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ABSTRACT

A functional paradigm was used as a means of interpreting why teachers and classrooms function as they do. An assessment of the nature and sources of the functional paradigms of high school biology teachers was the major consideration of this study. A population of 28 experienced high school biology teachers recognized for exemplary teaching and/or their professional involvement in science and biology education served as the study population. A modified clinical interview was used to identify the relevant conceptual framework and the major assertions of the functional paradigms held by these teachers. paradigms held by these teachers. The interview data and documentation in the field notes taken also revealed the strategies employed in the teaching of human genetics. Each teacher also completed three questionnaires. The results of this investigation were interpreted within the conceptual framework of four aspects of education, namely, teaching, learning, curriculum, and governance. (TW)

THE FUNCTIONAL PARADIGMS OF HIGH SCHOOL BIOLOGY TEACHERS

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INTRODUCTION

The fundamental paradigm for the educational process is founded on teaching and learning. The activity of teaching and learning involves the shared interaction of the teacher and student with the curriculum in an appropriate environment (Gowin, 1981). The influence of the teacher on student outcome is therefore the result of the interpretation of curriculum materials by the teacher and student, the teaching strategies employed, the teaching and learning situation or environment, and the teacher's and student's background, attitude, and behavior. These factors are adapted from Schwab's (1973, 1978) four commonplaces: subject matter, teachers, learners, and milieu. Most research concerned with these commonplaces has focused on describing how classrooms function with emphasis on the relationship between classroom processes and student outcomes (process - product concept). There has been less research emphasis on why classrooms function as they do other than those studies involved with the teacher decision making process.

In order to gain insight into why the classroom functions as it does, it is essential to focus on the teachers, how they teach, and why they teach what they do. The teacher's knowledge base, attitudes about the subject matter, perceptions of the student and teaching environment, and professional development and participation are essential features which govern a teacher's approach to the classroom. Crocker (1983) has advanced the concept of a functional paradigm as a means of investigating why teachers and classrooms function as they do. Crocker assumes that teachers are similar to other communities of scholars or practitioners in sharing common beliefs, values, exemplars, and routines which constitute a functional paradigm. He points out that identifying functional paradigms involves seeking commonalities among teachers rather than differences. The nature and structure of these prevailing paradigms or generalized methods of thinking are critical in addressing the issues of why classrooms function as they do.

An assessment of the nature and sources of the functional paradigms of high school biology teachers is a major consideration of this research project. The concept of a functional paradigm provides a means of interpreting why teachers and classrooms function as they do. The four commonplaces of education as proposed by Schwab (1973) and later Gowin (1981) serve as the conceptual categories in which to describe and interpret these paradigms. As a result, a more organized or systematic classification of the paradigms can be made. It is not the intent to suggest that there are only four categories which influence a teacher's organizational pattern or thought processes. It is rather a collaboration of these factors that form the functional paradigms that ultimately influence the teaching strategies employed in the classroom. Finally, a demographic profile of the biology teachers is presented in order to describe the relationship between selected professional characteristics and the teaching strategies employed. The contextual framework for this study focuses on the functional paradigms and the strategies related to the teaching of human genetics. Erickson (1986) considers this focus on social ecology - its process and structure - to be intrinsic in interpretive research on teaching.

The following questions provide a framework for this research:

(1) What is the nature of the function paradigms of high school biology teachers based on the four commonplaces of educating: teaching, learning, curriculum, and governance?
(2) How do the biology teachers acquire and assimilate the scientific knowledge (primary sources of information) needed to develop and implement effective teaching and learning strategies?
(3) How are the teacher/teaching and learner/learning paradigms related to the strategies the biology teachers employ in the teaching of human genetics?
(4) What is the teacher's perception of governance as related to the teaching of human genetics?

BACKGROUND

THE FUNCTIONAL PARADIGMS OF TEACHERS

The concept of a paradigm came into general use through the work of Thomas Kuhn (1970). In the postscript to the second edition of his book, The Structure of Scientific Revolutions, Kuhn (1970) discloses two different usages for the term paradigm. First, a paradigm represents the entire group of beliefs, values, and techniques, etc., shared by the members of a given community. The second meaning refers to the shared models or examples which characterize the community of scientists. Once these characteristics are identified, Kuhn acknowledged that the common problems, methods, and theories of the group can be used to describe the features of the shared paradigm.

Kuhn draws most of his examples from the natural sciences with the basic premise of shared examples as a way of recognizing and solving problems from the application of known methods of analysis, laws, and theories. To Kuhn, this process is normal science. The members of the group of scholars do not question the underlying principles. They go about solving new problems by using these familiar principles.

Imershein (1977) proposed an important extension of Kuhn's thesis. He stated that members of a social organization can also be considered as functioning under a prevailing paradigm. The shared examples or "exemplars" are used as models for continued activity within the organization. The concept of shared example provides the epistemological link between the activities, technology, and general framework of ideas which are tied into organizational operation. As in theories in scientific research, he suggested general principles for social organizations can be employed only when defined within a context of practice. It is the context of practice which clarifies the use of principles. In the case of scientific paradigms, what is provided by the paradigm are particular procedures to be carried out, methods to be followed, tasks to be accomplished, all in a particular manner. What must be provided by an organizational paradigm are not only exemplars for organizational tasks and procedures, but also exemplars for roles to be enacted in particular ways, in particular settings, and in particular relation to other roles (Imershein, 1977). Therefore, the paradigms determine the range of behavior considered acceptable, and sets the rules for the kinds of activities that occur, in a manner analagous to the function of a paradigm in science. Imershein proposed that research on organizations and organizational change focus more on the structure and use of organizational knowledge. Research must therefore investigate the content as well as the use of paradigm knowledge.

Crocker (1983), using both Kuhn's concept of paradigms as a theoretical basis and Imershein's application of paradigms, attempted to address the question of why classrooms function as they do, by asking about the nature of the paradigms under which teachers may be said to operate. His introduction of the term functional paradigm has been used to convey the conceptual basis for paradigms of teachers. These are likely to be founded in practical matters rather than in theory. Therefore the paradigms that unite the scholars who conduct research on teaching may not be the same as paradigms for a theory of teaching. This dichotomy is much the same as the difference between research in the social and natural sciences. As Kuhn (1970) observed, the social sciences are not necessarily dominated by a single school of thought although one dominant paradigm usually characterizes a natural science discipline at a particular time.

Crocker acknowledged this difference and directed educational researchers to consider the features that unite the community of practitioners or teachers. These features are essentially the functional paradigms. As a result, the community of educational researchers should be able to develop a more theoretical basis for the study of teaching. Even with different paradigms, researchers on teaching will be able to develop a variety of research strategies, an awareness of different areas of interests and problems, and recognize different aspects of teaching and learning episodes likely to be overlooked within a single paradigmatic framework.

Crocker continued this argument by assuming that teachers are similar to other communities of scholars or practitioners in that they share common goals, problems, exemplars, routines, etc., which constitute a functional paradigm. From this he defined functional paradigm as the concept that the characteristics which unite a community of practitioners are likely to be centered on practical matters.

These practical matters have a foundation in the four commonplaces of education - teaching, learning, curriculum, and governance (Schwab, 1973; Gowin, 1981). The commonplaces provide a framework for conceptualizing the phenomena of education. Gowin (1981) has proposed a theory of educating as an eventful process, that changes the meaning of human experience by intervention in the lives of people with meaningful materials. These materials are used to develop thinking, feeling, and acting as habitual dispositions in order to make sense of human experience by using appropriate criteria of excellence. Further, it is the interaction of these four commonplaces that makes the eventful process happen.

To teach, according to Gowin, is to extend, change, or give new meanings to experience. The teacher is responsible for translating the specialized knowledge and value claims of the discipline so that the student grasps the appropriate meaning of the materials. This responsibility for selecting, analyzing, and reshaping primary claims for purposes of educating is the interaction of the teacher and the curriculum (Gowin, 1981). Gowin extends the basic educative paradigm between teaching, curriculum materials, and learners as an "episodic" event to denote the flow of meaning among these three commonplaces. The techniques used to arrive at new knowledge are not appropriate for translating this material into meaningful teaching and learning events. Therefore, the interpretation and reconstruction of these materials is the critical interaction between teacher and curriculum. The concept of teaching is then to provide shared meaning between the teacher, learner, and curriculum materials.

This framework for the function of the effective teacher is applied to the present research study as it is concerned with the identification and interpretation of exemplars of effective biology teaching strategies based on the governing functional paradigms.

This emphasis suggests that research on teaching should focus on the commonalities of effective science teachers and their teaching strategies rather than their differences. This would lead us to explanatory principles as opposed to variations alone. The specific research effort in this study is directed toward biology teachers and the teaching of human genetics and how the commonplaces are integrated and influence the teaching process.

THE FOUR COMMONPLACES OF EDUCATING IN THE CONTEXT OF HUMAN GENETICS EDUCATION

Only during the past several decades has human genetics become a discipline rooted in the fields of general genetics (Mange and Mange, 1980). Combined with the medical sciences and their sophisticated techniques for diagnosis, prognosis, and treatment, human genetics provides tremendous opportunities to alleviate human suffering. The implications of human genetics knowledge and technology applies to health, family planning, childbirth, and family life in general. But, this growth has also created social, political, and legal problems that will not easily be solved. Consider the issues surrounding cloning, abortion, euthanasia, the green revolution, and genetic engineering, to cite a few. These concerns suggest a mission in the educative process, especially in the disciplines, such as high school biology, that deal with the human condition. Students should be able to understand and discuss the importance of these issues in order to function as informed citizens in a technically sophisticated society. Teachers, specifically biology teachers, should provide a source of accurate information that can be used to sort the misconceptions and misinformation and to form the basis for decisions about policies both public and personal.

These concerns are supported by the Project Synthesis biology team in their rationale of the desired biology program. The use of biological knowledge should enhance the understanding of oneself and to benefit the quality of life and living for human beings (Hurd, 1981). The Biological Sciences Curriculum Study (1982) interdisciplinary approach to human genetics education, from elementary school through adult life, attempts to instill in the public the understanding that health and disease are a function of human variability and are to a great extent dependent upon the interaction of genetic constitution and environmental conditions. In addition to health and social issues, Childs (1983) considered the biological properties of the genetic material as an important reason to know something about human genetics. Because of the control over cellular organization and metabolism, its power of replication, including its capacity to change by mutation, and its central position throughout the whole of living organisms, the genetic material (the DNA) has profound implications for an understanding of human personal individuality, the identity of man as a species, and the place of man in the biosphere, and the interdependency of all forms of life.

As part of a large-scale needs assessment survey in human genetics education conducted for the BSCS, Hickman, Kennedy, and McInerny (1978) surveyed 799 high school biology teachers and found that although they all included a genetics unit in their course, the vast majority of them (80%) completed two or fewer college-level courses in genetics, 7% have had none, and 37% have had one. Less than 25% of the teachers reported participating in some summer, academic year, or in-service institute in genetics. Scriver, Scriver, Clow, and Shok (1978) also found that most biology teachers involved in their study were unfamiliar with human genetics and in particular with the human data that illustrate the tenets of genetics in an interesting and relevant manner. These findings are generally supported by the Project Synthesis biology team (Hurd, 1981) when comparing the desired versus actual conditions of teaching and use of curriculum.

The current reports (Rosenthal, 1984; Yager, Aldridge, and Penick 1983; Harms and Yager, 1981) on the status of science teaching in the high school indicates the domin: :e of the textbook in determining course content, mode of instruction, and evaluation. It is therefore not surprising, that the topics in genetics most often included in the biology course and most often considered important are the same topics that appear in textbooks (Hickman et al., 1978; Scriver et al., 1978). They also reported that teachers tended to rate as more important the topics they already teach. The perceived needs for instructional resources is almost inversely proportional to what they now teach and what they feel is important.

It is within this philosophical context that the BSCS and the National Association of Biology Teachers (NABT) developed curriculum programs as an alternative to the traditional approaches in genetics. The BSCS developed the Basic Genetics: A Human Approach (1982) instructional program to relate knowledge in genetics to the life experience of individuals, families, and societies. The NABT devoted two issues of their journal, The American Biology Teacher (Jungck, 1984a, 1984b), to genetic engineering in order to update the knowledge of biology teachers and provide new materials for instructional purposes.

As progress in genetic screening and counseling continues, many students now entering child bearing age will be brought into contact with some form of genetic services. All will be called upon as citizens to consider such issues as new social and public policies evolve to accomodate rapid progress in medical genetics, other areas in biomedicine, and science in general (Smith and McInerney, 1985). Many of these human genetics issues that must be explored in an interdisciplinary approach will be controversial. But to avoid treatment of those topics because they are value laden will limit the decision making abilities of our students. Smith and McInerney (1985) analyzed selected legal cases to examine the assumptions that have guided the task of resolving dilemmas that result from new technology. They consider the important lessons for students and for society lie in analyzing the issues that have been raised as the courts reached their various decisions. Informed and dispassionate analysis is required from all segments of society to ensure that decisions rendered are reflective of societal consensus.

It is within this environmental context of controversy that governance plays an important role. The development of interdisciplinary human genetics programs will require cooperation of individuals, teachers, students, parents, and communities, with knowledge and experience in many aspects of human and medic . genetics. This collaboration is the focus for a meaningful human genetics education.

Therefore, in the context of teaching human genetics it is important to define the functional paradigms of biology teachers in terms of the four commonplaces or practical matters which unite teachers.

RESEARCH METHODOLOGY

Study Population

The study population in this research project was twenty-eight experienced high school biology teachers recognized for their exemplary teaching and/or professional involvement in science and biology education. Fourteen teachers from Massachusetts and fourteen from Maine participated in this study.

The majority (nineteen of the twenty-eight) of the teachers from both states were recognized as exemplary in the field of biology teaching by the National Association of Biology Teachers (NABT), the National Science Teachers Association (NSTA), or by state and local science teacher organizations. Thirteen of the teachers were recipients of the Outstanding Biology Teachers Award presented annually by the NABT to the exemplary biology teacher of each state. Three of the teachers received the prestigious Search for Excellence in Science Education (SESE) award given annually by the NSTA to the outstanding science teachers of the year in each state. Six others were finalists in the selection process for the SESE award.

This population of exemplary biology teachers provided the functional paradigms necessary to develop an understanding of the most effective and innovative teaching strategies and the rationale to support these methodologies.

School and Community Profile

The twenty-eight high schools represented in this study ranged from small, rural schools with a student population of 200 to large, city schools with a student population of 2400. The mean student population was approximately 1070. Most of the schools in both states were located in suburban communities although several of the schools in northern Maine were located in small farming communities. All of the school buildings were relatively new structures and appeared to be in very good physical condition. The classroom and laboratory facilities in all the schools were well equipped and well organized.

Data Collection

The modified clinical interview was used to identify the relevant conceptual framework and the major assertions of the function paradigms held by these teachers. The interview data and the documentation in the field notes also revealed the strategies employed in the teaching of human genetics.

The interview format in this study was derived from the two master concept maps developed by the author (Figures 1 and 2). These maps provided the basic direction of the interviews but allowed for flexibility because of the relationships of the concepts and propositions. This format guided the interviews in different directions based on the idiosyncratic approach of each teacher which revealed the individual conceptual framework of the teachers.

Each teacher also completed three questionnaires. The first was a <u>Professional Background Survey</u> developed by the researcher to identify information such as teaching experience, academic preparation, involvement in professional science teacher organizations, journals used in teaching, and professional presentations. This survey instrument also dealt with teaching strategies and the teacher's perception of the students, curriculum, and teaching environment. The second instrument, the Science Process Inventory (Welch and Pella, 1987), was administered to measure or assess an understanding of scientific processes, such as a knowledge of the methods, assumptions, and limitations of science. The final questionnaire was the Scientific Attitude Inventory (Moore and Sutman, 1970), used to assess some of the intellectual and emotional attitudes toward science.

Analysis

The data in this study were collected using both qualitative and quantitative methods. Qualitative data were obtained from the modified clinical interviews and an interpretation of the transcripts of these interviews. Quantitative methods included the development and analysis of the Professional Background Survey, Teaching Strategies Inventory, and Teacher Perceptions Inventory, and the use of the Scientific Attitude Inventory (SAI) and Science Process Inventory (SPI).

The data analysis in this study followed the format suggested by Erickson (1968) for ethnographic, case study, qualitative, participant observational, and interpretative research approaches. This strategy involved a systematic search of the interview transcripts, field notes, and survey documents for relationships among assertions and an interpretation of their meaning. This was accomplished by multiple readings of the entire data set. Major assertions were identified from the interview transcripts, survey questionnaires and fieldnotes and categorized into one of the four commonplaces: teaching, learning, curriculum, or governance. A second copy of the data sources was then used as working copy to identify the major assertions. They were cut out and filed according to the commonplace they referred to. The support for the assertions was accomplished by repeated analysis of the data bases in order to identify confirming and disconfirming evidence for each of the commonplaces. According to Erickson (1986), the critical factor is to identify a pattern of assertions from the entire data source that reveals relationships. The purpose is to show that an adequate amount of evidence exists for the assertions made and that patterns of generalization are actually as reported. With this format of interpretation, it is possible to discover particular meanings, meanings that apply to other similar situations, and the more generalizable meanings.

IV. RESULTS AND DISCUSSION

Demographics of the Survey

The demographic information in this section provides a general description or profile of the biology teachers in this study. This data was collected using the Professional Background Survey developed by the author. Only a summary of the data is presented in order to reveal the general nature of the professional characteristics of the teachers.

There were 28 high school biology teachers in this study of which 22 were men and 6 were women. The average age of the teachers was 45. They had an average of 19 years of teaching experience with 17 years of biology teaching experience. The majority (90%) of the teachers had been in their present school system for at least 15 years. Their teaching assignments were primarily in biology ranging from Advanced Placement courses to general level biology courses. The average number of students they taught was 76 in both rural and urban school settings. School population size ranged from 200 to 2400 with an average of 1069. Eighty-six percent of the teachers held a teaching certificate in biology as well as being certified in chemistry (57%), physics (14%), earth science (36%), and general science (64%).

The educational attainment of the teachers stressed both biology and education. The majority (79%) held at least a master's degree in biology, biology education, or education. Over 89% were a biology major in college with another 4% minoring in biology.

Eighty-six percent of the teachers were actively involved in professional science teachers organizations, especially the National Science Teachers Association and the National Association of Biology Teachers. They regularly attended national, state, and regional professional science teachers meetings as well as conducting workshops and giving papers at these meetings. They were also very involved in the National Science Foundation Summer Institutes and the genetics workshops given by organizations such as the March of Dimes and the Blood Research Institute (Scarborough, Maine).

They made extensive use of professional science and science teacher journals for professional development and teaching purposes. This use and the number of different journals used in their teaching was more than what was documented for the SESE science teachers. The majority (89%) perceived their background for teaching science, technology, and societal issues as more than satisfactory.

The general profile of the biology teachers in this study compared very highly with the description of exemplary science teachers in the NSTA Search for Excellence in Science Education program (Penick, Yager, and Bonnstetter, 1986; Bonnstetter, Penick, and Yager, 1983).

The Biology Teachers and the Human Genetics Curriculum

The research questions refer to the interaction of the biology teachers with the primary sources of scientific information in the field of human genetics. The questions "How do biology teachers acquire and assimilate the scientific knowledge (primary sources of information) needed to develop and implement effective teaching and learning strategies?", "How are the teacher/teaching and student/learning paradigms related to the strategies the biology teachers employ in the teaching of human genetics?" and "What is the teacher's perception of governance as related to the teaching of human genetics?" are answered by considering first, a summary of the corpus of scientific information deemed essential in human genetics by the scientific and science teaching communities, secondly, the major paradigms that identify the professional background and continuing educational development of the biology teachers, and finally, the paradigms that allow for the development and implementation of the educative materials and the teaching and learning strategies employed.

How then do these biology teachers maintain a level of currency in the field of biology?

Interviews with the twenty-eight biology teachers indicated a high degree of professional activism and interest in continued learning. Although this interest was expressed for many areas in biology, it was most apparent for the fields of genetics, human genetics, immunology, and immunogenetics. All of these fields are of high interest in research biology at the present time although a paucity exists in both the coverage in commercial biology textbooks and the consideration given in most biology courses.

It is evident from both the interviews and the survey data that continuous involvement with professional science teacher organizations, such as the National Association of Biology Teachers (NABT) and the National Science

Teachers Association (NSTA), provided these teachers with an avenue and resource for continued professional development. Eighty-six percent of these teachers belong and are active in professional science teacher organizations. Survey data further indicates that they attend national, regional, state, and local science teacher meetings on a regular basis and all have participated in the National Science Foundation institutes.

Biology teacher (BT 17):

"I'd much rather get together with my colleagues at these meetings to talk subject matter and philosophies and attitudes of teaching science rather than what goes on in faculty rooms or department meetings at school. These organizations can revitalize science teaching, they can stimulate, plant a seed for collaborative efforts, and be supportive".

Particularly important is the fact that in the past three or four years all of these biology teachers have attended at least one human genetics workshop or institute sponsored by the Foundation for Blood Research or March of Dimes. Several of the teachers have attended three or four of these workshops and institutes offered by these organizations.

As another example of their interest in the human genetics topic, at the most recent NABT convention in Baltimore (October 1986), the author observed fourteen of the biology teachers from this study in attendance at two major addresses presented on human genetics issues (Murray, 1986; Childs, 1986b).

The majority of these teachers (90%) also acknowledged the use of professional science and science teacher journals as being very important in their teaching preparation and classroom activities.

In general, these biology teachers are significantly more active in professional science teacher organizations and use the journals published by these organizations more than the exemplary science teachers recognized in the Search for Excellence in Science Education (SESE) program.

The human genetics workshops sponsored by the Foundation for Blood Research (Scarborough, Maine) and the March of Dimes (Boston area) were extremely important in providing the biology teachers with the necessary current information. These workshops were conducted by clinical geneticists actively involved in human genetics research. The geneticists presented topics such as human (clinical) genetics, laboratory genetics (cytogenetics), prenatal diagnosis, genetic screening, genetics of the future (gene mapping, gene therapy, genetic engineering, in vitro fertilization, genetic counseling), and ethical issues. Participating teachers also received packets of materials to serve as resources for themselves and their students, suggestions for laboratory exercises, up-to-date brochures and pamphlets on human genetics including specific disorders, glossaries of genetic terminology, audiovisual materials, as well as a subscription to a bimonthly newsletter to update materials.

The content acquired from the professional geneticists served as the primary knowledge claims or sources of information from which these teachers were able to process and convert into educative materials for student learning.

The interviews revealed the continual desire of these teachers to renew their knowledge base in biology, especially in areas of human biology issues such as human genetics. These teachers considered themselves persistent learners. This attitude about continual learning provided the basis for their enthusiasm of teaching and a sense of what they attempted to convey to their students.

The varied professional experiences of these biology teachers provided the knowledge base necessary to reconstruct primary claims into effective teaching and learning materials. Gowin (1981) considers that the criteria for excellence of educative materials come from the field from which work originates and from the standards of education. These biology teachers possess what should be considered the necessary parameters to judge criteria of excellence. Their years of teaching biology combined with their professional development efforts to stay current through workshops, institutes, courses, and meetings, as well as their use of current literature in science and science teaching provided them with the experience and knowledge base to effectively analyze and reconstruct primary claims into practical teaching and learning materials.

The design, implementation, and evaluation of these human genetics materials is an on-going process or activity with these teachers. Involvement in the development of these educative materials has occurred in a number of different ways. Several of these teachers have served as consultants for the Biological Sciences Curriculum Study project that developed the Basic Genetics: A Human Approach (BSCS, 1982), a high school biology instructional program, and Genes and Surroundings (BSCS, 1983), a junior high school program. They field tested and evaluated the experimental editions of these materials with their biology and life sciences classes. They also functioned as state and regional advisors for this project by conducting teacher workshops in the use of these materials. The resource guides developed in these projects are considered as the most comprehensive and adaptable human genetic resources for classroom use.

One of the biology teachers authored a two hundred page resource unit for second year biology classes entitled Human Genetic Control - Alladin's Lamp or Pandora's Box?. Maine Gene, one of the activities in this resource unit, is a simulation game about the recombinant DNA controversy. The game won the 1983 OHAUS AWARD for innovation in science teaching presented by the Ohaus Scale Company and the National Science Teachers Association.

Although all of these biology teachers incorporate bioethical issues into the human genetics unit, two of the teachers have developed a year-long bioethics course as a result of the interest and enthusiasm exhibited by their students in the study of genetics and human biology. The courses include human genetic diseases and birth defects as well as various other human biology issues such as death and dying, family planning, AIDS, and current event issues. These two teachers have also participated in national and international conferences on the teaching of bioethical issues and have been very active with colleagues in their local regions. According to various professional science teacher organizations, it appears that these are the only two formal high school bioethics courses offered in New England.

The majority of the biology teachers in this study have involved various people from the community in their classroom activities. Physicians, genetic counselors, and genetic researchers have participated in discussions with students. Several of the teachers had parents of children with genetic diseases and birth defects discuss the realities of this situation including the feelings and emotions in a family.

In an effort to include current social issues in their biology courses, all of the teachers took advantage of the media programming such as NOVA documentaries and articles in newspapers and popular magazines concerned with human genetics and biosocial issues. Many of these teachers required their students to select a genetic disease and acquire information in the form of articles, pamphlets, books, and resource people from the organizations involved in the study of the disease or birth defect. As a result, these classrooms had an invaluable source of information for students and parents. The rationale for this type of activity stemmed from the general dissatisfaction with the inadequate coverage of human genetics issues in high school biology textbooks. Their evaluation of the status of commercial biology textbooks confirm the findings reported earlier by Rosenthal (1983, 1985) that biosocial issues receive little attention in most textbooks. Although the textbook is still used as a resource by the students and teachers, there is apparently less emphasis placed on the importance of the role of the textbook. This finding is most interesting because it is the antithesis of the national trend in science teaching to rely heavily on the textbook as the primary resource (Project Synthesis 1981). The, result is the evolution of a set of educative materials that are tailored to the personal orientation of the teacher and student. In this way, they are "closer" to the materials and can claim "ownership" in the development and use of these materials.

The tentativeness of science as a discipline as warranted by the rapid evolution of knowledge in the field of human genetics was a concept that founded the philosophy of science for these teachers. Within their conceptualization of science, they acknowledged that science teaches 'how' to look for answers to problems and questions, rather than providing all the answers to societal concerns. An historical approach and the integration of science and the study of human genetics to other disciplines was a fundamental theme in their adaptation of the genetics materials used in the classroom. They indicated that the genetics concepts were important to understanding real life situations, such as the social and political decisions based on the relationship of science, technology, and society. Survey responses indicate that they considered themselves rather well qualified to teach science, technology, and societal issues.

The science content of the discipline was considered to be most crucial to an understanding of the methodologies and processes in the study of human genetics. Because of this fact, a genetic theme was a constant thread throughout the educative materials developed by these teachers and their biology programs.

The Scientific Attitude Inventory (SAI) and the Scientific Process Inventory (SPI) revealed the biology teachers' attitude toward science and their understanding about the methods, limitations, and ethics of science. In association with the interview data, they provide an understanding of how their attitudes and knowledge about how science 'works' contributes to their approach to teaching science in the classroom.

The total scores for the SAI of the biology teachers in this study is higher than for SESE science teachers in general, SESE biology teachers (Bonnstetter, 1984) and for the science teachers in the studies reported by Welch and Lawrenz (1982) and Lawrenz (1975). This is the case for both the emotional and intellectual components of this inventory.

The same situation occurred with the SPI score, where the biology teachers in this study scored higher than the science teachers reported in previous studies (Welch and Lawrenz, 1982; Lawrenz, 1975; Welch and Pella, 1967). The scores indicate a knowledge of science processes comparable to those of working scientists and somewhat higher than science teachers in general.

The knowledge and values about the nature and processes of science were the product of their experiences working with geneticists in workshops, formal courses, and laboratory settings.

This documentation indicates that these biology teachers are very innovative in the manner in which they acquire and assimilate current knowledge in the field of human genetics. They appear to have the necessary knowledge base in human genetics and biosocial issues to be able to work with the various primary resources, judge their educative value, as well as possess the ability to incorporate the information from these resources into their biology programs.

The major biology teacher paradigms associated with the curriculum as a knowledge base are summarized in the matrix in Table 1.

Student/Learning Paradigms

The human genetics curriculum provides the stimulus for meaningful learning episodes as both teachers and students recognize the importance of these issues in their daily lives. The interaction that results provides for the shared meaning essential for understanding human experiences and contributes to science literacy. This interaction is a triad involving the teacher, student, and educative materials. As previously indicated, the teacher identifies the materials considered meaningful for the student to study while the student views the material meaningful as presented by the teacher (Gowin, 1981).

All of the teachers created learning situations that would challenge the students using the biosocial issues raised in the study of human genetics. The rationale for this strategy was to further develop student interests and abilities, have them apply and integrate science concepts with disciplines other than science, and deal with misconceptions and misinformation. They felt that if students could effectively deal with these topics and with this approach that it would lead to a certain self-confidence and a sense of power. The teachers also acknowledged that students gained greater respect for their own opinions and values, as well as those of their peers.

How and what were these creative learning situations that allowed shared meaning experiences? Many of these teachers posed "dilemma situations", as one biology teacher referred to them. These problem solving and creative thinking approaches were used to discuss issues such as human experimentation, eugenics, cloning, recombinant DNA technology, and inheritance patterns of human genetic diseases and disorders. Other closely related topics, such as evolution, human reproductive, abortion, and science fiction concerns, were also considered. Because of the ethical concerns raised by these topics, the teachers found that the students approached these issues in an extremely serious manner.

The teachers used various measures to determine that their students were involved in more effective learning experiences. They received very positive feedback from the students regarding the class activities associated with human genetics issues. They found that the average grades on standard evaluation measures, such as essay and multiple choice exams, were generally higher than for other subject areas covered in the biology program. Interactions between students and between student and teacher were generally more involved and meaningful. Research papers, oral presentations, and laboratory reports generally were of higher quality showing more thought and effort in their preparation. Obviously, the students are more motivated to become involved with these genetics issues and therefore it is much easier for the teachers to follow up on student interests and develop their abilities.

It was apparent that these teachers were attempting to change the cognitive framework of their students by challenging them with these controversial topics. It provided the students with an opportunity to see the relationship of human genetics with other science and non-science disciplines and how they can be used to understand a biological problem. Most of the teachers expressed the general concern regarding the lack of knowledge and understanding students have concerning human genetics issues prior to their coverage in class. Especially evident are the misconceptions and misinformation derived from "street knowledge". Because of this fact, the teachers created these "dilemma situations" to change the cognitive maps of their students. Information acquired from popular television programs, magazines, and newspapers often are not based on valid and reliable science content. Many of these teachers indicated that they spend a great deal of time attempting to change these misconceptions and misinformation. Therefore, the choice of educative materials and instructional strategies is most critical in altering student misunderstandings. As previously reported, these teachers have the necessary teaching experience and expertise in human genetics issues to create this meaningful learning environment.

While most teachers would agree that creating an environment conducive to learning is a primary goal and expectation of their teaching and a way the students can increase their understanding, the teachers in this study were extremely emphatic about providing a humanistic condition for their teaching and learning to take place. The holistic goals of their teaching included the creation of a challenging learning environment where all students can succeed and develop their abilities through an understanding of their personal learning styles. They want students to apply their knowledge in science and other disciplines, appreciate the career implications of science in society, and effectively put their skills to work.

What then are the teaching strategies employed by these biology teachers as governed by their teaching paradigms that can effectively create such an environment?

All of the teachers considered problem-solving activities, decision-making situations, hands-on activities, including laboratory experiments, student to student discussions, and student interaction with teachers and other adults, as strategies that enhance the students understanding of the knowledge of science content and process, human genetics issues and the societal implications and student recognition of their own learning styles.

Problem-solving episodes took the form of both experiential and experimental activities.

The debate was a strategy used by many of the biology teachers to provide the forum for discussion of potentially controversial issues such as genetic engineering, genetic screening, prenatal diagnosis, recombinant DNA procedures, intelligence and inheritance, and reproductive technology. It is interesting that some of these topics were suggested by the teachers although in several instances the topic for debate was student initiated based on an event reported in the news media. The teachers expressed several reasons why this activity was an effective learning experience. One of the most important was because on the nature of the issues, the students realized that they would need the appropriate content or knowledge base in order to discuss the issue in an intelligent way. Because of the general lack of coverage of these issues in high school biology textbooks, the students had to acquire the information from alternative sources. These included resources such as science journal articles, interviewing genetic researchers and counselors, and contacting organizations such as the March of Dimes or genetic clinics. In this way, the students were actively involved in their own learning by seeking out the information, cooperating with their peers, interacting with adults, and eventually producing an argument for class discussion. All of the teachers involved in this process stated that they served as a facilitator rather than the traditional source of information.

In the Maine Gene, a simulation game written by one of the biology teachers, the students investigate the bioethical issues surrounding a recombinant DNA research laboratory and genetic counseling facility. In the simulation, each student in the class role-plays a citizen of this Maine community and will be a member of one of three special interest groups who attend a hearing by the city council. The function of each group is to promote their respective points of view concerning this proposed laboratory and counseling facility. Background information provides the students with real life issues dealing with the operations of a community, the expertise of genetic researchers, and the politics of special interest groups.

BT 23: The students become quite adamant about the view they are supporting. I think they learn a tremendous amount about the science, and the non-science aspects of it too, the political aspects, the social aspects, economic, ethical, and religious. It touches everything and they pick that up. In a way that's fun. It's different than if I was telling them all the stuff or if I was just giving them something to read.
.... I gave them a survey, an evaluation, afterwards, to see what they felt about what they got out of it. There was only one student in all my classes that didn't like it or say they learned something from it. All the rest were positive ......

WT: Why do you want to incorporate all of these issues, the social, political, and ethical issues into your biology program?

BT 23: Because life isn't just scientific. I mean a kid is going out of high school or college and facing a world where everything has all of these aspects to it and there is a lot of emphasis in scientific education on science, technology, and society and whenever something happens in science it affects all those other areas. I think too often we science teachers teach just the scientific parts of it and don't teach what the personal affects are going to be on a population and what is or isn't ethical and what we have rights to do. I think we have to broaden science classes to include more than just the basic science.......

The majority of the biology teachers indicated the BSCS instructional unit, Basic Genetics: A Human Approach, as an excellent source of educative materials for their high school students. They used the resource materials for both small group problem-solving and decision-making activities and whole class discussions. One of the topics most frequently used was the essays dealing with Huntington's Disease. The editorials, Levodopa Provocative Test and Ethics of Levodopa Test for Huntington's Disease, discuss the ethical issues associated with this human genetic disease. Two contrasting views on whether those at risk for this disease should be given the results of a test (assuming one were available) that would let them know whether they will develop the disease in midlife is the basis for discussion. The students consider the arguments and counterarguments concerning the possible psychological outcomes of learning that one is going to develop Huntington's Disease in later life.

BT 17: .... I thought this (approach) was great because in my teaching of a lot of these bioethical issues, the teacher involvement is simply to throw out the problems, never give an opinion, if it's still hanging, that's good. You want kids to think about it and there is a lot of group activity where they share ideas. Sometimes they'll say, "Well, what do you think", and I'll say my decisions are unimportant. It's how you process this information that's important; that's the BSCS input; so you can't eliminate subject matter confidence because if they don't have basic content background, they have nothing to make a decision on. ...... If they don't understand autosomal dominant diseases and the genetics involved, the whole idea is counter-productive so you have to la·· that groundwork....... In my teaching I think it is important that I train my students for the 21st century as well as today, so the things that I did when I first started teaching are not longer applicable and in the fields of genetics and say, immunology, bioethical issues are coming to the forefront today and some of us feel that since many of our students will probably never study biology again formally, then what is it we want them to be exposed to? They're going to forget facts so I shoot for general concepts, recurring themes that are build around certain topics. BSCS does that very nicely anyhow. They start to think in that mind set.... What some teachers are failing to do for whatever reason they're not reprioritizing what are the issues. I don't change for the sake of change but am sensitive to change that might be of some value to my students for now and their future........

An effective strategy described by a majority of these teachers was the use of laboratory and "hands-on" activities to stimulate learning and the application of student knowledge. They indicated that their students were more interested in the laboratory experiments when they were involved more than the traditional "cook-book approach" where the answers can be looked up in a textbook.

Most of the teachers considered even standard laboratory activities such as maintaining and measuring growth rates of plant cuttings as taking on a different emphasis when discussed in conjunction with cloning technology and how animal cloning is possible and the decisions as to would you really want to raise all humans the same way.

Other traditional types of laboratories activities such as pea plant crossings and albino corn plant studies have been used to provide the necessary background to discuss heredity versus environment in order to consider human qualities such as sports or musical ability, intelligence, and other topics that deal with what is based on the influence of inheritance or environmental factors.

Several of the classes are involved in the rearing and breeding of Xenopus laevis, the African tree climbing frog, to study in vitro fertilization procedures and the influence of hormones on growth rates and reproduction. This study brings up factors dealing with hormonal control of development and inheritance patterns in these animals. The interpretation and analysis of the laboratory experiments has led into a discussion of human infertility, the use of drugs to induce fertility, and the effects of these drugs on the embryo or fetus as to the potential genetic defects.

BT 10: .... I will use the genetics and reproduction in talking about the ethics of particular research projects, not only from the standpoint of the ethics of what kinds of organisms you use and how to do an experiment but also from the standpoint of the ethics of data reporting ......

BT 12 incorporates the study of animal behavior and genetics by designing laboratory activities with chameleons, Anolis sp., in order that the students observe behavioral patterns, such as dominance orders. As background information, they discuss gestures, body language, and the genetic basis and evolution of such behaviors.

This teacher also does a unit on biochemical genetics and uses the bacterium, Serratia marscescens, as the organism to illustrate gene functioning. The students grow several different colored strains of these bacteria in a culture medium to show the effect of gene interaction on the pigmentation patterns.

BT 12: .... It has always been my philosophy from the time I developed these courses, that the lab work was the most important and that I could teach the problem-solving and all these other things (skills) through the work of the lab....... I try to design labs that might have a variety of answers and would stress data taking and a variety of approaches..... Sometimes and often the best teaching goes on in the lab situation when you are working one on one and you are not standing in front of the class monitoring a discussion and imparting information flowing from teacher to student. I really do think a lot of good teaching and often best teaching comes out at that point........ I find labs harder because they have to be thought out ahead of time and you have to get the kids involved in them but I think that it makes the kids responsible for their own learning and in turn I learn more. I also stress writing skills in the AP course much more than the first year class where I might be stressing writing from the standpoint of short articles and short lab reports but from the standpoint of the AP class they actually turn in papers which are scientific papers. We've been on trips to the college libraries and how to use the data. .... It's impossible to keep up in all areas of this field so by stressing a research literature search it helps keep me current.

BT 14: .... I think another aspect of teaching the BSCS genetics program goes along with trying to teach an inquiry approach and not a lecture approach. The genetics program lends itself to the problem-solving and decision-making process and the basic skills of inquiry........ students today need to learn how to think and not to memorize, just to memorize. They need to genuinely learn how to think about the material. Not only that but I find it more interesting to teach that way. I think it is more exciting or more interesting to teach with an inquiry approach than to simply present the lecture and have them return the material back to me when it's done. I would rather talk with them about it.

The majority of the teachers considered "hands-on" activities to be more than just classroom/laboratory based. These teachers arranged class field trips to various genetic oriented research facilities to provide the students with more than a tour of the facility. Students were involved in actual laboratory activities while at these facilities which required direct contact with the research staff. This provided two major opportunities for the students, a career orientation and a formal discussion of the application of genetic screening techniques and related genetic diseases. In several instances, the teachers noted that these visits provided the students with their first opportunity to consider a biological career. The discussions with the research staff gave the students the forum to recognize that the knowledge they were acquiring had a direct application or meant something about a real-life issue.

Table 2 summarizes the various teaching strategies used by the biology teachers in this study. This data is comparable to the findings of Bonnstetter (1984) for SESE and a national sample of science teachers.

In the context of biosocial issues, the study of human genetics provides the opportunity for students to become involved in discussions of real-life situations through problem-solving and decision-making approaches. Specific dilemma situations that consider inheritance of genetic diseases and disorders allow students to apply biological knowledge to these discussions. An understanding of the concepts, principles, and theories in human genetics is most important for the application to discussing these real situations. Students are encouraged to group problem-solve, to brainstorm with others, and in general to learn from each other and not just from the textbook or from what the teacher says. The expression of ideas with a rationale for these ideas or answers is a fundamental component of the outcome of any learning episode.

Thinking and learning skills are developed by fostering a critical approach in the students approach to evaluating the resource materials they use, whether it is a textbook reading, a television documentary, or a visit to a research facility. Students are encouraged through discussions and analysis of data from readings and laboratory activities to challenge the data rather than accept it in a passive manner and to be aware of different points of view of researchers and fellow students. The emphasis on discussion is to develop an understanding of the content and process of science and human genetics. This approach requires a commitment from the student to recognize the importance of the issues being discussed and become involved with the material and fellow students in a meaningful way.

Through the use of manipulative activities such as experimental laboratory exercises, learning skills such as observation, prediction, inference, hypothesis testing, and data analysis enhance the problem-solving abilities of the students. Narrative documentation as in laboratory reports or other types of short scientific articles stress writing skills and the expression of scientific and genetics knowledge. This provides a forum for the exchange of ideas with the teacher and other students as well as a sense of the debate in the scientific community that surrounds many of these biosocial issues. In this way, a science as applied to real-life situations can be more easily understood. The conceptualization of the genetics content is extended to include the ethics, politics, and economic considerations and a better appreciation of the interdisciplinary nature of science with societal issues. The intent is to allow the student to recognize the currency of the material being studied along with the development of an enthusiasm for the life-long learning.

Finally, the teachers acknowledged the importance of creating a learning environment that was non-threatening for the students. This allows for the expression of student feelings and opinions, where the differences and the value of these differences will be recognized and accepted, and where the humanness in biology is maintained. In general then, the teachers wanted to provide an atmosphere of intellectual freedom where a sharing of knowledge and feelings was most important in providing a meaningful learning experience for all students.

GOVERNANCE AND TEACHING

The final research question to be addressed in this paper focuses on the functional paradigms of the teacher as applied to issues dealing with governance. The question "What is the teacher's perception of governance as related to the teaching of human genetics?" is considered from two viewpoints of the teacher. The first deals with the social setting in which the educative process occurs. This includes the atmosphere and attitudes of people that comprise the community and school environment. The second considers the social interaction of those involved especially the authority of the teacher in the educative process. Figure 3 is a concept map that illustrates the relationship of the components of the governance issue.

Gowin (1981) considers governance in the context of educating as the need to control the meaning that events are to have as educative events. It is therefore necessary to consider the governing influence of the social setting on the educative process because it is in this framework that the teacher, learner, and educative materials are brought together for shared meaning. In this study, the influence of the school administration and community are considered in governing the social setting. It is important to consider these components in order to understand how cooperation among people can achieve shared purpose and meaning in the educative process.

The authority of the teacher refers to their policy making powers regarding selection of the educative materials and the teaching strategies used in the educative process. In the sense of this study, this power represents autonomy in decision-making and is considered an extremely important consideration in order to a teacher to be effective (Sizer, 1984; Lightfoot, 1983).

Interview transcripts and survey responses provided the data sources for the information to address this question.

All of the teachers interviewed indicated that the school system allowed them to teach what they thought was important in biology including human genetics and the biosocial issues associated with these topics. Not only did they feel that they had complete administrative support but also that members of the community were most supportive of any decisions regarding classroom matters.

Table 3 is a summary of the major fundamental paradigms of these biology teachers as related to the teaching of human genetics.

RECOMMENDATIONS AND IMPLICATIONS

This research is a social ecologic study that attempts to describe and interpret the meaning of why high school biology teachers employ specific teaching strategies in the teaching of human genetics. The meanings are interpreted within the conceptual framework of the four commonplaces of educating: teaching, learning, curriculum, and governance. Therefore, this ecosystem or holistic approach serves as the theoretical base of interpretive inquiry for this research.

The construct of functional paradigm is developed to interpret why the high school biology classroom functions as it does. This paradigm construct seems an appropriate technique to consider the significant thought processes, beliefs, or values that biology teachers have for each of the four commonplaces. In this way, it is possible to interpret why the teacher is using a particular teaching strategy rather than just a description of how and what is being done.

In recent years, organizations such as the National Science Teachers Association and the National Association of Biology Teachers have made efforts to recognize exemplary teachers and programs. The efforts provide evidence about how science teachers make a difference in the educative process. A great deal of study has gone into the analysis of demographic information about these teachers and the programs.

The research focus of interpreting the functional paradigms as to why these teachers are doing what they do can only lead to a further understanding of the function teachers have in educating. Although the conclusions of this study are not prescriptive as to effective teaching strategies, the results allow the researcher a basis to consider teachers' thought processes.

This domain of research on teachers' thought processes presents a paradigmatic approach that has only recently emerged. The methodology of the interpretive researcher as applied in this study works from the particular description to the more general. The analysis of modified clinical interviews, survey questionnaires, fieldnotes, and site documents provides an effective strategy to identify the functional paradigms of these biology teachers. After analysis of all cases, commonalities of particular paradigms are identified. Only then are generalizable statements about the functional paradigms made. This interpretive approach seems an effective way to consider the teachers' thought processes as the context, situation or setting is important in influencing the teacher paradigms. In this way, a descriptive model of teacher thought processes adds to an understanding of the cognitive psychology of teaching for use by teacher educators, curriculum developers, school administrators, educational theorists, and by teachers themselves. A direct application can be made to teacher preparation programs in the form of suggestions and/or guidelines to consider in the development of a reflective professional teacher. In addition, a comprehensive study could be initiated to consider teacher thought processes in relationship to teacher action and their effects on student learning. Classroom documentation and videotapes could be made of a select group of teachers from the present study to observe the relationship of the teacher's functional paradigms to specific class activities.

The study of functional paradigms in the context of teaching human genetics was initiated because of the potential controversial nature of many of the issues in this field and the knowledge that the majority of high school and college level textbooks provide only a cursory coverage of these issues. If one of the goals of public school education is to develop a literate citizenry, then it requires that throughout a student's stay in school that they be challenged by real-life situations as they apply to society. The goals for human genetics education, provided by such groups as the BSCS Human Genetics Committee and the Project Synthesis Biology Focus Group, give biology teachers the guidelines for the development of educative materials for use in high schools and colleges. The relationship of science content, technological application of this science, and societal concerns, must be addressed in an effective education program in order to increase awareness about the human condition. Only then can the integration of thinking, feeling, and acting lead to meaningful learning experiences. An analysis of the biology teacher's functional paradigms regarding the teaching of human genetics provides an interpretation about the development, implementation, and evaluation of these meaningful experiences.

An appropriate extension of this research would be to see if the paradigms developed within the framework of the four commonplaces in this study applied to other knowledge bases in the field of biology or other science disciplines. Are the paradigm constructs generalizable to other science areas, especially environmental issues, such as the study of acid precipitation, toxic waste pollution, nuclear waste dumping and storage or chemical food additives? Can the science teacher thought processes and rationale for teaching controversial topics such as these be compared to those of the teacher's of human genetics issues? If commonalities can be identified are these paradigms generalizable to other science areas or other academic disciplines? These findings have the potential to contribute to an understanding of the cognitive psychology of teaching for use by all members of the educational community.

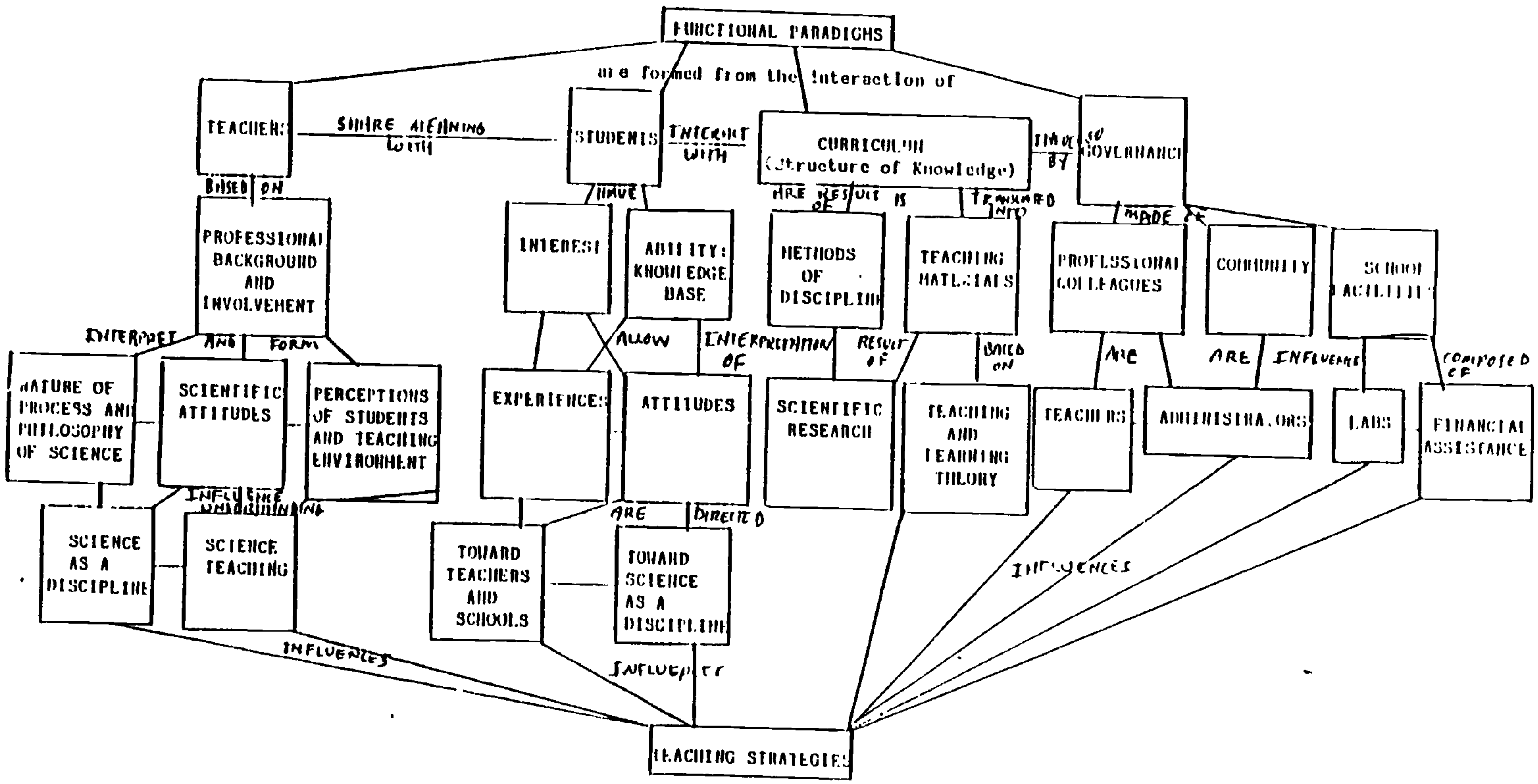

Figure 1. Composite concept map showing components of functional paradigms and their influence on teaching strategies.

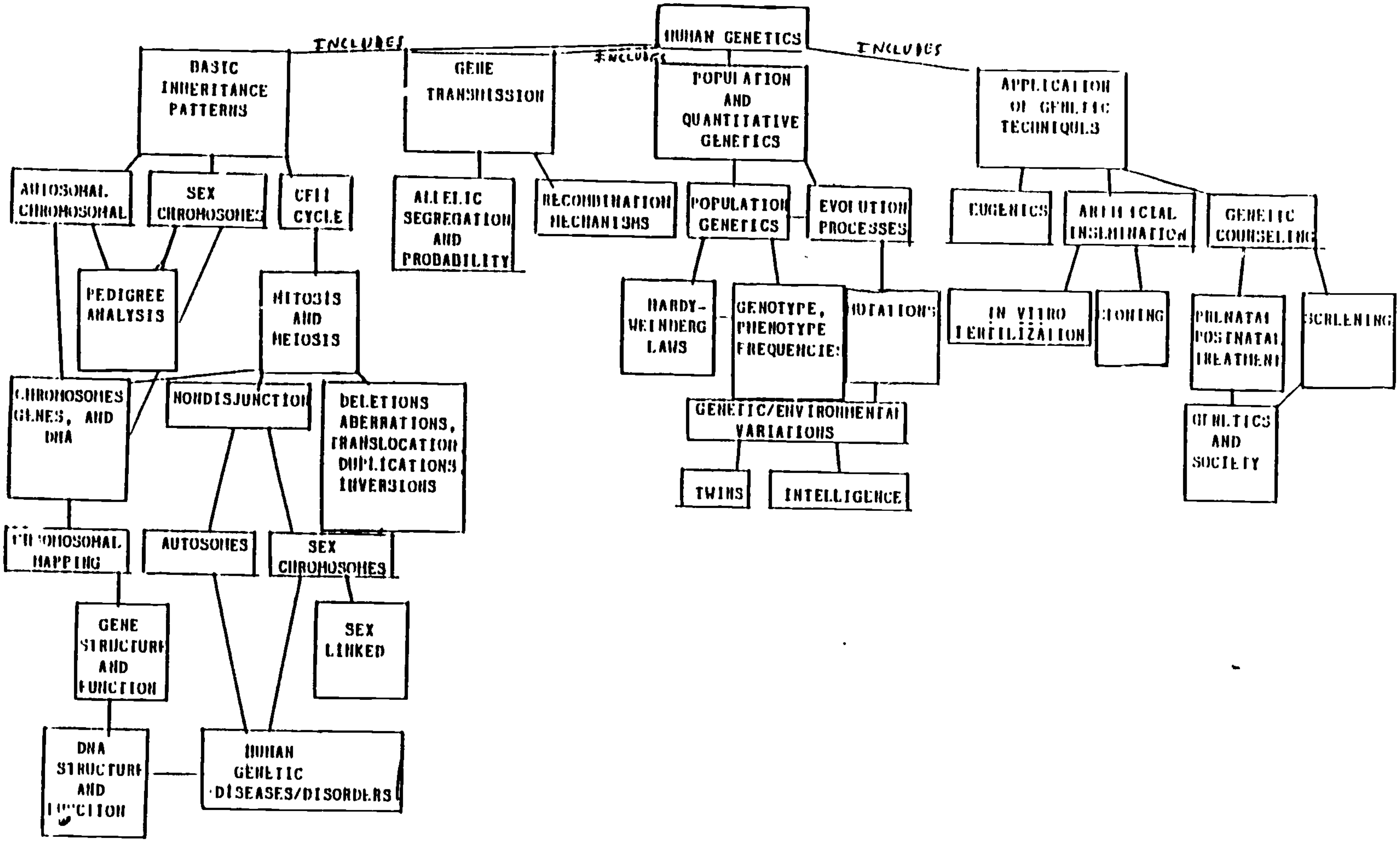

Figure 2 Concept Map of Human Genetics Topics.

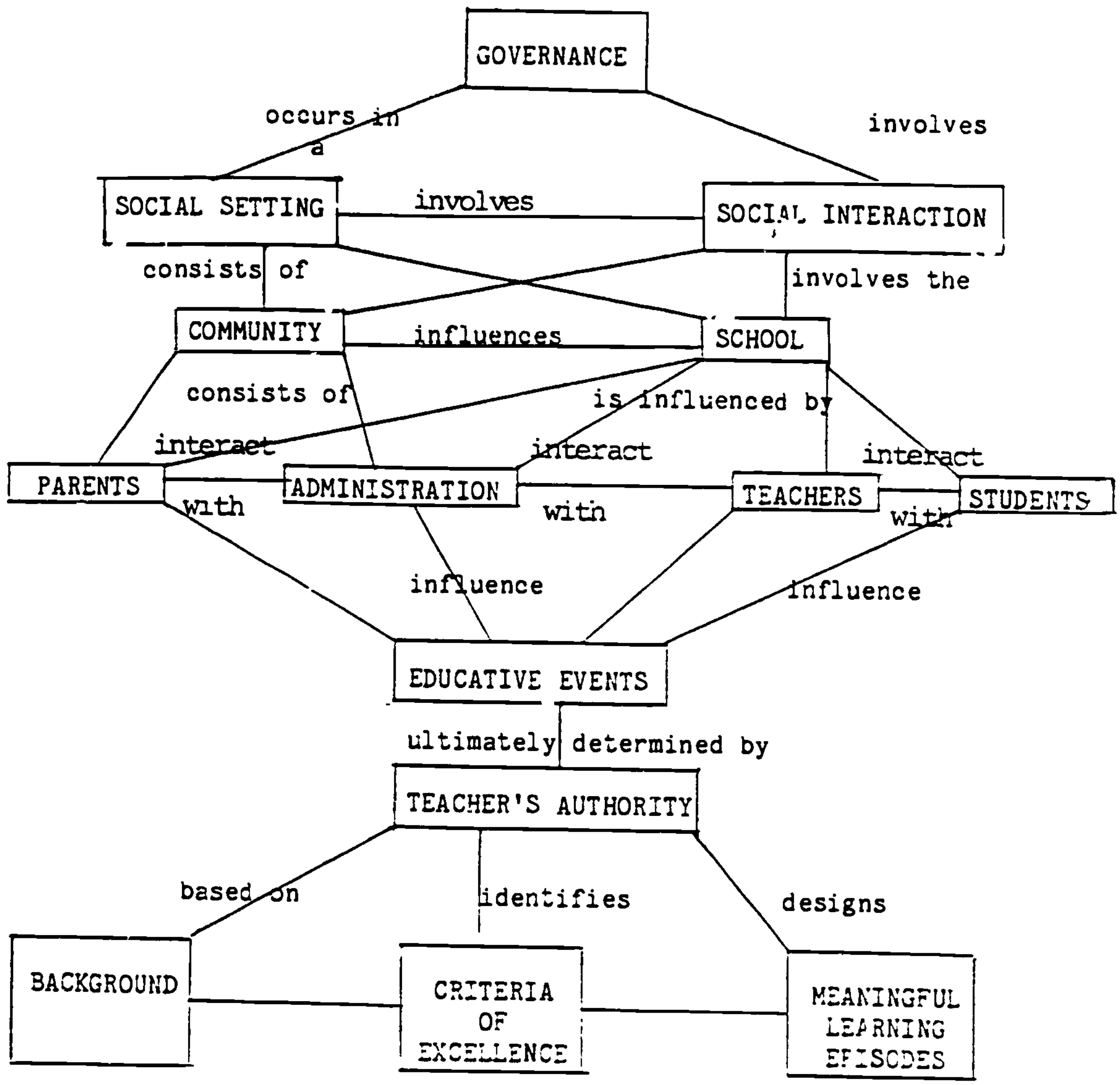

Figure 3 Concept map illustrating the major components involved in biology teacher's perception of governance in the educative process.

BIOLOGY TEACHER'S FUNCTIONAL PARADIGM	CURRICULUM (KNOWLEDGE BASE)
PROFESSIONAL ACTIVISM	1. Involvement in professional science teacher organizations 2. Use of scientific and science teacher journals 3. Sharing of ideas with colleagues' 4. Workshops 5. Working as a consultant 6. Design, implementation, and evaluation of educative materials
CONTINUED LEARNING	1. University/College courses 2. Summer Institutes 3. Work in science laboratory 4. Interaction with community resource people
NATURE OF HUMAN GENETICS	1. Tentativeness of science - rapid evolution of knowledge 2. Historical approach stressed 3. Content is important to understand process 4. Integrate science with other disciplines 5. Genetic theme throughout course and educative materials 6. Relate to S-T-S issues 7. Science teaches "now" to look for answers to problems/questions

Table 1 Conceptual matrix of biology teacher's functional paradigms and relationship to curriculum (knowledge base in human genetics).

FUNCTIONAL PARADIGM	TEACHING STRATEGY	HUMAN GENETICS EXAMPLE
Student will become a functioning, literate person in society . Understand tentative nature of science . Understand relationship of STS issues (science-technology-society)	Discussions of current events and genetics issues: . Biosocial/Bioethical concerns in society	Living with cystic fibrosis Huntington's Disease Relationship with special education students
Provide meaningful learning episodes . Apply and integrate science concepts with other disciplines . Recognize misconceptions and misinformation . Foster a critical approach to real-life situations	Problem-solving and decision-making strategies: . Debates . Simulation - role playing . Data analysis of laboratory results	Recombinant DNA technique Cloning Eugenics Human genetic diseases and and disorders: Ex. Tay-Sachs Sickie Cell Anemia Spinabifida Downs Syndrome Death and dying issues
Enhance existing student interest in controversial topics . Topics directly related to themselves . Develop self-confidence . Present career opportunities	Discussion - student centered: . Student to student interaction . Student and community resource professionals . Opportunity to express ideas Interviewing - Professional Resources: genetic counselors, etc.	Human reproductive technology . In-vitro fertilization . Birth control measures Parenting Human inheritance patterns Visit/work in laboratory facility
Develop science knowledge base, science process skills, and communication skills	Laboratory Activities: Hands-on . Individualized reports/research reports . Data-analysis/application . Narrative reports of findings . Oral presentations Library Research . Journal readings . Newspaper articles/media coverage	Human Genetic Diseases and Disorders Use of Organisms and Relationship to Human Condition: Bacteria, Frogs, Chameleons, Plants Use BSCS Modules or Other Teacher-Produced Educative Materials

FUNCTIONAL PARADIGM	TEACHING STRATEGY	HUMAN GENETICS EXAMPLE
Provide a humanistic environment for learning and teaching . Environment where all students can succeed . Environment where students can develop abilities to think through problems . Develop respect for their own ideas and opinions and values of peers	Discussions- . Student to student interactions . Student and teacher/adults . Role playing - simulation games Individualized Laboratory and Research Reports/Projects Case Study Approach Dilemma Situations - Decision-Making	BSCS Modules Cystic Fibrosis Report Bioethical Topics: Death, Diseases

Table 2 Conceptual Matrix to Illustrate Relationships of Biology Teachers' Functional Paradigms to Student Learning and Teaching Strategies

Table 3

FUNCTIONAL PARADIGMS RELATED TO THE TEACHING OF HUMAN GENETICS

(1) Students will become functioning, literate persons in society. This includes:
(a) an understanding of the tentative nature of science and
(b) an understanding of science, technology, and society issues.

(2) Provide meaningful learning episodes for students.
This includes:
(a) integration of science concepts with other disciplines,
(b) recognition of misconceptions and misinformation, and
(c) foster a critical approach to real-life situations.

(3) Enhance existing student interest in controversial topics.
This includes:
(a) dealing with topics directly related to the student,
(b) develop student self-confidence, and
(c) present career opportunities.

(4) Develop science knowledge base, science process skills, and communication skills.

(5) Provide a humanistic environment for teaching and learning to occur.
This includes:
(a) an environment where all students can succeed,
(b) an environment where students can develop abilities to think through problems, and
(c) develop respect for their own ideas, opinions, and values as well as those of their peers.

(6) Professional activism is very important.

(7) Continued learning experiences for teachers is necessary to maintain currency.

(8) Teacher understanding about the nature of science is important.

(9) Teacher autonomy/authority develops from the interaction of teacher, parents, administration, and community.

(10) Autonomy/authority allows teacher to determine the criteria of excellence for educative materials and teaching strategies employed.

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