begin to develop their own curricular materials for testing in Fall 1992.

TEACHER NETWORKED TEAMS (TNT)

We are testing a multicultural and interdisciplinary model for an academic alliance between elementary schools with high ethnic minority enrollments and Northern Arizona University that will improve the quality of science teaching in those schools by providing teachers with adequate support to implement good science programs. These teachers will play a pivotal role in helping minority students develop positive attitudes and excitement about learning science. The University has formed a partnership for excellence in education with ten elementary schools in northern Arizona. Each of these schools has an enrollment that is mostly minority Hispanic and Native American and seven schools are predominantly Native American. The project will provide training and long-term support for a Resource Specialist Team from each school; each team is composed of four teachers. We call the project Teacher Networked Teams (TNT) because our principal goal is to establish a critical mass of mathematics and science resource specialists in each school who will provide inservice support for their colleagues, and to link the team of each school with the other teams and with the Science and Mathematics Learning Center at Northern Arizona University. The project is part of a collaborative effort between minority schools in Arizona, communities, and Northern Arizona University. Within the University, the Science and Mathematics Learning Center, the College of Engineering and Technology, the College of Social and Behavioral Sciences, the School of Forestry, and the Center for Excellence in Education are contributing personnel and resources to the project.

TNT evolved from pilot teacher enhancement and student science training programs that were developed and implemented by the Science and Mathematics Learning Center. These pilots were developed with input from K-12 teachers and administrators, and are consonant with the major policy studies on science and mathematics education (e.g. *Project 2061, Curriculum and Evaluation Standards for School Mathematics, Everybody Counts, Elementary School Science for the 90's*, and Arizona projects like the state's *Science Essential Skills* document). Importantly, the program is based on strategies that successfully change existing formal education systems by incorporating interactional patterns that engage students' culturally-determined social and cognitive strengths into the teaching/learning process. TNT is a combination of the most successful elements of our earlier programs and emphasizes six major components.

1. **Multicultural and Ethnoscientific Workshops**: Workshops that focus on ethnic variability in academic achievement, with discussions of factors shaping the interactions among teachers and students, and exploration of strategies for intervention and improvement in mathematics and science education.

2. **Content Workshops**: A series of workshops that offers elementary teachers training in selected mathematics and science content domains as well as in pedagogical strategies. These workshops will focus on interdisciplinary approaches to teaching and learning science.

3. **Summer Research and Curriculum Development Internship**: For a three-week period during the summer, teachers will work with scientists and science educators on environmental science research projects. These projects will provide a thematic approach to integrate all disciplines that will serve as a prelude to interdisciplinary science in middle and secondary school, and as ways and means to develop curricular materials and process-oriented activities for their students.

4. **Science on the Move**: As part of its immediate support of the participating schools, the Science and Mathematics Learning Center will provide a van that visits the TNT schools with materials, instrumentation, and master teachers to help implement modules developed by each school's Resource Team.

5. **Resource Directory**: A TNT Advisory Council and TNT teachers will create a directory of resource materials that they can use for themselves and to advise colleagues from their respective schools. The Council is composed of prominent educators and scientists from Arizona,

including elementary science resource specialists, master teachers, science educators, and community representatives.

6. Development of a Regional Academic Alliance: The Science and Mathematics Learning Center is already coordinating teacher workshops and networks for Arizona teachers. The Center has a Resource Collection, computer networks in place, and serves as a major locus for mathematics and science education outreach and enhancement projects sponsored by Northern Arizona University.

The first three components of the program are aimed at developing competent and confident teams of teachers who provide the basis for developing and implementing culturally relevant, sound science curricula. Components 4-6 provide the ongoing support needed to maintain this change.

Teachers' Needs

The TNT of Arizona Project is a direct response to needs expressed by teachers throughout the state. In a recent statewide assessment of needs, two categories of teachers' needs stand out. First, in 90% of the school districts responding to the needs assessment questionnaire, teachers called for more inservice training in content domains, pedagogical strategies, and use of scientific equipment and instrumentation. Second, in almost half of the K-6 schools responding to the survey, there was a strong emphasis on a need for more equipment and supplies. Furthermore, in interviews conducted by Science and Mathematics Learning Center personnel with teachers from around the United States, five common concerns were found: (1) teachers nationwide want in-service training in content domains; (2) there is a call for more training in pedagogical strategies that include cooperative learning, writing across the curriculum, teaching science by doing science, and developing thematic units; (3) teachers want viable curricular materials that meet the increasing demands placed on them by administrators and state officials who are imposing recommendations from major policy studies; (4) many teachers need some kind of research experience that would help them understand the nature of science; (5) teachers and administrators desire a more diverse array of professional guild activities, like curriculum development groups, district and regional conferences, parent and community outreach programs, and computer networks.

Teachers of limited English proficiency (LEP) students and ethnic minority students have an additional set of concerns. Although these are difficult to simplify, four concerns stand out. First, there is evidence that an ethnoscientific approach provides the kinds of examples and problems that make science relevant to minority students (Reyhner 1988). Second, for LEP and multicultural classrooms, science achievement can be enhanced by "concrete, visual, and context-embedded" lesson plans (Ovando and Colier 1985, p. 205). Third, the coupling of second-language instruction and math-science instruction may provide students with more opportunities to develop a better understanding of the nuances in vocabulary and sentence structures. Fourth, teachers of minority students are seeking strategies that minimize cultural discontinuity in the classroom, trying to find ways and means to fit instruction to the cultural background of the students as much as possible (see Reyhner 1988 and references within). For teachers in multicultural classrooms there are few opportunities for training in ethnoscientific approaches, identifying context-embedded lessons, how to couple language and science instruction, and how to minimize cultural discontinuities.

TNT responds to these needs with workshops, seminars, materials, and long-term support that will help them meet the increasing demands and responsibilities placed on teachers as America tries to improve its educational systems in general, and mathematics and science education in particular. We focus on elementary school teachers because they have not received the attention and support they need. In fact, the most effective elementary program models are found in countries like Japan, the United Kingdom, Hungary, Germany, and Israel (Loucks-Horley et. al. 1990). We focus on the sizable Native American population of northern Arizona because of the proximity of the reservations to Northern Arizona University.

Objectives of the TNT Project

An overview of the TNT Program is shown in Table 1. Program goals are listed in Table 2. Each goal has been translated into specific objectives and the objectives operationalized into program activities. We have designed a program that meets teachers needs and we have already formed an articulation with schools that have enrollments dominated by Native American and Hispanic students. A particularly important point is that we have enlisted the help of community leaders and elders to make sure that our teacher workshops, curricular materials, Resource Directory, Resource Center, and Science on the Move Van will enhance science and mathematics education while meshing comfortably with cultural and community traditions.

We argue that a critical mass of teachers is needed in a school if that school and all of its teachers are going to move towards a transformation in mathematics and science education. There is ample evidence that the school building is the functional unit of change and implementation in American education, particularly in rural school districts (Goodlad 1984).

In mathematics, science, and technology education, Native American students suffer even more than other ethnic groups. Fifty-eight percent of Native American students leave school before receiving high school diplomas, while only 25% Caucasian students leave school before graduation (Hopkins 1988, Hopkins and Resta 1989). Furthermore, Native Americans tend to leave school at younger ages than "majority" students. The disparity persists beyond high school. Nineteen percent of Arizona's Caucasian students graduate from college. Approximately 4% of Native American students graduate from college and of these, only 0.04% receive undergraduate degrees in science and engineering (Bridgewater 1992).

SUMMER OF SCIENCE (SOS)

The Young Scholars Program is a five-week residential research internship project designed for 30 high school students. The model for the program evolved from five different student science training programs. Two of the programs were designed and implemented by Tashiro - a program for inner-city Cleveland students, and a Young Scholars Program developed with the Marine Biological Laboratory (Woods Hole, MA). The other three programs were developed and implemented at Northern Arizona University. Two were Young Scholars Programs in Physics/Astronomy and Biology, and the third was Project SEED, a chemistry program co-sponsored by NSF and the American Chemical Society.

All components of the SOS Project have been tested and are effective. They have been part of student programs and have been evaluated and refined during the past five years. Furthermore, the educational methods and approaches to original research have been presented for teacher enhancement workshops sponsored by Tashiro. Ten different kinds of workshops and research internships utilized the pedagogical and research methods we have developed in our student science training programs.

In short, we have tested and refined models for student science training programs and we have brought these models before a critical audience of K-12 and undergraduate teachers. Building upon past experiences, the success of our previous student programs, and the responses of our teachers, we feel that our new SOS program is especially innovative and substantive. Our target age groups are rising sophomores and juniors. These two cohorts are beginning to seriously consider college and career options and many students in these age groups have the social and intellectual maturity to do actual research. Furthermore, we have a well-developed network in the public high schools in Arizona and on the reservations which will assist us with recruitment.

SOS Goals and Objectives

High school students examine career options and begin to make commitments that shape and often constrain their future. As a group, our program faculty are especially concerned about academic and career access possibilities for disadvantaged minority students and majority female students. We have designed a five-week residential program that offers high school students an opportunity to examine career options in science by "doing" science and meeting with a range of scientists who represent five different discipline areas.

The four phases of SOS have specific educational objectives. In Table 3, we list specific goals for the educational and career counseling components of our program. As seen in this Table, **Phase I - Research Skills and Interdisciplinary Training** is an introduction to scientific research with an emphasis on developing the basic skills necessary to do research. The workshops and classes provide a solid introduction to experimental design and statistics, data analysis, learning how to read the original scientific literature, interdisciplinary problem-solving, using library resources, and analytical writing. In addition, computer training sessions, presentations by scientists from all the disciplines to reinforce the interdisciplinary nature of science, and seminars on the history, philosophy, and ethics of science are incorporated into this phase. And finally, we provide career counseling for students who are at an age when they should seriously begin to explore their career and educational options.

Phase II - Research Internship provides direct experience in the laboratories of active scientists. We also continue to provide students with workshops, presentations and seminars. In **Phase III - Scientific Conference**, we help SOS participants bring their research to a close and prepare a short paper, which they present at their own scientific conference. The conference of Phase III is the culmination of research training in Phase I and substantive research experience in Phase II. In **Phase IV - Teacher Workshops,** our follow-up and evaluation focus on short- and long-term effects of the program. For two years after the conclusion of SOS, we will maintain contact with students through a newsletter and survey questionnaires. The two-year follow-up will allow us to study the numbers of SOS students who enter college and the relative impacts of our program on their career and educational opportunities.

Drawing upon the best elements of our earlier programs, the hallmarks of the SOS Project are hands-on research with active research scientists, learning to use library resources and information bases, understanding experimental design, mastering methods of data management and analysis, and learning to communicate ideas, information, and the results of scientific research.

An especially unique aspect of SOS is the interdisciplinary training provided all students during the first 12 days of the program and the focus on experimental design and statistics (with emphasis on critical and creative thinking). Interdisciplinary educational approaches are still relatively rare, especially the coupling of interdisciplinary training, followed by discipline-specific research, and finally by a scientific conference in which students present their work. We also have evidence that the "collaborative" research training in our program will provide students some new perspectives on the ways scientific research is done.

The research training is complemented by seminars in the history, philosophy, and ethics of science, as well as by a series of career counseling workshops. The history/philosophy/ethics seminars help students gain a broader appreciation of science as part of human society. The career counseling component helps students understand how they can take charge of their own lives, seek out educational and career programs that interest them, find sources of financial support, and offer the best presentation of themselves in their applications to colleges and jobs.

SUMMARY

In brief, we feel that coupling inservice and student science training programs could have a profound impact on helping teachers implement new content domains, curricular materials, and pedagogical strategies in the home schools. Student programs provide a living laboratory in which to test both the conceptual and logistical facets of teaching. We argue that the coupling of inservice, preservice, and student programs could be an even more interesting strategy. In fact, this summer we are exploring the possibility of bringing preservice students into our inservice programs as interns, and then piloting program articulations among career teachers, preservice teachers, and students. This program will contribute towards the comprehensive model we are developing for the transition classroom of the 1990's. The transition classroom model is a framework that incorporates research in teaching and learning to provide a real "transition" between current classrooms and "ideal" classrooms developed from an empirical base. The model pays careful attention to transitions in science and mathematics from kindergarten to graduate school.

Table 1. The seven phases of the TNT Project and their scheduling.

Phase	Type of Activity	Schedule
Phase I	Formation of the School-University Alliance	Completed Dec 1991
Phase II	Preparation of Resource Directory and Workshop Materials	Oct - Nov 1991
Phase III	Multicultural and Interdisciplinary Workshops	Jan - Feb 1992
Phase IV	Mathematics and Science Content Workshops	Feb - May 1992
Phase V	Summer Research and Curriculum Development Internship	June 1992
Phase VI	Science on the Move Van: School Visits and Curriculum Planning	Sept -Dec 1992
Phase VII	Follow-up, Network Consolidation, and Evaluation	Sept 1992-July 1993

Table 2. Goals and Objectives of the TNT Project.

Goals	Program Objectives	Program Activities
Enhance Multicultural Awareness in Teachers of Minority and LEP Students	Incorporate culture-based science into major concepts and themes in their teaching.	Phase III: Two-day multicultural workshop and follow-up activities.
Enhance Interdisciplinary Training of Teachers to Enrich Mathematics & Science Curricula	Build units around major organizing concepts in science using specific topics from all disciplines of science in their teaching.	Phase III: Two two-day workshops covering interdisciplinary teaching and identifying content areas that need to be reviewed for substantive teaching.
Enhance Translation of Content Knowledge and Scientific Research into Course Design and Curricular Materials	Build into curriculum and instruction materials a constructivist perspective of learning that guides curriculum development and teaching strategies.	Phase IV: Minicourses in math and science content areas. Phase V: Curricular planning by TNT participants and school visits by the Science on the Move Van. Phase VI: Research and curriculum development internship.
Improve Immediate Support and Intervention Strategies	Develop Resource Specialist Teams as a model for the utilization of the minority school as the effective unit for improvement of science education.	Phase V: Curriculum planning by TNT participants and school visits by the Science on the Move Van.
Improve Long-term Support of Teachers and Schools	Assist Resource Specialist Teams with implementation of curriculum, access to resources and information, and peer coaching.	Phase VII: Continuing teacher workshops, developing telecommunications links, and presentations at regional conferences.
Evaluate the Efficacy of the TNT Model	Establish effective model-delivery system of TNT.	Phase VII: Longitudinal studies of schools and implement multivariate analyses of program impact.

TABLE 3. Educational Components of SOS and their Objectives

Program Elements	Educational Objectives
Phase I - Research Skills and Interdisciplinary Training	
Workshops in experimental design and statistics	To learn the scientific method, the differences between descriptive and experimental research, and to understand research design and data analysis.
Training in interdisciplinary problem solving	To learn about the interdisciplinary approaches to research problems and understand the features common to all disciplines as well as the idiosyncrasies.
Research trip to Lake Mary	To close Phase I with a "real-life" interdisciplinary research problem.
Training on computers	An introduction to the efficient use of powerful word-processing and statistics packages.
Training in reading complex scientific literature	To learn strategies for efficient reading and comprehension of complex literature, especially critical and quantitative analysis of results sections.
Workshops in library research skills	To understand how and why to search literature and information bases, create reference bases, and manage bibliographic data.
Training in scientific writing	To enhance skills in analytical and technical writing, especially the integration of prose and data analyses.
Seminars in the history, philosophy, and ethics of science	To develop a social and historical context for science as a knowledge base of scientists as scholars.
Individualized tutorials	To provide students with individual attention for both intellectual and social development during the program.
Phase II - Discipline-Specific Research Internships	
Research opportunities in the following departments: Physics/Astronomy, Biological Sciences, Chemistry, Environmental Science, Forestry	Hands-on research experience and individualized training in a discipline-specific research area.
Data Analysis Workshops	Continued support and training.
Departmental Seminars	Exposure to scientists in the same discipline, but different research areas.
Seminars on History/Philosophy/Ethics of Science	As described above.
Seminars on Scientific Writing	Preparation for Phase III.
Phase III - Scientific Conference	
Student Presentations	Culmination of research efforts.
Teacher Workshops	Coupling of teachers and students.

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A NATIONAL COMPARATIVE ANALYSIS OF MINORITY PRE-SERVICE TEACHERS IN MATHEMATICS AND SCIENCE

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INTRODUCTION

The 1990 census counted 249.6 million persons in the United States. The percentage of the total United States minority population is on a steady increase. In 1990, there were 30 million African-Americans in the United States. Hispanics were the second largest United States minority following African-Americans with 22.4 million. Asians and Native Americans also made up 7.3 million of the total population (Vobejda, 1991). In the next century, the United States will become a nation with an undeniable minority presence in virtually every region of the country. In preparation for this coming change, the American Educational System must put forth some effort in assuring that all children, including minority children, receive the best instruction possible.

In the 1980 census, thirty-three states had K-12 minority enrollments of 20 percent or more (Garibaldi, 1987). As we approach the year 2020, this number will probably at least double. The teaching force, as yet, does not reflect the same statistics. African-Americans, 80 percent of minority teacher population, make up the largest percentage of non-white teachers in the classroom today. In 1987, African-Americans, Hispanics, and Asian/Pacific Islanders represented 1.9 percent, and Native Americans 0.6 percent (Garibaldi, 1987).

The supply of teachers now approximates the demand; however, by 1995 more than one million teaching positions need to be filled and there may not be enough teachers to fill the positions (Haggstrom, Darling-Hammond, Grissmer, 1987). The supply of teachers is generally found in the nation's post-secondary institutions that house schools, colleges, and departments of education. If we compare the current demographics of K-12 enrollments with the enrollments of pre-service teachers in schools, colleges, and departments of education, the racial and ethnic composition of the replacement teaching force will be diametrically opposite to the racial and ethnic composition of the nation's classroom (AACTE, 1987). Research has not been carried out that examines the numbers of minorities entering the fields of mathematics and science teaching in schools, departments, and colleges of education.

REVIEW OF THE LITERATURE

According to the "Mathematics Report Card: Are We Measuring Up?" and "The Science Report Card: Elements of Risk and Recovery," minority students are not doing as well as their white counterparts. In science, minority students at ages 13 and 17 still appear to perform, on average, at least four years behind their majority counterparts (Mullis, 1988). In mathematics, achievement of black and Hispanic students is still well below that of white students at all age levels (Dossey, 1988). Due to the generally poor performance of minorities on science and mathematics achievement tests, programs need to be designed and implemented to improve the performance of minority students.

The need for minority teachers in mathematics and science as role models is paramount. Although parents have been, are, and will likely continue to be the preeminent significant adults in the lives of students (Galbo, 1984, 1986), teachers also are important as significant adults in the lives of students. The research literature suggests that students' relationships with important adults may be crucial for fostering healthy development (Galbo, 1986).

Little has been written that addresses the role model needs of minority students. Yet, when discussing minority students we are often discussing children from disadvantaged backgrounds. The teacher's role as a significant adult in a child's life increases greatly if the child is from a disadvantaged background (Yinger, Ikeda, and Laycock, 1970). There is a stronger need to communicate and develop a personal relationship with teachers and other school employees when coming from a disadvantaged background. Students from disadvantaged backgrounds are influenced by a circle of supporters, including teachers, in choosing the alternative of higher education when that circle supports and encourages youths to continue their education (Yinger, Ikeda, Laycock, 1970). Minority teachers can inherently better understand the needs of minority students and can more successfully communicate the education needs of minority youth, and engineer their educational achievement (Dilworth, 1987).

METHODOLOGY AND ANALYSIS OF DATA

This study researched the number of pre-service minority teachers in mathematics and science preparation programs in universities and colleges. Although there has been an effort to increase the number of minority teachers in the teaching force, it is important to determine if these efforts are increasing the pool of minority teachers in mathematics and science. The population of this study consisted of all colleges and universities that have schools, departments, and colleges of education. A questionnaire was sent to 1,228 schools, departments and colleges of education with 44.5 percent return rate. Even though this was a low response rate, this study represented the population and not a sample thereby making a 44.5% return rate very significant according to statisticians. The survey instrument asked the following question: What are the total numbers of persons enrolled in baccalaureate and postbaccalaureate educational programs in schools, colleges or departments of education in mathematics and science? The survey requested that the information be provided as follows: Science BS, Math BS, Science Post BS, and Math Post BS, with a breakdown of white, black, Hispanic, Asian/ Pacific Islander, Native American/Alaskan Native, and Other.

Science BS

The data was first analyzed by calculating a nationwide percentage. The overall percentages nationwide for Science/Math BS are listed in Table 1.

Table 1

Science/Math BS SCDE* Enrollments Percentages Nationwide

Field	N	White	Black	Hispanic	Asian	Native	Other
		%	%	%	%	%	%
Science	5760	83.2	5.5	7.9	1.3	-	1.2
Math	5754	84	6.3	6.2	1.8	-	1

*schools, departments and colleges of education

The data was then analyzed by the individual states (See appendix 1). The findings suggest that Alabama (50) and Delaware (45) have the largest percentages of blacks preparing to be science teachers. Puerto Rico (100) and New Mexico (65) have the largest percentages of Hispanics. Hawaii (27) and Oklahoma (9) have the most Asians. New Mexico (8) and Oklahoma (8) have the largest percentages of Native Americans. The Other category includes international students and persons who either refused to register their ethnicity or persons whose data was not available.

The data for the individual states for mathematics can be found in appendix 2. The findings suggest that Delaware (77) and Alabama (77) have the largest percentages of blacks in schools, departments and colleges of education pursuing careers in mathematics; Puerto Rico (100) and Hawaii (5) the largest percentages of Hispanics; Hawaii (13) and California (8) the largest percentages of Asian/Pacific Islanders; Alaska (9) and Nebraska (7) have the largest percentages of Native Americans.

Science/Math Post BS

The data analysis nationwide for Science/Math Post BS is in table 2.

Table 2

Science/Math Post BS SCDE* Enrollment Percentages Nationwide

Field	N	White	Black	Hispanic	Asian	Native	Other
		%	%	%	%	%	%
Science	1500	86.9	2.8	5.2	1.8	-	2.9
Math	910	87	5.9	4.0	1.2	-	1

*schools, departments and colleges of education

The data was then analyzed by the individual states. (See appendix 3). The findings suggest that Mississippi (83) enrolls the highest percentage of blacks in schools, departments, and colleges of education in post baccalaureate studies in science education. Texas (35) and Colorado (17) enroll the highest percentage of Hispanics. Mississippi (17) enrolls the highest percentage of Asian/Pacific Islanders. Alaska (9) and Oklahoma (8) enroll the highest percentage of American Natives.

Alabama (32) and Louisiana (32) enroll the highest percentage of blacks in schools, departments, and colleges of education post baccalaureate studies in mathematics. (See appendix 4). Texas (20) and California (19) enroll the highest percentage of Hispanics. New Jersey (6) and California (4) have the largest percentage of Asian/Pacific Islanders. Oklahoma (17) has the highest percentage of Native Americans.

DISCUSSION

With the changing demographics of American society and the nation's classrooms, educators and policymakers must begin to examine the racial/ethnic backgrounds of the nation's teaching force. Minority students are performing at a lower level in mathematics and science than their white counterparts. More racially/ethnically diverse science/mathematics teachers are needed to serve as positive role models for minority students.

The number of minority pre-service teachers in mathematics and science programs in schools, departments, and colleges of education is low. According to the data gathered in the baccalaureate programs, whites constitute 83.2/84 percent of the total enrollments. In post-baccalaureate programs, whites represent 86.9/87 percent of total enrollments in mathematics and science. West Virginia has 100 percent white enrollments in both mathematics and science on the baccalaureate and post-baccalaureate levels. Besides Puerto Rico, Texas has the most racially/ethnically diverse pre-service teacher pool on all four levels. Of the minority groups, blacks and Hispanics have the highest percentages of enrollments in all programs. Asian/Pacific Islanders and Native Americans are hardly represented at all. Educators and policymakers should be aware of these statistics in order to formulate procedures, programs, and policies to ensure that the enrollments of minorities in mathematics and science increases to reflect the upcoming student population that will be ethnically and racially diverse.

Some possible solutions to the lack of minorities represented in mathematics and science programs could be active recruitment of minorities and mentoring. Educators involved in teacher preparation programs in mathematics and science should approach qualified minorities and encourage them to go into the teaching profession. Minority job fairs could be instituted for undergraduates with an emphasis on education as a profession. Once these minorities are recruited, they should be actively mentored and provided with financial assistance. Universities that house schools, departments, and colleges of education should make an effort to attract minorities to their staffs to serve as mentors. There are some excellent programs at universities that are attempting to attract minority students to the profession. These programs, as of now, are few and sporadic. A concerted effort is needed by all educators and policymakers to assure that the future teaching force in mathematics and science is as diverse as the population that these future teachers will serve.

APPENDICES

Appendix 1

Science BS SCDE Enrollment by State and Race/Ethnicity: Fall, 1991

State	N	White %	Black %	Hispanic %	Asian %	Native %	Other %
Alaska	42	88	-	7	2	2	-
Alabama	6	50	50	-	-	-	-
Arkansas	37	100	-	-	-	-	-
Arizona	24	100	-	-	-	-	-
California	51	100	-	-	-	-	-
Colorado	58	82	-	14	-	2	2
Connecticut	-	-	-	-	-	-	-
D.C.	3	100	-	-	-	-	-
Delaware	98	49	45	2	-	-	-
Florida	136	90	2	4	4	-	4
Georgia	212	90	8	-	2	-	-
Hawaii	11	55	-	18	27	-	-
Iowa	197	97	-	1	2	-	-
Idaho	-	-	-	-	-	-	-
Illinois	149	90	5	-	2	-	2
Indiana	325	95	2	2	2	-	-
Kansas	46	91	3	2	2	1	-
Kentucky	822	76	14	4	4	-	2
Louisiana	127	80	13	5	-	-	2
Massachusetts	9	100	-	-	-	-	-
Maryland	101	93	3	-	-	-	4
Maine	52	98	-	-	-	-	2
Michigan	155	98	-	1	1	-	-
Minnesota	131	99	-	-	-	-	-
Missouri	313	95	5	-	-	-	-
Mississippi	-	-	-	-	-	-	-
Montana	25	92	-	4	-	-	4
North Carolina	26	85	12	3	-	-	-
North Dakota	22	100	-	-	-	-	4
Nebraska	17	94	-	-	-	-	6
Nevada	-	-	-	-	-	-	-
New Hampshire	15	100	-	-	-	-	-
New Jersey	28	68	14	11	-	-	7
New Mexico	223	20	4	65	-	8	3
New York	385	90	2	1	1	-	6
Ohio	33	88	6	-	-	-	6
Oklahoma	133	75	4	4	9	8	-
Oregon	-	-	-	-	-	-	-
Pennsylvania	338	96	2	1	-	-	1
Puerto Rico	224	-	-	100	-	-	-
Rhode Island	11	80	-	-	-	-	20
South Carolina	27	85	11	-	4	-	-
South Dakota	98	91	1	1	1	6	-
Tennessee	72	99	1	-	-	-	-
Texas	702	73	3	24	-	-	-
Utah	-	-	-	-	-	-	-
Virginia	142	83	13	1	4	-	-
Vermont	11	100	-	-	-	-	-
Washington	13	100	-	-	-	-	-
Wisconsin	80	98	1	1	-	-	-
West Virginia	30	100	-	-	-	-	-
Wyoming	-	-	-	-	-	-	-

Appendix 2

Math BS SCDE Enrollment by State and Race/Ethnicity: Fall 1991

State	N	White %	Black %	Hispanic %	Asian %	Native %	Other %
Alaska	44	80	2	2	7	9	-
Alabama	81	38	62	-	-	-	-
Arkansas	72	88	8	1	-	3	-
Arizona	42	91	-	7	-	2	-
California	37	78	-	8	8	-	5
Colorado	24	75	-	17	-	-	8
Connecticut	-	-	-	-	-	-	-
D.C.	2	100	-	-	-	-	-
Delaware	84	19	77	1	-	-	2
Florida	289	93	3	3	1	-	-
Georgia	210	91	5	-	4	-	-
Hawaii	81	38	-	50	13	-	-
Iowa	107	94	2	-	3	-	1
Idaho		-	-	-	-	-	-
Illinois	149	88	4	5	3	-	-
Indiana	631	95	3	-	-	-	1
Kansas	55	95	1	4	1	-	-
Kentucky	832	78	7	10	5	-	-
Louisiana	168	80	11	3	2	-	4
Massachusetts	6	100	-	-	-	-	-
Maryland	43	100	-	-	-	-	-
Maine	112	98	-	-	1	-	1
Michigan	110	97	-	-	1	-	1
Minnesota	190	97	-	-	-	-	2
Missouri	283	97	1	-	1	-	1
Mississippi	28	99	1	-	-	-	-
Montana	23	86	-	4	-	4	5
North Carolina	108	79	19	-	-	-	2
North Dakota	17	100	-	-	-	-	-
Nebraska	27	89	-	-	-	7	4
Nevada	-	-	-	-	-	-	-
New Hampshire	1	100	-	-	-	-	-
New Jersey	42	79	12	5	-	-	5
New Mexico	29	59	-	34	-	3	-
New York	448	94	1	1	-	-	4
Ohio	118	92	3	1	1	3	-
Oklahoma	113	82	8	2	2	5	-
Oregon	-	-	-	-	-	-	-
Pennsylvania	334	94	-	3	1	-	1
Puerto Rico	11	-	-	100	-	-	-
Rhode Island	71	94	-	3	1	-	1
South Carolina	75	100	-	-	-	-	-
South Dakota	31	100	-	-	-	-	-
Tennessee	60	97	2	1	-	-	-
Texas	349	52	4	42	2	-	-
Utah	-	-	-	-	-	-	-
Virginia	86	73	21	2	3	-	-
Vermont	5	80	20	-	-	-	-
Washington	30	90	-	3	3	3	-
Wisconsin	100	98	1	1	-	-	-
West Virginia	45	100	-	-	-	-	-
Wyoming	-	-	-	-	-	-	

Appendix 3

Science PBS SCDE Enrollment by State and Race/Ethnicity: Fall 1991

State	N	White %	Black %	Hispanic %	Asian %	Native %	Other %
Alaska	18	80	2	2	7	9	–
Alabama	–	–	–	–	–	–	–
Arkansas	1	100	–	–	–	–	–
Arizona	–	–	–	–	–	–	–
California	95	78	–	8	8	–	5
Colorado	95	75	–	17	–	–	8
Connecticut	–	–	–	–	–	–	–
D.C.	–	–	–	–	–	–	–
Delaware	–	–	–	–	–	–	–
Florida	55	93	3	3	1	–	–
Georgia	9	91	5	–	4	–	–
Hawaii	–	–	–	–	–	–	–
Iowa	1	100	–	–	–	–	–
Idaho	–	–	–	–	–	–	–
Illinois	214	88	4	5	3	–	–
Indiana	14	95	3	–	–	–	1
Kansas	21	95	–	4	1	–	–
Kentucky	–	76	5	3	7	–	9
Louisiana	63	84	10	2	1	–	3
Massachusetts	–	100	–	–	–	–	–
Maryland	43	100	–	–	–	–	–
Maine	–	98	–	–	1	–	1
Michigan	10	100	–	–	–	–	–
Minnesota	23	97	–	–	–	–	2
Missouri	48	97	1	–	1	–	1
Mississippi	6	–	83	–	17	–	–
Montana	14	71	–	–	–	–	29
North Carolina	46	98	2	–	–	–	–
North Dakota	–	–	–	–	–	–	–
Nebraska	–	–	–	–	–	–	–
Nevada	–	–	–	–	–	–	–
New Hampshire	–	–	–	–	–	–	–
New Jersey	–	–	–	–	–	–	–
New Mexico	15	98	2	–	–	–	–
New York	140	92	–	–	–	–	8
Ohio	6	100	–	–	–	–	–
Oklahoma	12	80	8	2	2	8	–
Oregon	–	–	–	–	–	–	–
Pennylvania	140	89	6	–	4	–	–
Puerto Rico	–	–	–	–	–	–	–
Rhode Island	21	52	–	–	–	1	48
South Carolina	96	88	10	–	–	2	–
South Dakota	–	–	–	–	–	–	–
Tennessee	6	83	17	–	–	–	–
Texas	103	61	1	35	2	–	1
Utah	–	–	–	–	–	–	–
Virginia	5	80	20	–	–	–	–
Vermont	5	80	20	–	–	–	–
Washington	30	90	–	3	3	3	–
Wisconsin	100	98	1	1	–	–	–
West Virginia	45	100	–	–	–	–	–
Wyoming	–	–	–	–	–	–	–

Appendix 4

Math PBS SCDE Enrollment by State and Race/Ethnicity: Fall 1991

State	N	White	Black	Hispanic	Asian	Native	Other
Alaska	9	100	-	-	-	-	-
Alabama	18	67	32	-	-	-	-
Arkansas	11	100	-	-	-	-	-
Arizona	-	-	-	-	-	-	-
California	67	66	10	19	4	-	-
Colorado	-	-	-	-	-	-	-
Connecticut	-	-	-	-	-	-	-
D.C.	-	-	-	-	-	-	-
Delaware	-	-	-	-	-	-	-
Florida	53	98	-	2	-	-	-
Georgia	-	-	-	-	-	-	-
Hawaii	-	-	-	-	-	-	-
Iowa	1	100	-	-	-	-	-
Idaho	-	-	-	-	-	-	-
Illinois	16	81	6	-	-	-	13
Indiana	9	100	-	-	-	-	-
Kansas	2	100	-	-	-	-	-
Kentucky	-	-	-	-	-	-	-
Louisiana	89	62	32	4	2	-	-
Massachusetts	-	-	-	-	-	-	-
Maryland	29	100	-	-	-	-	-
Maine	-	-	-	-	-	-	-
Michigan	4	100	-	-	-	-	-
Minnesota	2	100	-	-	-	-	1
Missouri	44	100	-	-	-	-	-
Mississippi	-	-	-	-	-	-	-
Montana	1	100	-	-	-	-	-
North Carolina	46	98	2	-	-	-	-
North Dakota	-	-	-	-	-	-	-
Nebraska	-	-	-	-	-	-	-
Nevada	-	-	-	-	-	-	-
New Hampshire	-	-	-	-	-	-	-
New Jersey	16	75	-	6	6	-	12
New Mexico	2	100	-	-	-	-	-
New York	86	95	1	1	2	-	2
Ohio	6	100	-	-	-	-	-
Oklahoma	12	75	-	-	-	17	8
Oregon	-	-	-	-	-	-	-
Pennsylvania	97	95	-	-	1	1	3
Puerto Rico	-	-	-	-	-	-	-
Rhode Island	14	50	-	-	-	-	50
South Carolina	66	85	15	-	-	-	-
South Dakota	-	-	-	-	-	-	-
Tennessee	4	100	-	-	-	-	-
Texas	94	75	-	20	3	-	1
Utah	-	-	-	-	-	-	-
Virginia	9	100	-	-	-	-	-
Vermont	-	-	-	-	-	-	-
Washington	1	100	-	-	-	-	-
Wisconsin	67	98	1	-	-	-	-
West Virginia	35	100	-	-	-	-	-
Wyoming	-	-	-	-	-	-	-

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LOOKING AT THE EARTH IN NEW WAYS

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What new technologies are being used to observe and interpret our planet's features and resources? What are the implications of these new ways of looking at the earth for classroom teachers? These were some of the main questions for representatives of the National Weather Service (NWS) and the U. S. Geological Survey (USGS) during a workshop at the Seventh Technological Literacy Conference.

David Kitzmiller of the National Oceanic and Atmospheric Administration (NOAA) described new remote-sensing systems to assist NWS personnel in better achieving their primary mission goal of forecasting conditions that can affect life and property. The NWS is in the midst of an extensive modernization and restructuring program. The key to the success of this project is implementation of new techniques, together with utilization of new applications of older technologies, to improve communication among parts of the nation's forecasting systems.

One major component involves a shift from in-situ sensors, often human-dependent, to automated remote sensors that can provide extensive, detailed observational information to local forecasters and national weather centers. In addition to improved weather satellites scheduled to come on-line in this decade, the new technologies include: Automated Surface Observing Systems (ASOS); Next Generation Weather Radar (NEXRAD); automated aircraft-based reporting systems, and other improved instrumentation for sampling the atmosphere, including new radiosondes, rockets, etc.

There will be greater reliance on local weather offices in the battle to analyze and interpret conditions that bring some 10,000 violent thunderstorms, 5,000 floods, 1,000 tornadoes, and several hurricanes to the United States each year, along with more favorable weather. The data processed by more powerful computers and new interactive software programs provide forecasters with "user-friendly" displays that have many windows which can be readily accessed. Color-coding and multi-layering techniques make images much easier to interpret. Along with the installation of new technologies, the plan involves reorganizing the NWS observational and forecasting system into fewer, but better equipped stations with highly trained personnel able to spend more time on interpreting the information.

Improvements in forecasting thunderstorms, lightning, and flash floods were used to exemplify how such new technologies can be utilized. These create the most dangerous weather conditions in this country because they generally develop and dissipate rapidly, and affect small areas, so they are hard to see with wide-range technologies.

Satellites can provide the broadest view of the early stages of storms with potential to develop into dangerous conditions. But the new generation of weather radars and surface networks of lightning detection sensors permit forecasters to follow movement and changes in mature storms in the detail necessary for accurate local prediction. Computer-linked networks make possible rapid dissemination of such information and allow earlier warnings to the public.

Weather radar was first used in the late 1950s to identify where storms pose threats of flash-flooding and other life- and property-threatening conditions. During the 1970s and 1980s, digitally-processed radar observations (an improvement on the simple monochrome analog displays usually available) greatly assisted forecasters in warning of thunderstorm events. But with the introduction during 1991 of NEXRAD in selected regions, forecasters now have much more powerful compute analysis and display capabilities.

NEXRAD is based on Doppler technologies that detect the velocity and direction of winds, even before clouds and precipitation develop. Officially known as "WSR-88D", NEXRAD is being introduced into ten selected sites by the end of this year, and will be deployed throughout most of the U.S. and in other selected regions before the end of this decade.

The returning radar echoes, processed by sophisticated software programs, creates a three-dimensional "picture" that depicts liquid water content, presence of updrafts and downdrafts, rainfall rates, and other features within a cloud system which enhances severe weather and flood forecasting skills. Doppler radar also permits identification of the wind movement that may lead to tornado formation, allowing forecasters to issue earlier warnings.

Lightning data can be obtained through a system of radio receivers capable of detecting the distinctive pulses from lightning strikes. The NWS forecasters analyze data purchased from private sector networks run by utility companies and other governmental agencies, such as the Bureau of Land Management. These provide high-quality, small-scale data not otherwise available.

New technologies are also being introduced to help atmospheric scientists conduct better research into what creates weather and to improve computer simulation models used to forecast changes. In addition to NWS projects, state and local government agencies and private corporations are also involved in trying to improve prediction of weather-related conditions through such efforts as new automated road and runway sensor systems and coastal climate networks. Much of this effort involves tremendous cooperation between government agencies responsible for keeping the general public aware of possible dangers and private corporations capable of designing and manufacturing new equipment.

M. Dennis Krohn of the USGS provided some examples of how new technologies are also permitting geologists to observe and analyze earth resources in ways barely envisioned just a few years ago. Aircraft- and satellite-borne sensors operating over a much wider range of electromagnetic wavelengths and resolution scales, together with more powerful networks of computers, permit detection and interpretation techniques over spatial and temporal scales previously impossible.

Krohn is quick to point out, however, that what we are seeing should be though of as "evolution, not revolution". Many of the advances derive from utilization of improved computer analysis techniques able to obtain new insights about earth processes by re-processing information obtained by earlier methods.

Satellites have been utilized to observe earth features for more than three decades. Earlier satellites were generally able to determine features at a relatively large resolution (such as 80 meters by 80 meters). But new technologies permit much greater resolution (e.g., 10 m by 10 m). In addition, many more wavelength channels can be detected by these new satellites, providing more data about the composition of the earth.

One important "advance", however, seems at first more like a step backwards. The USGS AVHRR data uses 1-km grids. But this is a case in which "the whole is greater than the sum of its parts" because by looking at the resulting mosaic of surface areas, investigators are less constrained by technical details and can focus more on the scientific problems under study.

By using improved spectral analysis techniques on the hundreds of wavelength channels now available from aircraft, researchers can identify the presence of important minerals to a degree not possible from surface investigations. Airborne detectors can pick up distinctive spectral signatures of certain minerals. In one study, it was possible to map locations of complex iron minerals within a mining region on the basis of their different spectral patterns detected from aloft. This revealed far more information about the region much more quickly and completely than was ever possible through surface investigations.

Computers also permit combination of different types of data for increased analytical insight. In one test, the gravimetric, geomagnetic, and topographic features of a region were displayed in a multi-tiered image on one computer screen. Other tests are underway to synthesize global data sets from various pieces. In some ways, we have a better understanding of some of the other planets than Earth because they have been systematically mapped.

One important application of these new techniques is permitting the USGS to provide "temporal views" of the Earth. Powerful computers can synthesize data obtained at different times to help recognize and understand changes. For example, programs have been created that permit changes in surface vegetation to be displayed in a color-coded map of the entire country. In this map, physiographic provinces clearly stand out, showing the connection between physical features and ecological results.

Much of this information will be available in a CD-ROM format. The goal is to create a set of six CD-ROM disks that will cover the entire globe. Even more amazing is that this can be done at a cost comparable to that of a single LANDSAT image twenty years ago!

The USGS plans to make such information readily available through a variety of networks. One such data-access network now coming on-line is the Global Land Information System (GLIS). GLIS consists of: "Directories" that contain summary information about data sets: "User Guides" that provide information about the sensor specification, extent of coverage, etc.; and "Inventories" that provide detailed information about data set entities. This permits researchers to determine what data are available about a region, evaluate samples, and request additional information.

Not only are such data of scientific interest, but also they are of tremendous educational potential. Children who can routinely view these global composites may develop intuitive understandings of our planet just by seeing the changing patterns. This goes right to the core of what science education strives to establish in the minds of students.

Michael Passow of the White Plains (NY) Public Schools and the American Meteorological Society then led a discussion about implications of such new technologies for educators. Foremost, it is obvious that these new technologies present the opportunity for stimulating new ways of looking at the Earth, ways which we should be trying to bring into our classrooms to excite students and help them develop skills in observing, analyzing, and solving problems affecting our planet. Using aesthetically-pleasing images and interactive techniques to study actual problems should prove much more effective than traditional teaching methods.

It is also obvious, however, that in the constrained budget climate facing schools today, we will not be able to do much to introduce these new technologies into the classroom, even if it were judged to be educationally sound to try to do so. Much of the technology needed to use the new information is not available to classroom teachers, nor is it likely to be in the foreseeable future. There is a chasm between what we are doing today in science research and what we are doing as teachers--we must search for ways to bridge this gap.

Perhaps one place to start might be through wider utilization of the new ways of looking at weather available to students and the general public on television. Many stations now carry high-quality weather broadcasting that incorporates displays obtained through satellite, radar, and lightning detection systems. Educators may be able to use videotapes of such programs for classroom use, giving students some exposure to these new technologies.

We should also try to build on the developing networks which bring scientists and engineers together with educators so that both better understand the needs of the other group. Scientists and engineers can work with teachers to design more effective classroom activities that develop the skills and knowledge needed for modern research, as well as teach the basis for "lifelong scientific literacy" to the vast majority of students who will not become scientists or engineers. Educators, on the other hand, can help teach the scientists and engineers how to make their complex technology more understandable to the general public.

We have exciting new ways to look at the Earth. But without mutual cooperation, the chasm between what we do in "real science" and what we teach in science classes will continue to widen, and the opportunity to enjoy these "views" will be missed.

* * *

For more about the National Weather Service Modernization and Restructuring Plan, contact the Transition Program Office, National Weather Service, NOAA, 1325 East West Highway, Silver Spring, MD 20910.

For more about the U.S. Geological Survey's programs, including GLIS, contact the U.S. Geological Survey, Reston, VA 22092.

The American Meteorological Society has established an Education Office to work more closely with teachers. It is located at 1701 K Street, N.W., Suite 300, Washington, D.C. 20006-1509.

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SCI-LINK: A TEACHER INSERVICE METHODOLOGY

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ABSTRACT

SCI-LINK: a teacher inservice methodology

SCI-LINK is a project to translate current scientific knowledge into teaching practices. A framework and methodology to bring environmental research into the classroom is introduced by presentation of current research findings, with site visits to the laboratory, field, and greenhouse.

A number of different strands are utilized during the Institute for teachers. Subject matter has focused on air and water quality issues. Cooperative learning is employed. Different science education philosophies and methodologies, such as AAAS Project 2061, NSTA Scope and Sequence; FAST, ChemCom, etc. are examined. Science teachers Grades 5-12 develop their own classroom computer applications specific to their subject areas.

Through collaboration, an enduring network of contacts will be established between the personnel in university and government research and state and local education agencies in two states (MN and NC) in different regions of the country. A model will be developed so that the SCI-LINK process can be replicated in other parts of the country focusing on different topics of significant current concern to those locales.

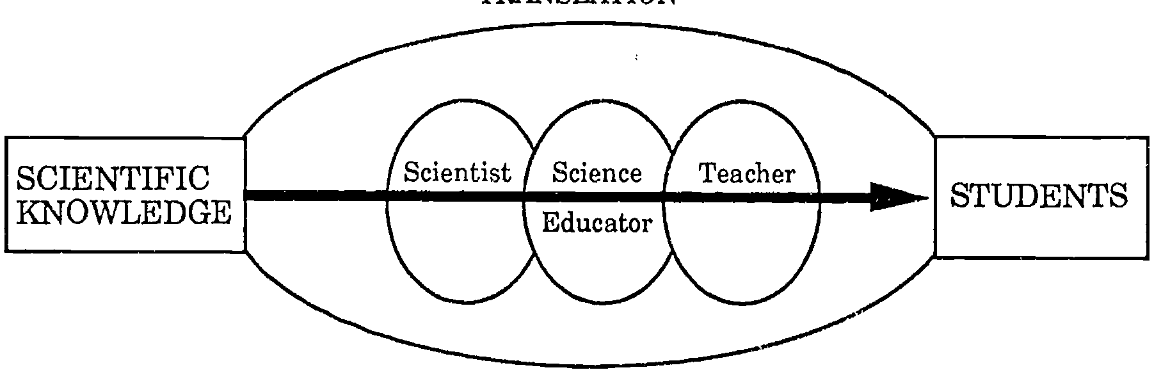
We seek to develop a model Teacher Inservice Institute which can be replicated and used by others. There are many component parts which we have tried, some which have worked, a few which have not. Three one-week workshops Summer 1990, two two-week Summer Institutes in MN and NC, Summer 1991 - all have been held. We plan to hold all of the aforementioned in one Summer 1992. This paper reports on our findings to date.

The Summer Institute. The Summer Institute experience is yet another in the continuum in the teacher's background learning. Institutes are not new in conceptualization. In the 1960's the National Science Foundation supported Institutes which provided many teachers with training and advanced learning they would not otherwise have been able to obtain. Many teachers attribute these early institutes to their own continuance in the field of education, albeit with changed foci and different related vocations to classroom teaching Grades 6-9 (verbal communication Shirley Hill, Norman Anderson). Long-range professional development was not at issue at that time, but we believe that the NSF Institutes provided just that. Now, after a period of about 20 years, these Institutes are again being held. How can organizers consider the design, development, and orchestration of these Institutes, in order to get the "most bang for the dollars"? What can we learn from other Institutes to do the best job possible?

In order to develop a model Institute for inservice teachers, we must consider certain basic questions. How do classroom teachers build on their already existing skills? How do they develop new techniques and strategies to use with their students? How do teachers update their knowledge base to be current in their subject area? In these Institutes, is it possible to develop "lead" teachers, who will in turn train other teachers?

The SCI-LINK Model. SCI-LINK, an innovative project linking scientists, teachers, and students to translate current scientific knowledge into teaching practices, is testing this process. As defined by Webster, a process is "something going on", as opposed to a project "a specific plan or design" which has a definite ending. SCI-LINK provides opportunities for research scientists to present current scientific findings on many different topics to science teachers.

According to Anderson (1991), "The need for....science instruction that incorporates the most up-to-date knowledge in science has never been greater. The knowledge explosion in science continues at an accelerating rate, which compounds the problem of keeping science teachers and programs current. At the same time, national and global problems of a scientific nature demand attention and beg for a place in the curriculum."



INFORMATION TRANSFER

To inservice teachers, we have tested many different time-frames. These include one-day sessions, one-week workshops, and two-week summer institutes. These all provide opportunities to transfer current research information from the scientists to the teacher Both graduate and renewal credit is offered for teachers.

How do classroom teachers present information about current environmental topics in the classroom? These environmental topics may be very controversial. Scientists do not agree. How can teachers present many viewpoints, perhaps even those opposing their own? How can teachers present these topics in a responsible manner?

Teachers arrive at the inservice with differing backgrounds - some have recently graduated and are in their first year of teaching; others are seasoned practitioners after 20 years of teaching. The group is a combination of all in between. How to present an inservice which will meet the needs of all of the participants?

The Institute. Stages of learning. We agree with the FAST program's labeling of the participants' experiences. Teachers first grope, then gripe, then grasp, group, and finally, act. This is all part of the group process, and we have found in each of our Institutes, workshops, and other teacher inservice programs, that these stages have been identifiable, and that teachers progress through these at different rates. The Institute organizer must recognize and realize that this process is taking place. In this way, the organizer is able to better cope with the situations which arise.

Sources of information. One source of information is not sufficient to cause an individual to actually "adopt" this information. Many sources are necessary, ranging from impersonal to personal, and from mass media to the expert, in order to achieve actual adoption of that information (Havelock, 1969).

Processing time. It is absolutely essential that there is time built in the Institute schedule so that teachers will be able to process and incorporate new information as their own. This means group time, individual time, as well as time to actually conceptualize new classroom activities. In the process of developing their own classroom activities, teachers are able to break down the information presented into usable pieces. In turn, the teachers are most positive (after the initial frustration of how and what to develop) and are so very enthusiastic that they return to their schools and teach their activities; i.e., they have incorporated new information which is useful for them immediately. Because they have **had** to develop an activity, they work well. We have found Hall's stages of concern about an innovation to be most applicable.

Table 1. Stages of concern about the innovation.*

Stage of Concern	Sample Expressions of Concern
0. Awareness	I don't know anything about it (the innovation).
1. Informational	I would like to know more about it.
2. Personal	How will using it affect me?
3. Management	I seem to be spending all my time in getting material ready.
4. Consequence	How is my use affecting kids?
5. Collaboration	I am concerned about relating what I am doing with what other instructors are doing.
6. Refocusing	I would like to know of something that would work even better.

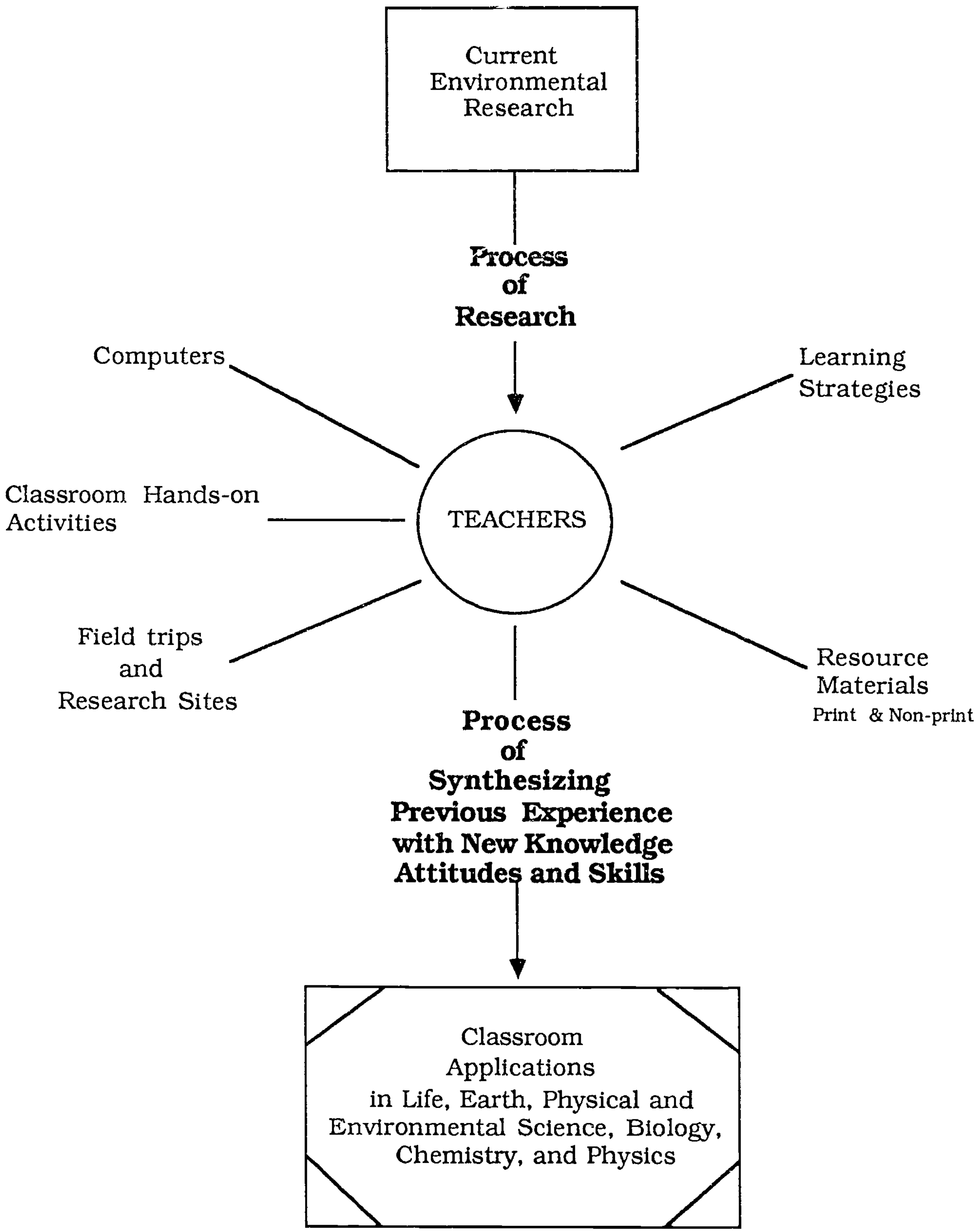
* Hall, 1976, from The Study of Individual Teacher and Professor Concerns About Innovations, p. 22.

There are many components or threads operating within the Institute.

Cooperative learning has played a most important role in all of our workshops. We have incorporated a number of the Johnson and Johnson, and Slavin techniques. These vary during the course of the Institutes.
Current science education philosophy. AAAS Project 2061, NSTA Scope and Sequence, STS and others are discussed.
Current curriculum development projects are presented.
The scientific method and all that infers - i.e., observational skills, analysis, synthesis, etc.
Computer time is an important component of the workshops and institutes.
Laboratory visits
Lecture time
Development of hands-on activities by the teacher participants.
Resources relating to the subject matter, and from many different sources and viewpoints, have been collected and are distributed during the workshops and institutes.

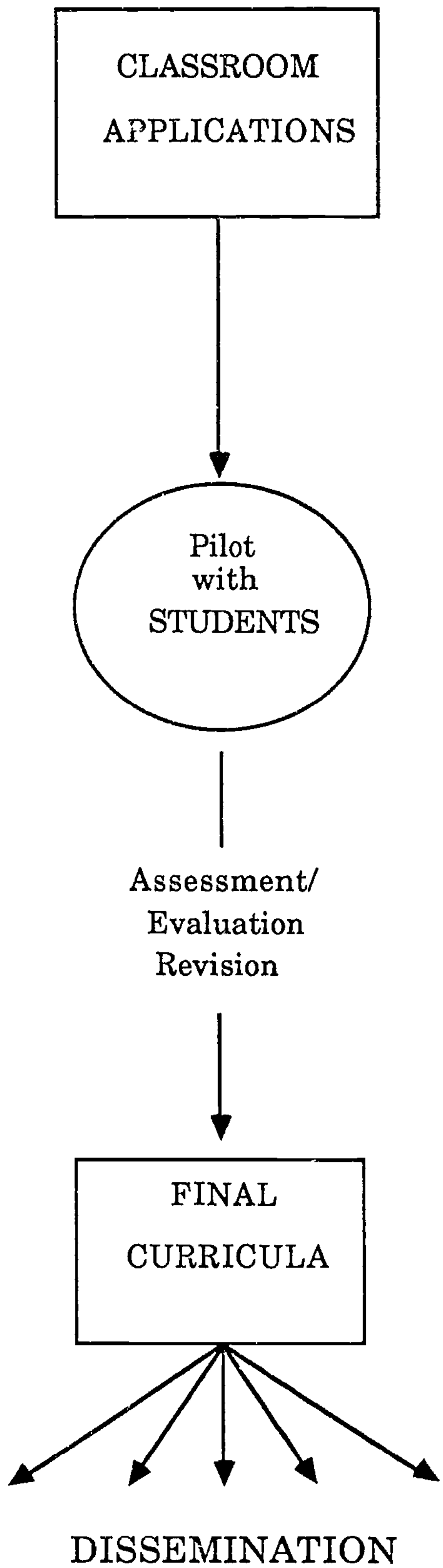
In addition to the above, there are many components which are absolutely essential to "make the Institute work". As in the case of much successful learning and teaching, there must be FUN, the UNEXPECTED, the CHALLENGE, the OWNERSHIP. We are not addressing these in our written portion, but these are purposely planned into the schedule.

THE PROCESS


Current Environmental Research
Process of Research
Computers
Learning Strategies
Classroom Hands-on Activities
TEACHERS
Field trips and Research Sites
Resource Materials
Print & Non-print
Process of Synthesizing Previous Experience with New Knowledge Attitudes and Skills
Classroom Applications in Life, Earth, Physical and Environmental Science, Biology, Chemistry, and Physics

STEP
TWO

THE PROCESS



Tentative Conclusions

We have learned a great deal from our experiences.

1. ***Every scientist's presentation and question/answer session should be immediately followed by a "processing time" for teachers to work together brainstorming specific classroom ideas and applications.*** It is most important that planners of institutes, workshops and other educational presentations for inservice teachers include this "processing time". Questions which teachers might consider are: How can I present this new topic in my class? How can I design a hands-on activity which will illustrate a concept around an issue? What topics will fit into my ongoing curricula? What idea(s) can be presented in a class period?

Dr. Joan Solomon (personal communication) has suggested that this processing time is essential. Evidently, this time enables the teachers to incorporate the new ideas and new thoughts presented by scientists. Then, teachers are more able to design hands-on activities to illustrate a specific concept which then can be infused into ongoing curricula.

2. ***Scientists who have previously been working with the science teachers are getting better at the process.*** Those scientists who have given presentations and laboratory tours for teachers in the past are better prepared now for the types of questions that teachers ask. These scientists give presentations which are most useful for teachers. These scientists contribute significantly to the overall outcome of the SCI-LINK project.

3. In the Institute, ***teachers' preconceptions about scientists were challenged.*** Teachers were very surprised to hear several scientists admit that they did not have all the answers. For teachers who often feel that they must provide all the answers for students, this discovery was important. So much so, that we suggested to scientists who followed, to be sure to include some ideas which had no specific answers, or variable alternative solutions. Another publication in press also relates our findings pertaining to other teacher conceptions about scientists.

4. ***The use of the computer by teachers is an efficient way to work***, even for those who have never had any experience with a computer. Putting the activity on the computer, handing in the computer disc first to the editor, and then the formatter, is an efficient, cost-effective means of information translation and curriculum development. Teachers know their own subject matter; they know where new information best fits within their own teaching schedule; they know their own state, school, and subject requirements. Teachers receive the draft activities in a well-organized, colorful packet about a month after the institute is over.

5. The ***development of activities on the computer*** is not an end in itself, but rather, a means to an end. Teachers use the computer to translate the

information presented by the scientists in formal presentations, laboratory visits, or field site visits. This information, in the form of finished activities, is essential to the teachers being able to use immediately the information for classroom dissemination and student learning.

6. *Individuals from differing viewpoints from both the private and public sectors* are a positive addition as teachers in the Institute.

We will try to replicate the SCI-LINK inservice model Summer 1992 at three sites in the state of North Carolina. These sessions will be only one week in length; each session will have a different director; each session will be in a different location at a different institution. The instructors have been chosen purposely because they have such different teaching approaches. If these three-week sessions and experiences are positive, we will hope to show that we can further develop the model and that it is transferable and replicable. We hope that this model can be used to enhance the process of science education by exposing teachers of science to a variety of current science-related environmental research on issues of global concern. More importantly, this model will be applicable to other topics. SCI-LINK is really a process - a continual, ongoing process - which uses the way teachers learn and teach, transferring information, to develop and train leadership teachers.

We seek to develop a model which will enhance "The education of teachers ...as ... a continuous process", which Hill calls "a seamless fabric" which extends throughout the college years and on into the later years of teaching. We seek to be a part of the development of citizens of the future who will be continual learners, who will have connections with the university, government agency and private sectors, addressing what Hill, in the Case for a New High School Mathematics Curriculum sees as the "wide diversity of needs, interests, and capabilities, yet provid(ing) a sound and useful background for all students".

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SCI-LINK, a two year project linking scientists, teachers, and students, seeks to develop a model framework for translating current scientific knowledge into teaching practices. In its second year, 1992, this project focuses on training Leadership Teachers; providing them with experiences that will assist them to improve understandings of scientific research; assist them in developing materials and the skills needed to translate current research findings; and to enhance their leadership abilities in peer teacher training.

To receive further information about SCI-LINK, please send a self-addressed stamped envelope to: SCI-LINK, 1410 Varsity Drive, Raleigh, NC 27606.

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A MERGER: SCIENCE INSTRUCTION AND HYPERMEDIA

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During the historic education summit held at the University of Virginia in September of 1989, President George Bush set six educational goals he expected our school system to accomplish by the year 2000. One of these goals addressed science education. President Bush said students in the United States will be first in science and mathematics achievement. To begin meeting this challenge, teachers must change the way science is being taught.

Science for All Americans (1989) insisted that teachers need to change their method of content coverage. The report recommended that ideas and thinking skills should be emphasized rather than having students memorizing facts. This can be accomplished by teaching fewer concepts, covering these concepts more thoroughly, and by encouraging critical thinking.

Certain teaching strategies and advanced technology applications can assist teachers in accomplishing this goal. Hypermedia can be merged with the Interactive Teaching Model, an information processing teaching strategy, to promote students' critical thinking skills and increase on-task behavior. In addition to nurturing higher level thinking skills, teachers can help students become independent, self-motivated learners by concurrently using Renzulli's Enrichment Triad as the basis for having students use process skills to develop their independent inquiry skills in science. This paper will discuss a merger of hypermedia technology and two instructional models.

Renzulli's Enrichment Triad

Renzulli's model is based on research about characteristics found in creative and productive individuals. Although Renzulli's Enrichment Model was first developed for gifted students, it can promote schoolwide excellence as it trains students to become independent, curious learners. Research studies suggest that gifted behaviors can be developed in persons who are not necessarily those with the highest standardized test scores (Renzulli & Reiss, 1986). This model takes students through several service delivery components; how three of these can be related to the Science, Technology and Society (STS) approach will be presented.

Renzulli's Type I Enrichment offers general exploratory experiences; it is a planned, systematic dimension. Students are exposed to new and exciting topics. These topics go beyond the areas of study found within the normal curriculum. This level is carried out through a variety of procedures such as "visiting speakers, field trips, demonstrations, and the use of audiovisual materials" (Renzulli & Reiss, 1986, p. 237). Type I sources can be developed over a period of years until the school has compiled an extensive directory.

After all students have completed a variety of Type I activities, they are given the opportunity to develop a given ability, skill, or interest to a higher and more complex level. Students are placed in or choose an open-ended process activity from available Group Training Activities (Type II Enrichment). Since Type II activities exist along a difficulty continuum, students of varying ability levels can participate successfully. Figure 1 shows a sampling of activities (Renzulli & Reiss, 1986, p. 285).

Figure 1:
Possible Ideas for Type II Activities

Locating information sources	Interviewing skills
Affective training in dealing with controversial issues	Photography and media skills
Organization, cataloguing and preparation of materials	Writing and editing
	Evaluation of primary and secondary source

Type III activities have students conducting actual investigations individually or in groups. Students pursue an area of investigation in which they have become interested. Letting students select their own inquiry topic promotes task commitment. Guiding students through levels I and II of Renzulli's model will help guarantee they have the skills to do level III independently.

An Introductory Lesson: HyperCard and the Interactive Teaching Model

A lesson delivery option within the Type I Enrichment Activities could be a display/demonstration/discussion using hypermedia and a teaching model. Research has shown that teachers who use information processing approaches are nurturing their students' thinking skills (Steinberg, 1985; Rosenshine & Stevens, 1986). The Interactive Model by Eggen and Kauchak (1988) is one such instructional model. Students proceed through three phases in an Interactive Model lesson. The lesson begins with an advance organizer; next, general content is separated into more specific subsets as students are led through progressive differentiation, and finally, the teacher helps students discern similarities and differences in the information through integrative reconciliation. The content facts are differentiated on the visual display.

In the Interactive Model, a flow chart is used to present and record information. By using hypermedia for the flow chart presentation, teachers can increase on-task behavior as students' attention is captured. Hypermedia can be can be used like a set of overhead transparency overlays. Information "builds" as the lesson progresses rather than having students see the whole flow chart from the beginning on a printed page (see Appendix A for sample cards from a stack).

The following case study illustrates how this three-way merger would be used in a middle or high school science class. The teacher chose the national problem of "snacking" as the unit topic of study. The attention being given to healthy eating on the national level as well as student concerns for their own body makes it a relevant topic.

Case Study Example

As students entered the classroom on the first day of class, a snack assortment was arranged on a back table. The sign on the table said, "Help Yourself." Most students took one of the snack baggies. Choices included fruits, desserts, and salty/crunchy servings. After everyone was seated, the teacher asked, "How many of you did grab a bite to eat as you came in?" Students were asked to raise their hands if they took a snack.

"There is an interaction between science, technology and society in many of our everyday habits...such as snacking. Americans are known for snacking **(this is the first part of the advance organizer/a generalization)**; we call it munching or nibbling," the teacher continued. "Let's look at what you ate. How many of you ate sweets? How many ate fruit? How many of you ate salty/crunchy food?"

"In addition to eating snacks, Americans are known for being overweight" **(this is the second part of the advance organizer/a generalization)**. "One cause of overweight is the fat content in our diet. Some experts have recommended that daily fat intake should stay within 10 to 30 percent of our calorie intake" (Friday & Hurwitz, 1982).

"Now, we will see how many fat grams were in the snacks you chose. (Turn on the computer and go through the stack. Sample cards from the "Fat" stack are found in Appendix A.) The teacher included the last two phases of the interactive model as the lesson proceeded **(the progressive differentiation and integrative reconciliation)**. As the different snack types were displayed on the visual outline, the teacher noted the serving amount and calories in each type baggie. Students were asked to calculate the percent of fat in each snack.

Students explored the concept that cultural differences in societies influence food choices, and even though a nutritional awareness has begun to sway American's eating habits, people may still choose unhealthy snacks because of taste, habit, or convincing advertisements. The teacher noted that while technology cannot solve all our problems (like personal choices), it can help inform consumers. Technology has allowed manufacturers to put nutritional content of foods on many packages.

At the close of the lesson, the teacher gave a second advance organizer by briefly describing some of the other Type I activities that would follow as this topic was being developed. These included a speaker, a simulation, and films in addition to teacher-led discussions (Renzulli & Reiss, 1986).

At the end of the Type I experiences, Type II group training activities followed. One group of students wanted to pursue interviewing several diet centers; they participated in a group training activity which taught them how to develop affective skills when talking and listening to others, how to design a questionnaire, conduct an interview, to locate community resources, and how to present their findings. By the time the group finished their training, each individual had enough simple training, necessary inquiry instruments, and background knowledge to independently conduct interviews.

Each person in the group then signed a Project Contract Form which was an agreement between his teacher and himself. The contract specified the project subject, who would be interviewed, the questions to be asked, what would be done with the data, and how the information would be presented.

The actual interviewing fell within the Type III activities. If students found they needed other help during the investigation, that training took place as the project was being implemented. The teacher provided feedback as the study proceeded and acted as an editor for each student or group's product.

Product presentation day was arranged so all student groups could share their projects. Peer evaluations were done and subsequently used by the teacher to write a narrative evaluation which included not only a product rating, but also noted strengths and weaknesses for that group during the inquiry process. Each group was asked to turn in a report that summarized their project and to reflect on what they felt went well and changes they would make if they could repeat the project.

Summary

This paper has suggested how an existing enrichment program model (Renzulli Enrichment Model) and a teaching model (Interactive Model by Eggen and Kauchak) could merge with computer technology (hypermedia) to enrich science instruction and address problems in society. If science teachers led students systematically through the three Renzulli Enrichment Model levels, students would be better prepared for independent inquiry. Parents would be less likely to have to do the work for the child during a science project. More important, the training inherent in the Renzulli Model and information processing teaching models helps prepare students to explore creative solutions for society's problems.

Using hypermedia as an interactive component of an information processing lesson's data display can complement instruction and stimulate critical thinking. Cognitive structures clarify relationships and hypermedia can show cumulative information as additional facts are categorized.

Teachers who are embracing STS as the science theory that will help the United States become not only a leader in science achievement but will help future citizens solve world problems, need instructional delivery methods. Information processing models of teaching and Renzulli's Triad Model are all based firmly on research. The components in Renzulli's Enrichment Triad and the Integrative Models are well defined and are readily accessed. Hypermedia is the newcomer, but computers in every classroom with an available hypermedia application will become commonplace in the future. Whether computer technology will be utilized to its highest potential depends upon the teacher's ability to integrate it with instruction. Using HyperCard for the data display in the Interactive Model is one example of interactive teaching that can stimulate critical thinking.

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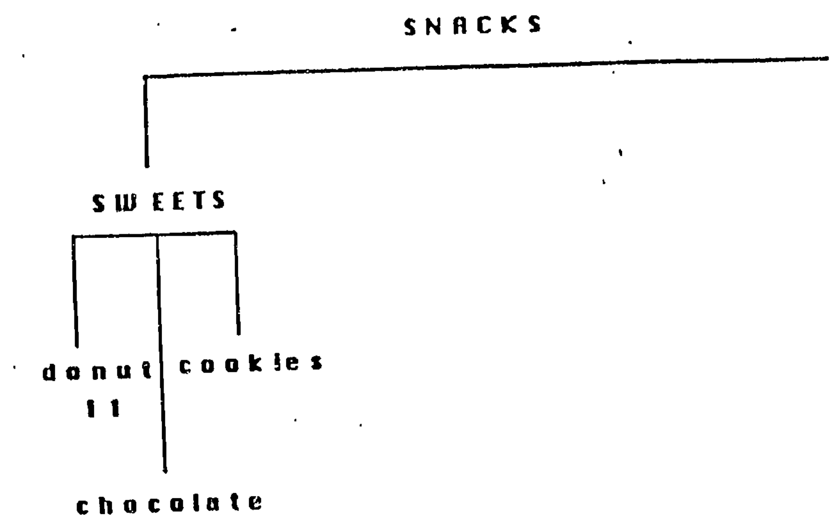
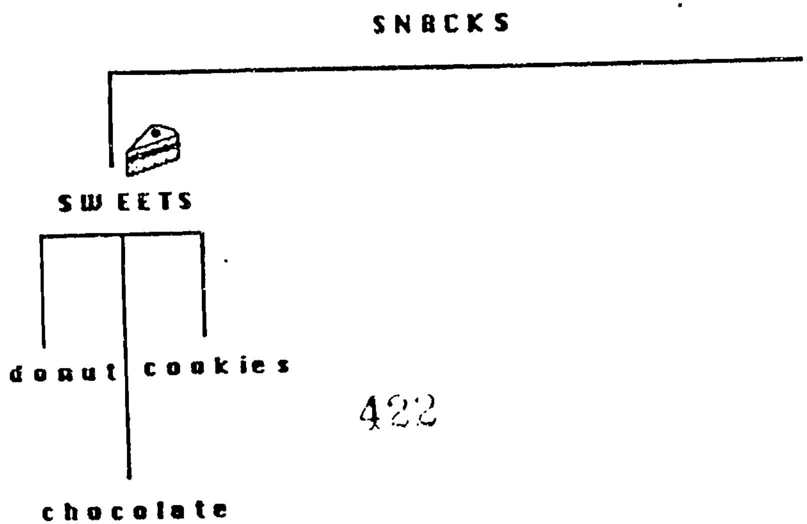
Appendix A: Sample of Some Cards in "Fat" Stack

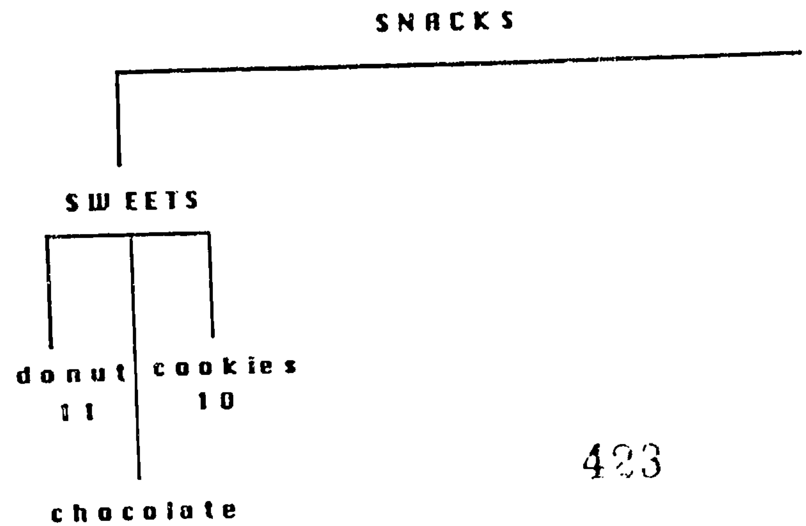
SNACKS

AND

FAT CONTENT







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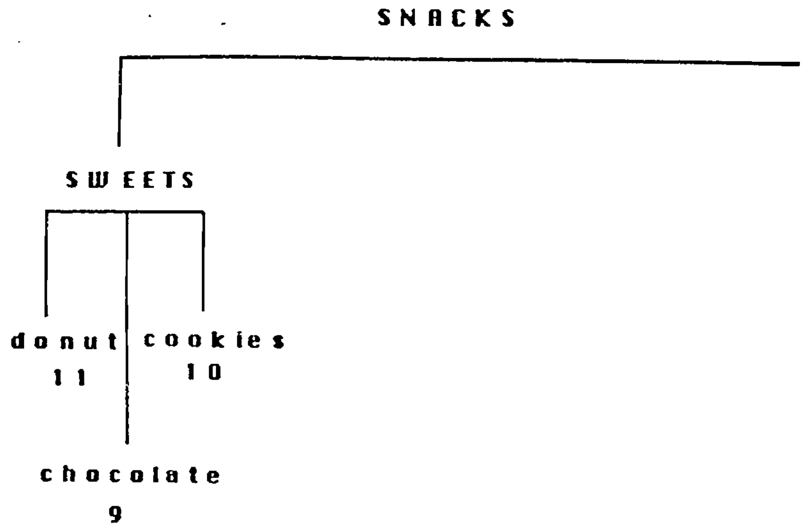

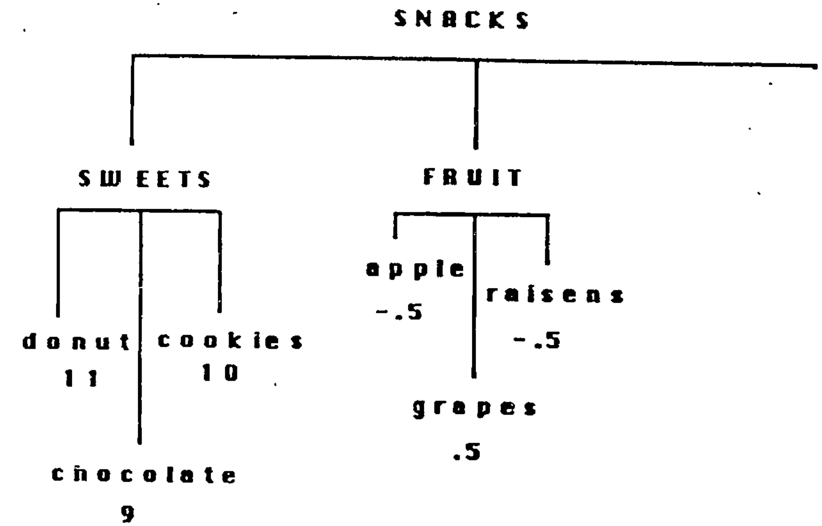

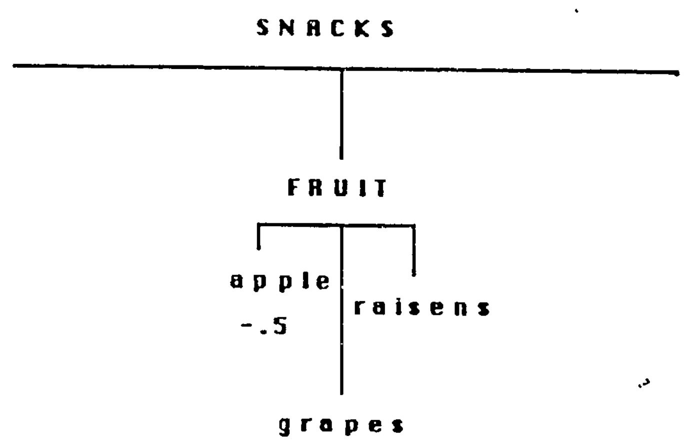

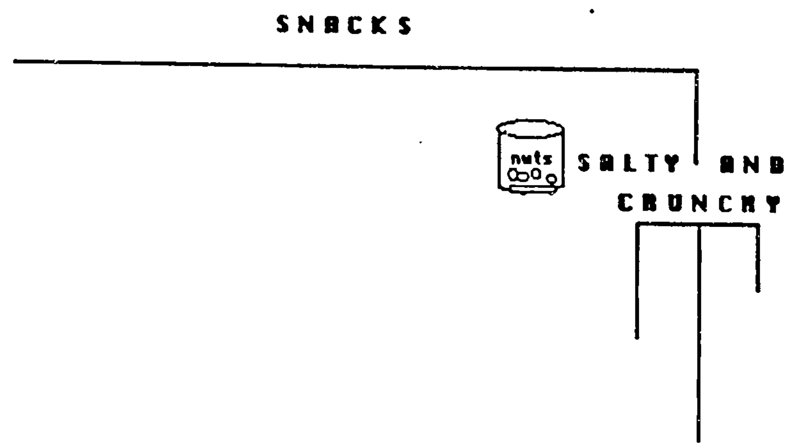

INTEGRATING SCIENCE AND TECHNOLOGY THROUGH INVENTION FAIRS

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Science education has a long tradition of emphasis on science process skills. These process skills, ranging from observation to hypothesis testing, form the basis of doing valid science. Their use results in the products of science, ranging from descriptive facts to theories and laws.

Technology is another human endeavor that includes both processes and products. However, there is no existing long-term tradition of what constitutes appropriate technology process skills to be modeled in the classroom. In fact, the technology process skills emphasized in the very recent past, as part of woodworking, metals, or other vocational courses, are not the appropriate process skills for current design technology.

The Utah State University approach is to integrate science and technology process skills within a STS framework of real-world problem solving. In such a setting, the student should function as a decision-maker, as a scientist, as a designer, as an engineer, as a fabricator, as a controller, as an evaluator, as an informed citizen, and as a consumer. In the literature of technology education, this approach is identified as **design** (Edwards, 1987). The "design loop" as used in the state of New Jersey (Introduction to Design and Technology, 1989) was used as an initial model for the Utah State University teacher preparation program. This model was revised to incorporate a stronger science component. The science-technology-society connection has been incorporated into science and social studies methods courses and an accompanying practicum.

Each term, in the science methods course, a different topic is selected for investigation. The topic becomes a major organizer for investigations that include aspects of science, technology and society. The excuse to investigate is approached from the standpoint of a potential inventor. The section that follows outlines the major steps in the science, technology, and society process-products integrated experience. Typically the invention fair is the culmination of the process. Our approach is to extend the process to a business venture.

Step 1. Learning About Inventors

This is a brief introduction to inventors as real-life people and to the challenges of inventing. In the initial activity, students are asked to make a drawing of an inventor. Characteristically the drawings are of wild-haired males in lab coats, with glasses, and having some wild or weird countenance. Students are then challenged to think of themselves as inventors. This activity is followed by a discussion of some modern-day inventors (Caney, 1985).

Step 2. Practicing Inventive Thinking (introduced concurrently with Step 3)

Most young children are naturally creative. Older children and adults quite often have moved away from thinking creatively and innovatively. They need to rediscover the true joy of creative or inventive thinking. The skills of brainstorming, attributing, associating, visualizing, making think drawings, and examining alternatives are assumed to be major precursors to inventive thinking. These skills are practiced in class as cooperative learning experiences.

Step 3. Record Keeping

Students are required to keep a detailed written-witnessed journal of all invention-related experiences. This journal should include ideas, decision-making accounts, design briefs, drawings, evaluations, and marketing plans. The primary purpose of the journal is to provide experience in technical and scientific record keeping and writing. This is a dimension of the school curriculum that is presently weak. A secondary purpose is to use the journal for evaluation purposes. The journal is an alternative to an exam.

A variety of decision-making strategies and reflective thinking processes are utilized in connection with brainstorming and examining alternatives. These processes are recorded in the journals as students do the activities. The journal also becomes the lab book.

Step 4. Analysis and Investigation

This component is based on a STS problem solving model. The model promotes thinking about problems from a variety of perspectives and better reflects the complexity of real-life problems.

STEPS		QUESTIONING STRATEGIES	CONSIDERATIONS
1.	DEFINE PROBLEM	*What is happening? *Why is this a problem? *What is the impact of the problem? *Is the impact good or bad? *How pressing is the problem?	ETHICAL SCIENTIFIC LEGAL AESTHETIC ECONOMIC EMOTIONAL POLITICAL
2.	GENERATE SOLUTIONS	*Propose a *variety* of solutions to the problem defined. *What could you invent to solve the problem?	
3.	FIND THE MOST APPROPRIATE SOLUTION	*What is the impact of each solution? *Can the solution be put into effect? *Given all considerations, what is the best solution?	

Each term a different topic is introduced as a basis for investigation. Recent topics have included diapers, hairdos, musical instruments, cookies, and toys.

Step 5. Framing a Design Brief

The STS problem-solving model introduced in Step 4 becomes the basis for writing a design brief. A design brief consists of a problem statement, identified contributing factors, proposed solutions, and justification for a possible technology-oriented solution. Though not a requirement for design briefs in general, this experience is structured to lead to inventing a new process or product.

Step 6. Information Gathering

This is the most detailed and lengthy component of the entire process. The majority of time is devoted to scientific investigations related to the problem. Science process skills are integrated with the inventive thinking skills introduced earlier in Step 2.

For example, if our problem was, "What can we do about the disposable diaper problem?" a possible scenario of events could be:

(A) Brainstorm questions about diaper use and disposal. State the questions in terms of, "I wonder.......," e.g., "I wonder what diapers are made of?" Students consider all dimensions of the STS problem-solving model. This procedure can be somewhat teacher-influenced by asking questions such as, "What are some political aspects of this problem?"

(B) The next step is to get very familiar with and knowledgeable about the problem. This could include interviews and readings, but is primarily a hands-on experience. It means getting to know all about the object or phenomenon being studied. The process begins with observing and describing attributes and includes application of as many of the science process skills as possible. Objects and phenomena are compared, contrasted, measured, classified, and subjected to scientific tests. The "I wonder......" questions in (A) above are modified to become hypotheses. Each hypothesis then requires experimental verification. A complete record of these investigations is kept in the journal.

Step 7. Solution Evolution

The purpose of this step is to provide a transition from the ideas of the design brief and scientific investigations to inventing a new process or product. It also ties back to Step 4. In the case of the diaper example, the question becomes: "What process or product can we invent that will improve the diaper situation?"

Again, the skills of brainstorming, attributing, visualizing, think drawings, and considering alternatives are used to obtain a rich pool of ideas. At this point, the design brief is modified to reflect the intent to invent a new process or product.

Step 8. Prototyping

In this step, students actually construct a model or prototype of their invention. The materials and skills needed vary greatly depending on student projects. Most students would benefit greatly from exposure to basic drawing skills or even a course in graphic design.

The approach in the Utah State University methods courses has been to restrict the invention process to one topic each term, e.g., diapers, cookies, cardboard, etc. This procedure alleviates the diversity of materials problem that would result if fifty students were all working on different topics.

Step 9. Testing and Evaluation

This step promotes the investigation of actual "workability" of the product or process being invented. Growing mushrooms on organic diapers may not be a good idea if the mushrooms are contaminated with potential pathogens. An idea for modifying human behavior may not be feasible if the cost in time or money is not acceptable to the consumer.

Step 10. Redesign/Re-implementation

Information gathered in Step 9 is used to modify the product or process for a more polished prototype.

Step 11. The Invention Fair

The fair provides an opportunity to share inventions. Similar to science fairs, invention fairs have rules and procedures, and they take a lot of time. For the purposes of the methods course, the fair is a sharing day, when everyone shares their inventions.

Step 12. Patents, Copyrights, and Trademarks

The purpose of this step is to provide basic information needed to protect an invention and to stimulate thought about forming a business. Every invention fair produces marketable ideas. For the purposes of the methods course, students go through a simulated patent search and patent applications.

Step 13. Paths to the Marketplace

This final step explores alternative ways to market an invention. Groups of students in the methods course do marketing research for their product.

Although this entire process requires a great deal of time, both in class and out of class, students and faculty feel that the real-world problem-solving approach is enjoyable and practical. Preservice teachers leave the science methods course confident about integrating science, technology, and society related topics.

Following successful completion of the science methods course, students enroll in other methods courses (language arts, math, reading, and social studies) along with a one-half day practicum in an elementary school classroom. This experience precedes student teaching or an internship. The STS theme is further built upon as students organize and teach STS thematic units in their practicum classrooms. This integrated approach to learning often incorporates all other curriculum areas in addition to science and social studies.

The tenants of science-technology-society provide a perfect connection for educating teachers as well as educating today's elementary and secondary school students.

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PROJECT 2061: A WORKING MODEL

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Lehigh University has taken the innovative step of granting to a professor of chemical engineering* a joint appointment in the College of Education. This substantive commitment makes possible the intensive interdisciplinary collaboration required for teaching and research in accord with the concepts and the objectives of Project 2061 (AAAS, 1989). We have, in fact, a working model of the Project--a model already proving to be effective for developing among K-12, future and practicing teachers enthusiasm for interdisciplinary, integrated teaching styles. The model also provides the base for bringing to colleges and universities changes needed to encourage more interdisciplinary collaboration in teaching--particularly at the undergraduate level.

The first concrete result of the collaboration is a secondary science methods course being team-taught by Lehigh's science education specialist and the engineer. The course combines Project 2061 concepts, cooperative learning and the inquiry/research approach. The nature of the course is illustrated by Table I which summarizes the syllabus for a semester class (3 hours each). Note that the course includes technological and engineering basics and information, and demonstrates their intimate relationship with science and mathematics. This is critical because while science and math emotions affects peoples' lives profoundly, they do so most often through the agencies of engineering and technology. Also, progress in science and math is driven to a great degree by progess in technology and engineering and vice versa. Despite all this, most people (including teachers) do not understand technology and engineering or their synergisms with science and

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*The engineer has taught and done research at Lehigh for 20 years. He also has extensive private sector experience. To prepare for the joint appointment, he spent a year of intensive interaction with the science specialist and also audited both of her science methods courses. In addition, he has worked closely with teachers and administrators in his local school district.

math. But teachers who can develop such an understanding will be able to use the familiar (the products of technology and engineering) as very comfortable vehicles for teaching their students about engineering and technology and how these affect their lives, and for guiding them from there to the interfaces with basic science and math--and beyond.

Another goal already achieved is cooperatively-directed doctoral projects focusing on research in science/technology educational programs. For example: one of our students is investigating the merits of using IBM's Personal Science Lab (PSL) (IBM, 1989) as a tool for helping to implement the Project 2061 approach coupled with the inquiry/research mode. The benefits of cooperative direction by a science educator and an engineer are obvious and compelling in such cases.

Planning is under way for:

1. A science methods course coupled with a hands-on science/technology course for elementary school teachers. Both will use approaches similar to those embodied in the secondary science methods course. The science/technology course students will use PSL along with more traditional hands-on lab methods, and will focus on "make and take" experiments. Within fairly liberal constraints, students will be permitted to move between both courses. The courses will be taught for the first time during Lehigh's 1991 summer session.

2. A PSINET telecommunications science/technology resource network will be developed, and teachers will be trained in its use and applications. The new network will differ from existing PSINET's in that it will have a strong technology component. The system should be "up" by late spring.

3. New science/technology/math content courses for elementary and secondary teachers are being created. These university level courses are being designed to meet the needs of teachers, and to be taught in a manner consistent with Project 2061 concepts. The course designs will incorporate ideas being solicited from experienced teachers.

4. Grant proposals are being written by the two collaborators. The proposed projects deal primarily with enhancement of the teaching process, and are based largely on the concepts discussed above.

The practical, content-related benefits accruing from the joint appointment are obvious. Equally important, if not more so, is that the Lehigh model makes it possible to present to teachers at all levels direct evidence that Project 2061 and related concepts can be implemented without pain, and that the goals are achievable by real people. We see also in the model a basis for building in the College of Education a highly interactive teaching and research team comprised of educators, scientists, engineers, mathematicians, historians, and others: A potent working model indeed for those who will teach our children. This vision, the very positive responses already demonstrated by our students, and the strong interests expressed by those who have learned of what we are doing, lead us to suggest that other universities evaluate the Lehigh model, and consider using it to develop their own cooperative programs.

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Table 1

WEEK	CONTENT/LAB	METHODS
1	General Introduction; Introduction to PSL	handout syllabus questionnaire (attitude) information
2.	Work with PSL; Simple experiments to learn use of system and probes	silly putty lab futures
3.	General discussion of content area; General systems in a house; systems and "items" involving energy; general introduction to energy concepts; thermal energy; discussion of first experiment and lab procedures.	project 2061 scope, sequence, coordination acid base labs
4.	LAB 1	
	Nature of thermal energy; Relationship between heat and radiant energy; Relationship between heat and fluid motion.	safety and law acid-base labs
5.	Discussion of Lab 1; More on the nature of thermal energy; Thermal properties of materials; Fluid motion and material properties that affect motion; heat and living systems; Discussion of Lab 2.	special students bubbles
6.	LAB 2	
	Relationship between heat and living systems; Relationship between thermal energy and mechanical energy.	curriculum and learner objectives
7.	Discussion of Lab 2; Concepts of mechanical energy and relationship to thermal energy; Introduction to electrical energy; Discussion of Lab 3.	curriculum placement
8.	LAB 3	
	Simple electrical circuits; Relationship between thermal energy and electrical energy; Relationship between electrical energy and mechanical energy.	conflict resolution microscopy
9.	Discussion of Lab 3; Relationship between electricity and magnetism; Generation of electricity; Discussion of Lab 4.	assessment chromatography

10.	LAB 4	
	Electromagnetism; Generation of electricity; Uses of electro-magnetic energy	science materials polymers
11.	Discussion of Lab 4; More on the nature of energy; Discussion of Lab 5	outdoor trip
12.	LAB 5	
	Totally student devised experiments using concepts and connections developed above; experiments must illustrate basic principles and practical applications.	professional growth leaf imprints
13.	Discussion of Lab 5; Putting it all together	slime lab
14.	Student Presentations	
15.	Student Presentations	

STS EDUCATION

IN

COLLEGES AND UNIVERSITIES

SCIENCE, TECHNOLOGY AND POLITICAL CHOICE: PART OF THE UNDERGRADUATE CURRICULUM

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How might new scientific and technological information be applied in a timely and knowledgeable fashion? A seminar course has been developed at Syracuse University as part of the Technology and Public Affairs Program which introduces students to problems that have substantial technical and scientific aspects as well as significant political and societal elements. The objective is to demonstrate the importance of considering many different points of view before recommending a course of action. Ideally about a dozen upper division students from a wide variety of backgrounds including the natural sciences, engineering, the social sciences, business administration, and journalism will participate.

Garrett Hardin, in his book Filters against folly (Hardin, 1985), discusses the dangers of bringing the narrow perspective of the expert to bear on complex problems. He recommends three filters which should be used in judging actions: the *numerate* which seeks quantitative information; the *literate* which seeks to understand what the action means; and the *ecolate* which asks "And then what?" since numbers and meaning are not sufficient to predict the outcome in a highly complex and interactive system. Having a diverse group of participants in the seminar will help prevent the tunnel vision that an individual from a specific discipline might use in viewing a problem.

This year the seminar is devoted to global warming which is an ideal topic for study. It is timely with new information appearing weekly in both the popular press and technical publications. Many people have strong opinions on the need for taking action since global warming is likely to influence the earth's climate. However there is also a large number who feel that no significant action is called for at present in light of uncertainties about the potential effects of global climate change caused by human activities and the high cost of restricting emissions of greenhouse gases. Furthermore since climate change is truly a global issue, any action must involve both the developed and the developing world.

To give all participants an understanding of the issue, several publications are being used. A popular book, Global warming (Schneider, 1989) provides a non-technical discussion of the topic. Changing by degrees: steps to reduce greenhouse gases (OTA, 1991) is a report produced by the Office of Technology Assessment for the United States Congress which provides an excellent overview of global warming with discussions of climate change, energy use and supply, and agricultural practices. One chapter addresses international aspects including population growth, technology transfer, and support for developing nations. A lengthy bibliography is included. The 1991 and 1992 editions of The state of the world (L. Starke, 1991, 1992), an annual report of the Worldwatch Institute on progress toward a sustainable society, also provides a global perspective on a variety of issues that affect climate change. A large amount of relevant information is available from the United Nations, particularly reports that have been written in preparation for the United Nations Conference on Environment and Development which will be held in June 1992 in Rio de Janeiro.

The seminar began with several weeks devoted to a discussion about climate and its natural cycles and recent trends before breaking into various *task forces* to focus on specific aspects of global warming.

In the current seminar one group is looking at models of global warming and long-term climate trends, a second at global warming and biological changes, and a third at implications of global warming for developing nations. If we had more participants, another group would investigate economic aspects of warming, but the full seminar will consider this topic. Each group will spend about a month developing its own set of priorities which its members feel must be part of any proposed plan of action. These will be presented to the seminar before a final course of action is proposed.

The process has not been completed so the final plan has not yet been formulated. Nevertheless some of its specific features are known. The question as to the magnitude of anthropogenic global warming contrasted with natural Milankovich cycle warming make it difficult to defend draconian and immediate actions. Yet despite uncertainties in our knowledge, inaction could have drastic consequences for humanity and other living things. Clearly actions which would be beneficial in themselves and simultaneously reduce the emission of greenhouse gases are the most reasonable.

Increasing energy efficiency can lead to savings of energy and reduced cost. The United States and Canada have the highest per capita energy consumption of any nations so that we can make substantial reductions. Vigorous support of alternate energy research and development is appropriate. The most obvious technology that could be introduced quickly in the United States is large-scale wind generated electric power. This technology has proven reliable and economic in California and the central portions of the United States have much greater potential for wind power. Longer term solar power development, perhaps combined with production and use of hydrogen as an energy storage system that can be shipped readily using gas pipeline, has great potential. What is important is the development and implementation of technology that does not harm the global environment and does not require drastic changes in the standard of living in the United States or the developed nations. Furthermore there is an opportunity presented by the ending of the Cold War to make a major reduction in military spending. Developing new energy technology may be a way to utilize some of the industrial strengths of the United States and provide needed jobs.

Any plan that deals with the developing nations must address two problems. First we must face up to the fact that population pressures greatly exacerbate *all* environmental and social problems in these countries and must make information available to them for use as they feel is appropriate. Second we must encourage development with appropriate technology so that these nations can improve their standard of living without causing dramatic increases in greenhouse gases or pollutants. We need only look at China to see the difficulties. Greenhouse gas emissions will go up significantly if this nation increases its per capita energy consumption, as it must to improve the standard of living for its people. China's reliance on coal means that the problems of carbon dioxide emissions and air quality are particularly acute. Some mechanism must be sought which will encourage the development and implementation of appropriate technology that is more benign.

There are several major objectives of this seminar. The first is to introduce students to problems that do not fit into the neat disciplinary structure of universities and colleges. Real problems cannot be viewed as matters of economics or technology or sociology or any other single academic discipline but may require considerations of many professions. It is useful and necessary for students to be able to work as a team with experts from other areas so that they can deal with complex problems. A second objective is to make students realize that scientific and technical problems are interesting and important even if they are not studying science or technology. Furthermore they will learn that finding solutions to technical problems requires a wide range of knowledge and that they can contribute. A third objective is to learn how to deal with uncertainty. In the case of global warming facts and predictions are in dispute, yet implications are sufficiently dire that action must be considered. And finally a course of action will be proposed, which will be reasonable, despite uncertainties. We even intend to submit our final report to several members of Congress urging them to action.

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IDENTITY AND COMMITMENT: INFORMATION, RHETORIC, AND THE RECRUITMENT AND RETENTION OF FEMALE ENGINEERING STUDENTS

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This is a report of a limited survey and interview study of male and female engineering students and students who transferred out of the engineering curriculum at a large state-related university. I would like to discuss the processes of "identification" and "commitment," related to other models of socialization and development, as keys to describing students who are "at risk" for transferring out of engineering despite at least adequate grade performance. These processes, coupled with a shift in rhetoric in the recruiting and demographic analysis literature on engineering, point to new opportunities for developing recruiting and retention programs for a diverse array of upcoming students. Adequate, and accurate information about not only the profession of engineering but student life as an engineer is important in developing a pre-commitment to engineering. Interaction with and investment by the faculty, often subsumed into issues of "climate," are of utmost importance to the continuation of student's experiences and the development of healthy identities and commitments.

Identification, that is, having a vision of a self, and commitment, asserting a relationship to a social group or role, are related to other models of socialization and development, and are keys to describing students who are "at risk" for transferring out of engineering despite adequate to exceptional grade performance. Looking toward models of development and socialization takes the question of pursuance and perserverance in scientific and technical careers away from the standard assumptions about ability and about students as passive elements in pools and pipelines.

The framework is derived from a study of students from a large state-related university. During the summer of 1990, 108 women and 64 men responded to a survey, and another 34 students interviewed, these being 28 females and 6 males. Students were randomly selected from the population of continuing students, and nearly all of the students transferring from the engineering program were polled. For women, 932 surveys were sent to the entire population of continuing students, 117 sent to the transferring students. For men, 150 surveys were sent to a randomly selected subset of the nearly 5700 students at the main and branch campuses. For transfers, 67 surveys were distributed randomly to one-third of the students leaving the college in the spring preceding the survey. The interviewees were selected from lists of students who had transferred from engineering, with an marginal over-representation of students with superior grades. The focus on students who transferred provided a comparison group from which the framework of identification and commitment could be developed. By focussing on the apparently academically able students who leave engineering programs, I wished to test the relationship between ability and perserverance in engineering.

The "pipeline" is an important "buzzword" in science and engineering education. Although the predicted shortages (Pool, 1990) of scientific and technical professionals have been faulted as inaccurate and perhaps self-serving on the part of the prognosticators, nonetheless the "5 by 5 rule" is currently in effect for projections of PhD production of scientists and engineers (Atkinson, 1990). That is, 5 percent of the US population of 22 year olds get baccalaureate degrees in the natural sciences and engineering, and 5 percent of that population goes on for the PhD. So while the precollege pipeline may be inadequate, what is relevant to my arguments here is that "[A] very large fraction of interested and qualified students are 'lost' to science and engineering between their freshman and senior years in college" (Atkinson, 1990:430).

What seems to be missing from these projections is that the engineering education system is currently <u>designed</u> to "leak out" half of the incoming students -- although this does vary across institutions. At the school studied, there are currently ceilings for enrollments in most engineering majors, based on facilities and faculty available for instruction in upper division courses. Grade point averages (GPA) after the first year are used as cut-offs for enrollment into majors, and some years they have been quite high (as high as 3.0 out of a 4.0 scale). According to enrollment statistics, in the semester preceding the survey, 58 percent of the students leaving the college were qualified with respect to overall GPA requirements (although they may not have had adequate performance in specific courses). A higher fraction of female students leaving engineering are "numerically" qualified. With a fixed number of places in the graduating class, nearly twice as many first-year students are enrolled as will eventually graduate. Even if they were all to do well, which they do not, half of them would have to leave, regardless of competence.

In the aggregate, at the institution in question, women have had attrition rates from engineering similar to men--the educational process has been equitably harsh. The reasons given for attrition vary, however. Further, these 'weed out' processes are grounded by unfounded assumptions on the part of engineering educators about learning, ability, cognition, development, pedagogy, and student life.

This paper focuses on the secondary socialization of engineering students, with the objective of understanding the retention problems of women and men, but women in particular. One way to redress the imbalance of women in engineering would be to make better progress with the ones who do select the program, rather than eliminating them. The objectives are to increase the recruitment of women into engineering, and to differentially promote their success upon enrollment. What I would like the reader to keep in mind is that the engineering curriculum and environment "wastes" a lot of students, many of them good, that are male or female, representing majority and minority backgrounds.

I develop my model along dimensions of commitment and identity, which are related by orthogonal axes. Students who formulate consistent identities and engage commitments to the intrinsics of engineering work as students or future professionals are more likely to persist. These factors fairly dominate measures of ability for a number of transferring students. Further, I can not treat academic ability as entirely an independent variable in these situations. This framework is derived from and consistent with psychological models and the sociological models of the responses of numerical minorities to issues of tokenism (Hamilton 1989; Kanter 1977).

Let me start with the group of students that can be characterized as "integrated" into engineering. These are "typical" successful engineering students. They like their academic work, and have envisioned for themselves successful careers as engineers in industry or perhaps roles in graduate school. This is the "traditional white male" student, although some numbers of women are well integrated into engineering. These students persist in engineering. They are likely to be well-connected to a network of friends, and probably study with other students from their classes. The most committed students will enjoy nearly all of their academic work, although none of the continuing students surveyed were completely satisfied with the teaching and testing styles at the institution in question.

Next are the students who have "assimilated" to engineering. These students have a good idea of what they are in engineering for: the money and job opportunities. Many view engineering education as something to be endured until they get into the "real world" -- an attitude of "getting over." They have heard, or experienced themselves, the notion that "you'll never use what you learn" or "industry will teach you everthing you need to know." While not fully committed to their academic work, they are generally well-identified with engineering as a profession. Future earnings and the immediate satisfaction of working with other engineering students motivate these students to persist in the curriculum. Calls for relevance, more application and less theory, and more exposure to "real engineering" in the curriculum are usually voiced by these assimilated students. They wish to be "real engineers" and are not interested in much of the academic work because of its perceived irrelevance.

For the above two groups, identification with engineering as an occupation is not a problem. These students are "engineers."

They are male or female. They usually have information, sometimes accurate, about their career prospects, and find these prospects appealing. The continuing students seek academic assistance from peers and directly from Professors and TA's more than the transferring students, suggesting that interconnections among students provide both identification and assistance for students.

For the remaining two groups, the problem of identification is compounded: the students may not have accurate information and/or they do not find their prospects appealing based on the information they do have. Students who are highly committed to their academic work, or specific fields of engineering: design, robotics, fighter aircraft, but are not well-connected to an identity of "engineer," can be thought of as marginalized. They currently come from the traditional pool of students, and often have extensive 'tinkering' and 'hands-on' experience. These students often work alone, and some, especially the male students, see the courses such as Speech, or History, or others in General Education as detracting from their goals. They most likely do not have a solid grasp of the very social nature of engineering work in industry or academia.

Female students are socially marginalized by harassment or discriminatory behaviors in the classroom. They study alone. Discrimination or harassment from professors, as gatekeepers and evaluators, can be debilitating. However it appears that <u>students</u> are more frequently the source of female students troubles: of those students (10 percent) who reported gender difficulties, most of the reports were based on behaviors of students. These range from being "assigned gopher tasks in labs" to being told that "women belong in the kitchen" or "don't know anything." Female students become excluded from study groups. Their intentions are suspect, and they perceive animosity directed at them in their environment. Some women will wish to or be able to handle gender-related difficulties, others will not. It is difficult to form an identity based on others who do not support or even actively undermine one's efforts. Additionally, these students are left out of the informal support networks and often do not have access to resources that assimilated or integrated students have through their peers.

The final group are the students who face rejection from engineering. Of course not all students are academically qualified for engineering. However, academically weak students, who are assimilated or only weakly marginalized in engineering may make it. They will have a peer network to draw on for assistance and encouragement, or they will be sufficiently motivated to work hard and make it.

Students who cannot forge identities as engineers, or cannot find reasons to commit to their academic environment will leave engineering despite their adequate and occasionally excellent academic performance. These students often do not "like" other engineering students: two women commented that they didn't like the other women in engineering because they were too competitive and aggressive. A male transferring student found that engineers were "self-centered and only out for a paycheck." These students cannot form identities around students they dislike. Students do not feel that they will be successful. They have high expectations for their performance and leave engineering because of their grades, although they were frequently doing <u>well enough</u> as engineers.

Transferring female students I surveyed had an average GPA of 2.87, transferring males 2.77 (on a 4.0 scale), but the female students thought they were doing worse-- they were lower in their self-evaluations: 2.82 versus 3.0 on a scale of 1 to 5--(much below average to much above average). This is statistically significant to the 0.05 level. Well over 50 percent of students transferring from engineering at the college in question had above a 2.5 GPA, the median cutoff for restricted majors. A woman transferring student had a 3.94 after her first year. It is evidence like this which suggests that engineering educators can not rely on their assumption that it is soley academic ability that they are selecting for through the curriculum.

Students rejecting engineering often do not have accurate information about what engineers do, or they believe that what they are doing in the classroom, which they are not enjoying, will be their careers. They also reject what seems to be a confining social role. Here is a selection from a rather classic, and long, written statement from a woman who transferred from engineering. She had a 3.62 GPA as a sophomore, and transferred into pre-med:

> Because I was aware of all the wonderful opportunities for female engineers today, I had a tough time choosing to leave. I left because the coursework offered no variety, and even when I had the <u>thrill</u> [emphasis in the original] of choosing a general education class, the stupid engineering department limited my choices (having to choose from the lists in the engineering handbook). I also switched because I was concerned that as an engineer I'd work with pipes and gauges for the rest of my life, and I love people.
>
> Transferring into pre-med initially makes me realize how much I like it. With the pre-med major I take all the science and math classes I love plus I even have room to pick up a minor in my block of free electives. Besides organic chem. and physics, I am now taking classes which teach me about the world in which I live. I'll be happy to graduate with more of a liberal arts education and not as another engineering product of this institution.

What would it have taken for a college of engineering to retain this student? A key word is "product", that is, many students come to feel like objects. In a recent American Society of Engineering Education publication, the cover featured "Total Quality Management" or TQM for producing better engineering products. The products portrayed were students marching in step out from a university on a hill. Dressed in blue suits, they had no faces, only boxes for heads and torsos, embossed with a large "Q." This symbolizes the objectification of students, which alienates them greatly and promotes their dis-identification. And it is perpetuated by engineering educators. Students, both male and female, were disappointed that they had to give up part of themselves to become engineers. But often they based their perceptions of the field on the limited amounts of information they have been given about "what engineers do."

Finally, the students who face rejection from engineering have difficulty in committing to the academic work. They find the classrooms boring, the faculty disinteresed, and the material difficult and of questionable relevance. Of course not everyone can like calculus, or differential equations, or thermodynamics, but often the content of the material is overshadowed by the dearth of involvement in the classroom. Recent studies, which should be very influential to engineering educators (Hewitt and Seymour 1991; Tobias 1990), illustrate these problems of "climate." Students feel alienated; they feel that the faculty don't care. For many students, if the faculty don't care, why should they? Attention to teaching and interpersonal interaction which many of the rejected students expect (particularly the women) prevents them from commiting to the work. Two of the students I interviewed left explicitly because of the teaching environment--including one with grades of just above 3.7 on a 4.0 scale.

I will frame the next issue in an appropriate technical metaphor. Rather than looking at students as fluid in a pipe which leaks out or otherwise "escapes," what happens if we look at the engineering education as a production process in an industry which, at this point in time, has a 50 percent scrap rate? Further, what if some of the "scrap" were actually of high quality and misdirected out of the production process? Would the industry survive for very long?

It should be noted here that engineering education not only selects against women, minorities, or other cultural groups, but it also selects against "white men" of certain personalities and interests. Research over the past thirty years has demonstrated that on average, engineers are not shy, artistic, nor are they particularly "liberal" (Perrucci and Gerstl 1969; Whalley, 1985; Caporael, 1980; Greenfield, et. al, 1982; Gardner and Broadus, 1990). Some commentators have argued that throughout the history of engineering education, it has been designed and revised with the intent to exclude. It has effectively prohibited the participation of women, minorities, and those of inappropriate class background (Noble, 1976; Noble, Forthcoming; Hacker, 1989). This will be a tough history to overcome. There are only so many "round pegs" in the world. Engineering is going to have to figure out how to allow the "square pegs" to become involved.

Commitment and identification can be addressed on various levels. The most important and effective is the individual classroom, which places great responsibility on a faculty member. That makes these recommendations the most difficult to implement. Group work, context-oriented projects, and accurate career portrayals (or the presence of career issues in any sense) are essential. As reported in science, the state of undergraduate chemistry has recently received critical attention to its teaching (Abelson, 1990). But as discussed in a recent AAAS report, what is most important is the radical restructuring of the curriculum and the institutions of engineering, science, and mathematics learning (Matyas and Malcom, 1991). Significant changes are required, to coordinate students' options and provide an educational (and not merely training) system responsive to a diverse body of students. But, even modest efforts in a few key courses would probably have significant benefits. Purdue University, as well as several liberal arts intensive programs, provide some indication of new directions for the engineering curriculum.

It is a commitment to the content of the engineering education and the social milieu of such work that keeps students in engineering long enough to finish. The way that engineering education is currently structured, identification with other engineers and ascription to the profession's values may play an even more important part than the technical content of coursework. Students complained of not having access to "real" engineering in their first two years. Classroom and extracurricular exposure to the wide range of opportunities for students with engineering degrees may keep some students in the baccalaureate programs.

Given the experiences related by students, it is no wonder that they are not enthralled with the work and do not complete bachelor's degrees, or the continuing students do not seek graduate degrees. The climate must be tolerable, but in the end it is the technical work which must motivate the student--it is currently the opposite for the undergraduate experience. Students cite "getting nothing" out of lectures, having professors read from the book or use lecture notes year after year, and unfair tests and "grading on the curve." Most often, they find material simply boring.

Humanizing technical work provides a particularly interesting challenge and opportunity for building student interest in regular technical classes -- STS approaches in a different context. In even the most mundane Emech class, examples of the social context of engineering can be incorporated into the curriculum. Students may find the relevance of some academic work because they have a full understanding of how it was developed, how it can or cannot be used, or how they might be using it in their future work. Current ideas about design in the curriculum are part of that agenda, but "putting people" into technology is essential.

I might add here too, that "putting people in" will make it easier for some women to identify with engineering. Transferring students mentioned leaving engineering because of their wish to "work with people." But engineers do work with others and for others, but somehow this fact eludes most students.

The engineering environment is "turning off" or "turning away" good students (perhaps we should consider that the first two years filters students out of engineering, while the last two, or three, filter students out of graduate school), but most of the diversity has been filtered out of engineering before students have selected majors. The educational system needs to replace a "weed out" philosophy with one of "nurturance" and "cultivation" (cf. Collins, 1990).

People have been calling for greater "flow" through the pipeline without a major examination of the leaks. One of the largest, and most accessible, leaks is in the college-level educational system itself. By thinking of students as individuals and as a scarce resource, the leaks in the pipeline are places where the educational process is wasteful, ineffective, and inefficient. Inviting more students into an inefficient system is wasteful. Recruiting and demographic analysis literature on engineering, point to new opportunities for developing recruiting and retention programs for a diverse array of upcoming students.

Interaction with and investment by the faculty, often subsumed into issues of "climate," are of utmost importance to the continuation of student's experiences and the development of healthy identities and commitments. In engineering, faculty treat women exactly the same as men (with but few exceptions with regards to harassment, which is mostly a funtion of the peer culture of engineering). But this equitable treatment is, as Hewitt and Seymour (1992) note, a large part of the problem.

These observations make it difficult for me to maintain enthusiasm for pre-college educational efforts. As one of the transferring respondents remarked in an interview, she felt she had been "brainwashed" at a science and engineering summer camp experience. Science and engineering had been presented as fun and invigorating. Undoubtedly she had the full attention of faculty and mentors. Science and engineering work was presented as challenging, but it was not debilitating. Yet her first year of engineering work as debilitating and alienating. As Tobias has noted, scientists and engineers do not look at their own place in the system, looking at the supposedly less-complex world of elementary schools as solutions to the problems they experience with enrollments. But their assumptions about ability, student life, and retention do not hold up, and their application of these assumptions through pedagogy, curriculum, and climate provides perhaps the greatest barrier to the solution of the problems they face.

We should not look at failures, but at the cause of failure--and certainly not assume academic ability is an independent variable (White, 1990). What we have, in transferring students, is failed identifications and failed commitments. We need to foster commitment to and identification with engineering by providing an invigorating and relevant education and environment. The students who are currently leaving engineering will settle for nothing less.

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"ETHICS IN THE ENGINEERING CURRICULUM"

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Three years ago, Polytechnic University introduced a course in engineering ethics as a new requirement in our curriculum. I would like to comment on the process we underwent in the adaptation of this course from three perspectives: First, I will discuss the course in terms of its form and content; second, I will indicate some of the resources we have used and the way in which we have used them; third, I will point out some areas that can prove to be problematic for one who is given the task of initiating and conducting an engineering ethics course in a technical school.

The following observations are based on my own experience. In fact, everything that I am about to say should be qualified by the realization that this is a description of one particular experience in implementing an engineering ethics course. In no way do I mean to convey the impression that this is the definitive version of what this kind of course should be like, or how it should be structured. My purpose, then, is not to present some paradigm to be emulated by others but, rather, to provide suggestions for those just getting started on such a project. At the same time, we might create a forum for the exchange of ideas among those of us who are actively teaching engineering ethics courses.

Let me now describe the structure of the course. There is one general lecture each week, delivered by me or a guest lecturer, and attended by all who have enrolled for the course. During the week following the lecture a series of small discussion groups meet to kick around the week's topic. I provide each faculty discussion leader with a weekly "packet" that includes: a summary of the week's lecture, a discussion guide based on questions related to the lecture, a film presentation, or an article previously distributed among the students. It is also during these discussion sessions that the students review for up-coming exams, or go over the correct answers for exams and quizzes already taken.

Final averages are made up of the following components: a midterm exam (20%), a final exam (30%), two quizzes (10% each), attendance (10%), participation (10%), and a short paper (10%).

With regard to the content of the course, the word "interdisciplinarity" says it all. From day one, the emphasis is on the fact that engineering ethics is an interdisciplinary topic, and necessarily so. I make it clear that this is a course in which the social--and, in particular, the ethical--implications of the engineering profession will be stressed.

It seems to me that any adequate course in engineering ethics should address most (if not all) of the following issues:

-An understanding of what it means to think one's way through a moral dilemma in a philosophical manner, i.e., by employing a kind of thinking that is autonomous, rationally-based, and universal in applicability.

-An analysis of what is means to be a "professional" or a member of a profession.

-An exploration of the history of engineering, i.e., of the rise and development of engineering; the origins and progressive innovations of professional engineering societies (and their codes of ethics); and the landmark cases responsible for making "whistleblowing" the household word that it is today.

-A treatment of the legal aspects of the engineering profession. This includes the history of engineering and its relation to the law; the legal responsibilities of engineers; and the legal rights of engineers (as in, for example, the signing of employment contracts).

-The sociological implications (and ethical dimensions) of engineering in both "developed" and "developing" countries.

-The psychological factors that enter into things such as team work and conflict resolution. And...

-The importance of honing communications skills--something that is essential for any professional.

All of these interrelated (and at times overlapping) topics indicate that what the philosopher, the historian, the sociologist, the psychologist--and of course what engineers themselves have to say--are all of great significance.

Next, I will turn to the topic of resources. Various media are available to assist instruction: videos, newspaper and magazine articles, newsletters, general guides, and classroom texts. A partial listing of these is included.

At this point, however, I would like to comment on engineering ethics textbooks. This is a relatively new field of academic study and available (suitable) texts are limited. Aside from this limitation, though, there is a further problem stemming from the fact that, while there are books on engineering, and books on ethical situations connected to the engineering profession, there are hardly any that show how to reason your way through moral dilemmas and then apply this theory to relevant engineering case studies. More often than not, we are faced with a situation wherein we have to supplement an "engineering ethics" text with an ethics text--usually a simpler guide than one would normally use in a traditional ethics course.

Lastly, I would like to point out some problematic areas to be expected in introducing a course like engineering ethics into a predominately technical curriculum. I do so with the hopes that some of what is said will germinate into more elaborate future discussions.

If you are an instructor at a technical institution you know that the vast majority of the students who are there are there because they have special cognitive skills that favor the analytic, not the abstract. They are used to dealing with clearly defined questions that have definite solutions. They are used to solving problems in "black and white" terms rather than pondering the gray realms of moral deliberation.

But, in all fairness, this is not peculiar to engineering colleges and universities. Anyone who has taught a humanities course knows the hurdles that are to be overcome; we are introducing a different way of thinking to people who are (intellectually speaking) already "set" in their ways.

Again, drawing from my own experience, I have a few ideas to consider if you are thinking of introducing a course on engineering ethics into a technical curriculum:

-MAKE IT RELEVANT. Show your students that what you are talking about is "real." You could discuss a topic such as cheating both on the academic level and in everyday affairs. (Newspaper articles can help with this. For example, last year the press had much to say about scandals involving the falsification of scientific research data.)

-SHOW AN INTEREST IN THE PROFESSION. This can be done in several ways: discuss professional engineering societies and their codes of ethics; try to use guest speakers--engineers actively employed by industry who have real-life stories to tell; get engineering faculty from your school to participate in the course either as group discussion leaders or guest speakers.

-SHOW WHAT OTHERS ARE DOING. Keep a newsletters file and make it available for student use; discuss organizations of interest such as Student Pugwash.

-SPEAK THE LANGUAGE OF THE NATIVES. Try to use examples and terminology your students can relate to and understand. Either avoid or carefully explain esoteric language.

-BE REALISTIC. A course in engineering ethics should be informative, and it must be taken seriously, but it should also be enjoyable for the students. Expect them to study and to learn, but do not present them with challenges geared for a philosophy or liberal arts major.

I would like to conclude with the observation that there is a similarity between my engineering ethics course and all the other courses I have taught. Always, there will be some who take the course in the same way in which they take all their other courses, with an air of indifference, seeing it as one more hoop they must jump through in the training ground of the academic circus. But also there are those who really learn something from the course--whose lives and professional careers will be, in part, influenced and enhanced by the ideas they were exposed to in engineering ethics. I would like to think that these are the people who will determine the course of future events.

RESOURCES

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INTRODUCING A COURSE IN BIO-TECHNOLOGY "INTEGRATING SCIENCE, TECHNOLOGY AND SOCIETY"

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Who, me? Start teaching bio-technology? Yes, now is the time to begin teaching about heart valves, artificial implants, mechanical joints, EKG monitors, pacemakers: all common terms used in the exploding field of bio-technology. This course could help increase student enrollments, stimulate interest and can easily be included in existing university, college and secondary vocational-technical programs. It also can serve to integrate and foster intra- and inter-departmental (technology, science, health, medicine, business, humanities) relations and curriculum development. The program can be used as a "stand-alone" course, independent research study course, or as a module to be included into existing technical and non-technical courses.

BIO-TECHNOLOGY -- THE WAVE OF THE FUTURE

The bio-technology field is booming, given the aging American people and emphasis on quality of life and health care. For example, according to Hahn (1990) "since 1900 the total U. S. population has tripled, but the number of people age 65 and over has risen eightfold, and by the year 2030, the elderly will make up 29 to 32 percent of our total population." The need to meet these demands will offer great career opportunities for bio-technical students.

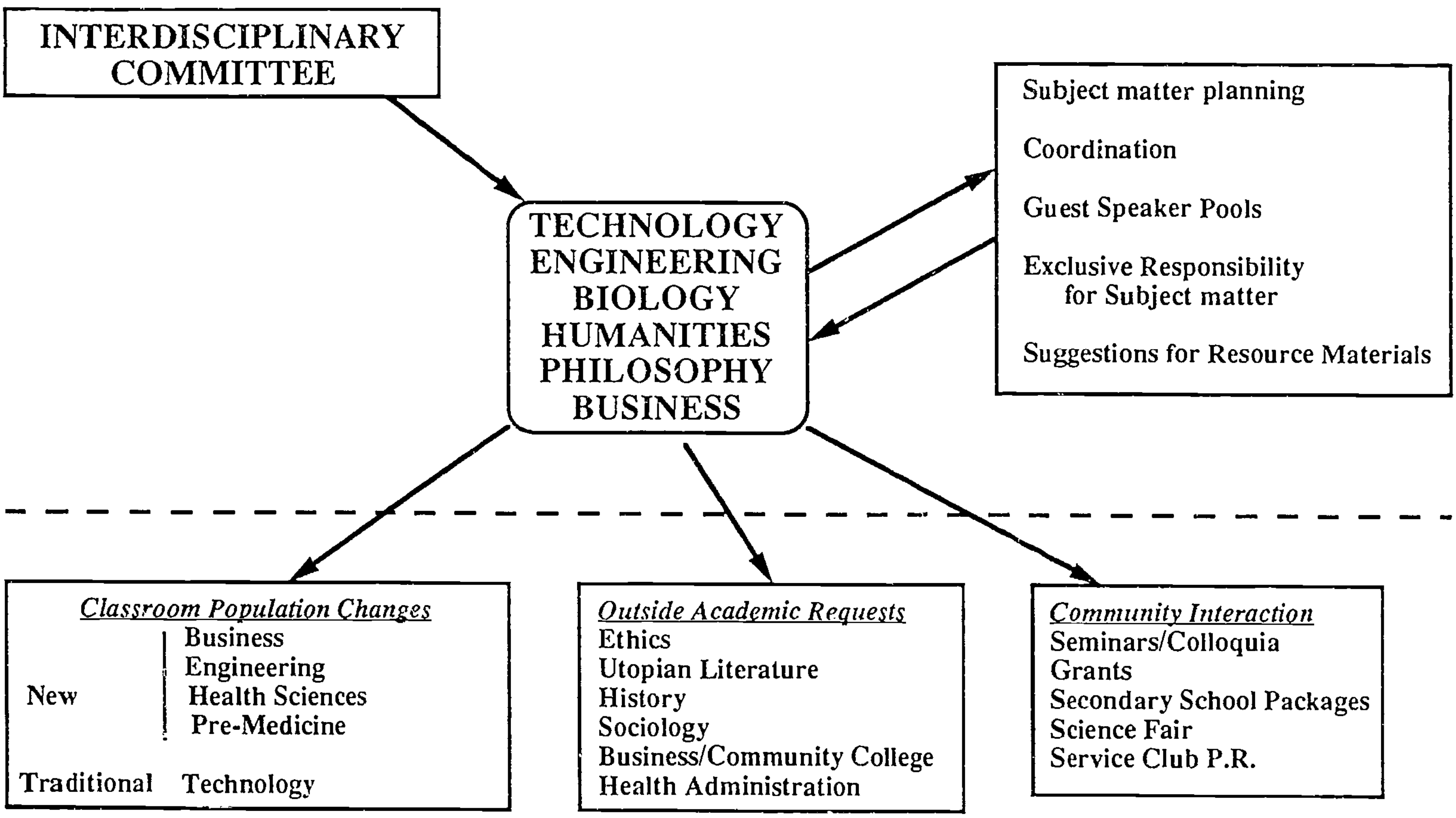
Manufacturing companies in bio-technology are in need of mechanical and electrical technicians and engineers, research scientists, and business people to help design, manufacture, and market bio-medical products and devices. Technicians and repair people are especially needed in hospitals, research centers and other medical equipment companies to maintain, troubleshoot, and service medical equipment.

Orthopedic, cardiovascular, neuro and other surgeons are greatly dependent upon bio-technical advances. Leach (1990), states that, "Orthopaedics has grown tremendously in the last few decades, offering constant advances in patient care -- but ongoing scientific research has been the fuel of our rock of popularity" (2). The bio-technical field is gaining popularity given the current interest in health and quality of life desired especially by the aging baby boom population. As this population continues to grow older, even greater demand will be placed on this area.

INTEGRATING SCIENCE, TECHNOLOGY AND SOCIETY

This course, or a variation of it, can serve to help integrate multiple disciplines of science, technology, health, ethics, engineering, humanities, industry and business. (Figure 1) It can be used to encourage mutual cooperation among disciplines in fostering a synergistic and team approach to education. Valuable knowledge, resources, and materials

FIGURE 1 **INTEGRATING BIO-TECHNOLOGY INTO THE CURRICULUM**



can be shared, broadening faculty and student experiences. A bio-technical subcommittee could be formed to enhance inter-departmental communications and establish course direction as well as decide logistics of storage of bio-technical materials, models and equipment.

PROPOSED BIO-TECHNICAL COURSE OUTLINE

A proposed course outline is presented in Table I. This suggested core outline can be taught as a basic "stand alone" course, or sections can be extracted and combined into existing courses depending on the level of sophistication and teaching facilities. For example, a vocational electronics program might emphasize sections VII through IX, while a graphics program would focus heavily on sections IV through VI. In the university, the course could provide the framework for advanced independent research study for those technology and engineering students interested in a bio-technical career.

In starting this course, the educator should first begin by forming a bio-technology subcommittee to obtain inter- and intra-departmental support. A basic proposal soliciting help from other departments (e.g., health, science, industrial, vocational or engineering, nursing, radiology) should be made to secure resources such as human anatomy models, diagrams, references, and other educational materials. Acquisition of several books covering aspects of bio-technology such as anatomy, physiology, and kinesiology, x-ray technology and radiology, mechanics, electronics, cardiac pacing fundamentals, electronic equipment troubleshooting and repair, and articles on the Federal Drug Administration would be essential. The bio-technology subcommittee is key to gaining sufficient exposure for the program within the school or university.

Making contacts with bio-technical companies and solicitation of their support in providing both resources and product samples is a key to the success of this course. Funding for a bio-technical course could be provided by bio-technical companies, medical facilities, government and other institutions. An area within your classroom could be designated as a bio-technical laboratory to help give credence and exposure to the program. In addition, publishing a news release on the course in the local school or community newspaper can help its success.

HISTORY AND PRINCIPLES OF BIO-TECHNOLOGY

The first section of the proposed bio-technical course serves to inspire and capture the interest and enthusiasm of the students. The evolution from medical implants and devices of the past to the present modern-day bio-technical products is included. Examples of electrical bone simulators, pace makers, and prostheses can be obtained through orthopedic, cardiac, and other bio-technology companies and shown to the students. The use of films showing actual implantation of these implants and devices by surgeons can be enlightening and educational.

An understanding of basic kinesiology and medical terminology, anatomy and physiology, bone and muscle development, and healing properties should also be covered. Nursing and health departments can provide valuable help in this section. Also, local area health providers (e.g., hospitals, medical clinics, nursing programs and other health organizations) can provide valuable assistance and resources for this section.

SCIENCE: CAUSES OF JOINT, ORGAN AND TISSUE DISEASE

The second section, takes a basic science approach and includes the major causes of joint, bone, organ and tissue disease. This section allows the students to understand the indications and need for artificial implants and devices. Typical causes of joint degeneration such as osteo, rheumatoid, and other forms of arthritis can be explained and shown. The science department can provide excellent resources and speakers in this section. Likewise, the science department might invite the technology department teacher to talk on the engineering of bio-technical products and relationship to the body. This can serve as a valuable method for the application of science to technology and society. The bio-technology subcommittee works well for this purpose in coordinating mutual areas of interest and experience. Examples of trauma can also be illustrated with the reconstructive approaches for repair. The instructor might actually invite to the classroom an orthopedic or neuro surgeon as a speaker in this section.

INTRODUCTION TO SCIENCE AND BIO-MECHANICS

Introduction to bio-mechanics is the topic of the third section and covers basic terminology such as curvatures, torsional behavior, tensile properties, sheer characteristics, fatigue tolerances relative to human flexion, extension, rotational and lateral bending and movements. Other aspects of stress and strains, isotropic materials, movement of inertia, modulus of elasticity, and mathematical models can be introduced. Depending on the level of sophistication of the students, various aspects of anatomy and physiology can be introduced. They can range from simple understanding of basic bones to a more in depth understanding of the interrelationships between muscles, bones, tendons, ligaments and other structures of human anatomy and kinesics. The science department can play a critical role in this section in mutual exchange of information. The design and application of surgical tables, suction and connecting tubing, surgical instrumentation, shunts, microscopes and medical hydraulic equipment can be included. This section might conclude with the topics of ergonomics which involves the study of work functions vis-à-vis movements of the human body.

FUNDAMENTALS OF RADIOLOGY AND X-RAY TECHNOLOGY

The fourth section is designed to provide a basic understanding of radiographic principles. The technician or engineer cannot escape the use of x-ray films in designing and working with bio-mechanical products. This segment can be optional depending upon the level of complexity of the course. Understanding fundamentals of x-ray, computerized tomography (CT), and magnetic resonance imaging (MRI) is also important. Local hospitals, schools of radiology, nursing or the medical and health departments can be excellent sources for assistance. Also, local radiologists can be invited as guest speakers to provide overall fundamentals of reading x-ray films. This section might conclude with the design of a simple orthopedic hardware device (e.g., plate, screw, pin or implant) through the aid of x-ray, CT or MRI films.

INTRODUCTION TO ARTIFICIAL JOINTS, IMPLANTS AND DEVICES

The fifth section, which is the core of the program, centers on an introduction to artificial joints. In this section, discussion based upon total hip, knee, shoulder and other joint replacements and arthroplasty can be shown and discussed as well as their mechanical engineering properties. Discussion of different properties such as use of titanium alloys, cobalt chrome, methyl methacrylate cement and other materials can be explored. Examples of allograft bone and skin from the Red Cross or other human skin process companies can be obtained. Many companies provide brochures and examples of actual implants and construction which can be readily shown and utilized by the students. In this section the nursing and technology departments can provide a natural and mutual relationship for curriculum development.

INTRODUCTION TO BIO-TECHNICAL GRAPHICS

The sixth section centers on bio-technical graphics. It covers the basic design process used in bio-technology and should include strategies in working with the end user (e.g., orthopedic surgeon, medical facility). The use of computer aided drafting (CAD) and other computer based systems is also covered in this section. This section might conclude with actual designs of artificial joint implants and reconstructive devices such as a total hip, shunt-valve or silicone body part.

FUNDAMENTALS OF BIO-ELECTRONIC TECHNOLOGY

The seventh section focuses on bio-electronic technology. This section alone could be expanded into an entire program for electrical/electronic students. Enhancing bone healing through the use of stimulators can be introduced. Other areas of interest might include pulsed electromagnetic fields in areas of delayed unions, avascular necrosis, and other typical orthopedic problems. The incorporation of bone healing devices into braces and supports can also be covered. This section includes basic bio-electronic terminology such as stimulation threshold, polarization, membrane potential, impedance and action potential. Basic experiments can be designed using sawbones, "artificial bones" and accessories recording simulated healing effects, electrical measurements and implantation. In addition, understanding common medical devices such as electromyographic nerve conduction velocity instrumentation, muscle stimulators, transcutaneous electrical nerve stimulation (TENS) and their theory, application and repair could be covered.

CARDIAC PACING FUNDAMENTALS

The eight section concentrates on associated bio-implants, monitoring and testing equipment used in cardiology. Examples of pace makers, various designs, characteristics, and applications can be shown. An appreciation of terminology such as arhythmia, automaticity, atrial tracking, blanking period, bradycardia, and cross talk can be introduced. Depending on the level of sophistication, specialized medical equipment and circuity and electro-physiology of pacing can be covered.

BIO-MEDICAL EQUIPMENT

The ninth section deals with the principles of medical testing and monitoring equipment. Devices such as anesthesia monitors, electrocardiogram, surgical lighting and temperature control systems, fiber optic surgical headlamps, blood pressure testing devices, surgery units, and more sophisticated equipment such as magnetic resonance imaging (MRI) and computerized tomography (CT) could be covered. Depending on the capabilities of the students, principles of troubleshooting and repair might be included. This section is particularly valuable for vocational students in preparing them for repair of this equipment commonly found in medical facilities. Also, the engineering student could concentrate on the design and manufacture of these devices.

DURABLE MEDICAL EQUIPMENT

The tenth section covers basic durable medical equipment (DME) commonly found in convalescent, physical therapy, and rehabilitation health care. This section is included because it is very easy to integrate at the high school level given its basic terminology and ease of understanding. For example, various continuous passive motion machines commonly used for all major joint rehabilitation to increase range of motion and strength can be covered. In addition, various power assisted equipment (e.g., power wheelchairs, physical therapy testing devices, electric beds, power lifts) along with typical construction and engineering of convalescent aids (e.g., walkers, traction units, quad canes, braces, supports and splints) is proposed.

HUMANITIES, ETHICS AND SOCIETY CONSIDERATIONS

The eleventh section provides brief coverage of Federal Drug Administration (FDA) guidelines relative to societal issues. It is important for the bio-technical student early on in their career to understand good ethics and guidelines for working in this field. Basic legal aspects (e.g., malpractice, patient rights, copyrights) along with the basic FDA approval process should be covered. In this section the humanities discipline can contribute regarding effects on society, moral obligations and the utopian dream. This makes an excellent topic for English honors classes to cover.

BUSINESS AND MARKETING

This section includes business and marketing principles related to bio-technology research, product development and marketing. The business department can play an important role in establishing curriculum in this section. Business students, in turn, could do a case study in bio-technology. Marketing and business people from the bio-technical field can also act as outside speakers.

PROJECT APPLICATION

The last section concludes with a practical "hands on" project application whereby students gain experience in designing and/or developing a bio-technical product or completion of a study. Students, through the use of "saw bones," could conduct a simulated bone growth stimulation study through measuring typical currents, voltages, resistances and other outputs to various applications. Another example might include the examination of a continuous passive motion machine (CPM). The student might write a paper on its design or actually construct one as a class project. Investigation of a cardiac pacemaker with design and measurements of electrical output and its relationship to the heart could be undertaken. Other examples might include the study of the mechanical/electrical construction of a defibrillator, EKG machine, TENS unit or blood testing laboratory equipment.

CONCLUSION

The continued growth of the high-tech and medical fields are pressuring our present-day curriculum of traditional engineering and technology programs to respond to the modern needs of bio-technology. An introductory course in bio-technology can successfully stimulate current students, attract new types of students, and provide a basic foundation for an exciting and rewarding career in this area. Principles and variations of this Bio-Technology course have been successfully employed at the author's institution. A bio-technology subcommittee has been formed, independent research courses have been developed and mini courses have been introduced with the cooperation of departments of engineering, science and humanities. A more comprehensive evaluation is planned after the program has been completed.

The challenge for educators in all disciplines is to work together in merging science, technology and society issues. Developing a comprehensive and integrated bio-technical program offers a valuable opportunity for us all.

TABLE I

BIO-TECHNOLOGY COURSE

I. HISTORY AND PRINCIPLES OF BIO-TECHNOLOGY

- A. Evolution of Bio-Technology
- B. Human Anatomy and Physiology
- C. Basic Kinesiology

II. SCIENCE: CAUSES OF JOINT, ORGAN, AND TISSUE DISEASE

- A. Arthritis
- B. Trauma
- C. Other Degenerative Disease

III. INTRODUCTION TO SCIENCE AND BIO-MECHANICS

- A. Forces and Load
- B. Properties of Materials
- C. Properties of Bone Tendon, Cartilage, and Muscle
- D. Structures and Function of the Musculoskeletal System
- E. Internal Fixation and Endoprostheses
- F. Ergonomics

IV. FUNDAMENTALS OF RADIOLOGY AND X-RAY TECHNOLOGY

- A. Fundamentals of X-Rays
- B. X-ray Film Handling
- C. Radiographic Quality
- D. Electromagnetic Radiation Principles
- E. Reading X-ray Films
- F. Computerized Tomography (CT)
- G. Magnetic Resonance Imaging (MRI)
- H. X-ray, MRI, and CT Techniques in Bio-technical Engineering

V. INTRODUCTION TO ARTIFICIAL JOINTS, IMPLANTS AND DEVICES

- A. Reconstructive Hardware
- B. Total Joint Replacements
- C. Methyl Methacrylate Constructs and Uses
- D. Allograft Donor Bone Processing and Application
- E. Artificial and Donor Tissue Expansion

VI. INTRODUCTION TO BIO-TECHNICAL GRAPHICS

- A. The Design Process
- B. Computer Aided Drafting
- C. Design and Application of Artificial Joints and Reconstruction Devices

VII. FUNDAMENTALS OF BIO-ELECTRONIC TECHNOLOGY

A. Bone Growth and Healing
B. Electrical Bone Stimulation -- Basic Terminology, Theory and Principles
C. Application of Bone Growth Stimulation
D. Transcutaneous Electrical Nerve Stimulators (TENS)
E. Electromyography and Nerve Conduction Velocity (EGM/NCV)

VIII. CARDIAC PACING FUNDAMENTALS

A. Pacemaker Technology and Circuitry
B. Electrophysiology of Pacing
C. Programmability and Specialized Circuits
D. Neurophysiologic Mechanisms

IX. BIO-MEDICAL EQUIPMENT

A. Anesthesia Monitoring Equipment
B. Electrocardiogram (EKG)
C. X-ray, Magnetic Resonance Imaging, Computerized Tomography

X. DURABLE MEDICAL EQUIPMENT

A. Continuous Passive Motion Machines (CPM)
B. Power Assisted Equipment
C. Convalescent Aids and Devices
D. Prosthetics, Braces and Soft Goods

XI. HUMANITIES, ETHICS AND SOCIETY CONSIDERATIONS

A. Practical Guidelines and Ethics
B. Basics of FDA Approval Process
C. Cultural and Society Responsibilities and Issues

XII. BUSINESS AND MARKETING

A. Effects of Bio-Technology on Business and Research
B. Marketing Bio-Technology Products and Services

XIII. PROJECTION APPLICATION

A. Developing a Prototype
B. Basic Bio-Implant Design and Construction
C. Simulated Project Application or Study

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SCIENTIFIC OPPORTUNITIES--ETHICAL CHOICES

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One of the fundamental questions facing society today in the area of medical technology is whether we ought to do all that biotechnology allows us to do. Concomitant questions include: who ought to benefit from what we can do and how shall we pay for it? These are the issues our students confront in a recently developed biomedical ethics course designed to fulfill a Core curriculum requirement in Science, Society and Technology at Hood College.

The course is interdisciplinary and team taught by a faculty member from Biology and one from Philosophy. The format of the course is organized around current issues and uses a case study approach to grapple with the questions. Students read different viewpoints and have discussions on abortion, severely handicapped children, death and dying, research and human experimentation (both physical and psychological), ethical dilemmas in obtaining informed consent, genetic engineering and genetic policy, the allocation of scarce medical resources and AIDS. These considerations assist the students in moving easily from questions that make an impact on them as individuals to questions having more societal impact and finally to considerations with ramifications in the international community.

The first issue, abortion, engages the students at a very personal level. While there are social concerns in this area, the students nevertheless tend to focus on its impact on them as individuals. The fact that Hood is a women's residential college and that most students are women accentuates the importance of this issue. Most students have a definite opinion about abortion before the readings or class discussion. The case study presents abortion in a less common light: a woman has conceived through in vitro fertilization and is bearing triplets but only wants one baby, thus she requests that the physician eliminate two of the three in utero. This brings students out of their preconceived ideas and stimulates new thought and discussion. As we move on to discussions of euthanasia, organ donors/harvesting organs, and research with human subjects (whether physical or psychological), however, the repercussions for society at large become more pressing. By the time the discussions reach genetic research, the just allocation of medical resources and the AIDS crisis, the students have been drawn from their very narrow individual concerns through wrestling with societal policies to decisions which affect the international community. What policies should we adopt with respect to these questions? How shall we allocate our resources? Who in our society shall benefit? How shall we pay for these benefits? How shall we cooperate with other nations in the international community in sharing expertise, resources, decisions as to how we ought to proceed?

The students in the course represent a broad range of backgrounds and majors who use the course as a Liberal Arts Core requirement more than an elective in their major. Most students are juniors or seniors and have had some course-work in science and philosophy, however, we cannot presume that the students have had a course in ethics or in genetics as a prerequisite (although there is a general prerequisite that the student have one course in philosophical inquiry and one in science at the 200 level). Thus, presentations of both the ethical theories and the foundation concepts in genetics provide a minimal conceptual basis for the case studies and textbook articles.

The introduction to ethical reasoning begins with the basic vocabulary used by ethicists. Students then focus on four ethical theories: two consequentialist (act and rule utilitarianism) and two non-consequentialist or deontological (a modified Kantian position: respect for persons and natural law). Although the focus is on these four views, the students are made aware that there are other legitimate ethical views (subjectivism, egoistic utilitarianism, intuitionism, and divine command theory among others). The students are also provided with a supplemental handout briefly describing W.D. Ross' intuitionism and prima facie versus actual duties. Ross' description of duties are often encountered in the literature in biomedical ethics, particularly the duties of nonmaleficence, beneficence and justice.

Rule utilitarianism, some form of respect for persons (or a theory based in human rights), and/or natural law theory represent the ethical basis commonly employed in biomedical ethics literature. These are also the theories most often used in policy decisions by hospital medical boards. Act utilitarianism is an excellent foil for rule utilitarianism, pointing up the latter's strengths and weaknesses. Of the four theories studied, natural law theory is probably the least understood. The opportunity presented in this class to use each of these theories in case studies assists the students in understanding the complexity and difficulties in all of them. We hope that the students will come away from this course well-grounded in the reasoning underlying these four theories, but will also realize the ambiguities in each of them and have some sense of other alternatives in making biomedical ethical decisions.

For this introduction to ethical reasoning, C.E. Harris' Applying Moral Theories has been used. Harris provides a concise summary of each view, criteria to evaluate the strengths and weaknesses of each view, and a checklist to use in applying each view. He also invites the reader to disagree with his assessments and so provides a context to encourage students to question each method of ethical reasoning. One serious difficulty with Harris' book is that he presents the modified Kantian position almost as if it were a rule-utilitarian view rather than a deontological view. This difficulty is not easily overcome when one is working with students who have little or no background in theoretical ethics. On the other hand, it is not insurmountable. On the whole, Harris' text provides a useful reference manual for students throughout the semester.

The introductory chapter in the other text used in the course (Shannon's Bioethics) provides the students with explanations of some of the primary concepts in biomedical ethics: nonmaleficence (do no harm), beneficence, informed consent, paternalism, rights, justice. With this background in the philosophical theories and terms, the class turns to an introduction to some of the medical advances.

The fundamental concepts in genetics are described in two overview lectures and a copy of The New Human Genetics published by the National Institute of General Medical Sciences is given to each student as a study guide. The necessary elements covered include: DNA, gene structure, human pedigree to assess genetic inherited traits that are dominant or recessive, sex-linked or not, and diagnostic techniques such as amniocentesis, karyotyping, restriction fragment length polymorphism (RFLP) with linked genetic DNA probes. Science majors often help non-science majors review these concepts in small groups. Additional scientific information is provided with each case study so that the essential medical conditions, tests, terms and treatments are clear. The intent is to provide the working knowledge necessary for clear understanding of the medical situation so that the ethical reasoning will be grounded in scientific facts. It is also important that the non-science majors learn to deal with scientific terms especially medical terms so that future interaction with physicians will be less intimidating

The course objective is to help students understand both how scientific techniques provide unprecedented choices to both individuals and society in the areas of medicine and health care and what philosophical principles may be used in arriving at decisions. Therefore each topic is brought into focus by the use of a case study which requires an individual written analysis of the case as well as discussion among students who choose the same ethical theory. Each student has chosen one of the four ethical perspectives studied (act utilitarianism, rule utilitarianism, respect for persons, or natural law). The student must do all the case analyses from the perspective she has chosen. She may not, for example, use rule utilitarianism for one case and natural law for another.

One class period is used for discussion of the cases. During this class the students who share the same perspective gather in a group to compare their individual analyses. Students may revise their analyses while in their groups, noting relevant facts or considerations that they had overlooked, or omitting facts that now seem irrelevant. It is interesting to note that although the members within each group realize their decisions should agree, their decisions frequently do not agree. They are then pressed to resolve the disagreement if possible. Sometimes the disagreement rests on differences in the understanding of important concepts ("human life," for example). The members of the group begin to realize that the application of the same principles may yield differing moral judgments. Each group reports to the class their decision (or decisions) reached on the case at hand. As each group presents its conclusions, other members of the class are encouraged to raise questions or make observations. The class then enters into a general discussion, comparing and contrasting the decisions reached. Frequently, the groups disagree about the moral judgment with the disagreement falling along consequentialist /nonconsequentialist lines. However, this is not always the case. The students find it interesting to see where the disagreements lie and why. There are times, however, when all the groups agree. Again, students are fascinated and curious to know why.

Finally, the students are required to keep a journal. The purpose of the journal is to provide the student an outlet to explore in more depth discussions in which the class has engaged, to give voice to her own opinions and feelings of ambiguity, to note other cases or related issues which are publicized almost daily, to see her own growth in thinking through these issues, to provide an outlet for expressions which are not just analytic, e.g., poetry, art, and cartoons. Although the students do not enter into the journal experience with great exuberance (students are too busy and have too many demands on them to want to take the time to make journal entries), the consensus opinion at the conclusion of the class is that the journal is a valuable tool and one that is genuinely appreciated, especially by those who took the time to do it well.

The following quote from one student's journal conveys the sense hoped for: "The case studies opened my eyes to other opinions, different from my own. It made me question my values and my position and sometimes change my mind. It raised questions that I didn't know existed. Even though I don't like writing journals, I learned a lot about myself and realized that I hadn't thought through a lot of my positions. I would probably not be an act utilitarian because I'm too much of a people person. I'm glad I chose that (view) for this class because I found that it wasn't for me. Overall, I learned a lot about ethical issues and a lot about myself from this class and this journal. I wish there was some way there would be part two to this class dealing with different issues."

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USING CONCEPTS OF TECHNOLOGY TO ENHANCE A WRITING ASSIGNMENT

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The writing assignments that I use in the Technology and Society classes are short reviews of a particular technology. In these reports students select any technology (an item, technique or process) of interest to them. After researching its historical development they write up an historical summary as the first page of the assignment. On the second page they write a description of how this technology was developed using the concepts of technology as a guide. This activity requires that they select the concepts that are appropriate and use them verbatim (underline) in the written assignment. I require a minimum of five and a maximum of eight concepts. On the third page the student comments on how the technology discussed in this article has impacted on the way people live and how it has changed the way people behave.

What you have read above describes the writing assignment that my students receive. The list of concepts are provided as a handout to the students at the beginning of class, together with the instructions for writing the short paper.

The purpose of using the concepts is to focus the students' attention on more than just a rewrite of technical information. The paper is formatted in a way so that students retrieve information from a resource for the historical section. The next two sections require that the students put their own thoughts together with the help of the concepts. This hopefully will encourage them to develop their own ability to recognize the impact of technology on society.

I have also applied this assignment to advertisements both as written assignments and as an oral activity with the students divided into small groups. While in the small groups the students are asked to discuss the technology in the advertisement and apply the appropriate concepts.

Following is the list of concepts that are handed out in class. I have divided the concepts into four groups with the bibliographical citation listed for each group. Beginning on page four is an example of a paper that I use in class and demonstrate to the class using the overhead projector.

CONCEPTS OF TECHNOLOGY

Additions to Kranzberg's laws

1. Promoters of a particular technology have a vested interest in retarding the introduction and growth of other inventions in the same field and can be expected to act accordingly.

2. No technology is as reliable and trouble free as the sales engineers claim.

3. Technologies may suffer or even fail in the marketplace for a variety of reasons wholly unrelated to their merits.

4. Products and services are often differentiated by creating an illusion of meaningful technological change.

5. Technology can be expected to contribute more to solving societal problems than the anti-technologists will admit--and less than the true believing engineer supposes.

6. Some new technologies require individuals to assume a great deal of risk and a society that can live with the thought of someone else taking risk.

7. We are woefully incapable of predicting the social, political, and moral impact of new technology.

Winpenny, T. R. (June, 1988). Dare anyone add to Kranzberg. Science, Technology & Society, 66, page 11.

Kranzberg's Laws

8. Technology is neither good nor bad; nor is it neutral.

9. Invention is the mother of necessity.

10. Technology comes in packages, big and small.

11. Although technology might be a prime element in public issues, non-technical factors take precedence in technology-policy decisions.

12. All history is relevant, but the history of technology is the most relevant.

13. Technology is a very human activity--and so is the history of technology.

Kranzberg, M. (1986). Presidential address. Technology and Culture, 27, 544-560.

Humankinds Special Power

14. Technology has become the means by which ideas and knowledge are turned into rational action.

15. Each technical advance has given new power and potential to the common man.

16. When the technical means have been appropriate to the needs of the people, standards of living have been enhanced, health has been improved, life lengthened and laborious toil reduced.

17. Time for leisure has increased.

18. Technology is central to the survival of human beings. It is the potential of the future upon which people can share a common ground with aspirations and hopes for the future.

19. It is important to understand the past and to design and create a more human and humane future.

20. Technology is not a finished product. In the history of humankind there are numerous turning points. The discovery of fire was such a turning point. Fire was the first source of energy for any animal outside its own muscles.

21. The substitution of mechanical for muscular effort during the Middle Ages (water wheels, windmills, horse collar, for-and-aft rigs for ships, heat engines, electric generators) have all served to increase the power and potential of each human being thousands of times.

22. Dissemination of information is vital to the development and operation of a technological society. A key development was movable type. Information is now transferred by electricity and via radiant energy.

23. Control of technical devices through the development of automatic controls. The concept of FEEDBACK and the development of the computer are all part of the communication and cybernetic revolution.

Devore, P. (1980). Technology: An introduction. Worcester, MA: Davis Publication, pages 13-15.

Can Technology be Defined

24. Technology is a powerful force that improves human productivity.

25. Technology is an extension of human physiological capabilities and biological potential.

26. Technology involves inventing new things and modifying the old ones to make them more efficient.

27. Technology is evident in every culture regardless of its level of sophistication or stage of development.

28. Technology creates new economic opportunities and, at the same time, new social problems.

29. Technology enables humans to exert control over the natural environment.

30. Technology liberates us from demeaning and demanding labor and therefore creates more leisure.

31. Technology has increased the human life span by conquering many debilitating diseases.

32. Technology incorporates human knowledge into physical hardware which will eventually respond to some human need or desire.

33. Technology is applied science.

34. Technology is a process for transforming raw materials into useful goods and services.

35. Technology is man-made.

36. Technology creates uselessness by displacing people and trivializing their work.
37. Technology has made many persons apprehensive about the future.
38. Technology is fundamental to the survival of mankind.
39. Technology is destructive to nature.
40. Technology is making the world increasingly incomprehensible.
41. Technology is future-oriented and therefore progressive.
42. Technology is motivated by a pragmatic (practical) or instrumental interest.
43. Technology utilizes the methods, tools, and skills typically characteristic of the process we call innovation.

Markert, L. (1989). Contemporary technology. South Holland, IL: The Goodheart-Willcox Company, Inc., pages 10-11.

The Zipper

Historical Development

The development of the zipper began in the late 1800s. Clothing worn during that time consisted of bulky undergarments with layer upon layer of outer garments. These were all fastened with laces, cords or rows of buttons. Getting dressed was often a time consuming process. Even stylish shoes of the times were buttoned or laced all the way to the knee.

Whitcomb Judson, being overweight, had great difficulty getting his boots laced. Being of an inquisitive mind he decided to create a new invention to fasten his shoes more quickly. He developed what was called a "slide fastener". He joined forces with Colonel Louis Walker, a shrewd lawyer and businessman to form the Universal Fastener Company. Two years later the Universal Slide Fastener for shoes was launched. "The Universal" was a chainlike contraption consisting of sheet metal hooks connected with wire rings. These chains of hooks on opposite sides were drawn together and fastened by using a slider. Before the user could fasten his or her boots, the slider had to be attached to the shoes with ordinary shoelaces.

Business was not bad, but unfortunately each pair of fasteners had to be made painstakingly by hand. They soon realized that automatic machines would be needed to produce the product economically. The first machine that was developed did not work and the project was abandoned. Judson worked out a new design for the fastener that could be more easily adapted to machine production. The new product was called the Hook and Eye design. The new fastener was not only promoted for shoes but for clothing as well. The new slide fastener was not secure. Clothing would pop open unexpectedly if the device was not used exactly as instructed and could not be bent, twisted or washed. Judson worked to sell the product to clothing manufacturers but with no success. Most sales were door to door and only to those interested in a novel product.

Two more years of effort were spent in perfecting the design and the newest fastener was called the Plako. It did not catch on and by 1909 the Hook and Eye Company was on the verge of bankruptcy. Another engineer was hired and after four years of research and experimentation the first truly practical, smooth-working, secure slide fastener was developed. Just before production a flaw was discovered; the new fastener wore out too quickly. Production was halted.

One year later, in 1914, the "Hookless #2" was introduced. It worked just fine, but the garment manufacturers were still leery. The real turning point for sales came in 1923 when the B. F. Goodrich Company introduced a style of rubber boot featuring the Hookless #2 slide fastener. An executive at the company coined the name "zipper". With this catchy name, the Hookless #2 slide fastener finally became accepted for use.

Concepts of Technology

The development of the zipper follows the basic definitions of technology: Judson developed new knowledge and new ways of doing things. He was able to conceptualize the gathering process of the shoelace into a gathering device that utilized hooks and links. Zippers were not easily used and required instructions and care in connecting them and in washing the clothing. The dissemination of information is vital to the development and operation of a technological society.

The first zippers were not reliable and often popped open. Judson and other inventors continued to perfect the zipper design and after 20 years felt that the product was a good one. The fact that the first designs were not reliable and trouble free reflects the over-exuberance that inventors seem to have when promoting their products. It also lends credence to the concept the no technology is as reliable and trouble free as the sales engineers claim. The fact that these inventors persisted with their idea shows that technology involves inventing new things (the original zipper) and then modifying the basic design (the final slide design) in hopes of improvement.

The zipper was a technology that was new and very different. At first it was not very reliable and did not sell. Even after it was perfected, the zipper still did not have universal acceptance. It could be said that the zipper was failing in the marketplace for a variety of reasons wholly unrelated to its merits. Consumers did not realize the advantages of the product and did not see the need for the device. It seemed to have its most success as a novelty item. The idea that people would purchase such items as a novelty shows that they are not completely comfortable with the device and needed to have an excuse to justify the purchase of such an item. They are not really taking the item seriously. This development shows that new technologies require individuals to assume a great deal of risk and a society that can live with the thought of someone else taking risk. In order for the zipper to be accepted it had to work. More importantly, consumers and society had to accept the idea of people using such a device. Even today there are groups of people who do not use the zipper on their clothing.

The zipper did create new economic opportunities for the inventor and for Goodrich in selling boots, although in this case the original inventor died before the zipper became really popular.

Technology and Societal Change

Clothing, boots, shoes, suitcases, duffel bags and many other items are now and have always been (it seems) connected with the universal zipper. It is a technology that is often taken for granted except when it sticks or becomes broken. Many of the changes in clothing can be attributed to the zipper. Clothes are easier to use and the designs have changed because of the ease with which the clothes can be worn. Zippers also play an important role in the ornamental design of some jackets, especially the black leather jacket and saddle bags often associated with the motorcycle and the clothing that motorcycle riders wear.

The zipper was first sold using door-to-door sales techniques. Selling objects in-person is required in order to convince the consumer that the object really does work. Zippers and many other items are no longer sold in this manner. The newest sales technique has become telemarketing where the general consumer is already educated on how the technology may work.

New technologies require that the public become educated in how to use them. Although the zipper seemed to be a small item and not very technical, the need for educating the public was still an important part of the technology becoming accepted in society.

Another use for the zipper appeared in clothing that was used in early flying machines. The zipper could hold the clothing tighter together at the seam and thus keep out the cold better than just buttons alone. This advantage may have lead to more cold weather applications in other severe weather clothing and certainly it is very effective in sleeping bags. The zipper may be responsible for providing people with additional confidence in their ability to keep warm and thus to encourage them to explore areas that would not have been possible without it. Another clothing application for the zipper has been in the use of removable liner and nylon shells that have removable jackets inside them.

The zipper has gone through many changes since if first appeared almost 100 years ago. Now most are made with nylon rather then metal and velcro has replaced many of the zipper applications. These improvements in the zipper show that technology is not a finished product and is continually changing. One last thought about the zipper and the word itself. Zipper has become a word with its own meaning and even may be used to remind a child to keep their mouth shut! It has been borrowed by the plastics industry for use with the "zip-lock" bag which really does not have a zipper on it.

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NATURAL RESOURCE MANAGEMENT FOR "AUTONOMY": LESSONS IN "COMMUNITY" THROUGH ENVIRONMENTAL EDUCATION SIMULATIONS

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Introduction

The focus of this presentation is on activities developed and used by the staff of the Penn State Conservation Leadership School (CLS) aimed at developing awareness of the concept of "community" through simulation. Philosophically, the CLS provides a unique learning opportunity for students by emphasizing problem-solving, issue analysis, group effort, and appropriate roles for varying learning styles. The environmental philosophy of the program is fairly straightforward:

1. Everything is related to everything;
2. There "ain't" no free lunch, environmentally (or sociologically) speaking;
3. You cannot throw anything away, but may move something from point "A" to point "B"; and finally,
4. You can make a difference!

Throughout the course of the CLS and again in the Advanced Session, students experience a three-tier hierarchy of learning, not easily replicated in public schools (but not impossible). The first is a field oriented, hands-on approach to natural resource investigation and analysis. This includes watershed analysis through water testing (abiotic) and habitat analysis (biotic index), forest inventory followed with silvicultural management plan development, or participation in planning and building of working alternative energy source models, to name a few.

A second level of learning is experienced when students have the opportunity (and responsibility) to apply first level skills into a larger scaled investigation entitled the "Public Hearing," putting students into antagonistic, opposing situations whereby rezoning of a parcel of land is argued in environmental, economic, political and sociological terms. Additionally, students develop a sense of ownership in the learning activity; they determine what needs to be learned, where to get information, and finally how to organize and present their information in a convincing fashion, all under the constant guidance of the instructional staff.

The third and final level of learning is that which occurs by "living" with the CLS. This takes the form of basic lifestyle changes: eating lower on the food chain, recycling virtually all waste, monitoring energy and water usage, and finally, by living within an educational "community." In the CLS learning community we all learn from each other; most instruction is handled by the staff. If information is unavailable, we determine where to find it. Everyone is involved and has an equally important role. There are no grades, the program is not obligatory, and as is the case of the Public Hearing--the curriculum is largely student driven.

"Community" as a Theme for Environmental Education Simulations

This brings us to the use of "community" as a central theme to the central integrative activity of the Advanced CLS-The Master Plan. In the Master Plan, students are given the 740 acres of Stone Valley Recreation Area (SVRA), which is the site of the CLS, and asked to develop the concept of "community" on this site, NOT A COMMUNITY! The difference is in examining the true nature of a community where autonomy, environmental impact, and quality of life are considered.

In the end students are asked to study issues related to human carrying capacity, production of food and energy, transportation, education, entrance requirements, population management and religious affairs, and present a working plan for their "community" to a panel of university representatives. Following a brief introduction to the writers and philosophies from which this activity is designed, is a discussion on the term "autonomy" and its interpretation within the creation of "community" in this activity.

Philosophical Foundations

The philosophical foundations for the concept of community rest on several key authors and contemporary thinkers within the global STS circle. First and foremost would be Ivan Illich and his philosophy of personal autonomy through "community," as a working alternative to industrialized, centralized, specialized production of goods and services prevalent in modernized societies. From Illich's perspective, we have passed through two watersheds in industrial development. Each of these watersheds represent a point at which a course of development was taken, exclusive of an alternative fork which Illich describes as "convivial development." Illich contends that as we look at future development, we need to consider the natural scale and limits with respect to human and environmental constraints; in essence we need to ensure development of tools which truly serve human needs, and do not create dependency and slavery to them.

The first watershed is characterized by the science and technologies common to the early industrial era. Prior to this watershed societies worldwide were more or less self-sufficient, relying on a regenerative, organic cycle of production with respect to agriculture, transportation and housing. Cultural elements of society including education, religion and governance tended to be localized, traditional and truly managed by the community. At the first watershed, occurring around 1913, Illich contends this is the point in history where, statistically speaking, an individual stood a 50/50 chance of receiving medical treatment from a specialist trained in a medical institution. At this point science began its dominance over the research and development of technologies and thrust it into industrialization and away from the individual. Where once local knowledge, customs, and culture provided for society's needs, now begins the era where science and technology take over. This was a time when the development of modern tools proliferated, dominated by the professions that used them, and thereby causing the population to become increasingly dependent on large, centralized, and professionalized services. While many of these modern tools brought immediate benefits (e.g., penicillin), it was the continuation of professional sciences and technologies that led to the second watershed.

Roughly, during the 1940s to 1950s, we began a shift into the second watershed characterized as the era of diminishing benefits received by the masses. Medicine, like education, begins to become a commodity, consumed by those who can afford it, and those who cannot afford it perceive themselves to be dropouts, or unhealthy. The costs to personal autonomy begin to take effect. Modern science and technology take on an autonomous role in and of themselves; they become necessary as verified by their own criteria. No longer is basic living a factor in society; man assumes his new role on the planet-that of being a consumer of goods and services. The human social paradigm shifts from that of "living" to one of "earning a living". Consequently, the urbanization, industrialization and centralization of all basic human services (e.g., food, energy, education, etc.) begin to extend their toll on society and the environment.

As is the case with the other authors to be mentioned, it is well beyond the scope of this paper to explicate further the teachings of Illich, however several of his books that serve as excellent back-ground reading include Toward a History of Needs, Tools for Conviviality, and Deschooling Society.

Other key elements to the philosophy of "community" are derived from Kirkpatrick Sale (Human Scale) and his thoughts on designing society and all of its support institutions (food, housing, etc.) within the "human scale." He is speaking here not only of the physical scale, but also the sociological scale of our technologies and systems. Sale cites the community as the oldest form of human socialization, which throughout history has exhibited a consistent scale in terms of numbers of citizens. After careful examination of economic, political, cultural and human density studies, Sale concludes there is a magic number for community population of between 500 (absolute minimum) and approximately 10,000. He argues that modern metropolitan cities have resulted from industrial production factors, not human considerations, and in fact have resulted in serious damage to their inhabitants.

The third of the major foundations is Jacques Ellul (The Technological Society) and his teachings on the scale of technology, not only in terms of physical scale, but in the dominance over human choice and freedom. Similar in nature to Illich's theory, Ellul contends that technology has, in and of itself, become an autonomous entity, sustaining a need for more of itself, providing the means to sustain itself, and creating increased demand for itself. Humans have dropped in status to mere consumers of technology, finding ways to adapt to it and adopting the simple role of technology operators. The notion of "work" vs. "job" is created; no longer does industrial man work to survive, but rather has a job within industry in order to earn the capital to purchase the goods and services necessary for survival.

Much of the work undertaken by the New Alchemists project in the 1970's reflects these philosophies, as does Robert Rodale's Regenerative Project, applied most notably to agriculture. Other writers worth noting here would include E.F. Schumacher and his books Small is Beautiful and Good Work, and Amory Lovins' testimony on "Soft Energy Paths." At this point it is safe to say that this activity is intended to create more questions than answers for our students. It is arguably designed to instill skepticism over the bigger, better, faster motive of modern, economically driven societies. And finally, this activity poses the questions--Is there an alternative to simply slowing down our degradation of the planet (e.g., old definition of conservation) that may fall outside the norms of today's society?, and Are there changes in lifestyles, social structure, economy, education and policy that will be necessary in order to create and maintain a sustainable community?

"Autonomy" Defined

In the case of this activity, a variety of approaches to the concepts of autonomy are taken. Students are asked to think about autonomy not only as a physiological self-sufficiency, but also as a means to meet psychological needs. In fact, they are asked to consider the interactive relationships between the physiological and psychological aspects of autonomy when designing their community.

Using Abraham Maslow's model of a human needs hierarchy, we can clarify these differences. The primary needs that must be met according to Maslow's model are the physiological needs such as food, water, oxygen, a stable metabolic temperature, and the like. The remaining four levels of needs might all be summed up under the heading of psychological needs. These would include: security, belongingness and love, and self-actualization. Security needs are those involving the freedom from fear of impending harm or death. Security is defined in a variety of ways from individual to individual and culture to culture. The need for love is defined as the need to feel that one belongs, that one is accepted and cared for regardless of his/her position within society. Esteem needs are met when an individual feels valued by some external source because of what s/he does. And finally, self-actualization, which is the need to behave in a certain way because within his/her own value system it is the morally and ethically correct thing to do.

A healthy community, as envisioned in this activity, should show traits which go a long way toward meeting these human needs. While it may seem that some of these needs have little connection to the resource base, history is rife with examples of societies that had degenerative, rather than regenerative relationships with their environment, and as a result, have failed. One form of failure was extirpation, as in the case of the Anasazi of the desert southwest. Evidence suggests that the Anasazi completely denuded many square miles of forest surrounding their village for the construction of their dwellings. In an effort to continue gathering wood, other functions of their society suffered. This deforestation, coupled with severe drought, contributed to the end of their civilization.

But perhaps nothing so clearly serves as an example of how relationships with the natural environment have had a significant impact on social structure as Easter Island. Evidence now strongly indicates that when the first Easter Islanders arrived, they found an island lush with vegetation, including abundant forests which provided soil stability. The trees provided wood for canoes, which were in turn used in fishing. But a theology developed calling for the carving and raising of massive stone heads which has made the island famous. Necessary to the raising of these carvings were logs, cut from trees, which added to the demand for wood already being harvested for other uses. It is believed that total deforestation resulted in soil erosion and a shortage of wood for canoe construction, all culminating in reduced food production and carrying capacity of the island. In essence, the regenerative capacity of the island was exceeded and the quality of life for the residents dropped dramatically. By the time Europeans arrived, Easter Island was populated by small warrior-dominated clans which spent considerable time fighting over the limited resources on the island, toppling and defiling each others' stone effigies, and practicing ritual cannibalism. Their society had evolved to a point where meeting their needs had become a crude, perverted way of survival. Initially, it was thought that people such as this surely could not have erected such marvelous works of art as these carvings, and that these must have been erected by another civilization.

Regeneration, as envisioned by Robert Rodale, is quite the opposite of the practices seen on Easter Island. Rodale's definition of regeneration is in fact, the same definition we at the Conservation Leadership School refer to as "conservation". In short, this term describes a relationship in which all elements involved improve as a result of the interaction. At the

CLS we define this as the relationship between the human elements of the planet (society, science, technology, economy, etc.) and the non-human elements of the planet (e.g., the natural resources), such that all elements improve over time until a level of stasis is achieved (that is until both elements are as healthy as they can be). Rodale's example of the gardener, while simplified, illustrates this concept. Over time both the gardener and the soil should improve (or maintain a stasis level of health). For the gardener this means food, exercise and self-esteem. For the soil this means fertility, minerals, water and a healthy balance of organisms within.

To summarize, the concept of autonomy is a healthy characteristic of the needs meeting role of the community. For the purpose of this activity, community is not defined as a parcel of land, with legal boundaries within which a group of people happen to reside (as a result of ethnic and economic similarities). That situation would be what is commonly called a community. Rather, we seek to define community as a set of relationships among people, and between people and the natural resources. This includes people-people, people-culture, and people-natural environment relationships. Physical constraints (e.g., topography and land resources) coupled with Kirkpatrick Sale's human constraints guide the physical size of community (Sale, 1980). Functions of the people, as they provide for themselves in a convivial, regenerative fashion, create the quality of life desired. Appropriate technology, human-scaled societal design, and a renewed definition of work as the link between autonomy and regeneration needs to be implemented.

While this activity includes some prescribed steps, much of its impact is derived from open dialogue among and between students and teachers. The entire concept of community is explored through the use of "The Master Plan," introduced by an introductory series of questions. The potential creativity in the set-up and running of this activity is infinite. Some questions used at the CLS during this process follow.

Natural Resource Management for "Autonomy": Lessons in "Community" Through Environmental Education Simulations Conceptual Questioning Ideas

To begin the initial discussion of community and autonomy, we use the following questions , followed by typical responses given by students (in Italics). These are not necessarily in order and should serve only as a conceptual guide to accomplishing the activity.

What is a community?
"a collection of houses and everything necessary for the survival of its citizens"*

What is necessary for their survival?
"...housing, food, water, health care, protection, education, industry, jobs, energy, transportation, government..."*

How many of these needs do we actually provide for ourselves?
"...we don't, we get a job so we can buy these things"

How can the production of these services/goods generally be characterized?
*"centralized, specialized, industrialized, technology and energy dependent, posing specific risks to environment, people and social structure"**

While participation in the industrialized work world allows us to buy what we need to survive, to what extent do we derive love, esteem and self actualization from this style of work?

Is autonomy desirable and, if so, why is it better than dependency on large scale, centralized and industrialized systems of production?

What has created the stigma of work in industrialized society which disdains "good work" (e.g., autonomous community functions)?

How does the notion of "work" change in a convivial, autonomous community? Is everyone required to contribute, or can they earn money from external industries and merely contribute money to the community?

How are other concerns of education, recreation, lifestyle and behavior regulated and provided for within the community? How is housing designed to be consistent with the philosophy of the community?

Does the concept of private ownership of land need to be examined? What political models are suitable to use in developing the philosophy of land ownership (in light of collapsing Communist societies)?

Have we reached a point at which technology is more than adequate, and that perhaps we should redesign our society to incorporate appropriate technology, human scale communities and human autonomy?

Given the limitations of this 700+ acres, to what extent can we design an autonomous, convivial type of "community"?

How does the way you manage (particularly how you protect) the resources affect what is or is not acceptable behavior and what does this mean for the type of community that must evolve or be mandated?

At this point in the activity, CLS students begin breaking into smaller subgroups to initiate further discussion and research in planning areas such as housing, transportation, agriculture, energy, recreation, and lifestyles. There are repeated meetings among and within these groups to develop a "Master Plan for Community," with plenty of frustration, enlightenment, learning and newly discovered questions along the way. In the end students gain a whole new perspective on the world in which they live and their potential impact, that everything is related to everything, you can't throw anything away, and there ain't no free lunch environmentally or sociologically speaking.

"Master Plan"
1992
Conservation Leadership School--Advanced Session

Introduction

The goal of the Master Plan is to provide students with an environmental management simulation in a multidisciplinary, integrated and field based format. The essential element to the Master Plan is the idea of Land Use Planning based on environmental and sociological factors. This system operates on a hierarchy of broad classifications of uses of land, placing land uses in the following order: (1) Protection, (2) Production, and (3) Development.

Environmentally, the plan is based on land data derived from various sources including field data and observations, soil survey information, local geography and hydrology texts, local demographic data and other sources. Students will assemble a series of land capability and limitations maps (primary) which will be presented to the landowner. This information will be considered by the landowner as s/he then details objectives for the use of the land. Appropriate combinations of primary maps (secondary maps) will be used to assess the suitability of stated land use objectives. These areas will be illustrated on secondary suitability maps. The final product is then presented as a comprehensive land use plan, based on owner objectives and secondary level land suitabilities/limitations.

Sociologically, the Master Plan activity focuses on the concept of "community" (see previous pages) as a guideline for directing both the types of development within the plan and the scope of the development. Human carrying capacity becomes an important consideration as students plan agriculture and development within the designated land area. Working within the broad and loosely defined concept of "community," students must consider the degree to which autonomous production of goods and services, typically derived from conventional, centralized sources will be dealt with in terms of maintaining both a high degree of environmentally and sociologically sound development policies.

The site for the management simulation is the 700+ acres of Stone Valley Recreation Area including all existing roads, buildings and surface features. Students will use virtually all of the natural resource inventory methods learned during the regular session of CLS in carrying out the master plan data gathering. In addition, several new inventories will be taught and used during this unit in conjunction with new integrative challenges as environmental and sociological factors are considered in the development of the final plan.

Philosophically, the master plan is based on ideas and procedures set forth in Design With Nature, written by Ian McHarg. To help introduce McHarg and his land use philosophy, the film based on his book and entitled, "Multiply and Subdue" is presented. This film graphically details the often economic-driven land use that occurs with little regard to the soil capabilities and long-term needs of the planet. McHarg illustrates the actual process he uses in developing a regional land use plan and is shown presenting this plan in the film. Sociologically, the Master Plan is based upon concepts derived from several authors including Ivan Illich, E.F. Schumacher, Kirkpatrick Sale and Jacques Ellul (see references).

Pedagogically, the master plan allows the student to learn at all levels of Bloom's Taxonomy and incorporates many learning styles. This activity emphasizes group cooperation in a physically and mentally challenging problem-solving situation; while simultaneously introducing students to alternative philosophies concerning the human technological society. Following is an outline of unit objectives which detail the function of Bloom's Taxonomy.

Master Plan Objectives:

At the completion of this unit students will have:

1. Increased their knowledge of natural resource inventory techniques.

2. Gained some comprehension of the inter-relationships between natural resources and the structure of human society regarding use of the natural resources.

3. Participated in the integration of natural resource inventory and analysis of societal institutions aimed at developing a comprehensive land use plan.

4. Used data analysis in the interpretation of the inventory data.

5. Had input into the synthesis of various stages of the master plan.

6. Participated in evaluation of land capabilities/limitations, land use priorities, community planning alternatives , and landowner objectives.

Master Plan Procedures

It must be noted up front that this is a complex and potentially time-consuming educational activity. However, the potential for this activity to either serve as an introductory activity to other units of study (natural resource management, history, social studies, etc.) or as a culminating, integrative activity to prior units is left to the creativity of the individual teacher. In any case, some understanding of Ian McHarg, Ivan Illich and other authors mentioned may prove invaluable and depending on the grade level used, may be incorporated as required reading prior to and during the activity. Therefore the time frame for the unit may last anywhere from several days to an entire semester. Given this pedagogical background, the following general steps can be used in carrying out the activity:

1. Introductory film: "Multiply and Subdue," based on Ian McHarg's Design With Nature.

2. Class/group discussion on "community" (see attached).

3. Discussion of actual (or hypothetical) land area to be considered. Local land, known and accessible to students is beneficial, supplemented with topographic maps, soil survey information, geological data, and sociological information (population, demographics, etc.). The role of "landowner" may be used to instill the desired parameters into the planning; this hypothetical landowner may be the medium to express the desired outcome of the "conceptual community."

4. Breaking down into smaller study groups (4-6 students); individual parcels of land within the total land area used in the Master Plan are assigned to each group. Each group is charged with visiting, inventorying and researching their parcel for various soil and topographical characteristics (see next section).

5. Individual planning groups, corresponding to societal functions (i.e., agriculture, housing, recreation, transportation, energy resources, lifestyle, and education) are formed to begin the next phase. This allows students familiar with various areas of the land to combine knowledge in tackling one particular phase of the Master Plan (see next section).

6. Individual planning groups meet as needed to develop preliminary land areas considered for their particular interest (i.e., agriculture).

7. All planning groups meet together to share preliminary land use considerations. Working with one common relief map, each planning group displays lands of interest to them, discussing areas of mutual interest and conflicting use. Concurrently, lifestyle and associated groups express concerns regarding the type and scope of proposed activities. The concept of autonomous "community" needs to be kept afloat during this process, as does moderation of greed in "gobbling-up" land for one particular land use. Remember, this is not a competition, but rather environmental and sociological quality should rule the planning!

8. Planning groups return to individual work sessions as needed to revise, research and plan for the second group sharing meeting.

9. All planning groups once again return to the common planning map to share individual plans. As in step 7, groups present and discuss plans, strive for common decisions and may in fact repeat steps 7 and 8 if needed.

10. Representatives from each planning group present final master plan to the "landowner." followed by review of the plan by students, teacher, outside authorities, etc. Discussion of the difficulties encountered, interrelationships discovered, resources explored, etc. may follow the final presentation.

The following sections describe the detailed steps involved in the field study mentioned in step #4 above. The soils and topographical features studied and assessed fall into these three categories, corresponding to creation of maps developed from the gathered data:

-Major landform Features/Hydrology
-Vegetation/ Visual Analysis
-Soils/Slope/Aspect

In each category of study, variables to be studied are identified and then characterized to facilitate transposing of this data onto "primary maps." These are made of clear acetate which uniformly highlight areas of limited use value and/or susceptibility to damage in darker areas, and stable lands suitable for development and/or not deemed as "preservation" areas left clear. By placing these maps over a base relief map, areas of common use potential/limitations begin to appear. The creation of "secondary maps" follows, based on the broad land-use categories: Protection, Production, and Development.

Resource Analysis Area #1
Major Landforms/Hydrology

Major Land-forms:

- -High pcints
- -Ridge lines
- -Uplands
- -Lowlands

Hydrology:

- -Watershed boundaries
- -Surface flow: streams, rivers
- -Standing water
- -Floodplains
- -Wetlands
- -Aquifer recharge areas (lowlands, etc.)

Regional Context:

Proximity to and within:
- -State
- -County
- - Existing development
- - Road/highway access
- - Waterways

Primary Maps:

Key:

	Zone 1 (Dark):	Zone 2 (Shaded):	Zone 3 (Clear):
Surface water	All surface water (lentic, lotic) and wetlands	Intermittent flows and ponds	Nonexistent
**Land forms	Floodplains, lowlands	Ridges, high points	Upland slopes
*Aquifer Recharge	Surface water interface areas	Lowland recharge areas	Uplands
**Water Quality	High, unacceptable contamination levels	Some contamination, under critical level	Little or undetectable levels

* requires research to complete primary map
** requires field research to complete primary map

Resource Analysis Area #2
Vegetation/Visual Analysis

Vegetation:

By Vegetation Type and Associations: spp. diversity, wildlife cover/food.
Agricultural vegetation: yield potential
Forest stocking and site index
Rare and endangered plant (and animal) species

Visual Analysis:

Views and Vistas:
- -Panoramic views
- -Lowland views
- -Local views
- -Site high point

Visual Barriers:

- -Views from Adjacent roads and properties

Primary Maps:

Key:

	Zone 1 (Dark):	Zone 2 (Shaded):	Zone 3 (Clear):
(FORESTRY) **Site Index	75 +	55-75	< 55
*Erodibility-forestry equipment limitations	Slight	Moderate	Severe
**Stocking Percent	Overstocked	Fully stocked	Understocked
*Agriculture-yield potential	Excellent	Average	Poor
**Wildlife Habitat (by vegetation type) -spp. diversity -edges, cover, etc.	Excellent	Average	Marginal/poor
**Rare and/or Endangered Species	Endangered spp. present	Rare spp. present	none present
*/**Historic Value	Visible remains present	Site features, no physical remains	Non-historic value
Scenic Value	Panoramic view	Scenic view into lo. 'ands	Little scenic value

* requires research to complete primary map
** requires field research to complete primary map

Resource Analysis Area #3
Soils, Slope and Aspect Analysis

Soils:

- -Erodibility
- -Depth to Bedrock
- -Drainage

Slope:

- -Low 0-15%
- -Medium 15-25%
- -Severe 25%+

Aspect (southern exposure):

-Cross section analysis of topography and vegetation along southern aspect slopes.

Soil Survey:

Limitations to use for:
- -Wildlife and Forestry
- -Agriculture
- -Recreation
- -Development

Areas requiring special management or protection

Present and recommended uses

Groundwater recharge and flow information

Primary Maps:

Key:

	Zone 1 (Dark):	Zone 2 (Shaded):	Zone 3 (Clear):
*Slope	15% +	8-15%	0-8%
*Erodibility	Severe	Moderate	Slight
Depth to Bedrock	<10'	10-20'	20' +
*Drainage	Seas. High Water table - poor drainage	Moderately well drained	Well-drained
*Southern Aspect	North slopes	East/West Slopes	South Slopes
**Cross-sectional Topography and vegetation analysis	(DRAWN AS SEPARATE ADDITIONS TO LAND USE PLAN, see following page)		

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* requires research to complete primary map
** requires field research to complete primary map

Secondary Map* Preparation

Land Use Priority:	Primary Maps Used:
I. Protection	
	Surface Water Land Forms Historic Value Scenic Value Slope Aquifer Recharge Rare and/or endangered species

Sites not requiring protection remain for further consideration as Production Sites.

II. Production	
	Site Index Forest mgmt. equip. limitations Stocking Level Wildlife habitat Vegetation diversity Agriculture-yield potential Slope

All remaining sites are deemed suitable for development (other than agricultural) under particular soil limitation guidelines.

III. Development	
	Stone Valley Land-Use Limitations Maps (roads, buildings, etc.) Aspect-Southern Exposure Cross-sectional Analysis Depth to Bedrock (Others as needed)

* Secondary maps will be developed for each priority area (I through III). The primary maps listed in the right hand columns will be combined into one secondary map for each priority.

I and II constitute secondary "Constraint Map" criteria. All remaining areas will be recommended to landowner as "developable" sites. Specific plans for development, (priority # III), Protection and Production (priority I and II) will be further developed after meetings between landowner and consultants.

Master Plan Meeting Schedule

Each instructor group will initially incorporate three study groups, each of which will conduct an in-depth land resource assessment for a given geographic region of Stone Valley. Each study group will perform analyses in the areas outlined earlier, referred to as Resource Analysis Area #1, #2 and #3 which include the following:

Resource Analysis Area #1: Major Land Forms, Hydrology and Regional Context
Resource Analysis Area #2: Vegetation and Visual Analysis
Resource Analysis Area #3: Soils, Slope, Aspect and Land-Use Limitations

Before beginning field research, study groups will review all existing maps and begin formulating primary maps. These will detail a suitability/limitation for one single feature (e.g., slope, etc.) and are explained in the Resource Analysis Area pages. The subsequent field study will be aimed at supplementing existing primary maps with actual field observations, inventories and other data.

Meeting Number:	Goals:
Introduction	Unit Objectives Film: "Multiply and Subdue"

BY STUDY GROUP:

1.

A. Initial study group meeting:
-review overall group goals and tasks.

B. Review available primary maps.

C. Prepare for Field Research:
-begin research for primary map development
-develop "questions" for additional research and field work.
-gather all necessary equipment, data sheets, etc.

2.

Field Research; the following are examples of types of research:
Hydrology: Biotic Index, Water Flow, Abiotic tests, etc.
Forestry: Basal area, tree count, stocking, species composition, etc.
Vegetation: Herbaceous cover, diversity and edges, species composition, rare and endangered species.
Visual Analysis: Esthetic value, panoramic views, aspect, historic and cultural significance, etc.
Others: (list here)

____

____

3.

Within study groups:
-Construct Primary maps (see "Resource Analysis Area" pages 4-6.

Collectively, with landowner:
1. Present initial "Land use limitations Study" to landowner.
-Identify protected areas, possible production areas and suggested development areas.(Secondary Maps)

2. Sign up for Planning Groups:
   - Protection
   - Production
   - Development
3. Solicit landowner objectives.

4. Review landowner objectives, collectively and within planning groups.

BY PLANNING GROUP:

4. A. Any additional field work and/or research relating to implementing landowner objectives and dealing with land use conflicts and limitations.

   B. Develop Secondary Maps (see page 7)

5. Incorporating landowner objectives and all necessary primary and primary and secondary maps, assemble the final land use master plan.
   Code by color and/or shade the final plan onto relief map.
   Prepare for final presentation.

6. MASTER PLAN PRESENTATION (Thursday evening)

****

Available *Stone Valley Land Use Limitation* and *Primary Maps*

Stone Valley Land Use Limitation Maps:
- Vegetation Types
- Soil Types
- Service Buildings
- Picnic/play Area
- Streets/Parking Lot
- Path and Trail
- Existing Features
- Typical Cross Section
- C.E. Camp Sewage Facility
- USGS Topographic Relief Maps

Primary Maps Available:
- Wildlife
- Septic Suitability
- Wetland Wildlife
- Openland Wildlife
- Forestry- Site Index
- Erodibility
- Surface Water
- Slope
- Aspect
- Depth to Bedrock
- Topography

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Award Ceremony
THE FIRST ROBERT RODALE LECTURE
"Building a New World"
Lester Brown, President World Watch Institute
Friday, February 7, 1992, 9:00 AM
Support Provided by Calvert Social Investment Fund

Networking K-12 Activities
APPLIED SCIENCE AND ENGINEERING SOCIETIES

Saturday, February 8, 1992

"Integrity in Science: Taming Fraud and Hype"

Sharon Begley, Science Editor, Newsweek
Walter Stewart, National Institutes of Health
Sunday, February 9, 11:00 AM

February 6-9, 1992
Radisson Plaza Hotel at Mark Center
Alexandria, VA

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The National Association for Science, Technology and Society (NASTS) was formed in 1988 to bring together the increasing number of persons and groups actively concerned with STS. In some ways, NASTS is a federation of already existing sectors of interest: K-12 educators; post-secondary educators; policy makers; scientists and engineers; public interest activists; museum and science center staff; religion professionals; members of the print and broadcast media; and participants from the international community. NASTS's goal is to provide a forum where members of these sectors can gather and take the pro-active stance to guide science and technology as reflections of our underlying values. NASTS seeks to provide the venue for all its members to meet as equals to discuss, debate, and share concerns for society's handling of science and technology. NASTS is organized as a 501(c)3 non-profit educational corporation. Its president and 15-member board of directors, elected by the membership, guides a staff consisting of a Corporation Chair, Members Services Director, Conference Manager, and Support Staff.

TLC-7 REGISTRATION AND INFORMATION

Plaza Foyer

Thursday, February 6	**4:00 PM - 8:00 PM**
Friday, February 7 and Saturday, February 8	**7:00 AM - 5:00 PM**
Sunday, February 9 *(Information only)*	**8:00 AM - 12:00 AM**

ANNUAL MEETING OF NASTS MEMBERS

Friday, February 7, 1992
Amphitheater, 8:30 PM

1. Welcome by President Stephen Cutcliffe. "Initiatives Undertaken This Year."
2. Open invitation to NASTS Members to attend:
   a. Dessert Reception, Saturday 8:45 PM
   b. Committee Lunch Meetings, Saturday 12:30 - 1:30 PM
   c. Planning Meeting for TLC-8, Sunday 12:30 PM
3. Honorary Membership Award to M.L. Kranzberg
4. Report by Corporation Chair Rustum Roy: Financial report and future of NASTS:
5. Election results for Board Members and Vice-President
6. Committee Reports:
   a. Position Papers
   b. Regional Chapters & Conferences
   c. STS Assessment and Evaluation
   d. Precollege Education Organizations
   e. International and Foreign Organizational Linkages
   f. Community Awareness Activities
7. Open discussion on initiatives and projects members would like to undertake through the association during the coming year.
8. Discussion of TLC-8:
   a. Overarching theme
   b. Suggestions for main speakers
   c. Location (report from Site Committee)

ADDITIONAL NASTS EVENTS

Friday February 7:

NASTS Members Meeting
Open to all conference registrants
8:30 - 10:30 PM

Saturday February 8:

STS Department Chairs Breakfast
STS Program and Dept. Chairs or their Representatives 7:30 - 9:00 AM
Lakeside 1 Retreat Center

NASTS Committees (lunch meetings)
Open to all conference attendees 12:30 - 1:30 PM
(see **page 12** for rooms)

NASTS Dessert Reception
Open to all conference attendees
Upper Foyer
8:45 - 9:30 PM

Sunday February 8:

Institutional Members Council Breakfast
Open to Official Institutional Members of NASTS
7:30 - 8:30 AM
Golden Ash Boardroom

TLC-8 Planning Meeting
Open to interested NASTS members
12:30 - 3:30 PM
Dogwood Room

SPECIAL ACTIVITIES

Information Marketplace:
Friday, February 7
Atrium, 11:00 AM - 1:00 PM

Bookstore:
Friday-Saturday, February 7-8
8:00 AM - 5:00 PM, Plaza Foyer

Exhibits:
Friday-Saturday, February 7-8
8:00 AM - 5:00 PM, Plaza Foyer

Breakfast, Lunch & Dinner Suggestions

There are several restaurants in the hotel to meet your tastes and budgets. Use your $1coupon at any of these.

The Plaza Cafe (quick breakfast, lunch or dinner)
Halyard's (seafood lunch & dinner)
Headliners (buffet breakfast, lunch & dinner)
Yannick's (French style fine dining)

SUBMISSION OF PAPERS

All presenters are urged to place 2 copies of their papers in the box near the registration table marked "TLC VII Proceedings." One copy will be given to the editor of the *Bulletin of Science, Technology and Society*. The other copy will go to the editor of the Annual TLC Proceedings which are submitted to the ERIC documentation and retrieval system. Leaflets with more detailed information is by the box. Papers not ready at the Conference can be mailed to the appropriate editors.

Other Hotel Services:

Shuttle Service: Complimentary van service is available every 1/2 hour to and from National Airport and the metro stop at National Airport. Additional van runs to specific points of interest can be arranged, in advance, for a nominal fee.

Health Club: The health club will be available without daily charge to conference attendees. There will be no charge for aerobic classes. There will be a reduced charge for racquetball courts of $3/hr.

INVITED THEME PROGRAMS

EDUCATION AND INFORMATION

"Applications of Telecommunications to STS Education: Present and Future"

Theme Co-Chair: **JON HARKNESS**, Science Specialist, Wausau School District, Wausau, WI.

Panelists: **LINDA ROBERTS**, Senior Analyst, Office of Technology Assessment, Washington, DC. **DOROTHY PERRECA**, Manager, National Geographic Kids Network, Washington, DC. **GAIL ARNALL**, President, Phoebus Communications, Inc., Fort Washington, MD.

Friday, February 7, 4:15-6:00 PM, PLAZA B

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"Science Education Intervention Programs on Behalf of Broadening Participation in Science, Technology and Society"

Theme Co-Chair: **JANICE KOCH**, Assistant Professor, Hofstra University, NY.

Panelists: **ALETA YOU MASTNY**, Project Director, Consortium for Educational Equity, Rutgers University, New Brunswick, NJ. **ALICE MILLER**, Director, Women's Center, Brooklyn College, Brooklyn, NY. **ELLEN WAHL**, Program Director, Girls Incorporated, New York, NY.

Saturday, February 8, 3:00-4:45 PM, PLAZA B

TECHNOLOGY, INDUSTRY AND WORK

"Industry-Education Partnerships"

Theme Chairs: **JULIANNE PRAGER**, 3M Company, St. Paul, MN and **ROBERT HUTCHINS**, Opportunities Academy of Management Training, Philadelphia, PA.

Presenter: **ALAN McCLELLAND**, Executive Director, Science Alliance, Rockland, DE.

Panelists: **JULIE STAFFORD**, Executive Director, Wisconsin Educational Partnership Initiative (sponsored by Cray Research Inc.), Chippewa Falls, WI. **JAMES JOHNSON**, Executive Scientist, 3M Company (ret.), St. Paul, MN. **PHYLLIS McGRATH**, Program Manager, Pre-College Ed.,GE Foundation, Fairfield, CT.

Friday, February 7, 4:15-6:00 PM, MARK I

MORAL, ETHICAL AND PHILOSOPHICAL PERSPECTIVES

"One World, Many Cultures"

Theme Chair: **CARL WOOD**, Principia College, Elsah, IL.

Panelists: **CONNIE BARLOW**, Science Writer, New York, NY. **GEORGE BUGLIARELLO**, President, Polytechnic University of New York, Brooklyn, NY. **LAURENCE DOYLE**, Redwood City, CA. **CLIFFORD MATTHEWS**, Department of Chemistry, University of Illinois, Chicago, IL. **EUGENE B. SHULTZ, JR.**, Elsah, IL.

Friday, February 7, 4:15-6:00 PM, (Part 1)
Saturday, February 8, 3:00-4:45 PM (Part 2)

Both in the MARK II

HEALTH AND BIOMEDICINE

"STS Inside the Beltway: Federal Experiments in Bioethical Policymaking"

Theme Chair: **ERIC JUENGST**, Director, Ethical, Legal and Social Implications Program, National Center for Human Genome Research, Bethesda, MD.

Panelists: **MICHAEL YESLEY**, Manager, Program on Ethical, Legal and Social Implications of Human Genome Research, U.S. Department of Energy Human Genome Project, Los Alamos National Laboratories, NM. **ROBERT COOK-DEEGAN**, Director, Division of Biobehavioral Sciences and Mental Disorders, Institute of Medicine, National Academy of Sciences, Washington, DC. **CHARLES McCARTHY**, Director, Office of Protection from Research Risk, National Institutes of Health, Bethesda MD.

Friday, February 7, 4:15-6:00 PM, MARK III

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"Genetic Discrimination: Problems & Perspectives"

Theme Chair: **ERIC JUENGST**, Director, Ethical, Legal and Social Implications Program, National Center for Human Genome Research, Bethesda, MD..

Panelists: **ABBY LIPPMAN**, Professor of Genetic Epidemiology, McGill University, Canada. **NACHAMA WILKER**, Executive Director, Council for Responsible Genetics, Boston, MA.

Saturday, February 8, 3:00-4:45 PM, MARK III

ENVIRONMENT & TECHNOLOGY, INDUSTRY AND WORK

Special Joint Theme Session
"The Role of Industry in Environmental Protection"

Theme Chairs: **HERB ELEUTERIO**, Du Pont Chemicals, Wilmington, DE and **JULIANNE PRAGER**, 3M Company, St. Paul, MN.

Panelists: **JOHN R. COOPER**, Director for Environmental Affairs, Du Pont Chemicals, Wilmington, DE; **ANTHONY D. CORTESE**, Dean of Environmental Programs, Tufts University, Medford, MA; **R.L. "BOB" DOSTAL**, Director of Corporate Safety and Environmental Affairs, Dow Chemical Company, Midland, MI; and **JAMES E. POST**, Professor of Management and Public Policy, Boston University, MA. **Robert P. Bringer**, Staff Vice President, Environmental Engineering & Pollution Control, 3M Co., St. Paul, MN

Saturday, February 8, 3:00-4:45 PM, MARK I

SCIENCE FOR NON-SCIENTISTS

"Technological Literacy For Non-Engineers"

Theme Chairs: **RUSSEL JONES** and **PAUL T. DURBIN**, Univ. of Delaware.

Panelists: Spokespersons for ABET (Accreditation Board for Engineering and Technology), **DAVID R. REYES-GUERRA**, and AAC (Association of American Colleges), **PAULA P. BROWNLEE.**

Saturday, February 8, 3:00-4:45 PM, DOGWOOD

SPECIAL SYMPOSIA

NETWORKING K-12 ACTIVITIES OF

APPLIED SCIENCE AND ENGINEERING SOCIETIES

Saturday, February 8, 1992, 9:15 AM - 4:45 PM
Location: Lakeside 1 Retreat Center

Morning Session: 9:15-11:15 AM

"Background & Conceptual Basis for ASE Involvement"

Keynote: **Rustum Roy**, Penn State, "K-12 Reform in the U.S.: The Long View"

Presentors: **Lawrence Grayson**, President, Engineers for Education
George Dieter, President, Federation of Material Societies
C.C.Mathewson, President, American Geological Institute

Post Lunch Session: 12:15 - 2:00 PM

"U.S. Science/Engineering Education: New Rationales for New Initiatives"

Keynote: **Ronald M. Latanision**, Chair, Primary and Secondary Education Committee, Massachusetts Institute of Technology

Presentations by Society Representatives- ***Show and Tell of Print, Curriculum and A.V. Materials***

SAE - **John Boynton**; AIME - **Frank Nolfe**; ASM - **Rod Allwood**; Geological of America;
Am. Meteorological Society; American Chemical Society; A.I. Chem. Eng.; and many others

Afternoon Session: 3:00 - 4:45 PM

"The Conceptual Basis for the Applied Science Route in K-12"

Keynote: **J. Myron Atkin**, Former Dean of Education, Stanford University (invited)

Joint Planning by Society Representatives

- Preparation of a Comprehensive Report on All Societies' Activities
- Preparation and Dissemination of "K-12 primers"
- Planning Collective Action of the Applied Science and Engineering Societies

FEDERATION OF MATERIALS SOCIETIES

Friday, February 7, 1992, 9:15 AM - 4:45 PM
Location: Lakeside 1 Retreat Center

Program: **Ronald Enstrom**, Sarnoff Laboratories, Princeton, N.J.
Chair: **George Dieter**, President of FMS, and Dean of Engineering, University of Maryland, MD.

The Federation of Materials Societies is holding a workshop during the TLC to coordinate the activities of materials science and engineering societies in K-12.

Times will be posted at the TLC Conference Registration Desk.

TEACHING MATERIALS SCIENCE AND TECHNOLOGY

A Hands-On Workshop For K-12 Teachers
Saturday, February 8, 1992, 9:30 AM - 4:30 PM

Location: All sessions in the Amphitheatre

SEVENTH ANNUAL TECHNOLOGICAL LITERACY CONFERENCE

SPECIAL OPENING PLENARY:

Thursday, 7:30 PM
Location: Plaza C

"Tho STS Approach: Pros and Cons"

Robert Yager, Vice-President, National Association for Science, Technology and Society and **Bill Aldridge**, Executive Director, National Science Teachers Association

PLENARY 1

Friday, 8:45 - 10:15 AM
Location: Plaza C

Welcome: **Steven Cutcliffe**, NASTS President
Introduction: **Robert Yager**, NASTS Vice President and TLC-7 Conference Chair

The First Rodale Lecture

Supported by the Calvert Social Investment Fund

Introduction: **Rustum Roy**, NASTS Corporation Chair
Presenter: **Ardath Rodale**, Chair, The Rodale Press
Recipient: **Lester Brown**, Founder and President of The World Watch Institute

Address by **LESTER BROWN:** "Building a New World"

Friday, 10:30 - 11:15 AM
COMMUNITY BREAKOUTS

This is a time to meet with peers to discuss the key STS issues addressed in the Plenary. Discussions begin immediately following the Plenary.

Plaza B - College Education
Christine Schoneweg, STS Grad. Student, Penn State
Plaza C - Education 9-12
Irma Jarcho, NASTS Board
Dogwood - Business and Industry
Isadore Sutton, STS Ph.D. Student, Penn State
Mark I - Education K-8
Cecily Pitt, STS Grad. Student, Penn State
Mark II - Government & Public Policy
Richard Deitrich, Conference Co-Manager, Penn State
Mark III - Environment
Judi Wakhungu, STS Ph.D. Candidate, Penn State

Session 1: Panels, Workshops, and Papers
Friday 11:30-12:30 AM

1.1 PANEL **ED/K-12** **Mark I**
A Student Centered Education: Creating Quality School Outcomes.

Problems within conventional K-12 education will be discussed and the PROJECT METHOD recommended, based on the demands of life after high school.

Paul Torda (moderator), T & S Division/ASME, Washington, DC and **Jeffrey Schneider**, NEA, Washington, DC

1.2 PANEL **WOMEN IN SCIENCE** **Mark II**
Women in Science: 5000 Years of Obstacles and Achievements

Case histories of women scientists, from ancient Egyptian times to the present, to show the positive and negative effects of discrimination.

Patsy Ann Giese (moderator), Slippery Rock Univ., Slippery Rock, PA; **Darlene Richardson**, Indiana Univ.,Indiana, PA; and **Connie Sutton**, Indiana Univ., Indiana, PA

1.3 PANEL **ED/Methodology** **Mark III**
Obstacles to Understanding Which Hinder STS Teaching.

Conventional "observation" methodologies will be examined, and new strategies for "observation" as the first step in the scientific method will be suggested which enhance both STS and science courses.

Barbara J. Reeves, Ohio State Univ.and **Cheryl Ney**, Capital Univ., Columbus, OH

1.4 PANEL **ED/College** **Dogwood**
Should Textbooks Be Old News: Is Controversy Better?

This presentation involves a recent study at WPI (Sabin, 1991) which dealt with a collection of current writings in Biology, From Gaia to Selfish Genes, edited by Connie Barlow.

Keith McCormick (moderator), **John Wilkes** and **Dan Sabin**, Worcester Polytechnic Inst., Worcester, MA

1.5 PANEL **STS/International** **Amphitheater**
Technology in Chinese Civilization

Former Program Director in Biochemistry at the NSF, H T Huang recounts the work of the Institute and discusses Sir Joseph Needham's epic, Science and Civilization in China

H.T. Huang, Deputy Director of the Needham Research Institute in Cambridge, England

Introduction by **William F. Williams**, Penn State Univ., Univ. Park, PA

1.6 WORKSHOP **ED/6-8** **Beech A**
Encouraging Students to Make Decisions & Take Action

Participants will experience a "hands-on" problem-solving activity from the New York STS Education Project which helps students to design activities related to their personal advancement.

Carolyn S. Graham and **William T. Perruzi**, NYSTEP Albany NY

1.7 WORKSHOP **TECH LIT/Computers** **Beech B**
Information Literacy, Social Studies, and the Classroom of the Future

A vision of a classroom of the future is offered in which current computer technology is combined with some new software created by the author.

Duane Morin, SS & PS Department, Worcester Polytechnic Inst., Worcester, MA

1.8 WORKSHOP **ED/K-12** **Hickory**
Teacher Networked Teams (TNT) and the Transition Classroom

The TNT model will assist teachers in overcoming the traditional barriers to teaching science. This model enables the evaluation of modules and curricular frameworks. Attendees will receive a summary of this workshop by mail.

Diane Ebert-May (moderator), **Jay Shiro Tashiro** and **Paul Rowland** Northern Arizona Univ., Flagstaff, AZ

1.9 WORKSHOP **ENVIRONMENT** **Chestnut**
Paper or Plastic?

This presentation by the Chemical Education for Public Understanding Program (CEPUP) features student activity from the module *Plastic in Our Lives* with follow-up discussion.

Herbert D. Thier, Univ. of California, CEPUP, Berkeley, CA

1.10 WORKSHOP **ED/STS Paradigm** **Poplar**
What is STS? A Tutorial Workshop

Participants will be introduced to an STS paradigm through For Earth's Sake activities, a mini-simulation on subliminal messages, activities on hazardous waste, and sample lessons.

Toni L. Miller, Springfield High School, Akron, OH

1.11 PAPERS **ED/Biotechnology** **Walnut A**

11:30-12.00 **Daniel R. Tomal**, Purdue Univ. North Central, Engineering & Technology, Westville, IN, *"Introducing A Course In Bio-Medical Technology--Integrating Science, Technology and Society"*
12.00 12:30 **William J. Wells**, Louisville, KY, *"Planning for the Baselines in Technological Literacy: A Glimpse at Change in Mental Health Care"*

1.12 PAPERS **ED/Methodology** **Walnut B**

11:30 12.00 **Jane Abbott**, Past President NABT, Oceanographic Institute, Florida, "Marine Biology From an STS Perspective: The Jason Project at the Harbor Branch Marine"
12:00-12:30 **Anat Zohar**, Princeton, NJ, *"Developing Critical Thinking As An Important Component of Scientific Literacy"*

1.13 PAPERS **ED/Minorities** **Cherry**

11:30-12:00 **Betty W. Barber** and **John M. Kmetz**, Kean College of NJ, Union, NJ, *"Two Successful Programs for Minority High School Juniors"*
12.00 12:30 **Manuel A. Gonzalez and J.A. Bazler**, Lehigh University, Easton, PA, *"Minority Teachers in Mathematics and Science"*

1.14 PAPERS **ED/Design** **Golden Ash**

11:30 12.00 **Donald Daugs**, Utah State Univ., Logan, UT, *"Integrating Science & Technology Through Invention Fairs"*
12.00 12.30 **Michael J. Shannon**, Center for Design & Technology Education, Englewood, NJ. *" What is Design? Why Design Education?"*

LUNCH Break
12:30 - 1:30 PM

There are several restaurants in the hotel: **The Plaza Cafe** (quick breakfast, lunch); **Headliners** (buffet breakfast, lunch & dinner); and **Halyards** (seafood lunch & dinner)

Session 2: Panels, Workshops, and Papers
Friday, 1:45 - 2:45 PM

2.1 PANEL **ED/STS Paradigm** **Mark I**
Is STS an Interdisciplinary Alternative to Specialization?

The panel will discuss whether STS offers a significant interdisciplinary model for academia in the face of rampant specialization and zealously protected disciplines.

James Steele (moderator), **Kent Moore**, **Cletus Sellers**, and **Karen Forcht**, James Madison Univ., Dept of Sociology, Harrisonburg, VA

2.3 PANEL **ED/Dept. of Energy** **Mark III**
Science and Technology Education: A Primary Mission of the Department of Energy's National Laboratories.

The Oak Ridge National Laboratory (ORNL) provides a dynamic environment for science and technology education. Various programs providing D.O.E. educational opportunities will be discussed.

W. Mamie Johnson (moderator), **Terry L. Lashley** and **Helen S. Payne**, ORNL, Oak Ridge, TN

2.4 PANEL **STS TEXTBOOKS (2 hours)** **Dogwood**
College-Level STS Textbooks: Their Origination and Use

Three authors of college-level STS textbooks will describe the origination and intent of their works. Several educators will also discuss the use of these books in courses. (second session: 3.4)

Stephen Cutcliffe (co-moderator), Lehigh Univ.,Bethlehem, PA; **Robert E. McGinn**, Stanford Univ., Stanford,CA; **Rudi Volti**, Pitzer College, Claremont, CA; **Ron Westrum**, Eastern Mich., Ypsilanti, MI; and **Leonard Waks** (co-moderator), Penn State Univ , Univ. Park, PA

2.6 WORKSHOP **EDUCATION/9-12** **Beech A**
The Mt. Baker High School Problem-Solving Model

This nationally-recognized, real world, problem-solving model is designed to motivate teachers to incorporate STS activities in their classes.

David C. Tucker (moderator), Mt. Baker High School, Deming, WA; **Robert Yager**, Univ. of Iowa, IA; and **Jon Harkness**, West High School, Wausau, WI

2.7 WORKSHOP **ETHICS.** **Beech B**
Frozen Rhetoric? Public Impact on the Ice-Minus Field Trials.

In April, 1987, a genetically engineered micro-organism was applied to strawberry plants in California. The face-off between scientific rhetoric and public opinion will be examined, and audience participation used in this case study.

Susan A. Hagedorn, VA Tech, Blacksburg, VA

2.8 WORKSHOP (25 limit) **ED/Methodology** **Hickory**
Teaching Science and Technology With Toys.

Participants will enjoy a hands-on demonstration of how to teach using toys. A variety of commercial and home-made toys can enhance the understanding of biological, earth-science, and technological concepts.

Prent Klag, Utah State University, Logan, UT

2.9 ADDRESS **Research & Development** **Chestnut**
Science, Technology, and Society in JAPAN

Hideto Nakajima, Research Center for Advanced Science and Technology, Univ. of Tokyo, JAPAN

2.10 WORKSHOP **TECH LIT/Information** **Poplar**
Linking Federal Opportunities and Educational Capabilities

The presentation will consist of explaining the FEDIX and MOLIS on line information services. An on-line demonstration will be provided and participants will logon to the system.

Patricia DeVeaux, Federal Info. Exchange, Inc., Gaithersburg, MD

2.11 PAPERS **PHILOSOPHY** **Walnut A**

1:45 2:05 **James R. Gray**, Northern KY Univ., Highland Heights, KY, *"The New Paradigm for an American Work Ethic"*
2:05-2:25 **Dennis Rohatyn**, Univ. of San Diego, Alcala Park, San Diego, CA, *"A Science without Technology:A Plea for Temperance"*
2:25-2:45 **Brent Waters**, Univ. of Redlands, Redlands, CA. *"A Meditation on Fate and Destiny in a Technological Age"*

2.12 PAPERS **ED/Methodology** **Walnut B**

1:45-2:15 **Gerard Fourez**, Univ. of Namur,BELGIUM. *"Epistemological Foundations for STS Teaching."*
2:15-2:45 **Joan Judge Mirabel**, Towson State Univ.,Towson, MD. *"Disconnected Kids: Is It Society? Is It Technology? Or Just Plain Science?"*

2.13 PAPERS **WOMEN IN SCIENCE** **Cherry**

1:45-2:15 **Suzanne K. Damarin**, Ohio State Univ., Columbus, OH, *"The Worlds of Women, Mathematics and Technology"*
2:15-2:45 **Janice Koch**, Hofstra Univ., Hempstead, NY, *"Lab Coats and Little Girls"*

2.14 PAPERS **ED/Nuclear Power** **Golden Ash**

1:45-2:15 **Paula M. Getzin**, Kean College, *"Low-Level Radioactive Waste -- What New Jersey is Doing About It"*
2:15-2:45 **Melissa McMahon** and **Teri Drake**, WPI, Worcester, MA, *"Nuclear Power: The Dream and the Realities"*

Session 3: Panels, Workshops, and Papers
Friday, 3:00 - 4:00 PM

3.1 PANEL WOMEN'S APPROACHES **Mark I**
After Eve: Various Women's Approaches to Religion, Values, and Science.

This panel will feature four synthetic presentations from very different starting points: feminist, creation-centered, womanist, and earth-centered. An open discussion will follow.

Mary E. Hunt (moderator), WATER, Silver Spring, MD; **Jane Blewett**, Earth Community Center, Laurel, MD; and **Sara Ebenrock**, St. Mary's College of Maryland, Prince Frederick, MD

3.3 PANEL ED/9-12 **Mark III**
Integrated Math, Physics, Technology in Content and Delivery

This panel discusses an N.S.F. project for integrating high school math, physics, and technology education. A teacher team will share results, outcomes, conclusions, and recommendations.

Jula Scarborough (moderator), Northern IL Univ., DeKalb, IL and a Math. Physics and Technology Teacher Team from Project School: **Susan Brennan, Don Miner** and **Ray Skeen**.

3.4 PANEL STS TEXTBOOKS (2nd hour) **Dogwood**
College-Level STS Textbooks: Their Origination and Use

Continuation of session 2.4. Four authors of college-level STS textbooks will describe the origination and intent of their works. Several educators will also discuss the use of these books in courses.

Stephen Cutcliffe (co-moderator), Lehigh Univ.,Bethlehem, PA; **Robert E. McGinn**, Stanford Univ., Stanford,CA; **Rudi Volti**, Pitzer College, Claremont, CA; **Ron Westrum**, Eastern Mich., Ypsilanti, MI; and **Leonard Waks** (co-moderator), Penn State Univ., Univ. Park, PA

3.5 PANEL ED/Assessment **Amphitheater**
Assessment on STS Education at K-12 Levels

An international committee of seven educators has been planning symposia and workshops dealing with assessment in STS education. NATO, ICASE, and UNESCO presentations are planned; and NASTS attendees are invited to share in these plans.

Dennis Cheek (moderator), NYSTEP, Albany, NY; **Herbert Brunkhorst**, California State Univ., San Bernardino, CA; and **Glen Aikenhead**, Univ. of Saskachewan, Sask., CANADA

3.6 WORKSHOP ED/K-6 **Beech A**
Learning Cycle Approach to Space Science Topics

The workshop will model use of the learning cycle as an organizer for STS episodes based on space science topics. Each participant will receive a set of curriculum materials.

Donald R. Daugs, Utah State Univ., Logan, UT and **Dale A. Bremmer**, NASA/ASEP, Hattiesburg, MS

3.7 WORKSHOP ED/STS Paradigm **Beech B**
The Elements of Technology: Implications for STS Curricula

This presentation will identify a consensus listing of eleven elements of technology. Participants will dialogue on these elements and, if they wish, continue to interact through mailings.

Richard E. Peterson, NC State Univ., Raleigh, NC

3.8 WORKSHOP ENGINEERING **Hickory**
Thermodynamics Concepts You Didn't Know But Ate Anyway-Popcorn

A group of senior Chemical Engineering students demonstrate popcorn-making techniques as the framework to illustrate concepts in thermodynamics and to stimulate some basic engineering design discussion.

T.M. Regan (moderator), Univ. of Maryland, College Park, MD; Undergrad. Students at Maryland: **E. Menegaux, M. Heard, J. Lanning, P. Shriner**, and **C. Williams**; and Undergraduate at Howard Univ.: **C. Sawyer**

3.9 WORKSHOP ENVIRONMENT **Chestnut**
Restoring and Enhancing Regional Wetlands

Wetlands preservation policy lacks practical guidelines and general education programs to facilitate public understanding and participation. An awareness video will be shown, teaming facilitated, and resource materials distributed.

Joseph Sanders, S. CA Assoc. of Science Specialists, Long Beach, CA

3.10 WORKSHOP FUTURES STUDIES **Poplar**
United Nations Futures Research and You

This workshop will report on the progress of the Millennium Project of the United Nations University, the Smithsonian Institution, and the Futures Group, then involve participants in ways to work with the Project.

Jerome C. Glenn, United Nations Univ.,Washington, DC

3.11 PAPERS ETHICS/Medical **Walnut A**

3:00-3:30 **Paul Samuel di Virgilio**, Univ. of Toronto, Ontario, CANADA, *"A Time of Uncertainty: The Impact of the Open-ended Time Frame on Biomedical Ethics"*
3:30-4:00 **R. Eugene Mellican**, Univ. of Massachusetts, Lowell, MA, *"Beyond the Right to Die: Reality Versus Abstract Issues"*

3.12 PAPERS SCIENCE FOR NON-SCIENTISTS **Walnut B**

3:00-3:30 **Michael A. Hayden**, Mississippi State Univ., Mississippi State, MS, *"Building a General Education Core Around Technological Literacy"*
3:30-4:00 **R. Hudspith**, McMaster Univ., Hamilton, Ontario, *"Teaching STS Concepts to Non-Engineers Using Design Projects"*

3.13 PAPERS ED/STS Paradigm **Cherry**

3:00-3:20 **Marguerite Gravez**, Penn State Allentown Campus, Fogelsville, PA, *"Was STS born in XVIIIth Century France? A Case Study for Today"*
3:40-4:00 **Uri Zoller**, Haifa Univ.-Oranim, Div. of Chem. Studies, Kiryat Tivon, ISRAEL, *"STS Initiatives Across the World: Wishful vs. Research-Based Reality"*

3.14 PAPERS ENVIRONMENTAL **Golden Ash**

3:00-3:20 **James E. Barr**, Nicholls State Univ., Thibodaux, LA, *"Ten Years Later: Have Opinions About Environment Changed?"*
3:20-3:40 **Charles H. McLaughlin**, Ball State Univ., Muncie, IN, *"The Integration of Environmental Issues Within Technology Education"*
3:40-4:00 **John S. Nettleton**, Cornell Cooperative Extension, New York, NY, *"Urban Forest Project: An Example of In-Community Environment Education"*

INVITED THEME PROGRAMS
Friday 4:15 - 6:00 PM

EDUCATION AND INFORMATION

"Applications of Telecommunications to STS Education: Present and Future"
PLAZA B

Theme Co-Chair: **JON HARKNESS**, Science Specialist, Wausau School District, Wausau, WI.

Panelists: **LINDA ROBERTS**, Senior Analyst, Office of Technology Assessment, Washington, DC. **DOROTHY PERRECA**, Manager, National Geographic Kids Network, Washington, DC. **GAIL ARNALL**, President, Phoebus Communications, Inc., Fort Washington, MD.

TECHNOLOGY, INDUSTRY AND WORK

"Industry-Education Partnerships"
MARK I

Theme Chairs: **JULIANNE PRAGER**, 3M Company, St. Paul, MN and **ROBERT HUTCHINS**, Opportunities Academy of Management Training, Philadelphia, PA.

Presenter: **ALAN McCLELLAND**, Executive Director, Science Alliance, Rockland, DE.

Panelists: **JULIE STAFFORD**, Executive Director, Wisconsin Educational Partnership Initiative (sponsored by Cray Research Inc.), Chippewa Falls, WI. **JAMES JOHNSON**, Executive Scientist, 3M Company (ret.), St. Paul, MN. **PHYLLIS McGRATH**, Program Manager, Pre-College Education, GE Foundation, Fairfield, CT.

HEALTH AND BIOMEDICINE

"STS Inside the Beltway: Federal Experiments in Bioethical Policymaking"
MARK III

Theme Chair: **ERIC JUENGST**, Director, Ethical, Legal and Social Implications Program, National Center for Human Genome Research, Bethesda, MD.

Panelists: **MICHAEL YESLEY**, Manager, Program on Ethical, Legal and Social Implications of Human Genome Research, U.S. Department of Energy Human Genome Project, Los Alamos National Laboratories, NM. **ROBERT COOK-DEEGAN**, Director, Division of Biobehavioral Sciences and Mental Disorders, Institute of Medicine, National Academy of Sciences, Washington, DC. **CHARLES McCARTHY**, Director, Office of Protection from Research Risk, National Insts. of Health, Bethesda MD.

MORAL, ETHICAL AND PHILOSOPHICAL PERSPECTIVES

"One World, Many Cultures"
MARK II

Theme Chairs: **CARL WOOD**, Principia College, Elsah, IL.

Panelists: **CONNIE BARLOW**, Science Writer, New York, NY. **GEORGE BUGLIARELLO**, President, Polytechnic University of New York, Brooklyn, NY. **LAURENCE DOYLE**, Redwood City, CA. **CLIFFORD MATTHEWS**, Department of Chemistry, University of Illinois, Chicago, IL. **EUGENE B. SHULTZ, JR.**, Elsah, IL.

This program is continued on Saturday, 3:00 - 4:45 PM

Dinner Break
6:00 - 8:15 PM

There are serveral restaurants in the hotel to meet your tastes and budgets. Use your $1 coupon at any of these:

Halyard's:	Seafood specialties
Headliners:	Menu, buffet after 7:30 PM
Yannick's:	French style fine dining

NASTS MEMBERS MEETING
Friday, 8:30 - 10:00 PM

Location: Amphitheater

Open to all conference registrants. See Page 2 for agenda.

Session 4: Panels, Workshops, and Papers
Saturday, 8:00 - 9:00 AM

4.1 PANEL ETHICS **Mark I**
Introducing Societal Issues in School Science Courses

Kohlberg's theory of moral growth forms the basis for discussing a rationale and technique for introducing ethical issues into conventional chemistry, physics, and biology courses. Illustrative teaching material will be distributed.

Richard F. Brinckerhoff, Phil'',.. Exeter Academy, Exeter, NH

4.2 PANEL GRAD PAPERS/Global Issues **Mark II**

8:00-8:20 **Kyunghee Ham** and **Rebecca Wykoff**, Univ. of Delaware, Newark, DE. *"A Structural Approach to the Environmental Crisis"*
8:20-8:40 **Emmanuel Durosomo**, Univ. of Delaware,Newark, DE, *"A Technology Adoption Framework for Sub-Saharan African Agriculture"*
8:40-9:00 **In-Whan Jung** and **John Byrne**, Univ. of Delaware, Newark, DE. *"The Politics of Nuclear Development in South Korea"*

John Byrne (moderator), Univ. of Delaware, Newark, DE

4.3 PANEL ED/K-6/Tech Lit **Mark III**
The Science in a Technological Society Project, Plus a Technological Literacy Model

This presentation will discuss the K-6 Science in a Technological Society Project currently implemented in Israel, plus a technological literacy model developed at M.I.T. which uses Cybernetics as a case study.

David Chen, Tel Aviv Univ., Tel Aviv, ISRAEL

4.4 PANEL SCIENCE FOR NC SCIENTISTS **Dogwood**
The Sloan Foundation's New Liberal Arts Program

Background information on the NLA Program is presented, followed by discussion of available course materials. Books, monographs, and syllabi for general college students will be displayed.

Samuel Goldberg (moderator), Alfred P. Sloan Foundation, New York, NY and **John G. Truxal**, SUNY-Stony Brook, NY

4.6 WORKSHOP ED/K-8 **Beech A**
Family Science and Family Math: A Hands-On Workshop

Attendees will be involved in several hands-on sample activities from both the Family Science and the Family Math programs which have been introduced to New York City schools.

Stanley M. Brodsky (moderator), City Univ. of NY, New York, NY; **Peggy Noone**, Northwest EQUALS, Portland, OR; and **Josephine Urso**, Community Sch. Dist. #15, Brooklyn, NY

4.7 WORKSHOP ED/STS Paradigm **Beech B**
A History Lab for Teaching STS

The workshop presents a format for a classroom "lab" activity as well as a semester-long research project by using common and not so common products of technology to engage students in STS issues.

Edward Pershey, Tsongas Industrial History Center, Lowell, MA

4.8 WORKSHOP ENVIRONMENT **Hickory**
Water Technology: A Lab Approach

Water quality, purification, and conservation are the subjects of two short labs and three group activities in this hands-on, lab-approach workshop being piloted in Nevada. Packets of materials will be distributed.

A. Emerson Wiens, IL State Univ., Normal, IL and **Anthony Gilbert**, St. Cloud State Univ., St. Cloud, MN

4.9 WORKSHOP ED/Minorities **Chestnut**
Teaching Science and Technology to Limited English Proficient (LEP) Students

A 23-minute videotape of ten LEP students from Kean College of N.J. will be shown. Instructors in mainstream science and technology classes can modify their methods to accommodate LEP students. Handouts will be distributed.

Judith W. Rosenthal, Kean College of New Jersey, Union, NJ

4.10 WORKSHOP ED/Science **Poplar**
Whether Science Fairs...For Young Children?

Are young children cognitively and emotionally ready for science fairs? Participants will be led through the process of running the Walden-Lincoln School Science Fair in New York City.

Bernice Hauser, The Horace Mann School, Bronx, NY and
Helen Canover, Science Consultant to NY City Public Schools, NY

4.11 PAPERS ETHICS **Walnut A**

8:00-8:20 **Michael Alfano**, Polytechnic Univ., Brooklyn, NY, *"Ethics in the Engineering Curriculum"*
8:20-8:40 **Mary Ella Savarino** and **Ann Boyd**, Hood College, Frederick, MD, *"Scientific Opportunities -- Ethical Choices"*
8:40-9:00 **Joseph Sanders**, So. CA Assoc. of Sci. Specialists, Long Beach, CA, "Using Values To Improve Scientific and Technological Literacy"

4.12 PAPERS SCIENCE FOR NON-SCIENTISTS **Walnut B**

8:00-8:30**Barrett Hazeltine**, Baylor Univ., Waco, TX, *"Weaving Technology and Human Affairs"*
8:30-9:00 **Harry L. Conley**, Murray State Univ., Murray, KY, *"'Chemistry in Action' Videos in a Consumer Chemistry Course"*

4.13 PAPERS ED/Systems **Cherry**

8:30-9:00 **Aline M. Stomfay-Stitz**, Christopher Newport College, Newport News, VA, *"Robotics: STS Curriculum Strands Integrated with Language Arts and Social Studies for Middle/Secondary Students"*

4.14 PAPERS ED/College **Golden Ash**

8:00-8:20 **William B. Blesser**, Polytechnic Univ., Brooklyn, NY, *"Science Via Science Fiction"*
8:20-8:40 **James D. Lubbers**, Grand Valley State Univ., Allendale, MI, *"Designing a New Science Curriculum for Preparing Elementary Teachers"*
8:40-9:00 **Uri Zoller**, Haifa Univ.-Oranim, Kiryat Tivon, ISRAEL, *"Student-Centered, STS-Oriented College Freshman Chemistry Courses"*

PLENARY 2

Saturday, 9:15 - 10:15 AM
Location: Plaza C

Introduction: **Julianne Prager**, Community Service Exec., 3M Corporation, St. Paul, MN

Speaker: **Robert P. Bringer**, Staff Vice President, Environmental Engineering and Pollution Control, 3M Company, St. Paul, MN

"One Industry's View of Sustainable Development"

Saturday, 10:30 - 11:15 AM
COMMUNITY BREAKOUTS

This is a time to meet with peers to discuss the key STS issues addressed in the Plenary. Discussions begins immediately following the Plenary.

Plaza B - College Education
Christine Schoneweg, STS Grad. Student, Penn State
Plaza C - Education 9-12
Irma Jarcho, NASTS Board
Dogwood - Business and Industry
Isadore Sutton, STS Ph.D. Student, Penn State

Mark I - Education K-8
Cecily Pitt, STS Grad. Student, Penn State
Mark II - Government & Public Policy
Richard Deitrich, Conference Co-Manager, Penn State
Mark III - Environment
Judi Wakhungu, STS Ph.D. Candidate, Penn State

TEACHING MATERIALS SCIENCE AND TECHNOLOGY
A Hands-On Workshop for K-12 Teachers
Saturday, 9:30 AM - 4:30 PM

All sessions in the Amphitheatre

SCHEDULE

9:30 - 11:00	**James Jacobs**, Norfolk State University
11:15 - 1:00	**Gary Miller**, Lehigh University
3.00 - 4:30	**Steve Pilppo**, Richland High School, Washington

For sixteen years, **Dr. James A. Jacobs**, Professor of Technology at Norfolk State University has worked with teachers, teacher educators, science and engineering professors, and scientists and engineers in government and industry to develop activities for integrating materials science and engineering into K through 12 curricula.

Professor **Gary Miller** of Lehigh University, has several years experience of introducing teachers to the world of materials so that they in turn can alert their students to this dynamic field which has excellent career potential.

Steven Pilppo is a teacher at Richland High School, with seventeen years experience. He teaches a Materials Science Technology program, working with the University of Washington Materials Science School, NASA, the Boeing Aircraft Company, and numerous local industries.

Teachers will be provided with instructional modules for introducing concepts in materials science and technology as well as getting hands-on experience with activities to support the concepts in the modules.

Topics will include materials, structures, properties, and applications; municipal solid waste: disposal and recycling of materials; and methods for developing simple inexpensive techniques for teaching materials technology.

Session 5: Panels, Workshops and Papers
Saturday, 11:30 - 12:30 PM

5.1 PANEL **ED/Methodolgy** **Mark I**
Looking at the Earth in New Ways

Recent work has given us much new information about, and understanding of, the earth: its atmosphere, oceans and seas, and lands. How can educators best make use of this?

Michael Passow (moderator), White Plains Middle School, White Plains, NY; **David H. Kitzmiller**, National Oceanographic and Aeronautical Agency, MD; and **Dennis Crohn**, US Geological Survey, Reston, VA

5.2 PANEL **GRAD PAPERS** **Mark II**

11:30-11:50 **J.L. Croissent**, Rensselaer Polytechnic Inst., Troy, NY, *"Identity and Commitment: Information and Rhetoric and the Recruitment of Female Students to Engineering"*
11:50-12:10 **Carolyn M. Massie**, Univ. of Virginia, *"A Merger: Science Instruction and Hypermedia"*
12:10-12:30 **J.L. Croissent**, Rensselaer Polytechnic Inst., Troy, NY, will read a paper from Paul N. Meixner, RPI, Troy, NY, *"Technological Choice and the Military: Constructing the Seawolf"*

5.3 PANEL **ED/6-8** **Mark III**
Iowa Scope, Sequence & Content: A Real Grassroots Reform

Robert Yager (moderator), Univ. of Iowa, IA; **Curt Jeffryes** and **Chuck Eilers**, Croston Schools, Creston, IA; **Larry Kimble**, Mt. Ayr Schools, Mt Ayr, IA; and **Scott Hoegh**, E. Union Schools, Afton, IA

5.4 PANEL **ED/Evaluation** **Dogwood**
The Worcester Sixth Grade S-STS Unit Evaluation Studies

Reports on the researches by the Worcester Project into various aspects of STS teaching and materials.

John Wilkes (moderator), **Keith McCormick**, **Melissa McMahon**, **Terri Drake**, **Michael Fontana** and **Greg Shearman**, WPI, Worcester, MA

5.6 WORKSHOP **TECH LIT/Writing** **Beech A**
Using 'Concepts of Technology' to Enhance Writing Assignments

An activity used to induce students to think not only about a technology but about how it was developed and its impact on society.

John Renzelman, Wayne State College, Wayne, NE

5.8 WORKSHOP **ENVIRONMENT** **Hickory**
An STS Study of Water for Middle Level Students

Hands-on investigations of the unique properties of water and examinations of local water resources and their management.

Joanne K. Gallagher, Tamarac Middle School, Melrose, NY and **Jane Cappiello**, Bethlehem Central Middle School, Delmar, NY

5.9 WORKSHOP **ED/5-12** **Chestnut**
STS OHIO Project-An Elem. & Second. Teacher Training Project for Ohio

Hands-on activities (groundwater contaminations, AIDS, road saltation etc.) developed by this Project.

James D. Meinke, Ohio State Univ., Lakewood, OH; **Rebecca Rees**, Lima, OH; **Mark Rathge**, Lakewood City Schools, Lakewood, OH, and **Mark Wizniewski**, Ohio State Univ., OH

5.10 WORKSHOP **ED/Field Trip (Part I)** **Poplar**
Exploring Our Backyards: A Field Experience & Workshop for Educators

Strategies for integrating hands-on, interdisciplinary and inquiry-base learning into a single approach. (second part session 6.10)

Gary Benenson, Mitchell Bleier and Rebecca Dyasi, City College of New York, New York, NY

5.11 PAPERS **ETHICS** **Walnut A**

11:30-11:50 **Robert Gordon**, Private Consultant, Arcadia, CA, *"Ethics From A Scientific Basis"*
11:50-12:10 **Jesse S. Tatum**, Michigan Technological Univ., Houghton, MI, *"Values, Technology and the Future: Escaping the 'Device Paradigm' Impasse"*
12:10-12:30 **Beverly A. Sauer**, Univ. of Maine, Orono, ME, *"Premium Data: Discovering the Underlying Values and Assumptions that Shape Problem Identification/Accident Analysis in the Mining Industry"*

5.12 PAPERS **ED/Training Project** **Walnut B**

11:30-12:00 **Harriett S. Stubbs**, N. Carolina State Univ., Raleigh, NC, *SCI-LINK-An Inservice Teachers Training Methodology Linking Scientists with Teachers with Students"*
12:00-12:30 **Margaret Wiseman**, WI Public Broadcasting Ctr., Madison, WI, *"Making Sense of STS Teaching: Three Constructs to Guide Classroom Research"*

5.13 PAPERS **STS/International** **Cherry**

11:30-12:00 **Bernard den Ouden**, Univ. of Hartford, West Hartford, CT, *"Technology Transfer and Potable Water:Case Studies from India/ Dominican Rep."*
12:00-12:30 **Ania Groblcki**, Univ. of Witwatersrand, Johannesburg, South Africa, *"Democratising Technology in South Africa: How a National Science and Technology Policy Can Help"*

5.14 PAPERS **ED/STS Working Module** **Golden Ash**

11:30-12:00 **Judith Bazler** and **Marvin Charles**, Lehigh University, Bethlehem, PA, "A Working Model of Project 2061"
12:00-12:30 **Leonard Waks**, Penn State Univ., University Park, PA, *"The Responsibility Spiral: A Curriculum Framework for Science Literacy"*

LUNCH Break 12:30 1:30 PM

Lunch available in hotel at: **The Plaza Cafe** (quick lunch and dinner), **Headliners** (buffet), and **Halyards** (seafood)

NASTS Committee Meeting Rooms

12:30 - 1:30 PM

Committee Members should purchase a quick lunch and bring along with them to the meeting.

NASTS Position Papers	**Hickory**
Regional Chapters & Conferences	**Cherry Boardroom**
STS Assessment & Evaluation	**Poplar**
Precollege Education Organization Link	**Chestnut**
International & Foreign Organization Link	**Walnut A**
Community Awareness Activities	**Walnut B**

Session 6: Panels, Workshops, and Papers
Saturday, 1:45 - 2:45 PM

6.1 PANEL SCIENCE FOR NON-SCIENTISTS Mark I
A Model Course for Teaching Technology as Liberal Arts

A report from a task force of the International Technology Education Association on a proposed course built around: history, systems, impacts and futures.

A. Emerson Wiens (moderator), Illinois State Univ., Normal, IL; **Edward C. Pytlik**, West Virginia Univ., Morgantown, WV; and **Michael Hayden**, Mississippi State Univ., Mississippi State, MS

6.2 PANEL ENVIRONMENT Mark II
Environmental Commodification and Technological Inequality

This panel will expllore how industrial development is developing communities through market transactions which cause a transformation of the environment and the social into the commercial.

John Byrne (moderator), Univ. of Delaware, Newark, DE; and **Steven M. Hoffman**, College of St. Thomas, St. Paul, MN

6.3 PANEL ED/6-8 Mark III
The Iowa Scope, Sequence & Coordination Module Development Cycle

A report on a grass roots effort, the products of which are currently being tested at all Iowa SS & C centers.

Gary F. Varrella (moderator), **Lawrence Kellerman** and **Dan Boyd**, Univ. of Iowa, Iowa City, IA

6.4 PANEL ED/Evaluation Dogwood
Cognitive Styles, Learning Styles, and Response to STS Curricula

A brainstorming and discussion session in which the responses of participants will be compared with those obtained in recent studies at WPI.

Keith McCormick (moderator) and **John Wilkes**, WPI, Worcester, MA

6.6 WORKSHOP ED/9-12 Beech A
STS Activities & Teaching Practices In High School

Two STS science activities--"Your Turn to be Lawyer" and "Why the Fizz?"--taken from a newly published Grade 10 textbook.

Glen Aikenhead, Univ. of Saskatchewan, Saskatoon, CANADA

6.7 WORKSHOP ED/Methodology Beech B
Innovative Educational Techniques

Innovative teaching techniques--in different disciplines--to increase participation and improve learning of people from diverse backgrounds in areas of study heretofore limited to a select few.

Lisa Novemsky, Phyllis Bolling, Doris Fleischer, Ronald Gautreau, and **Frieda Zames**, NJ Inst. of Technology, Newark, NJ

6.8 WORKSHOP ENVIRONMENT Hickory
Natural Resource Management for Autonomy: Lessons in Community Through Environmental Education Simulations

Environmental simulations created for the Penn State Conservation Leadership Schools which force participants to examine the social implication of management decisions.

James P. Hamilton, Penn State Mont Alto, Mont Alto, PA and **George Vahovlak**, Penn State Univ., University Park, PA

6.9 WORKSHOP ED/At Risk Chestnut
Science Teaching in the 90's: Reaching At-Risk Learners

A brief overview of at-risk students and of research into the teaching of such students followed by demonstrations of successful intervention strategies for elementary and middle school teaching.

Gail Smith, Lehigh Univ., Bethlehem, PA

6.10 WORKSHOP ED/Field Trip (Part 2) Poplar
Exploring our own Backyards: A Field Experience and Workshop for Educators

A field trip in the immediate vicinity of the conference center to explore environmental interactions. (continued from session 5.10)

Gary Benenson (moderator), **Mitchell Bieler**, and **Rebecca Dyasi**, City College of NY, New York, NY

6.11 PAPERS ED/Training Project Walnut A

1:45-2:05 **Paul C. Jablon**, Brooklyn College, Brooklyn, NY, *"Where Does STS Fit Into the Elementary Teacher Preparation Program?"*
2:05-2:25 **Peter A. Rubba**, Penn State Univ., University Park, PA and **Randall L. Wiesenmayer**, West Virginia Univ., Morgantown, WV, *"Enhancement Project at Penn State and West Virginia Universities"*
2:25-2:45 **W.H. Vanderburg**, Univ. of Toronto, Toronto, Ont., CANADA, "A Report Card on STS in Engineering Education"

6.12 PAPERS ETHICS Walnut B

1:45-2:15 **Robert E. McGinn**, Stanford Univ., Stanford, CA, *"Ethical Issues of the Built Environment"*
2:15-2:45 **Caroline Whitbeck**, MIT, Cambridge, MA, "Rethinking Applied Ethics: Lessons From Engineering"

6.13 PAPERS SPACE Cherry

1:45-2:15 **Michael Fontana** and **Greg Shearman**, WPI, Worcester, MA, "Astronomy, the Solar Sytem and the Space Program"
2:15-2:45 **Robin Winship** and **John Wilkes**, WPI, Worcester, MA, "Is There a Future for Space Commercialization?"

6.14 PAPERS STS/Partnership Golden Ash

1:45-2:15 **Phillip A. Heath**, Ohio State Univ. at Lima, Lima, OH and **Rebecca C. Rees**, Lima City Schools, Lima, OH, *"Teaching STS With Partnerships: Some Basic Considerations"*
2:15-2:45 **Robert E. Horvat** and **Joyce Swartney**, Buffalo State College, Buffalo, NY, *"Pathways for Understanding Technology: A Local Industry-Education"*

INVITED THEME PROGRAMS
Saturday 3:00-4:45 PM

ENVIRONMENT & TECHNOLOGY, INDUSTRY AND WORK

Special Joint Theme Session

"The Role of Industry in Environmental Protection"
MARK I

Theme Chairs: **HERB ELEUTERIO**, Du Pont Chemicals, Wilmington, DE and **JULIANNE PRAGER**, 3M Company, St. Paul, MN.

Panelists: **JOHN H. COOPER**, Director for Environmental Affairs, Du Pont Chemicals, Wilmington, DE. **ANTHONY D. CORTESE**, Dean of Environmental Programs, Tufts University, Medford, MA. **R. L. "BOB" DOSTAL**, Director of Corporate Safety and Environmental Affairs, Dow Chemical Company, Midland, MI. **JAMES E. POST**, Professor of Management and Public Policy, Boston University, MA. **Robert P. Bringer**, Staff Vice President, Environmental Engineering and Pollution Control, 3M Company, St. Paul, MN

SCIENCE FOR NON-SCIENTISTS

"Technological Literacy For Non-Engineers"
DOGWOOD

Theme Chairs: **RUSSEL JONES** and **PAUL T. DURBIN**, Univ. of Delaware, DE

Panelists: Spokespersons for ABET and AAC

EDUCATION AND INFORMATION

"Science Education Intervention Programs on Behalf of Broadening Participation in Science, Technology and Society"
PLAZA B

Theme Co-Chair: **JANICE KOCH**, Assist. Professor, Hofstra Univ., NY.

Panelists: **ALETA YOU MASTNY**, Project Director, Consortium for Educational Equity, Rutgers University, New Brunswick, NJ. **ALICE MILLER**, Director, Women's Center, Brooklyn College, Brooklyn, NY. **ELLEN WAHL**, Program Director, Girls Incorporated, New York, NY.

HEALTH AND BIOMEDICINE

"Genetic Discrimination: Problems & Perspectives"
MARK III

Theme Chair: **ERIC JUENGST**, Director, Ethical, Legal and Social Implications Program, National Center for Human Genome Research, Bethesda, MD..

Panelists: **ABBY LIPPMAN**, Professor of Genetic Epidemiology, McGill University, Canada. **NACHAMA WILKER**, Executive Director, Council for Responsible Genetics, Boston, MA.

MORAL, ETHICAL AND PHILOSOPHICAL PERSPECTIVES

"One World, Many Cultures"
MARK II

Theme Chairs: **CARL WOOD**, Principia College, Elsah, IL

Panelists: **CONNIE BARLOW**, Science Writer, New York, NY **GEORGE BUGLIARELLO**, President, Polytechnic University of New York, Brooklyn NY. **LAURENCE DOYLE**, Redwood City, CA **CLIFFORD MATTHEWS**, Department of Chemistry, University of Illinois, Chicago, IL **EUGENE B. SHULTZ, JR.**, Elsah, IL.

(continued program from Friday, 4:15 - 6:00 PM)

PLENARY 3
Saturday, 5:00-6:15 PM
Location: Plaza C

Introduction: **Janice Koch**, Asst. Professor, Hofstra University, NY.

Speaker: **Sheila Tobias**, Author They're Not Dumb, They're Different*, Overcoming Math Anxiety, and Succeed With Math.

"They're Not Dumb, They're Different -- What Can We Learn From our Learners?"

*** Copies of this book are available at the registration desk**

Dinner Break

6:15 - 8:30 PM

There are serveral restaurants in the hotel to meet your tastes and budgets. Use your $1 coupon at any of these:

Halyard's:	Seafood specialties
Headliners:	Menu, buffet after 7:30 PM
Yannick's:	French style fine dining

NASTS Dessert Reception

Saturday, 8:45 - 9:30 PM
Upper Foyer

Open to all conference attendees

Session 7: Panels, Workshops, and Papers
Sunday, 8:00-8:50 AM

7.1 PANEL SCIENCE FOR NON-SCIENTISTS Mark I
Developing the Core Courses for a Major in Liberal Arts and Technology

The development of these courses to date and expectations for the future.

Christopher Dreisbach and **Alexander Hooke**, Villa Julie College, Stevenson, MD

7.3 PANEL STS/Partnership Mark III
A Blueprint for Establishing Successful University-Community Programs

Programs to expand the communication of scientific and technological advances to the educational community and maximise their integration at various levels in the community.

Louis A. Iozzi (moderator), **Robert Bonja** and **Daulat N. Husain**, Cook College, Rutgers Univ., New Brunswick, NJ

7.4 PANEL STS/International (Part 1) Dogwood
Finding the Common Academic Foundation: STS Around the World

An examination of various STS programs in Canada, Europe, South America, and the United States -- including their cooperative linkages. *(second part of this is session 8.4)*

Lars Fuglsang (co-moderator) and **Jan Annerstadt**, Roskilde Univ., Roskilde, DENMARK; **Leonard Waks** (co-moderator) and **Carl Mitcham**, Penn State Univ., University Park, PA; and Gerard Fourez, Univ. of Namur, BELGIUM.

7.5 PANEL ED/College (Part 1) Amphitheater
ECSEL WORKSHOP

Three different approaches to the solution of a small-scale design problem: the design of an energy-efficient house. *(second part of this is session 8.5)*

Leon Trilling (moderator), MIT, Cambridge, MA; **Gary Benenson**, City College of New York, New York, NY; **Anthony Amos**, Penn State Univ., University Park, PA; **Gretchen Kalonji**, Univ. of Washington, Seattle, WA; **Rick McCuen**, Univ. of Maryland, College Park, MD; **Carmen Cannon**, Howard Univ., Washington, DC; and **Adeboyejo Oni**, Morgan State Univ., Baltimore, MD

7.6 WORKSHOP ED/K-6 Beech A
STS in the Elementary Science Curriculum: Problem Solving & Science Process Skills

Ideas, examples and strategies to create science lessons that will help develop elem. students' problem solving and science process skills.

Henry D. Dobson, Bloomsburg Univ., Bloomsburg, PA

7.7 WORKSHOP ED/7-12 Beech B
The Siege of Tyre - Technology of Ancient War

Integrating social studies, science, mathematics, art skills and technology into the curriculum using the seige of Tyre as the exercise.

Michael Jaeger, Eastern Oregon State College, La Grande, OR

7.8 WORKSHOP ED/Methodology Hickory
Power-to-the-Pupils

Experience HOPS (hands-on problem solving) and get the HOTS (high order thinking skills) in response to a problem offered by the presenter.

Ronald W. Revere, Former Physics Teacher, Field Rep. for Lego Dacta

7.11 PAPERS ENVIRONMENT/Law Walnut A

8:00-8:25 **Dennis Smith**, Business School Liverpool Poly., U.K., *"Business & the Environment: Ed. Challenge for STS?"*
8:25-8:50 **John B. Mahaffie**, J.F. Coates, Inc., Washington, DC, *"The Future of Macroengineering: Moving to Complete Management of the Planet"*

7.12 PAPERS ED/Development Policy Walnut B

8:00-8:25 **Carl S. Frankel**, Penn State University, University Park, PA, *"The Whale, the Reactor, and NASA"*
8:25-8:50 **Ekke Mertz**, Director of Environments Programs, Univ. of Heidelberg, GERMANY, *"What Can Technical Education Contribute to Environmental Welbeing?"*

7.13 PAPER Religion &Technology Cherry

8:00-8:25 **David K. Nartonis**, Christian Science Church, Boston, MA, *"How Should Non-Technical Solutions be Judged?*
8:25-8:50 **Sreco Zakrajsek**, Ministry of Ed. Slovenia, YUGOSLAVIA, *"STS in Slovenia?"*

Session 8: Panels, Workshops, and Papers
Sunday, 9:00 - 9:50 AM

8.1 PANEL ETHICS **Mark I**
Moral and Ethical Issues for Students in the Global Classroom of Tomorrow, Today

Using an integrated bio-ethical unit and a cross-cultural exchange unit (USA/USSR) participants will be asked to identify cross-cultural issues and to respond to an ethical problem.

David Wallace (moderator), Christa McAuliffe Institute, Washington, DC,Jo **Blackwood**, Virginia Tech, Blacksburg, VA; and **Walt Tremer**, Southern Lehigh High School, Coopersburg, PA

8.2 PANEL **ED/Evaluation** **Mark II**

Technological Literacy Education as Viewed Through the Lenses of Conflicting Curriculum Theories

Technological literacy education from the perspective of five major curriculum theories: Academic Rationalist; Technical/Utilitarian: Intellectual Processes; Social Reconstruction/Participation; Personal/Self Actualization

Thomas Erekson (moderator), Bowling Green State Univ.,Bowling Green, OH; **Dennis Herschbach**, Univ. of Maryland, College Park, MD; and **Scott Johnson**, Univ. of Illinois, Campaign, IL

8.3 PANEL **STS/Partnership** **Mark III**
Science, Technology, and Society as Community Outreach

An STS critique of format content and outcome of several programs aimed at developing community awareness of public issues.

Robert A. Walker (moderator), Penn State Univ., University Park, PA; **Robert J. Tollefson**, Buena Vista College, Storm Lake, IA; **Gwen Blair-Frazier**, N.H. Dept of Ed, Concord, NH, and **Ellie Kibrick**, Special Services, Arlington, VA

8.4 PANEL **STS/International (Part 2)** **Dogwood**
Finding the Common Academic Foundation: STS Around the World

An examination of various STS programs in Canada, Europe, South America, and the United States -- including their cooperative linkages. *(continued from session 7.4)*

Lars Fuglsang (co-moderator) and **Jan Annerstadt**, Roskilde Univ., Roskilde, DENMARK; **Leonard Waks** (co-moderator) and **Carl Mitcham**, Penn State Univ., University Park, PA; and **Gerard Fourez**, Univ. of Namur, BELGIUM

8.5 PANEL ED/College (Part 2) **Amphitheater**
ECSEL WORKSHOP

Three different approaches to the solution of a small scale design problem: the design of an energy-efficient house. *(cont. from session 7.5)*

Leon Trilling (moderator), MIT, Cambridge, MA; **Gary Benenson**, City College of New York, New York, NY; **Anthony Amos**, Penn State Univ., University Park, PA; **Carmen Cannon**, Howard Univ., Washington, DC; **Gretchen Kalonji**, Univ. of Washington, Seattle, WA; **Rick McCuen**, Univ. of Maryland, College Park, MD; and **Adeboyejo Oni**, Morgan State Univ., Baltimore, MD

8.7 WORKSHOP **ENVIRONMENT** **Beech B**
1991/92 Green Index: A State-by-state Guide to the Nation's Environmental Health-- How Does ... r State Rank?

The two best and two worst states will be discussed to show how the ratings were made. Examine how your state's rating might be improved.

Jane Abbott, Past Pres. NABT, Waterville, ME

8.8 WORKSHOP **ED/7-12** **Hickory**
Science-The Central Subject

An elementary hands-on science lesson that includes language arts, mathematics and social studies. This lesson illustrates curriculum restructuring STS style, Participants will be the students. Hand-outs will be provided.

Beverly Nelson, Rutgers Univ., Ridgwood, NJ

8.9 WORKSHOP **ED/Political Action** **Chestnut**
Science, Technology, and Political Choice: Part of the Undergraduate Curriculum

A demonstration seminar examining problems that do not fit the traditional college disciplines. The implications of the evidence require action despite the uncertainties.

Martin L. Sage, Syracuse Univ., Syracuse, NY

8.10 WORKSHOP **ED/6-8** **Poplar**
Teaching Problem Solving Through Science & Technology

Four model units, currently being used in 6-8 grade science in northern Delaware exemplifying hands-on teaching constructed around technology and cross-curricular integration.

David Mioduser (moderator) and **Brian Gong**, Educational Testing Service, Princeton, NJ

8.11 PAPERS **INDUSTRY/Energy** **Walnut A**

9:00-9:25 **E.S. Cassedy**, Polytechnic Univ., Brooklyn, NY, *"The Solar-Hydrogen Vector - A New Concept for Sustainable Energy Technologies"*
9:25-9:50 **Michael A. Hayden**, Mississippi State Univ., Mississippi State, MS, "The Technological Literacy Needs of Industrial Technologists"

8.12 PAPERS **ED/Methodology** **Walnut B**

9:00-9:25 **Keith McCormick**, WPI, Worcester, MA, *"An Overview Stressing Key Findings and Enlightening Pitfalls"*
9:25-9:50 **Jane Berndt McGinnes**, George Washington Univ., Portsmouth, OH, *"Hands On Science From the Left! Brain Preferences and Development for a Wholistic Approach to Science Teaching"*

8.13 PAPERS **ED/Social Change** **Cherry**

9:00-9:25 **Frank M. Bosworth**, Bowling Green St. Univ., Bowling Green, OH, *"Social Change and Economic Development: A View From Two Program Perspectives"*
9:25-9:50 **Hana Novokova**, Research Institute of Pedagogy, Prague, CZECHOSLOVAKIA, *"STS and Social Change in Eastern Europe"*

PLENARY 4

Sunday, 10:00 - 10:50 AM

Location: Plaza C

Introduction: **Robert Yager**, Conference Chair, NASTS Vice President

Speaker: **Luther Williams,** Assistant Director for Education and Human Resources, National Science Foundation, Washington, DC

"Science and Mathematics Education for the 21st Century"

SPECIAL SUNDAY SESSION:

"Integrity in Science: Taming Fraud and Hype"

Sunday, 11:00 AM - 12:15 PM

Location: Plaza C

Introduction: **Rustum Roy,** NASTS Corporation Chair (moderator)

Presenters: **Sharon Begley**, Science Editor, Newsweek
Walter Stewart, National Institutes of Health

CONFERENCE WRAP-UP & FUTURE PLANS

Stephen Cutcliffe, NASTS President
Robert Yager, Conference Chair, NASTS Vice-President

Brief Address by Student Pugwash

TLC-8 PLANNING MEETING

Sunday, 12:30 - 3:30 PM

Location: Dogwood Room

Open to Interested NASTS Members

TLC-7 PLANNER-AT-A-GLANCE

Special Notes	What, Who, & Where
	THURSDAY: February 6, 1992
	7:30 PM - 9:30 PM Speicial Opening Plenary (Aldridge and Yager)
	FRIDAY: February 7, 1992
	7:30 - 8:30 Breakfast
	8:30 - 9:00 Opening and Welcome (Cutcliffe)
	9:00 - 10:15 Plenary 1 (Brown)
	10:30 - 11:15 Community Breakouts
Information Marketplace 11:30 - 1:30	**11:30 - 12:30 Session 1**
	12:30 - 1:30 Lunch Break
	1:45 - 2:45 Session 2
	3:00 - 4:00 Session 3
	4:15 - 6:00 Invited Theme Programs
	6:00 - 8:00 Dinner Break
	8:30 - 10:30 NASTS Members Meeting
	SATURDAY: February 8, 1992
STS Dept. Chair's Breakfast - Lakeside I	**7:00 - 8:00 Breakfast**
	8:00 - 9:00 Session 4
	9:15 - 10:15 Plenary 2 (Bringer)
	10:30 - 11:15 Community Breakouts
	11:30 - 12:30 Session 5
NASTS Committees Lunch	**12:30 - 1:30 Lunch Break**
	1:45 - 2:45 Session 6
	3:00 - 4:45 Invited Theme Programs
	5:00 - 6:15 Plenary 3 (Tobias)
NASTS Board Dinner	**6:30 - 8:30 Dinner Break**
	8:45 - 9:30 NASTS Dessert Reception in Upper Foyer
	SUNDAY: February 9, 1992
	7:00 - 8:00 Breakfast
	8:00 - 8:50 Session 7
	9:00 - 9:50 Session 8
	10:00 - 10:50 Plenary 4 (Williams)
	11:00 - 12:15 Special Session (Begley, Roy, Stewart)
	12:15 - 12:45 Closing Plenary (Pugwash, Outgoing Pres., Incoming Pres.)

TLC-7 CONFERENCE EVALUATION FORM

Please complete and return to registration table (boxes labeled "TLC-7 Evaluations") or mail before February 15, 1992 to NASTS, 133 Willard Bldg., University Park, PA 16802.

1. With which one sector do you most closely affiliate?

____ Science and Engineering
____ Print and Broadcast Media
____ Public Interest Sector
____ K-12 Education
____ Post-Secondary Education
____ Museums, Science Centers, Other Informal Education
____ Profession Pertaining to Values, Ethics, or Religion
____ Science and Technology Policy Making
____ International STS
____ Other: ____________________

2. How did you hear about the conference?

3. Why did you come?

4. What did you like best about the conference?

5. What one aspect would you most like to see improved next year?

6. What topics would you most like to have covered next year?

7. Who would you like to hear address the conference next year?

8. Is there some way you would like to participate next year? (Include your name & phone number, or contact us.)

9. What do you think about the Radisson Mark Plaza Hotel as a conference site?

10. What additional comments or suggestions do you have?