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EMERGING CURRICULA FOR COMPUTER SCIENCE

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EMERGING CURRICULA FOR
COMPUTER SCIENCE

by

Christine Chavez Gomez

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

ARIZONA STATE UNIVERSITY

August 1985

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EMERGING CURRICULA FOR

COMPUTER SCIENCE

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has been approved

August 1985

APPROVED:

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Co-Chairperson

Supervisory Committee

ACCEPTED:

Department Chairperson

Dean, Graduate College

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ABSTRACT

This study was an attempt to bring some order to the quandary raised by the mandate of the 1983 Nation at Risk report that one half year of computer science be required of all high school students. The primary question was: What is computer science?

Using the grounded theory approach to research with the Delphi technique, theories grounded in data fell into three main areas: definition, curriculum, and support essentials.

Theory related to definition. The definition of computer science is: information processing, study of design, study of computers, programming, and problem solving.

Theory related to curriculum. The curriculum content for computer science encompasses the following: concepts of the computer, programming methods, problems, programming languages, and application.

Theory related to support essentials. The elements essential to supporting computer science are: training, personnel, software, financing, concerns, programming vs. applications, and level of instruction.

From these theories a detailed description of computer science, a suggested curriculum, and recommendations for

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support systems were derived. Finally, recommendations for implementation and further research were enumerated.

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CHAPTER I

INTRODUCTION

In its recent, widely publicized report, A Nation at Risk: The Imperative for Educational Reform, the National Commission on Excellence in Education (1983) recommended that one half year of computer science be required of all high school graduates.

The commission has taken the position that the teaching of computer science in high school should equip graduates to: (a) understand the computer as an information, computation device; (b) use the computer in the study of the basics and for personal and work-related purposes; and (c) understand the world of computers, electronics, and related technology.

Further, the commission asserted that state and local officials, including school board members, governors, and legislators, have the primary responsibility to incorporate the proposed reform in their educational policies and fiscal planning (National Commission, 1983, p. 24).

Therefore, the task of the researcher was to identify and contact state and local officials, including school

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board members, governors, legislators, and others "who determine or control educational policy at the local level." The researcher proposed a population that would consist of school board member(s), school district superintendent(s), the superintendent of public instruction, the assistant to the governor of Arizona, the State Board of Education, the chairpersons of the Arizona Senate Education Committee and House Education Committee, representatives concerned with educational issues, legislators, the State Board of Education, the North Central Association, teacher associations, the executive director of the Arizona School Boards Association, and other policy makers as the study emerges.

Leuhrmann (1983) stated that A Nation at Risk (National Commission, 1983) did not address curriculum considerations for computer science. For example, who will train teachers to teach computer science? Which department should be responsible to teach computer science--and who would do so? Which type of software would be compatible? If mandated, who would finance textbooks, hardware, software, and teacher training costs? What are some of the concerns, issues, and trends that are facing teachers who use computers or will be using computers in the classroom? Should the emphasis be on programming or applications in the classroom? At which level of instruction should computers be introduced?

Educators find it difficult to know the content that should be included for the proposed computer science course,

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since limited research has been done in relation to computer science at the secondary level.

Statement of the Problem

Without requirements for content and guidelines for establishing a computer science course, educators will lack the information needed to design courses to prepare the high school graduate with the necessary computer skills.

If the experience of people who have set up computer science classes at the secondary education level could be gathered and made available to others planning such courses, establishing these courses would become simpler, with potentially better results. The purpose of the present study is to generate a theory that will provide a basis for a curriculum in computer science. In order to gather data from which to generate the theory, answers to the following questions were gathered:

1. What is "computer science"?

2. What subject matter should be included in "computer science"?

3. What should be required of teachers to teach computer science (skills, certification, coursework, and training)?

4. Who should teach the recommended computer science course?

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5. Who determines or controls educational policy at the local level?

Need for the Study

According to Luehrmann (1983), the principal defect in the national report, A Nation at Risk, is the vagueness of the term computer science. He further observed that the issue of specific knowledge and skills must be dealt with and made concrete. Otherwise, he cautioned, any school can teach anything under the heading of "computer science," and many students will emerge with little preparation in the fifth "New Basic."

Further, he contended that the report offers little help in defining course content. For example, Item a (understand the computer as an information, computation device) and Item c (understand the world of computers, electronics, and related technology) sound like the goals of a "computer awareness" or "computer appreciation" course, in which the student may only read about computers but never actually touch one or learn how to control it. Item b (use the computer in the study of the basics and for personal and work-related purposes) might mean nothing more than knowing how to load and run a program in some traditional subject area--using a word processing program, for example.

These goals are trivial, he wrote, as compared with the skills and mastery goals that probably come to the mind

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of a teacher of computing. Further, the word understand is liable to broad interpretation.

Computer technology, which has gained local, state, and national attention, plays an important role in successful preparation of students as future employees. Also, teachers must be prepared to meet these technological demands. While teachers have no need to become programmers, some proficiency in the computer language is necessary for those who want to cope with technology in the classroom.

Thus, uncovering theories about the curriculum for the proposed high school graduation requirement, computer science, will have a twofold benefit. First, the findings of this study should be helpful to teachers in their instruction of computer science. Second, and more specifically, some teachers, computer specialists, educational policymakers, and chairpersons have expressed their concern and interest in the study.

Assumptions

In conducting this study, it was assumed that the participants conveyed truthful and accurate responses to the researcher. It was also assumed that the researcher displayed the required skill in analyzing and synthesizing the data.

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Definition of Terms

The following terms as used in this study are defined:

BASIC: Beginners All-Purpose, Symbolic Instruction Code; an easy-to-use, high-level language often used for business data processing because of its user orientation.

COBOL: Common Business Oriented Language. A programming language that simplifies data processing programs; its instructions are similar to English.

Computer program: A set of instructions directing the computer to perform a task.

Computer programmer: A person who designs, writes, tests, and implements the programs that process data on a computer system (Shelly & Cashman, 1980).

Debugging: The process of eliminating mistakes from a flowchart, a computer program, or malfunctions from a hardware device.

Delphi technique: A means of arriving at a consensus without bringing together intended participants, experts, or others in a face-to-face situation (Hillestad, 1977).

Grounded theory: A research method that allows for the discovery of theory from data rather than the verification of theory.

Hardware: The physical equipment of a computer system.

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Information processing: The processing of data representing information and the determining of the meaning of the processed data (Spencer, 1978, p. 210).

Keyboarding: The act of placing information into various types of equipment through the use of a typewriter-like keyboard ("Statement," 1984).

Language: Any of various codes in which software can be prepared.

LOGO: A higher level interactive programming language that assumes the user has access to some type of on-line terminal.

Looping: A sequence of operations usually repeated a controlled number of times within a procedure.

Microcomputer: A small, low-cost computer. A microcomputer contains at least one microprocessor and can be contained on a board or chip.

Networking: A data base in which each of the elements is linked to the others through pointers.

PASCAL: A programming language designed to make it easy to write programs using structured techniques.

Software: Programs that are written for computer systems.

Terminal: A peripheral device with a visual display unit and keyboard allowing data input and output (Elliot, 1982).

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Word processing: The storage, manipulation, and processing of data as needed in the preparation of written communication using terminals and related devices.

Summary and Organization of the Study

Chapter I introduces a recommendation from A Nation at Risk (National Commission, 1983) that one half year of computer science be required of all high school graduates and the problems that arise from the recommendation.

Chapter II presents a description and procedures of the grounded theory method and the Delphi technique.

Chapter III abstracts and synthesizes the findings of the study.

Chapter IV presents the summary, conclusions, and recommendations.

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CHAPTER II

METHODS AND PROCEDURES

Since the purpose of this study was to generate a theory that would provide a basis for a curriculum in computer science, and not the verification of preexisting theories or sets of hypotheses, the inductive research technique called grounded theory was chosen as the overall research method. Glaser (1978, p. 6) stated that the grounded theory method can be used as a general method of analysis with any form of data collection: survey, experiment, or case study. Further, Owens (1982) stated that it is important that the naturalistic research design provide for multiple data sources and methods or strategies of collection.

The Delphi technique, a consensus data-gathering device or strategy, is one technique that was used to carry out the analysis and help generate theory in this study.

According to Guba and Lincoln, a posteriori specification has a definite advantage of its own--it results in grounded theory: theory that is based on and verified by real-world data. On the other hand, a priori hypotheses represent a guess about what is likely to be the case. If one guesses right, that is fine; but if one guesses wrong,

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the hypotheses are disconfirmed. Grounded hypotheses, however, are connected with the real world--they do not represent guesses, but, rather, directions indicated by actual information (Guba & Lincoln, 1983, p. 102).

Definition of Grounded Theory

Grounded theory refers to the creation of theories from data that are systematically generated from research. In theory-building research, human experience provides the raw data with which the researcher begins to work. Through reflection, the researcher begins to identify the meaning of experiences, which then enables the researcher to develop a theory. This theory will provide insight into the nature of a particular type of experience.

The way the researcher collects the data, codes the data, integrates categories, generates memos, and constructs theory are all part of the processes of both generating theory and research--all guided and integrated by the emerging theory.

The outcomes of the research, therefore, are evolving continually; this leads to Glaser and Strauss's view of theory development as a "process" and an "ever-developing entity," not as a perfected product (Glaser & Strauss, 1967, pp. 1-2).

In contrast, the traditional method of theory development may rely on standard methods of research that are not

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directly formulated, controlled by, or related to how the theory will be developed.

Generating theory in grounded theory research is done by a human being who at times is intimately involved with the data. As the research develops, the analyst becomes "wise" about the data--how to code and memo the main problems and processes and how to interpret and explain them theoretically.

In Theoretical Sensitivity, Glaser stated:

> Thus, the grounded theory method offers a rigorous, orderly guide of theory development that at each stage is closely integrated with a methodology of social research. . . . In contrast, traditional methods of theory development rely on standard methods of social research that are not directly formulated, controlled by or related to how the theory will be developed. This is typical in verificational studies, which use testing methods developed apart from the method used to generate testable hypotheses. (Glaser, 1978, p. 2)

Thus, in grounded theory, the theory is a strategy for handling data in research and providing memos of conceptualization for describing and explaining. The theory should also be understandable to laymen and should provide clear enough categories and hypotheses so that crucial ones can be verified in present and future research. Theory that can meet these requirements must "fit" or apply to the situation being researched and "work" or explain when put to use at some future time.

Grounded theory is a sophisticated, careful method of idea manufacturing; the conceptual idea is its essence. The

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best way to produce is to think about one's data to generate ideas. Focusing on generating ideas that fit and that work takes considerable time and effort. Generating a theory involves a process of research (Glaser & Strauss, 1967, p. 6).

Grounded theory research, also known as qualitative methodology, has been systematized for use in research efforts since the 1960s.

Background

In the late 1930s, researchers had used qualitative data in a nonsystematic way, in combination with their own logic and common sense. Qualitative data consisted of very small amounts of theory, mainly just detailed descriptions.

However, after World War II, quantitative researchers started translating theoretical concepts into research operations, thus resulting in the challenge of testing theory rigorously. Advances in quantitative methods initiated the zeal to test unconfirmed theories with the "facts."

Glaser and Strauss (1967) stated the following concerning qualitative research:

> Qualitative research, because of its poor showing in reproducing the scientifically reproducible fact, and its sensitivity in picking up everyday facts about social structures and social systems, was relegated, my men like Storeffer and Lazarsfeld, to preliminary, exploratory, groundbreaking work for getting surveys started. Qualitative research was to provide quantitative research with a few substantive categories and hypotheses. Then, of course, quantitative research

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> would take over, explore further, discover facts and test current theory. (p. 15)

The strength of this position, which soon gained popularity in American sociology, required evidence of quantitative analysis, such as sampling, coding, reliability, validity, frequency distributions, conceptual formulization, hypothesis, and presentation of evidence.

However, a smaller number of sociologists took other positions when they began to confer about verification when speaking of qualitative data (testing, proving, tentativeness, demonstrating, etc.). What was being heard was, "Since we are so accustomed to qualitative data, let's verify with such data, as they do with quantitative data" (Glaser & Strauss, 1967, p. 16). Quantitative verification then put pressure on sociologists to clarify and codify all research operations--which leads to systematization.

Glaser and Strauss took the position that:

> there is no fundamental clash between the purposes and capacities of qualitative and quantitative methods of data. What clash there is concerns the primacy of emphasis on verification or generation of theory--to which head discussions on qualitative versus quantitative data have been lined historically. We believe that each form of data is useful for both verification and generation of theory, whatever the primacy of emphasis. (Glaser & Strauss, 1967, p. 18)

> In many instances, "both" forms of data are necessary--not quantitative used to test qualitative, but both used as supplements, as mutual verification and, most important for us, as different forms of data on the same subject, which, then compared, will each generate theory. (Glaser and Strauss, 1967, p. 17)

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Down-to-earth qualitative research was done at the University of Chicago during the period from the 1920s to the 1950s. However, only in the last 16 years, since the publication of The Discovery of Grounded Theory in 1967, has the grounded theory research method been developed for use in systematized research efforts (Glaser, 1978, p. 2).

Nature

The grounded theory method can be easily used as a general method of analysis with any form of data collection--survey, experiment, case study--even though it is uniquely suited to field work and qualitative data. The grounded theory method combines and integrates data collection; it provides a method for investigating previously unresearched areas and a new point of view in familiar situations (Stern, 1980, p. 20).

The transcending nature of grounded theory makes the researcher more sensitive to his data--where to collect more data and where to take them conceptually. No matter how far the researcher goes in generating theory, it appears as merely "openers" to what he sees that could lay beyond (Glaser, 1978, p. 22).

In Theoretical Sensitivity, Glaser stated:

> The grounded theorist is not a theoretical serf. He is merely a theorist among theorists, trying to generate good ideas that fit and work, placing other sociologists and defying them, claiming analytic freedom, and learning the respect and recognition worthy of this

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> theory and its contribution. He claims this freedom in a field that paradoxically, readily gives credit of all ideas to another, as if one had no idea (or right to one) until it came from some other. (Glaser, 1978, p. 9)

However, it has been discovered in grounded theory methodology that the researcher using an emergent fit soon goes beyond an originator's idea in many unanticipated, complex ways and therefore leaves the originator far, far behind. To further explain this, Glaser (1978) defined "emergent" fit as the process of refitting the categories to the data they seem to indicate, as new categories come into view (p. 41).

The grounded theorist does not always have to look for areas that are untouched by other theory, so as to ensure the originality of his theory. Glaser stated:

> It is a joy to blaze a new theoretical trail into an untouched area of inquiry--safe, too. But we have found in doing studies in well-trodden fields that there is still quite enough space for new work, if it is grounded. New categories are always generated which increase the understanding of and traction over the area. And most importantly, a well done grounded theory will usually, if not invariably, transcend diverse previous works while integrating them into a new theory of greater scope than extant ones. This is a useful contribution. (Glaser, 1978, p. 10)

The grounded theorist discovers that in generating good ideas it is what he does say that matters, not what he doesn't say. The researcher has to work with what data he has; he cannot work with what data he doesn't have. The end result is that he can claim only what he did. The ideas that resulted are important because of their theoretical

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power. However, the ideas that did not emerge because of lacking theoretical importance account for nothing in the data.

Glaser (1978) stated:

> To be sure there will always be gaps. If his colleague is pointing out a wisdom, not a whim, the analyst merely scans his data for indicators and comparisons and may generate a similar new category or a property of a category that corresponds to the gap. (p. 10)

Glaser looked upon this "gap" or "misses in the data" as lending itself to the possibility of growth. As he stated, "misses are also possibilities in research or teaching to the person who sees them, not an occasion to down the author for more coverage" (Glaser, 1978, p. 10).

To help explain the nature of grounded theory methodology, one must compare the methodological characteristics of "traditional" research and "naturalistic" research, of which grounded theory is a part.

Comparisons

Guba and Lincoln (1983) examined the characteristics or "postures" of "traditional" and "naturalistic" research (p. 65). The second part. a table from their book (pp. 72-76), depicted the following postures (see Table 1):

1. Instrument.
2. Timing of the specification of data collection and analysis rules.
3. Design.

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Table 1

Derivative Postures of the Scientific and Naturalistic Paradigms

Postures about	Paradigm: Traditional	Paradigm: Naturalistic
General Characteristics		
Preferred techniques	Quantitative	Qualitative
Quality criterion	Rigor	Relevance
Source of theory	A priori	Grounded
Questions of causality	Can x cause y?	Does x cause y in a natural setting?
Knowledge types used	Propositional	Propositional and tacit
Stance	Reductionist	Expansionist
Purpose	Verification	Discovery
Methodological Characteristics		
Instrument	Paper-and-pencil or physical device	Inquirer (often)
Timing of the specification of data collection and analysis rules	Before inquiry	During and after inquiry
Design	Preordinate	Emergent
Style	Intervention	Selection
Setting	Laboratory	Nature
Treatment	Stable	Variable
Analytic units	Variables	Patterns
Contextual elements	Control	Invited interference

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4. Style.
5. Setting.
6. Treatment.
7. Analytic units.
8. Contextual elements.

Instrument

The scientific inquirer is likely to develop a paper-and-pencil test or questionnaire or to use a physical device for the purpose of collecting data. The researcher perhaps undergoes this development in the belief that he is an imperfect, nonobjective instrument. The naturalistic researcher, however, is much more likely to depend on himself as the instrument, perhaps because it is frequently impossible to specify with precision just what is to be assessed.

Guba and Lincoln's position was that humans as instruments have been dramatically underemployed and probably ought to be used more often. Human beings as instruments possess at least one virtue lacking in all others--judgment and empathy, along with the flexibility to be able to use it (Guba & Lincoln, 1983, p. 140).

Timing of the specification of data collection and analysis rules. Traditional inquirers can specify all the rules for data collection in advance of the inquiry. They know the hypotheses to be tested and can develop the instruments appropriate to the variables involved. In fact, the

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instruments will yield measures of known properties so that it is possible to estimate ahead of time what type of analysis should be carried out. Naturalistic inquirers, by contrast, are not allowed a priori formulation. Their data accrue in the rawest form and must be categorized after the fact.

Design. In traditional inquiries designs must be constructed before the fact. Moreover, once a design has been implemented, the design cannot be altered, since such an alteration would confound the variables and thus make a meaningful interpretation of findings impossible. Within the naturalistic paradigm a design can be specified only incompletely in advance. The design emerges as the investigation proceeds. Also, the design is in constant flux as new information is gained and new insights are achieved.

Style. Within the traditional realm, the style has been one of intervention--the independent and dependent variables are isolated and the context is arranged so that the variables, and only these variables, can account for whatever findings emerge. Such situations, better termed experimental, have the advantages as rigor, but also the disadvantage of loss of relevance. In comparison, the naturalistic researcher depends on selection. They sift through a variety of naturally occurring events without intervention.

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Setting. Traditional researchers lean toward the laboratory setting (for control), while naturalistic researchers prefer to conduct their investigations in natural settings. Thus, the laboratory is in essence a context-free environment.

Treatment. The traditional researcher conceptualizes an entity being evaluated--for example, a new school curriculum--as a "treatment." However, the concept of treatment is unknown to the naturalistic researcher, since it implies some form of manipulation or intervention.

Analytic units. The analytic unit of the traditional realm is the variable, and all relationships are expressed as between variables or systems of variables. By contrast, the naturalistic realm instead emphasizes the complex patternings that are observed in nature.

Contextual elements. Traditional inquirers seek to control all extraneous elements that can distract them from the phenomena of central interest or confuse the effects of those phenomena. Naturalists, however, actually welcome interference so that they can better understand "real world events" and sense their patterns. Guba and Lincoln described the naturalistic researcher as one who wants to know how the entity being evaluated works in the worst of all possible worlds (Guba & Lincoln, 1983, pp. 72-75).

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Further, Phyllis Noerager Stern, a proponent of grounded theory research, also stated that grounded theory methodology differs from the more traditional methodologies in the following ways:

> 1. The conceptual framework develops from the data rather than from previous studies, although previous studies always influence the final outcome of the work. Therefore, a review of related literature follows rather than precedes the process of data collection.
> 2. The researcher tries to discover dominant processes in the social scene rather than just describing the unit being studied.
> 3. Each piece of data collected is compared with every other piece of data rather than comparing totals of indices. This comparison is known as "qualitative comparative analysis." . . . Comparative analysis entails checking one piece of data with other pieces of data until concepts begin to emerge and interrelationships among the concepts can be established.
> 4. The collection of data may be modified according to the advancing theory. For example, false leads can be dropped or more questions can be asked when it seems necessary to do so.
> 5. Rather than follow a series of linear steps, the researcher is involved in several research processes at once. For example, the researcher examines the data as they arrive, begins to code, categorize, conceptualize, and writes the first few thoughts concerning the research report almost from the beginning of the study. (Stern, 1980, p. 21)

Because grounded theory methodology allows the continuous integration of newly acquired data, it is ideally suited to the interacting nature of field research. Increasingly, this methodology has been recognized as a viable and useful approach for conducting research in the educational field.

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Use of Grounded Theory

Guba and Lincoln posed the following question concerning which research method is best--the traditional approach or the naturalistic approach (grounded theory)--in education:

> It is likely that question can be answered only in the specific terms of a particular inquiry; some questions can be better understood within a physiological framework and thus call for a scientific paradigm, but others are more properly understood as mental manifestations and therefore require a naturalistic paradigm. But these grey areas, troublesome as they may be, are not sufficiently frequent to undermine the high probability that the naturalistic paradigm will be found preferable in the large majority of behavioral inquiries and, most assuredly, in the large majority of educational evaluations. . . . Field studies are called for, and field studies cannot be carried out experimentally but only naturalistically. (Guba and Lincoln, 1983, p. 82)

Robert G. Owens stated in his article, "Methodological Perspective: Methodological Rigor in Naturalistic Inquiry: Some Issues and Answers," that since the 1950s the so-called "theory movement" has been popular in educational administration. He further explained that a major factor in the "theory movement" was the recognition that the social and behavioral sciences had much to contribute to the study of administration--not only theory, concepts, and knowledge drawn from these sciences, but also their research traditions (Owens, 1982, p. 2).

Further, in the book, Theoretical Sensitivity, Glaser (1978) stated that two of the four new directions in

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grounded theory are health education and evaluation research. Glaser gave statements of several authors who have taken grounded theory in new directions.

Glaser summed up his opinions about new directions for grounded theory in Theoretical Sensitivity by saying:

> New uses and directions of grounded theory are just beginning to be proliferated. Grounded theory is a general methodology for generating theory. It is not wedded to sociology or social science--let alone to a school or position in sociology. It is useful in any field that wishes to generate an inductive theory from systematically collected data, whether qualitative or quantitative. And generated theories which fit, work and are relevant have potentially many specific uses, for many fields. (Glaser, 1978, p. 158)

Casey (1984), Wilson (1981), and Lariviere (1984) used grounded theory in their studies relating to business. Casey (1984) applied grounded theory to generate substantive theories about the perceived personal skills, knowledge, and attitudes needed by beginning clerical workers for successful job performance. Wilson (1981) similarly used grounded theory to help generate theories about the perceived managerial skills, knowledge, and attitudes needed by selected certified administrative managers in the San Francisco Bay area for effective job performance. The objective of Lariviere's (1984) study was to generate theories about the types of needed communication tasks and competencies insurance marketing representatives perceived to be important in their functions as marketing representatives.

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Glaser also added to the researcher's rationale for using grounded theory methodology as discussed below:

> Why bother generating grounded theory when in each area of life there are people in the know? These people in the know are so knowledgeable that they think they can predict, explain, and understand just about everything that happens in their terrain, field, area, or world. They are the leaders and consultants; they are their and their colleague's own sociologists. They run the world on their "know." In front of these people a sensitive sociologist (or educator) is humble. He can never know as much with his methods and research. To act as if a sociologist (or educator) knows more, is an effrontery to the knowledgeable person. But he can contribute a great deal by providing the man in the know with substantive theory.
>
> With substantive theory the man in the know can start transcending his finite grasp of things. His knowledge which was heretofore not transferable, when used to generate theory, becomes transferable to other areas well known to him. (Glaser, 1978)

Grounded theory can be applied and adjusted to many situations with sufficient exactitude to guide the researcher's thinking, understanding, and research--which leads us to the issue of the validity of grounded theory research.

Validity

Validity in the grounded theory research method is obtained through accurately depicting the thoughts and ideas of the individual being observed or interviewed. Therefore, the validity is based on the accurate interpretations the researcher applies to the data collected. The interpretations then become theories, which are grounded or solidly rooted in the data.

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That theoretical relevance is the basic idea of generating theory was stated by Glaser and Strauss (1978):

> A belief in tests of significance can also, in the process, direct one's attention away from theoretical relevance of content toward confusing statistical significance with theoretical analysis. Merely being statistically significant does not mean that a relationship is or should be of theoretical relevance. Such relevance depends on the meaning of the association as it relates to the theory. Also, the statistical analysis methods (i.e. analysis of variance) are not theoretical analyses. They are merely techniques for arriving at a type of fact. It is still up to the analyst to discover and analyze the theoretical relevances of these facts. (p. 5)

To further the researcher's authenticity, Guba and Lincoln described the term triangulation as a process of "comparing and contrasting information drawn from different sources, and/or determined by different methodologies" (Guba & Lincoln, 1983, p. 116).

Triangulation

Triangulation is useful for verifying information on the same event from different actors or participants and also produces more confidence in the data generated by different methodologies. In his book, Unobtrusive Measures, Webb (1966) contended that once a proposition has been confirmed by two or more measurement processes, the uncertainty of its interpretation is reduced greatly. Therefore, as he concluded, triangulation, though difficult, is very much worth doing because it makes data and findings credible.

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Denzin summarized triangulation thus:

> Triangulation forces the observer to combine multiple data sources, research methods, and theoretical schemes in the inspection and analysis of behavioral specimens. It forces him to situationally check the validity of his causal propositions. . . . It forces him to temporarily specify the character of his hypothesis. . . . It directs the observer to compare the subject's theories of behavior with his emerging theoretical scheme. (Denzin, 1971, pp. 166-82).

Guba and Lincoln cautioned that obviously the naturalistic investigator cannot place very much confidence in single observations or deductions. Each observation will contain its own error. However, when various bits of evidence all tend in one direction, that direction assumes far greater credibility (Guba & Lincoln, 1983, p. 107).

In sum, the basic criterion for generating theory is theoretical relevance, and it is up to the researcher to sample his or her quantitative findings on this basis. Guba and Lincoln (1983, p. 122) and Owens (1982, p. 15) also stated that an "audit trail" will verify the researcher's data even more so. The audit trail is discussed later in this chapter.

Process

Maxwell and Maxwell (1981) condensed grounded theory methodology into five steps: (a) collection of empirical data, (b) concept formation, (c) concept development, (d) concept modification and integration, and (e) production of the research report.

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Glaser (1978) stated that the route from data collection to the finished writing is a process formed by taking double-back steps. As one moves forward, one constantly goes back to all or some of the previous steps.

The steps involved in this study were a synthesis of the methods and procedures suggested by Glaser, Strauss, Stern, Guba and Lincoln, and Maxwell and Maxwell. In outline and flowchart form, respectively, Figures 1 and 2 illustrate the steps in grounded theory research methodology that were followed in this study. The steps and procedures will be described as they related to this study. Similar illustrations depicting the Delphi technique are presented later in this chapter, along with the procedures used in the study.

The first step in the grounded theory research process is the collection of empirical data.

Collection of Empirical Data

In employing grounded theory methodology, the researcher must first identify the population under study and then proceed to the collection of the data. The methods used for data collection may vary. Data may be collected from interviews, observations, documents, meetings, raw notes from interviews and observations, communiques, or from a combination of these sources (Guba & Lincoln, 1983, p. 228; Stern, 1980). Researchers may begin their field work

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I. COLLECTION OF EMPIRICAL DATA

  A. Identification of the Population
  B. Collection of Research Data

II. CONCEPT FORMATION

  A. Coding
    1. Types of coding
      a. Substantive
      b. Theoretical
    2. Rules for Coding
      a. Explaining
      b. Analyzing
      c. Coding
      d. Memoing
  B. Categorizing

III. CONCEPT DEVELOPMENT

  A. Reduction of the Data
  B. Selective Sampling of the Literature
  C. Selective Sampling of the Data
    1. Theoretical saturation
    2. Emergence of properties

IV. CONCEPT MODIFICATION AND INTEGRATION

  A. Theoretical Memos
    1. Ideas
    2. Freedom
    3. Sortable
  B. Theoretical Sorting
    1. Rules of sorting
    2. Generation of hypotheses

V. PRODUCTION OF THE RESEARCH REPORT

<u>NOTE</u>: Data collection, coding, and analysis and writing are going on simultaneously in an interactive fashion

Figure 1. Outline of steps in grounded theory research.

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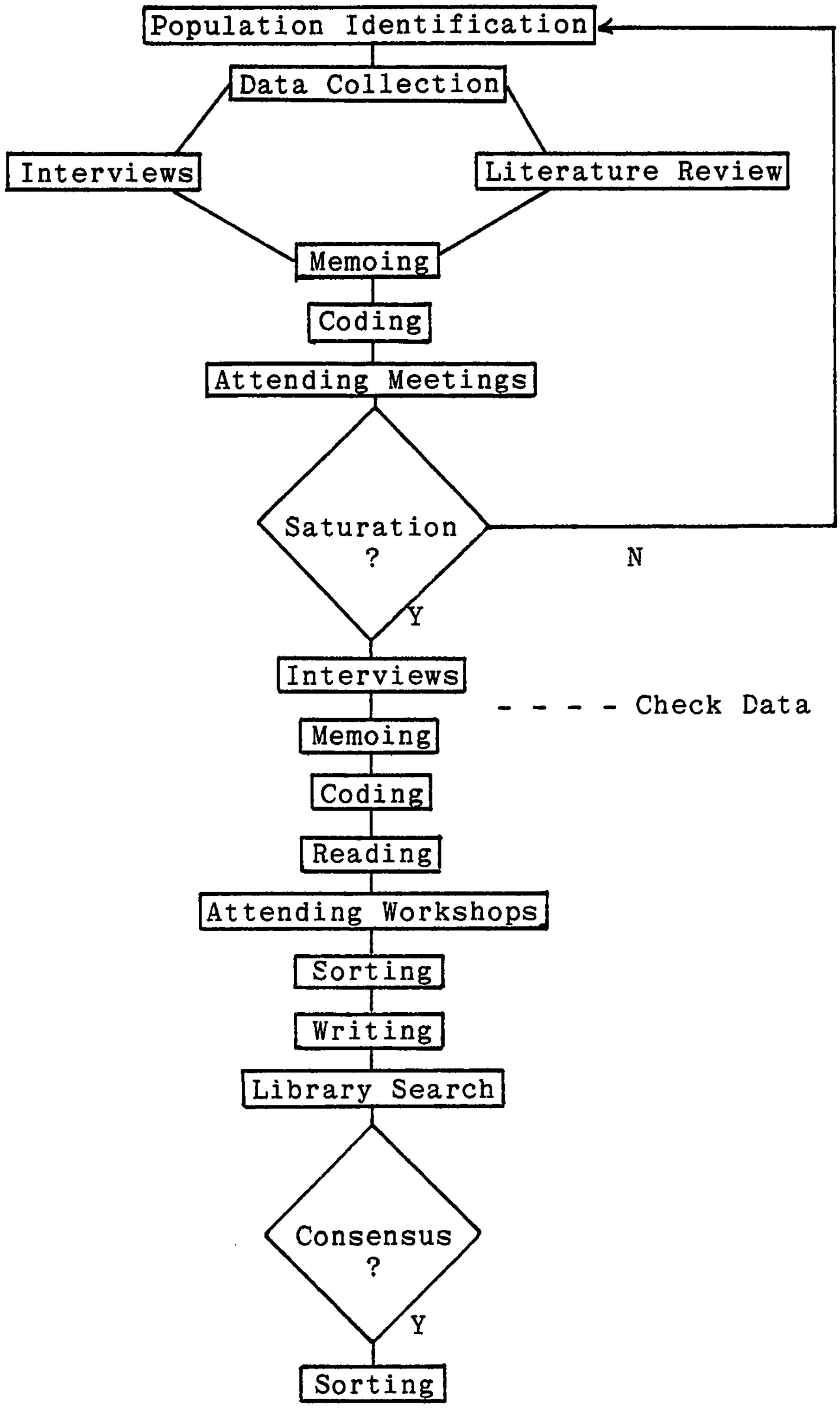

Figure 2. Flowchart of steps in grounded theory research.

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by attending special events that pertain to the study or talking to knowledgeable people in the area relating to the study to obtain leads to track down more data.

The sampling process in grounded theory research differs from the sampling process in other types of research methodologies. The researcher does not limit the data collection to a predetermined set of sources. According to Glaser:

> the analyst can go anywhere and talk and listen to anyone and read anything with virtually no problem in mind and little training in a perspective, provided he is capable of conceptualization. (Glaser, 1978, p. 44)

Glaser (1978) stated that researchers with some training find it more comfortable to enter the field with a question or a problem in mind, a general perspective, and some beginning concepts and field-research strategies. Although the researcher is being less than completely open when he enters a field with a general perspective or concept, he can still be quite receptive to the data; several researchers do start their field work with initial strategies (Glaser, 1978).

Identification of the Population

The concept of a statistically valid "sample population" does not apply to grounded theory. The groups or individuals selected in the sampling process are based on their ability to contribute to the development of the theory. As suggested by Glaser and Strauss (1967):

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> The basic criterion governing the selection of comparison groups for discovering theory is their theoretical relevance for furthering the development of emerging categories. The researcher chooses any groups that will help generate, to the fullest extent, as many properties of the categories as possible, and that will help relate categories to each other and to their properties. (pp. 49-50)

Glaser and Strauss (1967) further recommended:

> Since groups may be chosen for a single comparison only, there can be no definite, prescribed, preplanned set of groups that are compared for all or even most categories (as there are in comparative studies made for accurate descriptions and verifications). In research carried out for discovering theory, the sociologist cannot cite the number and types of groups from which he collected data until the research is completed. (pp. 49-50)

Generating relevant theories from data is a paramount objective in qualitative research, and the researcher could not tell beforehand how many professionals or "policy makers" would be interviewed or to what degree each one would be studied, nor how long the interview would take (Glaser, 1978). Therefore, interviewees who determine or control educational policy were chosen as they emerged and were recommended to the researcher by those who already had been interviewed.

The researcher's efforts to collect data from the interviewees spanned a 3-month period. In March of 1984, the researcher conducted the first interview on a pilot basis. Through the initial interview, the researcher tested and refined questions used in future interviews. The pilot study helped the researcher determine some of the plans for

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computer science and those responsible for its implementation. Information from the pilot study was used as a guide for the open-ended interview questions.

Following the initial interview, the recipients of the interview were determined as follows:

1. As those who "control or determine educational policy" were identified, a letter explaining the purpose of the study was sent (Appendix A). Permission was also requested for their participation in the interview. Glaser (1978) posed the basic question in theoretical sampling as: "What groups or subgroups does one turn to next in data collection, and for what theoretical purpose?" (p. 47).

2. A follow-up phone call determined if the prospect was willing to participate in the study. If so, the name of the participant was requested.

3. Once permission was granted from the participant, an interview was scheduled. A follow-up phone call verified the date and time of the interview.

4. Thank-you letters followed the interview (Appendix B).

A letter requesting an interview was then mailed to the local school district superintendent, a local school principal, a school curriculum superintendent, a computer science specialist of a local school district, the Arizona governor's aide on education, and an Arizona State University administrative services professor (computer). The

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principal of the local high school referred his letter to the math/computer chairperson of his school; the curriculum superintendent referred his letter to a computer science specialist in his district.

After the initial interviews were completed, the researcher continued to interview an additional five participants who responded favorably to a phone call and letter. The proposed participants were the superintendent of a high school district, a computer/math chairperson, a computer science specialist, the governor's aide on education, and an Arizona State University computer administrative services professor.

A letter requesting an interview was mailed to the president of a local governing board who had been recommended by one of the interviewees. Also, a letter requesting an interview was mailed to the president of the State Board of Education, who delegated her letter to the executive director of the Arizona School Boards Association. Theoretical saturation was reached at this point concerning some categories and their properties. A letter was then mailed to an Arizona senator for education requesting an interview.

As suggested by Glaser and Strauss (1967):

> The criterion for judging when to stop sampling the different groups pertinent to a category is the category's theoretical saturation. Saturation means that no additional data are being found whereby the sociologist can develop properties of the category.

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> As he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated. (p. 61)

Therefore, interviews were also conducted with the president of a local governing board, the executive director of the Arizona School Boards Association, and the senator for education. In all, nine participants contributed their comments and perceptions, as well as their time and interest in the researcher's study. However, a participant dropped out after the first Delphi questionnaire was mailed. Her reasons are detailed in Appendix C). Therefore, eight participants were involved in the study thereafter.

Collection of the Research Data

The initial interviews were conducted in March 1984 to determine the parameters of the unstructured interview technique recommended by Glaser and Strauss (1967). The authors stated that open-ended conversations with no time limit allow interviewees freedom to communicate feelings and attitudes, as well as factual information about the issues. The interview was deemed the most appropriate data collection technique.

Bingham and Moore (1959) stated that the interview process is appropriate for obtaining facts, whether of personal history, opinion, or attitude, which only the person being interviewed can supply. Guba and Lincoln (1983) stated the following concerning the interview as a

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tool for data collection: "Interviewing is the preferred tactic of data collection when in fact it appears that it will get better data or more data or data at less cost than other tactics" (Guba & Lincoln, 1983, p. 155). How one talks, to whom one talks, and for what purpose one talks are all important to the researcher.

Although nine participants had been contacted, levels of saturation of the data were reached after six interviews. Following the initial interview, the remaining eight interviews were conducted from April through June of 1984. The researcher reintroduced the study and assured each participant of confidentiality. The interview lasted approximately 2 hours. The interviews were taped when there was no objection from the interviewee. In all cases, notes were written or recorded directly after the conclusion of the interview.

Lofland (1971) expressed belief that the unstructured interview is designed to discover what kinds of things are happening, rather than to determine the frequency of predetermined kinds of things that the researcher already believes can happen.

The researcher becomes so attuned to the surroundings, attitudes, thoughts, and ideas of the interviewee that during this state, theoretical sensitivity guides the researcher in such a way that significant events can be noted and recorded. Douglas (1976) asserted that the

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interviewer is both a part of the situation and the instrument through which recording occurs.

A demographic information sheet (Appendix D) was prepared that served as background data for research interpretation.

Glaser and Strauss (1967) pointed out that the researcher goes out of his way to look for groups that stretch diversity of data as far as he possibly can, just to make certain that saturation is based on the widest possible range of data on the category (p. 61).

The researcher asked each interviewee of any meetings or other activities pertaining to the study she might attend. The researcher was immediately invited to attend a meeting of the Governor's Task Force for Computers in Education.

A series of ongoing events the researcher attended and time involved are illustrated in Table 2. The ongoing events were also coupled with ongoing research of related literature, and always keeping "an ear open" for any other materials pertinent to the study.

Concept Formation

In the concept-formation state, a tentative conceptual framework is generated using the data as reference. The researcher attempts to discover the main problems in the social scene from the point of view of the subjects that

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Table 2

Events Attended by the Researcher

Event	Hours Involved	Date
Governor's Task Force on Computers in Education (initial meeting)	2.5	5/3/84
Second meeting of the task force	3.0	5/22/84
School Board Meeting, Tempe Union High School District (about computers)	3.0	5/24/84
"New Directions in Keyboarding" (workshop by Dr. L. Erickson, UCLA), Tempe, Arizona	1.0	6/30/84
Faculty meeting at Mountain View High School, Mesa, Arizona (about use of computers; by Superintendent Zaharis)	1.0	12/5/84
"Computer Graphics in Business Education" (Tempe, Arizona; Dr. Steve Golen)	1.0	2/26/85
Computer Showcase Expo, Phoenix, Arizona	2.0	3/9/85
Total hours	13.5	

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participated in the study, and how these subjects dealt with the problem, as suggested by Stern (1980). The researcher makes a choice regarding the relative salience of the problems presented in the scene under study by carefully comparing all data as they are received.

In this study, the research was directed at discovering the content and guidelines of computer science. At this stage, terminology, curriculum, and support essentials were considered to be the central focus or framework for the study.

Two key processes highlight this phase of analysis: coding and categorizing the data.

Coding

According to Glaser (1978), a code is a word or phrase selected by the researcher to capture the essence of meaning in each unit of analysis. Coding helps the analyst fracture the data, then conceptually group the data into codes. The code then becomes the theory that explains what is occurring in the data. Coding helps the researcher to become free from the empirical bond of the data; it allows the researcher to transcend the empirical nature of the data while at the same time it conceptually accounts for the processes within the data in a theoretically sensitive way (Glaser, 1978). According to Guba and Lincoln (1983), coding is the process whereby raw data are systematically

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transformed and aggregated into units that permit precise description of relevant content characteristics.

Types of coding. Glaser (1978) referred to coding as the generation of ideational codes--the building block of theory. Substantive and theoretical are the two types of codes to generate.

Substantive coding includes open coding and selective coding. Open coding is coding the data in every possible way. Glaser (1978) phrased this as "running the data open." The analyst codes for as many categories as might fit. The researcher must generate an emergent set of categories and their properties that fit, work, and are relevant for integrating into a theory. Open coding allows the analyst to see the direction in which to take the study by theoretical sampling, before the researcher becomes selective and focuses on a particular problem. Thus, when the researcher does focus, he is sure of relevance. Open coding teaches the researcher the kinds of categories that can handle the data theoretically, so that the researcher knows how to code all data. If all data cannot be coded, the emerging theory does not fully fit and must be modified (Glaser, 1978).

The substantive coding emerged as follows:

- Application of computers, not programming, should be taught

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- Fear of using computers
- Computers not a passing fad
- Autonomy
- Control issue
- Disparity in school districts
- Computer science not clearly defined
- Financing of computers/financial commitment
- Integration of computers/tool
- BASIC--sloppy
- Advanced placement test
- Programming at high school level
- Different departments to teach computer science
- Personnel to teach computer science
- Policy makers
- Skills
- Keyboarding
- Leadership
- Local level should control
- Mandates from the state
- School board rules/local level
- Teachers, principals, administration
- Separation of departments
- "Turfism" problem
- In-service training needed
- No training for teachers now
- Nation at Risk report vague

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- Elementary/junior high applications
- Fundamentals important

Theoretical coding is the conceptualization of how the substantive codes may relate to each other as hypotheses to be integrated into a theory. As the data become available, the researcher codes the material for conceptual ideas. This process involves going over the data line by line in order to identify what is happening in the data. Glaser (1978) also suggested that the researcher, while coding an incident for a category, compare the incident with the previous incidents in the same and different groups coded in the same category; this method is known as the constant-comparison method.

The two types of coding frequently go on simultaneously; however, often the researcher will focus on substantive coding when discovering codes within the data and more on theoretical coding when theoretically sorting and integrating his memos. The theoretical coding consisted of the following, which helped the researcher conceptualize ideas:

- Computer usage
- Content
- Departmentalization
- Definition
- Financing
- Support essentials

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- Computers in the curriculum
- Language/programming
- Personnel
- Software
- Training
- Vagueness of report

Glaser (1978) stated:

> It is in the beginning with open coding--and a minimum of preconception--that the analyst is most tested as to his trust in himself, in the grounded method and in his skill to use the method and as to his ability to generate codes and find relevance. Many of our students suffer the initial anxiety that, in fact, nothing will emerge because they doubt their skill. They soon discover the opposite. Constant comparison (of data) literally forces generation of codes. (p. 57)

In order for the coding process to occur, certain rules must be followed.

Explaining data. The researcher needs to ask the following questions from the beginning of the study: (a) These data concern a study of what? (b) What is happening in the data? In this study, the latter question was asked by the researcher after the initial interview. The researcher was able to open-code the data and develop broad categories that had begun to emerge from the data collection.

Analyzing data. The researcher needs to analyze the data line by line, constantly coding each sentence. This

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line-by-line approach forces the researcher to verify and saturate categories, thus creating an emergent fit.

In this study, the researcher analyzed the data line by line, constantly coding each phrase or sentence. For example, the researcher coded "software," "teacher training," "concerns," "level of instruction," "financing," and "programming vs. applications" under the category of support essentials. As the researcher analyzed the different responses to the question, "What problems do you see now or will foresee concerning the new course, computer science?" the researcher found the responses of "software," "teacher training (certification, skills, course work, qualifications)," "concerns," "level of instruction," "financing," and "programming vs. applications" to be frequent. Thus, by constantly comparing the data collected, the researcher was able to determine that those "properties" were considered important.

Coding data. The researcher must do all of his own coding in order to generate theory. A coder hired for this task has no stake in the analysis and therefore has little motivation to pursue theoretical notions necessary for theoretical completeness. In this study, the researcher did all of the coding. The researcher found that performing the coding process was most effective when done immediately

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after the interview--while the data were fresh in the interviewer's mind.

Memoing data. The researcher must always interrupt coding to memo an idea so that ideas, a necessary ingredient for theory development, are not forgotten. In this study, the researcher memoed any thought or idea that came to mind before, during, and after the interview.

Categorizing

Stern (1980) said:

> Considerable similarity exists between the treatment of data in the continuous comparative method and in the computer method of factor analysis. However, the investigator's brain serves in place of the computer. Data are coded, compared with other data and assigned to clusters or categories according to obvious fit. (p. 21)

Glaser and Strauss (1967), wrote: "A category stands by itself as a conceptual element of the theory. A property in turn, is a conceptual aspect or element of a category" (p. 23).

Guba and Lincoln (1983) enumerated five canons of good category:

> First, categories must "reflect the purposes of the research": the design must include conceptual definitions.
>
> Second, categories must be exhaustive; that is, it must be possible to eventually place each datum in one category or another.
>
> Third, categories should be mutually exclusive; that is, no single content datum should fit into more than one cell or category.

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> Fourth, categories must be independent. The assignment of some piece of data should not in any way affect the classification of other pieces of data.
>
> Fifth, categories must be derived from a single classification principle; levels of the analysis that are conceptually different must be kept separate. (p. 243)

Further, the categories should emerge from the data; in this way, the classification system would be well grounded. In this study, for example, "terminology" formed the property of the category "definition." "Definition," "curriculum," and "support essentials" emerged as categories.

Concept Development

Three major steps--reduction of the data, selective sampling of the literature, and selective sampling of the data--serve to both expand and intensify the emerging theory in the concept development state. The first two processes could be considered as inductive because they involve searching for clues; the third process can be considered as deductive because the concepts, already formed, are now verified (Stern, 1980).

In order to understand concept development in the grounded theory research process, it is important, according to Glaser (1978) to understand that:

> in generating theory it is not the fact upon which we stand, but the conceptual category (or a conceptual property of the category) that was generated from it. In discovering theory, one generates conceptual categories or their properties from evidence; then the

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> evidence from which the category emerged is used to illustrate the concept. The evidence may not necessarily be accurate beyond a doubt, . . . but the concept is undoubtedly a relevant theoretical abstraction about what is going on in the area studied. (p. 95)

The processes of reduction of the data, selective sampling of the literature, and selective sampling of the data are detailed below.

Reduction of the Data

At this point in the research, the researcher has developed a number of different categories. Each category has been compared with other categories to see how they connected. The researcher then begins to ask: "Is there some umbrella under which all these categories fit?" (Stern, 1980). For example, the question of what should be the guidelines or the content of "computer science" become linked, or formed under the general category "curriculum."

Selective Sampling of the Literature

Stern (1980) wrote: "Here the existing literature, used as data, is woven into the matrix consisting of data, category, and conceptualization. Literature is carefully scrutinized, and the concepts compared as data" (p. 23).

In this study, eight major educational reports and their support for computers in the curriculum fit comfortably with the emerging theory, and became supporting data for the present study. Also, the attempts of some high

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schools to integrate computer science in the curriculum also helped the researcher in proving that there is no direction for computer science.

In relation to the review of literature, Stern (1980) suggested that "although a review of research is in order before a study is begun, a second search is now necessary as processes begin to emerge" (p. 23).

Following Glaser and Stern's approach to reviewing the literature, the data in this study were collected from the field first. The data collection was followed by analyzing the data, with generation of theory beginning to emerge. When the theory seemed sufficiently grounded and developed (after nine interviews over a 3-month period) then the literature in the field was reviewed and the theory related to it through integration of ideas. The theory was not likely to be preconceived by preempting concepts by waiting to review the literature until the emerging theory was sufficiently developed (Glaser, 1978).

Selective Sampling of the Data

The researcher may collect additional data at this time in a selective manner for the specific purpose of developing the hypotheses and identifying the properties of the main categories. This process, known as theoretical sampling, is the collection of data to advance the theory (Stern, 1980, p. 22).

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Glaser (1978) stated that the researcher should have certain qualifications to participate in selective theoretical sampling. He said "the researcher should also be theoretically sensitive--by training--so he has the tools within him to self consciously conceptualize and formulate a theory as it emerges from the data" (p. 36). The process of theoretical sampling took place when the researcher asked: "What is computer science?" "What do other authorities say is computer science?" "Why is 'computer science' so vague?" These questions were asked to identify the properties of the main category, "definition."

Stern (1980) suggested:

> It can be seen that selective sampling is a deductive process. The conceptual framework, developed from the data, is now tested by collecting data which proves or disproves the framework hypotheses. Concepts which cannot be supported by the data are dropped. It is unlikely that the conceptual framework would be discarded entirely at this point, but it may be altered, expanded, or juggled. (p. 21)

Theoretical saturation. Theoretical saturation is the point in time when no new information is being received that further explains that particular aspect of the emerging hypotheses (Stern, 1980).

Concerning theoretical saturation,

> as he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated. He goes out of his way to look for groups that stretch diversity of data as far as possible, just to make certain that saturation is based on the widest possible range of data on the category. (Glaser & Strauss, 1967, p. 61)

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In this study, theoretical saturation was reached after six of the nine interviews were conducted.

Concept Modification and Integration

Two processes dominate this stage: theoretical memo writing and theoretical sorting. In this stage, the researcher compares a concept to a more highly developed concept to discover their relationship; and, once again, related concepts are compared with the data for validation (Stern, 1980, p. 23). Stern admonished:

> The reader is reminded here that continuous comparative analysis is a matrix operation rather than a linear endeavor. Therefore, although stage four is a wrapping-up process, it will have proceeded in concert with other phases. (p. 22)

Theoretical Memos

Glaser suggested that the core stage in the process of generating theory is the writing of theoretical memos. If the analyst skips this step by going directly from coding to sorting or writing, he is not conducting grounded theory. Glaser (1978) stated, "Memos are the theorizing write-up of ideas about codes and their relationships as they strike the analyst while coding" (p. 83).

Memos lead to ideas. Memoing is a constant process that begins when first coding data and continues through reading memos or literature and sorting and writing. Memoing should continue until the very end of the procedure

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in grounded theory research. The writing of memos captures the "frontier of the analyst's thinking" as he codes, sorts, or writes his data (Glaser, 1978, p. 83).

Ideas. Glaser (1978) stated that the ideational development in memos accomplishes at least five important aspects of generating theory:

1. It raises the data to a conceptualization level.

2. It develops the properties of each category that begin to define it operationally.

3. It presents hypotheses about connections between categories and/or their properties.

4. It begins to integrate these connections with clusters of other categories to generate the theory.

5. It begins to locate the emerging theory with other theories with potentially more or less relevance.

When the researcher writes memos or ideas, the analyst draws out properties of the descriptive data collected. Glaser (1978) wrote:

> Drawing out the theoretical properties of the code eventually saturates the code by helping define boundaries of it, the empirical criteria on which the code rests, the conditions under which it emerges or is evident, and its theoretically coded connections and significance to both the data and the major theoretical themes in the data. (p. 85)

Freedom. According to Glaser (1978) a memo can be a sentence, a paragraph, or a few pages. Therefore, good

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prose is irrelevant. The purpose of memos is to record ideas only (p. 84).

Memos were written as phrases, not paying any attention to correct English structure. For example, under the heading "vagueness of report," "didn't state content of computer science," "recommendation written as if computer literate," and "not clearly defined" were some of the memo phrases used in this study.

The freedom of memoing permitted the researcher to work faster, by having to think only of the idea, and not its presentation. Stern (1980) asserted that ideas for analysis occur at an uneven pace and at unlikely hours. The researcher found this to be true. As soon as an idea would arise in the researcher's mind, quickly the memo pad was sought.

Sorting. The sorting process enables the researcher to cluster concepts. Memos are sorted into piles, and the writing of the report becomes a write-up of memos. Glaser (1978) stated that memos cannot be sorted by machine because they conclude on emergent meanings unknown beforehand (p. 87). The sorting process leads to "theoretical" sorting, or an integration of the theory.

Theoretical Sorting

Theoretical sorting, according to Glaser (1978), is a crucial step in formulating grounded theory. The objective

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of theoretical sorting is to create an integrated model by which to write the theory, since sorting forces connections between categories and properties.

At this stage, the researcher has almost completed the fieldwork, and coding is almost saturated. The researcher might be tempted to skip sorting and go directly to writing. However, if the researcher skips the sorting process, it is likely that there will still be a theory, but it will be linear and less than fully integrated (Glaser, 1978, p. 116). Performing the sorting process will allow the researcher to know where to go next if certain rules of sorting are followed.

Rules for sorting. Glaser (1978) suggested the following rules for the sorting process:

> 1. Each memo should be introduced by a title or caption which is the category or property that the memo is about. (p. 89)

For example, in the memo pad were divided the following captions: Memoing on "language," "control," "integration," "concerns," "personnel," "content," "support," "vagueness," "certification," and "training." Whenever the need arose to memo a certain idea, the researcher stopped and memoed a certain idea under the specific heading.

The second rule Glaser (1978) suggested is:

> 2. Any other category or property which appears in the memo should be highlighted or underlined, so the memo could be sorted for this concept also. (p. 90)

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The researcher did underline certain words or phrases on her memo pad. For example, "in-service training" was underlined under the category "support essentials."

Glaser (1978) wrote the third rule as:

> 3. If two categories or their properties appear in the memo, the relationship between the two should be discussed and categorized or highlighted in some way so this hypothesis could be sorted for also. (p. 90)

One theory for the repeated response "More training, especially in-service training, is needed for teachers concerning microcomputers" might be stated as "in-service training to help teachers use microcomputers in the classroom is needed."

The fourth rule stated:

> 4. Memos should be typed on at least one carbon so the researcher can easily scissor, tape, and sort, in new combinations without losing an original. (Glaser, 1978, p. 90)

However, Glaser (1978) also suggested in rule number five that:

> 5. Memos can also be put on small pieces of paper or index cards (one memo per piece) which makes them sortable. (p. 91)

The researcher in this study coded memos on yellow pads, as well as on index cards for easy sorting.

The last rule Glaser (1978) stated is:

> 6. The researcher should be psychologically prepared to sort memos wherever they may fall. (p. 91)

Glaser (1978) suggested that

> one must be reminded that a memo, like all writing, tends to become a precious set of ideas which can

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> appear inviolate to its author and sorting can easily splatter the original idea. Even if it is in favor of a better set of ideas, it may be hard to do. (p. 91)

Production of the Research Report

According to Stern (1980), the research report differs in several ways from the more familiar report of quantitative studies. Since the research report for a grounded theory investigation presents the substantive theory, the supporting data are substantiated by the researcher. Stern stated the three differences as follows: "Three such differences are the use of the literature as opposed to the method of utilization of the literature in quantitative studies, the absence of numerical data, and the use of field notes" (p. 23).

Since the researcher used grounded theory as the overall research method and the Delphi technique as one way to gather and analyze data, writing the initial draft was difficult. Glaser (1978) mentioned the problems the researcher may encounter in writing the initial draft:

> English and professional editing. The latter includes weeding out needless redundancy, clarifications of confused or mixed analysis, trimming and adding illustrations, footnoting, integrating, reintegrating, weeding out unit focus and conceptual style and other needs or sections and subsections. English editing can be hired or drafted among friends. (p. 136)

In the final stage of grounded theory methodology, writing is a write-up of piles of ideas from theoretical

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sorting. Glaser and Strauss (1967) described the process of writing:

> We also construct a theory that is readily modifiable. The analyst should underscore these points in his writing, because his writing probably will be read mainly as a fixed conceptual description, not explanation, by most readers. (p. 225)

Thus, the researcher should not write descriptive statements about people, but rather should make theoretical statements about the relationship between concepts (Glaser, 1978, p. 133).

The final step is writing the final draft. At this point, the researcher has made all the necessary changes and corrections, the final draft is ready to be typed and submitted.

The Delphi Technique

Grounded theory was chosen as the overall research method. The Delphi technique was one way used to gather and analyze data for this study.

The Delphi technique is a way of collecting and organizing opinion on a topic in an effort to produce a convergency of group consensus. This technique is accomplished through a series of three or four questionnaires dealing with a variety of future questions. A series of statements concerning the issue is formulated, and the respondents are asked to react to each according to their own perceptions. Contact is made with the respondents

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through a set of mailed questionnaires with feedback from each round of questions that is used to produce more carefully considered group opinions (Rossman and Carey, 1973). Rossman and Carey further explained that this relatively new method provides a way to gather opinions and/or information from intended participants, experts, or others in a position to render assistance regarding the problem at hand (p. 248).

Similarly, Dalkey (1967) stated that the Delphi technique is the "name of a set of procedures for eliciting and refining the opinions of a group of people" (p. 1). Dalkey stated that the basic characteristics of the Delphi procedure are as follows:

> 1. Anonymity. Anonymity is achieved by using questionnaires or other channels of communication where specific responses are not associated with individual members of the group.
> 2. Iteration with controlled feedback. Iteration consists of performing the interaction among members of the group in several stages: typically at the beginning of each stage the results of the previous stage are summarized and fed back to the members of the group, and they are then asked to reassess their answers in light of what the entire group thought on the previous round. Controlled feedback allows interaction with a large reduction in noise.
> 3. Statistical group response. Finally, the group opinion is taken to be a statistical average of the final opinions of the individual members of the group. . . . By using a statistical group opinion, group pressure toward conformity is further reduced, and probably more important, the opinion of every member is reflected in the group response. (Dalkey, 1963, pp. 8-9)

Hillestad (1977) declared that a consensus of experts is required in certain types of research, perhaps to develop criteria of some sort. However, getting the experts

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together to arrive at a consensus is impractical in terms of time and money. Conferences for the purpose of arriving at decisions about procedures, recommending courses of action, or perhaps determining characteristics of good teachers, for example, are inefficient and ineffective ways of reaching agreement on these matters. She explained that the "Delphi technique is a means of arriving at a consensus without bringing the panel together in a face-to-face situation" (p. 70).

Enzer (1969) described the Delphi technique as:

> a form of controlled conference accomplished in discrete steps. Judgments are elicited from a group, areas of consensus and dissensus are identified, reasons for extreme positions are elaborated, and judgments are re-examined in light of the earlier group consensus and the reasons given for extreme positions. Delphi conferences typically maintain anonymity among the participants, elicit all inputs simultaneously, and provide feedback to the participants at appropriate intervals. . . . The Delphi technique is highly effective in producing a converging group consensus. (p. 10)

Weaver (1971a) spoke of the Delphi technique as an "intuitive methodology for organizing and sharing expert forecasts about the future" (p. 267).

Ezell and Rogers (1978) argued that the Delphi methodology was not a technique for producing "truth" about the future, but represented consensus of opinion about "what might be" (p. 125).

The Delphi technique, also known as a needs assessment device, has been used in several research efforts.

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Background

The Delphi technique was developed by Olaf Helmer and his colleagues at the Rand Corporation in the early 1950s to obtain group opinion about urgent defense problems. The Rand Corporation conducted studies comparing face-to-face discussion against the controlled-feedback method of the Delphi technique. Results of their study confirmed the idea that "face-to-face discussion tended to make the group estimates less accurate, whereas, more often than not, the anonymous controlled feedback procedure (of the Delphi technique) made the group estimates more accurate." The Delphi technique was named by its innovators after the greatest of all Greek oracles, Apollo's Delphi Oracle.

Pfeiffer (1968, p. 82) compared the Delphi technique to a simple questionnaire procedure. He concluded that the Delphi technique was not only more successful in obtaining a consensus on many items in the questionnaire, and at least a majority opinion on others, but also improved the accuracy of these opinions.

The application of this technique to the field of education is increasing (Johnson et al., 1975).

Strauss and Ziegler stated four objectives for any Delphi exercise:

1. To explore or expose underlying assumptions or information leading to differing judgments;
2. To seek out information that may generate a consensus of judgment on the part of the respondent group;

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3. To correlate informed judgments on a topic spanning a wide range of disciplines; and,
4. To educate the respondent group as to the diverse and interrelated aspects of the topic. (Strauss & Zeigler, 1975, p. 254)

Sackman (1975) similarly noted other objectives of the conventional Delphi: (a) forecasting of specified events, long-term or short-term; (b) the generation of quantitative estimates (costs, market demands, number of users) from a set of participants; and (c) aimed at qualitative evaluations (scales of agreement, disagreement, preferences among alternatives) (p. 8).

Any study that attempts to deal with future events tends to raise concerns over the strengths and weaknesses of the technique. Rossman and Bunning (1978) noted the following strengths of the Delphi technique:

1. It avoids persuasion, leadership influences, hidden agents, personality conflicts, and other problems encountered in group decision making.

2. It allows a variety of individuals, perhaps widely separated geographically, to participate equally.

3. It provides documentation, including minority opinions.

In a discussion about the manifest and latent productivity of the Delphi technique, Mandanis (1969, p. 165) said that the output from Delphi activities need not only be a consensus, or a dissensus, on matters explored. He contended that perhaps more importantly, participation in

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Delphi would give those involved a learning experience that would not be available by any other means.

Pyke (1970) similarly claimed:

> The Delphi method seeks to preserve the advantages of the committee approach while eliminating the disadvantages. Each expert on the "committee" is dealt with separately in a sequence of "rounds" during which his anonymity is preserved. Thus the individual may give free reign to his imagination without risking his reputation. (p. 144)

He also asserted that:

> By withholding the identity of the source of a particular opinion or argument relevant to that opinion, statements must be judged strictly on their own merits--they cannot be influenced by the personality, reputation, or seniority of the proponent. (p. 143)

Other major strengths of the Delphi technique are as follows:

1. The technique is simple to use. Advanced mathematical skills are not necessary for design, implementation, and analysis of a Delphi project (Strauss & Zeigler, 1975).

2. As the Delphi provides anonymity, many psychological barriers to communication are overcome, such as reluctance to state unpopular views, to disagree with one's associates, or to modify previously stated positions (Enzer, 1970; Pfeiffer, 1968).

3. The Delphi provides a framework within which individuals with diverse backgrounds can work together on the same problem (Enzer, 1970).

4. A major strength in the technique is the flexible, but limited, time parameters that individuals have in which

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to respond at their own convenience. This flexibility allows persons to participate who perhaps would not be willing to share their time under other conditions (Brooks, 1979).

Rasp (1973) concluded an article on the Delphi technique with this paragraph:

> The Delphi technique has strength and utility. The process collects and organizes judgments in a systematic fashion. It gains input. It helps to establish priorities. It builds consensus. It organizes dissent. In short, the Delphi does provide useful data for decision making. It has proved itself a valuable new tool for those who must help make seminal decisions. (p. 325)

However, there are critical problems with any attempt to predict the future through this type of methodology, as discussed below:

1. Delphis are slow and take a long period of time to execute and complete the series of questionnaires (Brooks, 1979; Rossman & Bunning, 1978; Strauss & Zeigler, 1975).

2. Considerable administrative work is associated with the technique, such as (a) the maintenance of individual records for each respondent to determine changes and prior ratings, (b) the preparation and mailing of several questionnaires, and (c) the tabulation of data (Cyphert & Gant, 1970, p. 422).

3. The panel of experts could be too homogeneous or like-minded, producing a skewed data set (Strauss & Zeigler, 1975).

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4. The Delphi offers little explanatory power, except dissenting opinions. The researcher has no way of knowing why one response was selected over another or why participants moved to consensus (Rasp, 1974, p. 325).

Sackman (1975) criticized the Delphi procedure by stating:

> In such a study, no one is accountable for the results and their use as a basis for decisions: the investigator objectively reports expert opinion; the panelists are protected by anonymity; and the user of the findings says that he is following the best advice available from experts and he is not responsible for what they say. (p. 16)

Of more serious consideration, however, are Sackman's concerns about the influence of the feedback received by the participants after each round. After the first round the judgments are no longer independent; the second and third rounds "produce strict correlated or biased judgments" (p. 15).

Sackman further said that the Delphi technique "deliberately manipulates responses" (p. 51) to reduce differences among the panel members, claiming this to be consensus. He stated further that after the third or fourth round the individualist, the one who maintains his position, is a threat in that lack of agreement demands yet another round of the questionnaire.

Gordon and Ament (1971), in a discussion about the inherent problems of the Delphi technique, said:

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> The only thing certain in dealing with the future is that forecasts will seldom prove entirely correct or complete. Inevitably, there will be discoveries and events which cannot be anticipated: new scientific understanding for which no paradigm exists, political traumas, natural catastrophes. (p. 5)

Rossman and Carey (1973) quoted Weaver's recent report entitled The Delphi Method: Background and Critique concerning the procedural limitations of the Delphi technique. Weaver stated that the Delphi is weak because:

1. There is little emphasis on the grounds or arguments that might convince one of the forecasts' reasonableness.

2. There is no mechanism to distinguish hope from likelihood, reasonable judgment from mere guessing, priority and value statements from rational argument.

3. There is no feeling of confidence and desirability from statements of probability (Weaver, 1971b).

Hillestad (1977) warned that in the Delphi technique, as in any of the other data-gathering techniques, one must keep in mind that surveys of opinion do not form an adequate basis for policy decisions. Surveys of opinion must be supported by facts to be of value. Surveys and all data gathering must result in valid and reliable findings.

Validity

Helmer (1967) discussed the issue of validity and the Delphi technique. He stipulated that to be of practical

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value the group response should move in the direction of a logically defensible answer:

> Validity may be considered established only in an intuitive sense, in that those participating in such an experiment appear satisfied that the method is both fair and efficient in obtaining the information collectively possessed by the group. (p. 5)

Jolson and Rossow (1971, p. 521) were also concerned about the validity of the Delphi technique. However, the results of their experimental investigations were inconclusive.

The Rand Corporation conducted studies comparing the face-to-face discussion against the controlled-feedback method of the Delphi technique. The results of the studies confirmed the idea that "face-to-face discussion tended to make the group estimates less accurate, whereas, more often than not, the anonymous controlled feedback procedure (of the Delphi technique) made the group estimates more accurate" (Dalkey, 1969, p. 18). Pfeiffer (1968, p. 82) similarly compared the Delphi technique to a simple questionnaire procedure. His conclusions were that the Delphi technique was not only more successful in obtaining a consensus on many items, and at least a majority opinion on others, but also improved the accuracy of those opinions.

As previously discussed, validity of the participants' statements on the three-round questionnaires was achieved through the process of "triangulation"--a process of "comparing and contrasting information drawn from different

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sources, and/or determined by different methodologies" (Guba, 1978, p. 116). Formulation of the three Delphi questionnaires was arrived at by writing statements that were gathered from the panel of experts during their interviews using grounded theory methodology. The writeup of memos and the freedom to sort the participants' ideas into a written, numerical format, allowing them to respond to their own ideas, resulted in the verification of their information to the researcher.

As suggested by Webb (1966), triangulation, though difficult, is very much worth doing because it makes data and findings credible.

As the validity of a study is important to a researcher, the rationale for using a research method is likewise as important.

Rationale

Since the purpose of this study was to generate a theory that would provide a basis for a curriculum in computer science, a data collection process, the Delphi technique, was employed to accomplish this purpose.

Pallante (1976) stated the following:

> The Delphi technique, in its simplest form, eliminates committee activity altogether. It replaces direct debate by a carefully designed program of individual sequential interrogations interspersed with information and opinion feedback.
>
> Perhaps most significant, the technique has generally been used to produce what will happen rather than to seek agreement concerning what should be.

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> In conclusion, the Delphi technique is a method for systematic solicitation and collation of expert opinions. It is applicable whenever policies and plans have to be based on informed judgments; it is applicable to virtually any decision-making process. (p. 89)

The technique is basically a method of collecting and organizing opinion on a topic in an effort to produce group consensus. This gathering is accomplished through a series of three or four questionnaires dealing with a variety of <u>future</u> questions (Rossman & Carey, 1973, p. 248).

In an educational application of the Delphi technique, Weaver (1971a) listed the following areas in which the technique could be used: (a) a method for studying the process of thinking about the future, (b) a pedagogical tool or teaching tool that forces people to think about the future in a more complex way than they ordinarily would, and (c) a planning tool that may aid in probing priorities held by members and constituencies of an organization (p. 271).

Several steps are included in the Delphi process, as outlined below.

Steps Using the Delphi Technique

The steps involved in this study using the Delphi technique were a synthesis of the methods and procedures suggested by Cyphert and Gant, Brooks, Chaney, and Rossman and Bunning. Figure 3 illustrates grounded theory categories and properties that were the basis for the formulation of

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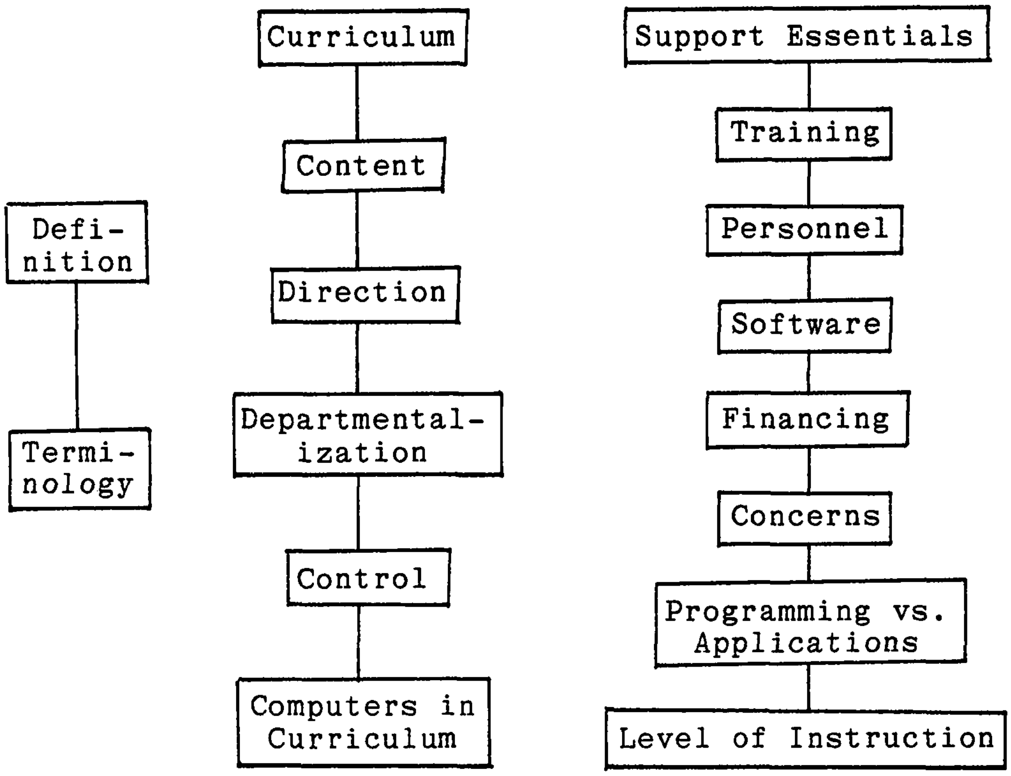

Figure 3. Grounded theory categories and properties.

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the Delphi questionnaires. Figure 4 illustrates the steps that were followed in the study using the Delphi technique. The exact procedure may vary depending on the type of study and the anticipated results.

Brooks (1979) outlined the Delphi process into eight steps:

1. Panel of experts is identified.
2. The willingness of the individuals to participate is determined.
3. Individual input on a given issue is gathered and combined into basic statements.
4. The data provided by the panel are analyzed.
5. The assembled group input (questionnaire) is mailed to each panel member for assessment.
6. The new input is analyzed by the researcher. The results, indicating the distribution of responses, is returned to the panel.
7. Each participant is asked to examine the data and to reassess his own position based on the group's responses. A participant whose personal position varies significantly from the group norm is asked to provide a rationale to support the divergent view. The length of the rationale (remarks) is limited to keep responses brief.
8. The input is analyzed by the researcher. The input is shared, in addition to the minority supporting statements, with the panel. Each member is asked again to review his position; and, if still not within a specified range, to support that position with a brief rationale. (pp. 377-378)

Brooks pointed out that three mailings are sufficient to achieve the consensus desired, and that little or no change could be expected after four mailings.

One of the first steps, however, in the Delphi technique is identification of the population.

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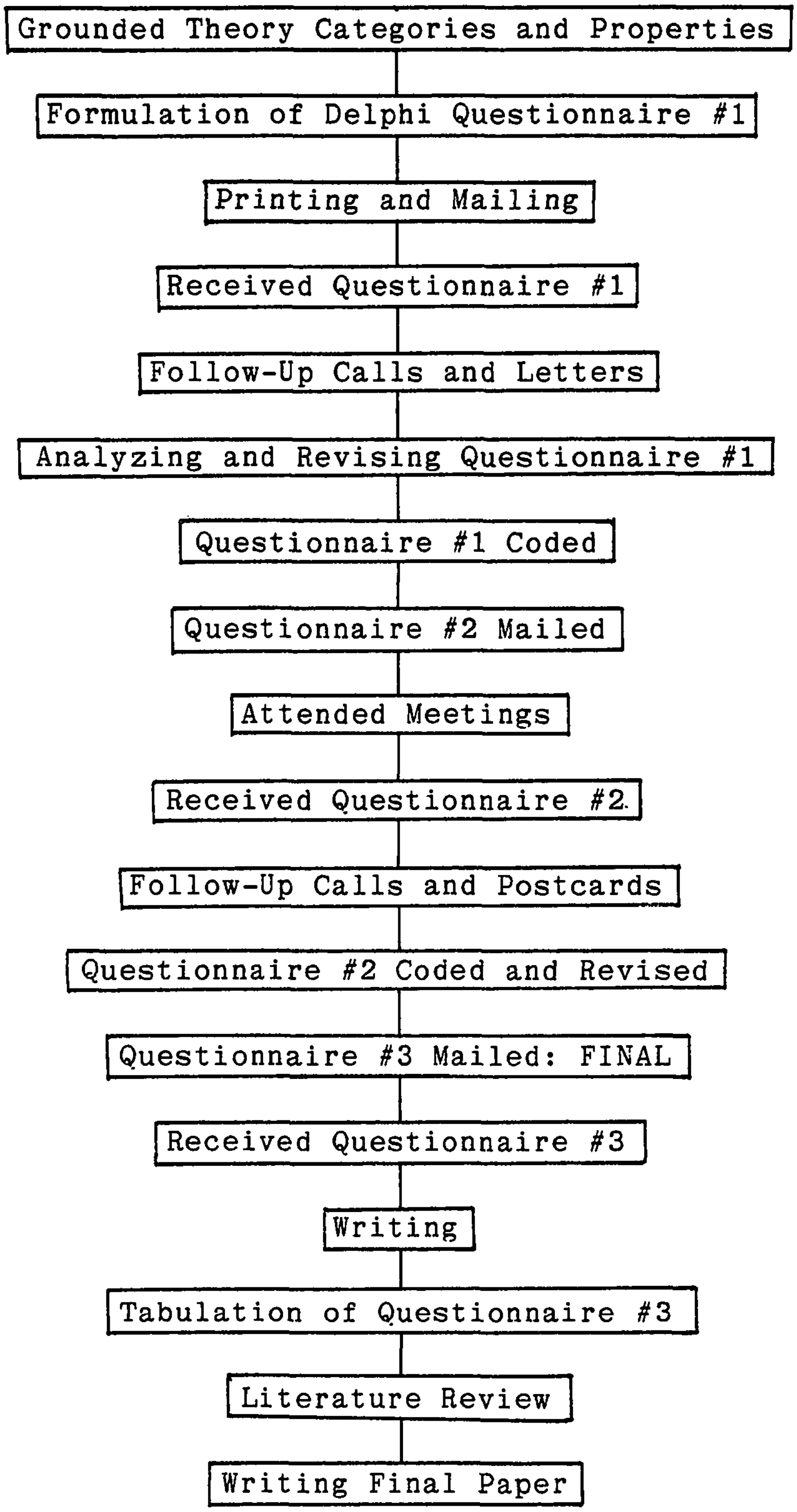

Figure 4. Flowchart of steps in the Delphi technique.

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Identification of the Population

In a fashion similar to that of the grounded theory methodology, the concept of a representative sample population does not apply to the Delphi technique. The population for this study consisted of the same individuals who participated in the grounded theory interviews. The participants consisted of members of a lay group (governing board members), professional educators (university professors, a computer science coordinator, a computer science specialist, and a superintendent), and an aide to a public official.

In a Delphi study, the study population is known as the "panel of experts," "sample of experts," or "Delphi panel." Boucher and Lazar (1971, p. 3) suggested that the selection of the participants for the Delphi panel is important because analyzing the future requires judgment. The judgment of any participant will be influenced by such items as his or her age, position in society, level of education, and level of confidence about individual ability to deal with the subject being explored. Defining the panel of experts, however, can be a problem for the researcher.

Defining the Panel of Experts

The panel of experts tends to consist of persons whom the investigator knows or who have been recommended as

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participants because such persons are likely to cooperate and not drop out of the study.

Pyke (1970) stated the following concerning the problem of defining the Delphi panel:

> Expert opinion, which can be extremely useful in the solution of a variety of problems, is particularly valuable in the preparation of forecasts. The expert has a good feel for the historical trends in his specialty . . . . He is undoubtedly well aware of significant research which is underway in his field and of the potential benefits likely to be derived therefrom, and he has probably given some thought to contributions which might be expected from his specialty in response to various socio-economic stimuli. (p. 143)

The researcher, however, may be tempted to include in the panel all who are influenced substantially or who can make a significant and/or unique contribution to the resolution of the problem.

Enzer and de Brigard (1970) stated that the composition of the panel is important to the success of any Delphi study, since the quality of the output is entirely dependent upon the arguments presented by the panel. Further, the key factors considered in selecting a Delphi panel are the kind of expertise required for the subject being discussed and the identity and availability of the most appropriate people to provide the needed coverage (p. 62).

Cyphert and Gant (1970) used the Delphi Technique to determine opinions held by various groups toward a college of education. In their study, opinions were solicited from seven groups of persons including some professional

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educators, lay groups, public officials, civic groups and some classroom teachers. The respondents were not experts, and some refused to participate on the grounds that they lacked expertise in the field.

Once the panel is defined and selected, the next step in the Delphi technique is to determine the willingness of the participants, or panel.

Willingness of the Panel

Gordon (1971) maintained that one of the key elements in the successful accomplishments of a Delphi study is the identification of appropriate and willing respondents (p. 14).

Cyphert and Gant (Hillestad, p. 72) pointed out that "in order for prospective participants to take part in a study, they must be made to feel that their response is valid."

The researcher in this study solicited the cooperation and participation of the same nine individuals who were interviewed using the grounded theory methodology. The researcher mailed a letter to each panel member explaining they were selected because of their expertise in the area of education (Appendix E, Cover Letter 1). The Delphi technique was explained in the letter to the members. One panel member dropped out of the study after the first questionnaire was mailed. Her reasons for dropping out

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are explained in a letter the panel member mailed to the researcher, as shown in Appendix C.

On this study, the panel of experts were cooperative in each round of questionnaires; in fact, some members reported to have considered the Delphi technique interesting and disclosed that the process was a learning experience for them. They indicated that, although considerable time was required to complete each of the questionnaires, they did so because of the importance of the study and their interest in the technique.

The last step concerning the panel of experts is to determine the size of the panel.

Size of the Panel

The problem of the number of participants that should be used in a Delphi study was discussed by Martino (1968, pp. 138-144). He contended that the Delphi technique is administratively workable if the group of experts is not too large. He did not specify what number or range of participants was feasible.

Dalkey (1969, p. 11) recognized the problem that a group of experts cannot be selected randomly out of a total pool; he recommended that the number of experts employed in a Delphi study number between 17 and 29.

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Following determination of the size of the Delphi panel, the formulation and administration of the Delphi instrument was the next step in the Delphi technique.

Formulation and Administration of Delphi Questionnaires

A number of variations of the Delphi technique have been employed by groups and organizations in conducting future-probing studies. Pfeiffer (1968) described a variation. He stated that the first questionnaire may call for a list of opinions involving experienced judgment, perhaps a list of predictions of recommended activities. On the second round, each expert receives a copy of the list, and is asked to rate or evaluate each item by some such criteria as importance, probability of success, etc. The third questionnaire includes the list and the ratings, indicates the consensus if any, and asks the experts either to revise their opinions or to specify their reasons for remaining outside the consensus. The fourth questionnaire includes lists, ratings, the consensus and minority opinions (Rossman and Carey, 1973, pp. 248-249).

Questionnaire 1

The researcher solicited the cooperation of nine individuals for a panel of experts to whom a series of three questionnaires were sent regarding emerging curricula for computer science at the high school level. The first-round

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questionnaire consisted of 10 items derived from statements delineated from the following sources: (a) the literature, (b) grounded theory interviews the researcher conducted with the panel of experts, (c) governing board meetings and other meetings related to the study, and (d) interviews with individuals who had knowledge of computer use in education. The researcher organized the statements on the questionnaire according to the particular category and properties that arose using grounded theory methodology.

As shown in Appendix F, Questionnaire #1, Statements 1-13 pertained to the definition of computer science, Statements 14-26 and 59-69 pertained to curriculum, and support essentials of computer science were itemized in Statements 32-58 and 70-108.

On October 10, 1984, the Delphi questionnaire was mailed, together with a cover letter, to the panel of experts as indicated on the cover letter in Appendix E. Each participant was once again asked to participate in the study. The researcher requested the participant to make judgments about selected statements for computer science by means of a three-phase instrument. A brief description of the Delphi technique was given. The process of the technique was detailed in four steps in the cover letter.

For the first step, the researcher indicated that she would treat the data and return the results to the participants so that they could revise, delete, or add to the

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statements. For the second step, the researcher stipulated that on succeeding rounds, or phases, the individuals whose judgments deviated from what other respondents tended to give were requested to justify their judgments. The third step stated that the justifications would then be summarized, returned, and counterarguments would be elicited. After the second and third rounds, the researcher indicated that she expected the statements gathered would decrease in number. For the last step she stated that a conclusion could then be reached concerning emerging curricula for computer science at the secondary education level. The panel members were asked to indicate whether they strongly agreed, agreed, disagreed, strongly disagreed, were undecided, or were neutral toward each statement.

The participants were invited to add any remarks under each statement. A postage-paid envelope was enclosed for returning the completed questionnaire by October 23, 1984. Further, the researcher wrote that each participant would receive a copy of the study when completed.

On October 17, 1984, the first of nine questionnaires was received. The researcher mailed a thank-you letter on October 19, 1984, to the first participant. From October 19 through October 26, 1984, the researcher received five more completed instruments. The researcher found it necessary to make follow-up phone calls to participants whose questionnaires had not yet been received by the end of October 1984.

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Once all questionnaires were received, the researcher analyzed the results from Questionnaire 1. One panel member withdrew from any further participation in the study. Thereafter, eight participants were included in the study. Statements that were poorly worded or repeat statements were deleted for the preparation of questionnaire #2. If the members indicated that statements should be revised, the researcher did so. For example, statement #33 on Questionnaire 1 read "Software is well written and has good user instructions." Remark statements from the panel members for this statement were "not all software" or "some software." Therefore, the researcher revised the statement to read "Some software is well written and has good user instructions." After the instrument was revised, the researcher developed Questionnaire 2 and a cover letter.

Questionnaire 2

On November 28, 1984, Questionnaire 2 and a cover letter were mailed to each panel member. Statements were color coded so the participants could review their previous answers and see how other members responded. The researcher found color coding was quite painstaking, time consuming, and tedious. As indicated on Cover Letter 2, Appendix G, the Phase 1 choices were marked in shocking pink. Phase 2 choices, which the other experts tended to choose, were marked in super green. If the choices and what the other

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experts tended to choose overlapped, then the choices were highlighted in turquoise blue.

The participants were invited to go through all of the statements again, making judgments just as they had done in Phase 1. However, this time their choices were to be marked with a black pen. In this round, the researcher explained that if the Phase 2 choices did not agree with what the other participants tended to mark in Phase 1, they were to explain in a few words in the "remarks section" why they chose the responses they did. Six statements were deleted, and some statements were revised. Questionnaire 2 (Appendix H) consisted of 102 statements. Thus, the careful review of each item was important. The new or revised statements were not colored. Questionnaire 2 was to be completed and returned by December 13, 1984. The researcher later discovered this date was a poor choice because of the upcoming holidays.

On December 12 and 13, 1984, three of the eight questionnaires were received. The researcher mailed postcards thanking each of the participants for their cooperation (Appendix I). Reminder follow-up postcards were mailed to four panel members on January 15, 1985; one follow-up phone call was made. All questionnaires were finally received by February 27, 1985. One of the panel members misplaced the questionnaire and another questionnaire was mailed; the

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researcher color-coded once again. Thank-you postcards were also mailed to the participants.

Again, the researcher analyzed Questionnaire 2. Four statements--#37, #46, #61, and #85--required deletion, and nine statements were revised. One statement in particular that required revision was Item #49 on Questionnaire 2. Statement #49 read, "One terminal or microcomputer is provided for each 10 students involved in computing." Four of the eight participants responded that this statement should be revised to read that "one microcomputer is provided for each two students involved in computing." Other changes that were necessary after reviewing Questionnaire 2 that would be new on Questionnaire 3 are shown in Figure 5.

In addition to the revisions shown in Figure 5, a statement that the participants repeatedly recommended for deletion because it doesn't make sense or is poorly worded was statement #85 on Questionnaire 2. Statement #85 read: "Computer science at the high school level is good for school districts who are not using computers." Once the researcher had finished analyzing Questionnaire 2, Questionnaire 3 and the cover letter were then developed.

Questionnaire 3

The researcher developed Questionnaire 3, which consisted of 98 statements. The task of color coding the

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Questionnaire 2	Questionnaire 3
39. BASIC has enough capability for an introductory computer science course and is available on most systems.	38. BASIC has enough capability for an introductory computer science course.
63. Computers are sometimes integrated in all areas of the curriculum.	59. Computers should be integrated in all areas of the curriculum.
65. Many colleges and universities recognized the need for computer science curricula for the training of teachers.	62. Some colleges and universities recognize the need for computer science curricula for the training of teachers.
67. Certification of teachers in computer science should be required as a result of the advanced placement test in computer science.	64. Certification of teachers should be required.
69. At least two or three computer science courses should be required for all secondary education teachers.	66. A minimum of two or three computer science courses should be required for all secondary education computer science teachers.
77. A need exists to emphasize computer applications, not programming.	74. A need exists to emphasize computer applications, not programming at the high school level.
78. Students now entering the ninth grade are computer literate.	75. Some students now entering the ninth grade are computer literate.
95. A computer-literate person understands the fundamentals of how to operate the equipment and how to interface with the equipment.	91. A computer-literate high school student understands the fundamentals of how to interface with the equipment.

Figure 5. Changes from Questionnaire 2 to Questionnaire 3.

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results was also completed. The cover letter (Appendix J) and Questionnaire 3 (Appendix K) were mailed to each participant on March 12, 1985. The letter stated that Phase 3 was the last phase of the study. Once again, their responses from Phase 2 were marked in shocking pink. The Phase 2 choices the other experts had selected were marked in "super green." If their choices were similar to the responses of the other participants, the statements were marked in the resultant colors pink and green. The revised statements were highlighted in turquoise blue to gain the participants' attention that a new response was necessary. Again their choices were to be marked using a black pen. In this round, participants were not told to make any remarks. The panel members were requested to return their results by March 22, 1985. The researcher enclosed $10 cash for their cooperation in the study and a postage-paid envelope for mailing.

By April 2, 1985, the researcher had received all of the questionnaires. Thank-you letters were mailed (Appendix L) to all panel members. One participant indicated that he liked the instrument and later wondered why he answered the way he did and wanted to change his mind on the statements in the questionnaires.

Upon analyzing Questionnaire 3, the researcher discovered that one of the participants had forgotten to answer one of the statements. The researcher phoned the

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participant, but could not contact the panel member until later; the researcher could not tally the final results until all statements were completed. On April 9, 1985, the researcher completed the final tally. It should be noted that since the beginning of the study three panel members had assumed different positions.

The Audit Trail

The "audit trail" reflected the sources the researcher used in this study to help generate a theory that will provide a basis for a curriculum in computer science.

Guba and Lincoln (1983) recommended that an "audit trail" be maintained throughout the course of a naturalistic study. This process should consist of documentation of the nature of each decision in the research plan, the data upon which it was based, and the reasoning or guidelines that entered into it (p. 122).

An audit trail has a twofold purpose: (a) sufficient evidence remains so that someone external to the inquiry could review the processes and results of the inquiry and (b) determine whether the processes were appropriate and the results were reasonable and credible.

The concept of auditability, rather than reliability, requires that the work of one evaluator or team of evaluators can be tested for consistency by a second evaluator or team. After a close examination of the first evaluator's

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work, the second evaluator can conclude if, given that perspective and these data, the same conclusion would have been reached.

A basic component of the audit trail is the investigator's log. A log is an annotated index to the audit trail. The trail itself consists of numerous documents that carefully preserve the record of the investigator. Such documents could consist of raw or summary notes from interviews, records of meetings about the research, interview guidelines, all documents used as data sources, decision rules by which data were categorized, and/or completed documents that may have been assigned as part of the study (Owens, 1982, p. 17).

The researcher's audit trail consisted of the following documents:

1. Raw notes from meetings. The researcher attended meetings of the Arizona Governor's Task Force on Computers in Education on two occasions. Notes were compiled about the concerns and issues of the use of computers in education.

The researcher also attended a faculty meeting at Mountain View High School concerning computers. The Mesa Public School's superintendent was present at the meeting. Raw notes were gathered from that meeting.

At Arizona State University, in Tempe, the researcher decided to attend a workshop on keyboarding--"New Directions

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in Keyboarding"--at which Dr. L. Erickson, from the University of California at Los Angeles, spoke of the trend of using microcomputers to teach typewriting.

Further, the researcher was invited to attend a governing board meeting for the Tempe Union High School District. Notes were taken pertaining to the use of microcomputers in various subject areas; observational notes also were taken concerning the various presentations that were made by the different departments within the school district about computers.

A seminar entitled "Building a Quality Computer Education Program," sponsored by the Bureau of Education and Research, created an interest in the researcher to gather notes from this seminar. The adaptability of the computer in business was the highlight of notes gathered by the researcher when she attended a seminar at Arizona State University entitled "Computer Graphics in Business Education," by Dr. Steve Golen. Further, the researcher attended a Computer Showcase Expo held at the Phoenix Civic Plaza, in Phoenix, Arizona. Observational and hands-on notes were taken concerning educational software and hardware.

2. Raw notes from interviews. The researcher decided to interview the computer science specialist from the Mesa Public School District; notes were gathered from that interview.

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3. Completed documents assigned as part of the study. The researcher investigated the 1983 Arizona Revised Statutes, Title 15, Education, pamphlet concerning the local governance of schools.

4. All documents used as data sources. The booklet, Education Under Study, an analysis of recent major reports in education, was analyzed for information by the researcher pertinent to computers.

5. Records of meetings about the research. Minutes of governing board meetings were analyzed concerning the use of computers in the classroom.

The results from the Delphi technique are reflected in the categories and their properties as discussed in the next chapter.

Summary

Chapter II has been an attempt to explicate the grounded theory method of analysis by presenting the procedures that were followed in this study. The steps involved in this study were a synthesis of the methods suggested by Glaser, Strauss, Stern, and Maxwell and Maxwell.

One of the data-gathering devices, the Delphi technique, was also described: the identification of the population, instrumentation, and administration of the Delphi instruments. The steps involved in the data-gathering stage of the study consisted of a synthesis of the

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methods suggested by Cyphert and Gant, Brooks, Chaney, and Rossman and Bunning.

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CHAPTER III

FINDINGS AND DISCUSSION

This chapter describes the three major categories and their subcategories, or properties, that emerged from the data.

Categories and Conceptual Derivations

The categories and the properties that emerged in the study were:

Definition--Terminology.

Curriculum--Content, Direction, Department, Control, and Computers in Curriculum.

Support essentials--Training, Personnel, Software, Financing, Concerns, Programming vs. Applications, and Level of Instruction.

Results include the related literature, the audit trail, the Delphi instruments, and interviews using the grounded theory method.

Results Related to Definition

Terminology was a property of the category "definition." The results related to the definition of computer science are as follows:

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Strong disagreement arose in all three phases of the Delphi instruments about whether teachers who use computers in the classroom can teach anything under the heading "computer science." One individual who participated in the grounded theory interviews asked the question, "Is 'computer science' the same as 'computer literacy' and 'computer awareness'--who knows?"

The Arizona governor's Task Force on Computers in Education (1984) indicated that 12 leading schools now in place in Arizona teach computer science. However, a closer look reveals that the definition for computer science is not clear. The report shows that "computer science" in some schools is defined and taught as "computer awareness," "BASIC," "LOGO," or "PASCAL."

Pollack (1982, p. vii) stated that there is no "standard" (i.e., universally inoffensive) definition of computer science. In fact, the existence of such a discipline continues to be a debatable point for a substantial number of people. Pollack further wrote:

> Consequently, we are looking at a very new area of inquiry, with direct forerunners limited to a handful of strikingly prophetic individuals. In some views, computer science is more aptly termed "information science" because its domain is seen to encompass all information processing systems, including biological ones. (Pollack, 1982, vii)

To indicate the vagueness of the definition of computer science, Poirot and Groves (1976) stated that "computer science education" as a whole is in a rather chaotic stage,

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primarily because of the rapidity with which this science has developed. More recently, introductory computer science courses have been introduced, covering topics such as computer history, logic, and flowcharting. For the most part, teachers (generally in the mathematics department) with little or no training in computer science have been expected to use the computer in their classrooms and to implement a computer science curriculum (Poirot & Groves, 1976).

Consensual results from the Delphi technique indicated that:

1. Computer science is the study of information storage, processing, interpretation of data, study of equipment, and programs that effectively and efficiently perform data handling tasks.

2. Computer science is the study of design, basic structure of what a computer is, kinds of applications, major functions of a computer, networking, and programming.

3. Computer science is the study of programming, engineering, repair, and maintenance of computers.

4. Computer science is the teaching of programming in various languages.

5. Computer science is designed to teach the student to use the computer as a means of learning problem-solving skills.

6. Computer science is an established field.

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Strong disagreement arose in all three phases of the Delphi instruments for the following statements:

1. Computer science is the teaching of more sophisticated types of equipment.

2. Computer science is the study of computer awareness and computer literacy.

3. "Computer information" systems is a better term to use than "computer science."

The literature revealed from one source that "computer science" refers to an area of study that may begin in secondary schools and continue in postsecondary institutions. Studies in computer science and technology for some students would include comprehensive work in computer architecture, computer operations, computer programming, and computer applications (Stevens, 1981).

Another source indicated that computer science includes computer programming; however, it goes much beyond programming and provides students with a perspective from which they can examine computers (Spencer, 1978).

Ralston and Reilly (1983) stated:

> Computer science is concerned with information processes, with the information structures and procedures that enter into representation of such processes, and with their implementation in information processing systems. It is also concerned with relationships between information processes and classes of tasks that give rise to them. (p. 364)

Rogers and Austing (1981) also stressed the importance of determining a clear definition of computer science in the

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secondary school. Following their conference on mathematics education, the authors stated:

> Specification of topics to be studied as well as definition of the focus of the course is needed. Suggestions for facilities, both computer and support materials, and for administrative considerations such as academic credit and course prerequisites, might expedite establishment of such a course (Rogers and Austing, 1981, p. 651)

Terminology

In an interview, a computer science specialist from a local school district stated the following concerning the terminology in A Nation at Risk:

> The report created an awareness for districts who are not integrating computers in the curriculum; it did a poor job of stating what "computer science" is.

In the educational report, Academic Preparation for College (The College Board, 1983), computer science was not addressed. The report outlined what college entrants need to know and be able to do; it states only that "competency in computer usage" is needed for college entrants.

Results Related to Curriculum

The category "curriculum" included the following properties: content, direction, department, control, and computers in curriculum. Results gathered concerning curriculum were:

Simply issuing mandates without formulating appropriate course content or offering guidelines for implementation is

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not an effective approach. A closer look at some mandates that now exist reveals that curriculum content not only is missing, but is being shifted from one desk to another. Unfortunately, some of the legislators and administrators issuing the mandates have had little experience with computers in the classroom, and they are anxious to defer curriculum-content decisions to the "experts."

Some school districts have attempted to formulate curriculum for the recommended computer science course. The Anderson (California) Union High School District implemented a new course for the 1983-1984 school year. The one-semester course was designed to meet the needs and interests of the general student and to cover a variety of topics, including elementary problem solving with BASIC, the history and evolution of computers, computer systems (terminology and components), DATA communications, career opportunities, computer languages, and applications (Bell, 1983).

Baird (1982) suggested that a two-semester course for high school students be implemented for computer science. Some of the concepts he recommended for the first semester were:

1. practice in making appropriate use of computers as tools for problem solving;
2. realistic concepts of the power, usefulness, and limitations of computers;
3. knowledge of the role of computers in current information processing and the effect on social structures of the application of computers;
4. a context from which to consider possible future directions in computing. (p. 331)

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The second semester of computer science would include:

1. redefine assigned tasks into smaller, more easily solved sub-tasks for solution by coding;
2. provide support for teamwork approaches with problem complexity;
3. provide readings for background understanding of the "real world" of computers in science, business, and industry;
4. to produce students who can write, test, correct, and implement readable code in Pascal, and modify it as needed. (p. 332)

Content

The Report of the Governor's Task Force on Computers in Education for the State of Arizona (Task Force on Computers, 1984) stated that the issue of planning is of key importance in the implementation of computers in the schools. A recent study of the National School Board Association shows that, of the 95% of schools that have purchased computers, less than 15% have a written plan or guidelines for the use of computer technology. Further, the only curricula content recommendations the task force report offered was a "generic" continuum of instruction for three common areas of emphasis: problem-solving/programming, software applications, and computer technology awareness.

The following recommendations for course content in computer science arose from the Delphi instruments:

1. Problem solving, including defining the problem, breaking the problem into subproblems, concept of the algorithm, and graphic representation of the solution, should be a study topic in computer science.

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2. Programming methods (including documenting, programming style, manual reading, debugging, branching, looping, and structured programming techniques) is a study topic in computer science.

3. Programming language (including language syntax, functions and subroutines, input/output, simple sorting, searching, file structures, file manipulation) is included as a study topic in computer science.

4. The history of computing (including people and events, trends and predictions, generations of computers, and the effects of computers in our modern world) is a study topic in computer science.

5. Social and ethical implications (including computer crime, privacy and security, careers in computing, economic effects, benefits to users, and futuristics) is a study topic in computer science.

Spencer (1978) suggested that a computer science course is an in-depth semester or full-year course whose goal is the mastery of at least one programming language (usually BASIC). It also includes the study of computer applications, algorithm development, flowcharting, computer hardware, computer history (past/present/future), advanced software topics, and career information. A course in computer science considers all aspects of the computer, what it is, what it does, and how it works.

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Rogers and Austing (1981) offered suggestions for a one-year course in computer science at the secondary level. They suggested that problem solving, including defining the problem, concepts of algorithms, and graphic representations of the solution, be presented, in addition to programming methods, programming style, documentation, debugging, and technique. Computer environment, areas of application, the history of computing, and social and ethical implications should also be discussed.

Ralston and Reilly (1983) stated that there is no consensus opinion on the part of computer scientists themselves on the nature of an appropriate high school educational program in the computer discipline.

Direction

Luehrmann (1982) warned of the problems that could arise if there is no clear-cut direction for computer science:

> Within five years, a substantial number of college entrants will have completed a two-semester "advanced placement computer science course" equivalent to the better introductory computer science courses now offered at universities. These students will know many algorithms and data structures. Their knowledge will effectively make obsolete many of the introductory computer science courses currently in place in colleges and universities. Computer science courses will undoubtedly be overcrowded at the university level as high school students seek advanced training in computer applications only to find traditional computer science courses in the curriculum. (pp. 2-3)

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Consensus for direction of a high school computer science course indicated the following from the Delphi questionnaires:

1. The direction of a secondary-school-level computer science course is to provide the student with a realistic concept of the power, usefulness, and limitations of computers.

2. Computer science students are provided with a context from which to consider possible future directions in computing.

3. Realistic concepts of the power, usefulness, and limitations of computers are stressed in a computer science course.

4. Computer science students are well aware of the broad spectrum of computer applications.

5. Elementary algebra or geometry is required for computer science.

There was no consensus from the Delphi panel experts that keyboarding should be a required skill for computer science students.

Department

Consensus indicated that computer science is a separate department. A governing board president stated that "turfism is really a problem as to whether computer science

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should be a separate department; and, if not, in which department should it be taught?"

Justine Baker conducted a survey of 78 superintendents in 50 states regarding their preferences concerning the roles of computer science in secondary schools. Respondents stated their preferences with respect to (1) a computer science department in each secondary school, (2) every teacher required to take three computer science courses, (3) a computer science department and every teacher trained in basic uses of the computer, and (d) none preferred. Respondents were divided into users and nonusers of computers. A majority of the users preferred option 3, and a majority of the nonusers preferred either option 1 or option 3 (Baker, 1976).

Spencer (1973, p. 13) stated that a survey course in computer science may be offered for general enrollment, or the subject matter may be integrated into existing courses. Perhaps the easier way is to implement the survey course. He did not, however, mention in which department computer science should exist.

Control

The audit trail revealed that the local governing board maintains the power to control and determine educational policy at the local level (Arizona Revised Statutes, 1983, Title 15, Education pamphlet). The control issue is

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important because the National Commission on Excellence in Education (1983) stated in A Nation at Risk that state and local officials, including governing board members (governing board, governors, and legislators) have the primary responsibility to incorporate the proposed reform in their educational policies and fiscal planning. Similarly, results strongly indicated that politics influences the curriculum.

According to the recent report published in the School Board News, the governing board is often looked upon to provide leadership at the local level. The report stated the following:

> Reaching a new standard of academic excellence by 1995 requires clear educational objectives, strong leadership and firm commitment at all levels. Goals must be set and progress toward these goals assessed. We must recognize the necessary investment, assess the cost, and accept the responsibility for participation at Federal, state and local levels, in both the public and private sectors. ("Educating Americans," 1983, p. 2-3)

Further, the report stated: "Local school boards should foster partnerships with business, government and academics to encourage, aid and support in solving the academic and financial problems of their schools" (pp. 1-2).

Computers in Curriculum

The notes gathered from a seminar meeting attended by a local school district's computer specialist (audit trail) reflected the idea that focus should be on curriculum, not computers. Computers should become part of the curriculum;

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curriculum development is critical. Focus on the use of technology, rather than on the technology itself, was the major theme of the seminar.

Many brochures indicate that conferences that are taking place throughout Arizona and the country are highlighting the theme of implementing computers in the curriculum. For example, a miniconference scheduled for July 30-August 2, 1985, in Oregon, sponsored by Gregg/McGraw-Hill Publishing Company, was planned to stress implementing computers in the business education curriculum. Also, an August conference at the 1985 Employability Skills Conference was billed as emphasizing the idea of implementing microcomputers in the curriculum. Random House sponsors a "Computer Motivated Learning Workshop" designed for decision makers "who want to know how the microcomputer can meet specific needs in organizing and implementing the traditional curriculum." The session includes lecture time, a workbook, and computer hands-on time (Elliot, 1982, p. 25).

At a workshop on keyboarding at Arizona State University, by Dr. L. Erickson from the University of California at Los Angeles spoke of the trend of using microcomputers to teach typewriting. At a governing board meeting for a local high school, discussion centered on how microcomputers are used in various content areas in the high schools;

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presentations were made by teachers from various departments on how they use computers in their disciplines.

The results from the Delphi technique indicated strong agreement concerning computers in the curriculum:

1. Computers should be integrated in the curriculum to enhance learning.

2. Computers should be integrated in all areas of the curriculum.

Many of the recent educational reports state how and why computers should be implemented in the curriculum. Boyer (1983) stated: "Schools should relate computer resources to their educational objectives; all students should learn about computers; learn with computers; and learn from computers" (p. 109). Boyer further stated that technology should be a part of "the common core curriculum" (p. 111).

One sad note was Boyer's statement that we have technology with little school-related content; computer companies are marketing hardware and even giving sophisticated equipment, while failing to help educate the teachers and failing to prepare first-rate material linked to school curricula or objectives.

The use of computers in the classroom should be managed so that students receive both the benefits of the equipment and increased familiarity with this technology was a recent recommendation (National Science Board Commission, 1983).

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"Action Recommendation 5" from an educational report, Action for Excellence (Task Force on Education, 1983) stated that existing learning time should be made more effective through the use of high-quality and up-to-date textbooks and through the use of technologies in education: computers, film and videotape. Further, one of the basic skills and competencies for productive employment as recommended in the report is the ability for students to understand the basic functions of a computer device (terminal, CRT, etc.).

Roach (1983) stated that the microcomputer will be used as the object of instruction, the medium of instruction, and the tool for administrators. As the object of instruction, the educational system must teach students about computers, about software concepts and programming, and about computers in society. As the medium of instruction, teachers will have the opportunity to utilize computers as an aid for instruction in skill building, simulation, and tutorial modes.

The arrows in Figure 6 represent the flow of trends over time from the mainframe computer to the microcomputer. As the microcomputer appeared, it was originally used in the classroom and now is appearing in laboratory settings (De Vault & Harvey, 1985, p. 84).

Computers will serve to enhance the current curriculum but will at the same time create potentials for new curriculum not previously envisioned. When this happens, the

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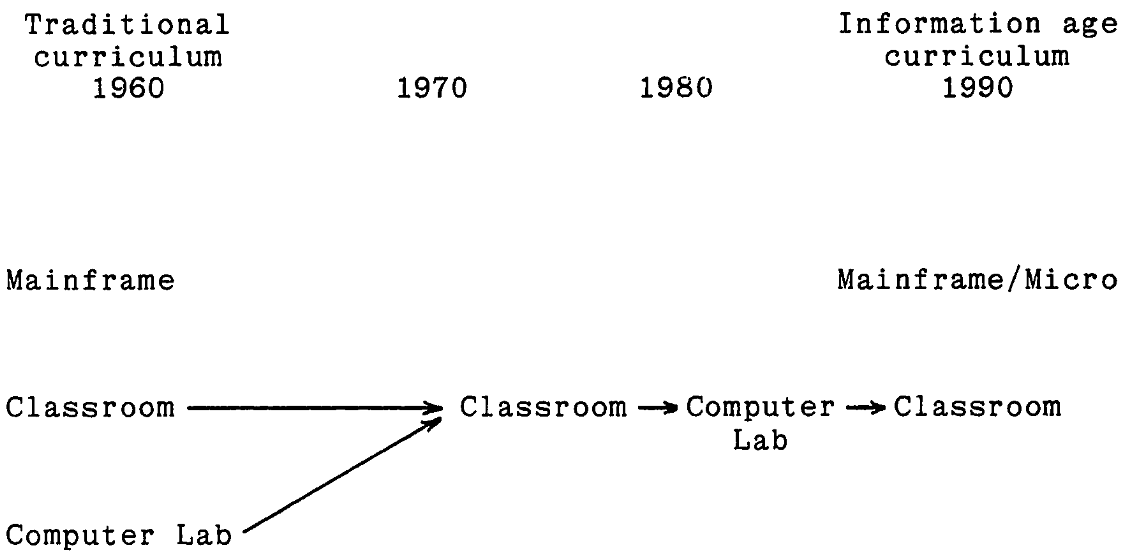

Figure 6. Flow of trends over time from the mainframe computer to the microcomputer.

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computer will become a tool that serves curriculum goals: traditional goals and goals of the information age.

The Utah Business Education Association recently adopted a resolution. One of the statements included in the Utah resolution was:

> All business teachers should integrate the use of the computer in all subject areas in the business curriculum, including bookkeeping/accounting, personal finance, records management, business communications, word processing, data processing, and office procedures in order to familiarize students with the computer as an office tool and to better prepare the student for the office of today. (Stocker, Neal, Lutz, & Fadala, 1983, p. 30)

The authors advised that students should understand how computers may be used in most phases of business.

Results Related to Support Essentials

The following properties were identified under the category "support essentials": training, personnel, software, financing, concerns, programming vs. applications, and level of instruction. Results related to support essentials were:

Training

Consensus arose from the Delphi instruments concerning teacher training:

1. School districts on the local level need to provide more computer in-service training for teachers.

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2. Some colleges and universities recognize the need for a computer science curriculum for the training of teachers.

3. The advent of the advancement placement test in computer science forces the implementation of training teachers for computer science.

4. Certification of teachers in computer science should be required.

5. Teachers are not trained and are not being trained for computer science.

6. A minimum of two or three computer science courses should be required for all secondary education, computer science teachers.

7. A need exists for qualified high school computer science teachers.

8. The colleges of education need to provide training in computers for teachers.

When interviewed, one individual posed the following question concerning training for teachers: "Should not universities create methods classes for teachers concerning computers--and more specifically, computer science?"

Governor Bruce Babbitt stated in a summary of proposals to the Arizona legislature that 90 million Americans will be working with computers on the job by the year 1990. He stated that we must ensure that teachers are equipped to instruct children in the use of computers in the state of

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Arizona. He called on the State Board of Education to include basic computer knowledge as a requirement for state certification. He encouraged school districts to make provisions for training teachers (Babbitt, 1983).

Luehrmann (1983) claimed that until more teacher training programs are available in computer science at the secondary level, however, many teachers will find themselves teaching computing because of a personal interest, but with little or no formal training.

Taylor and Poirot (1984) conducted a study in 1983 concerning the certification of high school computer science teachers. A major portion of their study was devoted to certification programs and the identification of computer science courses most appropriate for such teachers. They warned that few teachers have or will have the skills needed to teach high school computer science courses that go beyond elementary computer use.

Based on the evidence collected in their study, Taylor and Poirot recommend that all programs designed to train high school computer science teachers should include the following types of courses:

1. A required component of six courses to include:
   - Introduction to Programming and Algorithm Design, including programming using a high-level language such as Pascal.

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- Advanced Topics in Programming and Algorithm Design.
- Computers and Education, including analysis of the major instructional uses of computers, and exposure to LOGO.
- Computers and Society
- Programming Languages, including the definition and structure of languages and the comparison of existing high-level languages.
- A choice of either Introduction to Computer Systems or Microcomputer Systems and Applications, with programming applications in BASIC, regardless of choice of course.

2. A group of elective courses that includes:
   - Computer Assisted Instruction.
   - Introduction to File Processing.
   - Data Structures.
   - Fundamentals of Computer Organization and Digital Logic.
   - Assembly Language Programming.

3. A course on the materials and methods of teaching computer science, that is taught by a person or group of persons who have the appropriate expertise should also be required (Taylor & Poirot, 1984, p. 118).

Ragsdale (1982) commented on the skills needed for computer science teachers:

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> The change in skills for computer science teachers will be primarily one of increasing level of the subject matter. That is, the topics to be covered in a secondary level computer science course will become more like the material which is currently covered in university computer science courses. In addition to becoming more knowledgeable about the subject matter, the computer science teachers should also master different instructional techniques which are more appropriate to higher levels of instruction. (p. 52)

Milner (1981) stated that there is much legitimate criticism of unqualified teachers who use computers. Currently, only four states in the United States certify teachers of computer science. Milner further wrote that some administrators appear to recognize the need for more trained teachers. Dennis (1977) surveyed 686 secondary school principals in Illinois and found that 71% saw a need for computer science teachers, 55% saw a need for state certification in computer science, and 82% felt that some computer science is valuable in the background of any teacher.

Personnel

Who will teach the proposed computer science course?

The following statement was agreed upon in the Delphi questionnaires: Computer science is sometimes offered for credit through the math, science, and business education programs.

Varnon (1984) asked several questions concerning personnel for the computer science course as proposed by the National Commission on Excellence in Education: Who is

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teaching computer science courses in our high schools now? What are the state requirements for teaching computer courses? Who should be teaching the courses? Are business teachers prepared for this opportunity?

Varnon (1984) suggested that the opportunity afforded to business education to teach computer science is clear. She wrote the following in her article entitled, "Computers and Business Education: Opportunity and Responsibility":

> Will we (business educators) recognize the opportunity and accept the responsibility, or is our discipline--our profession--to be placed "at risk" by a college preparatory curriculum and our own inability to grasp an unprecedented opportunity, the opportunity to bring every high school student into a business classroom as a part of a national effort to remove our nation from "risk"? (p. 25)

Slesnick (1984) stated that most teachers need not be programming experts, nor do they need to train the entire student population to be expert programmers. Concerning the personnel who will teach computer science, she contended that, except for those who teach high school computer science courses, teachers need not be experts in computer science.

Software

The report of the governor's Task Force on Computers in Education (1984) issued the following statement concerning software:

> There is a tremendous need for software in the districts, particularly a need for access to software for purposes of experimenting with its use in the schools.

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> We believe that the Governor should pursue legislation which would increase for a two-year period state income tax deductions for companies that manufacture or distribute educational software in Arizona and which donate software to our schools. . . . There is a chronic shortage of software in the districts. (p. 26)

A shortage of software definitely exists. Several teachers from one district reported they were creating their own software programs.

Results from the audit trail indicated that criteria for evaluating software also need to be addressed by teachers who use computers in the classroom. For example, the researcher purchased software at a Computer Showcase Expo that she thought would be useful in her intermediate and advanced typing class. However, she discovered the software was not designed for the microcomputers at her school. She was guilty of not evaluating the software. A recent law, A.R.S. § 15-723(B), effective July 27, 1983, states that "the Department of Education is required to (a) provide a lab in which to screen all educational software and (b) to provide a directory to educational software which is to be distributed to all schools in the State" (Title 15, 1983, p. 75).

New computer courses for teachers are being formulated: courses that include software evaluation, curriculum planning, and the use of software tools (word processors and spreadsheets).

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Consensus from the Delphi technique indicated that other and similar problems exist concerning software:

1. Computer science teachers need to learn how to evaluate software.

2. Good software for education is scarce.

3. Not only availability, but compatibility of software is a current problem for computer science teachers.

Financing

At the recent meetings in the governor's office, the issue of a new mandated course, "computer science," was not addressed, let alone the financing issue. The governor and legislature for Arizona have only recently been asked to support in their budgets a software directory, direct funding for software/hardware acquisitions for universities (not schools), a pilot school program, and the funding of the Department of Education Center for Computer Education. Computer education was not defined by the governor.

Concerning the financing issue, one of the recent governing board meetings (audit trail) disclosed that the concern of teachers within that school district was whether or not the governing board would approve financing more computers.

Results from the Delphi instruments clearly indicated a consensus that school districts need to make financial commitments for more computers.

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<u>Concerns</u>

The following statements were agreed upon by the "panel of experts" in the Delphi technique:

1. Computers are not a panacea for everything.

2. Computers are not a passing fad; computers are here to stay.

3. Computer literacy courses are slowly being eliminated in the curriculum as students become better prepared in the lower grades.

4. The generation of today is better prepared about computers before entering high school.

5. Some students now entering the ninth grade are computer literate.

6. School districts are "jumping into" the purchase of computers.

7. A cultural difference of owning computers is arising for high school students.

Children with home computers will outpace those who lack them. The Carnegie Foundation's Boyer (1983) warned: "The gap between the educated haves and the have-nots may well increase" (p. 5).

8. Computer science is a good start, but not an end.

9. The fear of computers still remains a problem for some teachers.

Five types of fear face teachers today: (a) fear of making a mistake or appearing foolish, (b) fear of

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authority, (c) fear of peers, (d) fear arising from either overmotivation or undermotivation, an (e) fear of change.

10. The role of a teacher in the classroom is changing as a result of the computer.

11. School districts need to become more involved and flexible in the area of computer science.

12. Computer science teachers need to consider the relevancy of topics discussed in the classroom.

13. Computer literacy can be defined.

Programming versus Applications

At a faculty meeting in the school at which the researcher teaches, the school district's superintendent said that a change from computer literacy in the elementary and junior high schools to programming would soon be implemented. The change from programming and operations on the high school level would convert to computer applications in the content areas. Notes from a seminar that a local school district's computer science specialist attended indicated that not many more than 10% of students in programming may find a job in some programming occupation. Further, he stated that "teaching programming alone does not teach problem solving." He also questioned the idea that "since students do like to take it [programming], has it become the basket weaving course of the 80s?" Does programming exist

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in the high schools because nobody knows what else to teach? (Slesnick, 1984)

The Delphi technique results showed consensus that a need exists to emphasize computer applications, not programming, at the high school level.

Level of Instruction

A superintendent anticipates a revision of emphasizing programming on the junior high level instead of the high school level. The level at which to teach keyboarding has become an issue with curriculum planners and administrators. One local school district's computer science specialist indicated that the district was pilot testing keyboarding of microcomputers at the levels of kindergarten through third grade.

The introduction of computers at the lower grade levels is not new:

> In a single classroom, desk-top computers will enable students to work at their own speeds and on different subjects at the same time. New research indicates young brains grow in spurts--not at a steady, continuous pace, as previously thought. As a result, school curricula will be tailored to match stages of brain development. ("Education?" 1983, p. 5)

As a result of the introduction of computers at lower grade levels, it is not unusual to hear students being called micro-whiz-kids.

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Summary

This chapter described the three major categories and their subcategories, or properties, that emerged from the data.

The categories and properties were a result of the related literature, the audit trail, the Delphi instruments, and interviews using the grounded theory method.

Results relating to definition, curriculum, and support essentials were presented.

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CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter contains the hypotheses, grounded theories, and conclusions developed after examining the results in Chapter III. Recommendations based on the grounded theories that evolved in this study are presented.

Hypotheses Related to Definition

The results in Chapter III have been compared to identify as many similarities and differences as possible, and then integrated into the following hypotheses.

Computer science is perceived to be:

1. An area of study, which may begin in secondary schools and continue in postsecondary institutions, that would include studies in computer architecture, computer operations, computer programming, and computer applications.
2. Information science, encompassing all information systems, including biological ones.
3. Information processes, with the information structures and procedures that enter into representation of such processes, and with their implementation in information processing systems.

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4. The study of information storage, interpretation of data, study of equipment, and programs that effectively and efficiently perform data handling tasks.
5. The study of design, basic structure of a computer, kinds of applications, major functions of a computer, and networking.
6. The study of programming, engineering, repair, and maintenance of computers.
7. The teaching of various languages.
8. A means of learning problem-solving skills.
9. An established field.
10. Computer awareness.
11. Computer literacy.

Theory Related to Definition

Computer science is information processing, study of design, study of computers, programming, and problem solving.

Hypotheses Related to Curriculum

The results discussed in Chapter III have been integrated into the following hypotheses.

Suggestions for the curriculum content of an introductory computer science course include:

1. Practice in making appropriate use of computers as tools for problem solving.

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2. Realistic concepts of the power, usefulness, and limitations of computers.
3. Knowledge of the role of computers in current information processing and the effect on social structures of the application of computers.
4. A context from which to consider possible future directions in computing.
5. Redefine assigned tasks into smaller, more easily solved subtasks for solution by coding.
6. Provide support for teamwork approaches with problem complexity.
7. Provide readings for background understanding of the "real world" of computers in science, business, and industry.
8. Write, test, correct, and implement readable code in PASCAL, and modify it as needed.
9. Elementary problem solving with BASIC, the history and evolution of computers, computer systems (terminology and components), DATA communications, career opportunities, computer languages, and applications.
10. Define the problem, break the problem into subproblems, concept of the algorithm, and graphic representation of the solution.
11. Programming methods, including documenting, programming style, manual reading, debugging, and structured programming techniques.

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12. Branching and looping.
13. Social and ethical implications, including computer crime, privacy and security, economic effects, benefits to users, and futuristics.
14. The mastery of at least one programming language.
15. Flowcharting, computer hardware, and advanced software topics.

Theory Related to Curriculum

The curriculum content for computer science encompasses concepts of the computer, programming methods, problems, programming languages, and application. A general curriculum for computer science is shown in Figure 7.

Hypotheses Related to Support Essentials

The results discussed in Chapter III have been integrated into the following hypotheses.

Suggestions for support essentials include the following:

1. A course on the materials and methods of teaching computer science taught by a person or group of persons who have the appropriate expertise is suggested for computer science teachers.

2. A core curriculum designed to train high school computer science teachers is suggested.

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I. CONCEPTS OF THE COMPUTER

A. Power

B. Application

C. Limitations

D. History and Evolution

II. PROGRAMMING METHODS

A. Documenting

B. Debugging

C. Branching and Looping

III. PROBLEMS

A. Solution

B. Graphic Representation

C. Algorithms

IV. PROGRAMMING LANGUAGE

A. BASIC

B. PASCAL

C. COBOL

D. LOGO

V. APPLICATION

A. Career Opportunities

B. Economic Effects

C. Futuristics

D. Privacy and Security

Figure 7. General curriculum for computer science.

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3. A skills requirement that includes becoming more knowledgeable about the subject matter and the mastery of different instructional techniques that are more appropriate to higher levels of instruction for computer science teachers is suggested.

4. A certification requirement for computer science teachers is suggested.

5. Criteria and financing for the evaluation of software by teachers who use computers in the classroom is suggested.

6. Emphasis on applications, rather than programming, at the high school level is suggested.

7. The introduction of computers at lower grade levels is suggested.

Theory Related to Support Essentials

The elements essential to supporting computer science are training, personnel, software, financing, concerns, programming vs. applications, and level of instruction.

Conclusions

The following conclusions concerning definition, curriculum, and support essentials were based on the hypotheses and grounded theories generated.

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Definition

The definition of computer science should be:

1. The study of information storage, processing, interpretation, of data, study of equipment, and programs that effectively and efficiently perform data-handling tasks.
2. The study of design, basic structure of a computer, kinds of applications, major functions of a computer, and networking.
3. The study of programming, engineering, repair, and maintenance of computers.
4. The teaching of programming in various languages.
5. A means of learning problem-solving skills.
6. Information science encompassing all information systems, including biological ones.

Based on the definition of computer science, computer terminology is determined by each particular discipline in which the computer is used. The components for "definition" illustrate the usage of computer science for business education, mathematics, and the science disciplines (Figure 8).

Curriculum

The curriculum content for an introductory computer science course should be:

1. Elementary problem solving with BASIC, the history and evolution of computers, computer systems

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Discipline	Definition
Business education	Computer science is the study of information storage, processing, interpretation of data, study of equipment, and programs that effectively and efficiently perform data-handling tasks.
Mathematics	Computer science is the teaching of programming in various languages and a means of learning problem-solving skills.
Science	Computer science is the study of design, basic structure of a computer, kinds of applications, major functions of a computer, networking, and programming.

Figure 8. Components for "definition."

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(terminology and components), DATA communications, career opportunities, computer languages, and applications.

2. Realistic concepts of the power, usefulness, and limitations of computers.
3. Provide readings for background understanding of the "real world" of computers in science, business, and industry.
4. Writing, testing, correcting, and implementing readable code in PASCAL, and modifying it as needed.
5. Defining the problem, breaking the problem into subproblems, concept of the algorithm, and graphic representation of the solution.
6. Programming methods, including documenting, programming style, manual reading, debugging, and structured programming techniques.
7. Language syntax, functions, subroutines, input/output, simple sorting, searching, file structures, and file manipulation.
8. Branching and looping.
9. Social and ethical implications, including computer crime, privacy and security, economic effects, benefits to users and futuristics.
10. Flowcharting, computer hardware, and advanced software topics.

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Support Essentials

The educational preparation required of computer science teachers should be:

1. A course on the materials and methods of teaching computer science.
2. A core curriculum consisting of the following courses:
    a. Introduction to programming and algorithm design using PASCAL.
    b. Computers and education with the exposure to LOGO.
    c. Computers and society.
    d. Programming languages.
    e. Introduction to computer systems or microcomputer systems and applications.

    Elective courses that include:
    a. Computer-assisted instruction.
    b. Introduction to file processing, data structures.
    c. Fundamentals of computer organization and digital logic.
    d. Assembly language programming.
3. A skills requirement that includes becoming more knowledgeable about the subject matter and the mastery of different instructional techniques

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that are more appropriate to higher levels of instruction.

4. A certification requirement.

Recommended personnel to teach computer science should be computer science teachers from the mathematics, science, or business education areas.

Educational policy at the local level should be determined or controlled by the local governing board.

Recommendations

Recommendations include implementation and research recommendations.

Implementation Recommendations

1. Universities and colleges need to provide methods classes for teachers to teach computer science at the high school level.

2. Evaluation of computer science at the university level is needed as students become better prepared in computer science at the high school level.

3. Implementation of more in-service training in computers for teachers is needed at the local level.

4. Implementation of an organization or association should be created at the local, state, and national levels for computer science teachers.

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5. Implementation of a committee to evaluate software is needed.

Research Recommendations

On the basis of this study, the following questions could be raised in the development of a curriculum for computer science:

1. Are computer science teachers available?
2. What educational preparation do the available computer science teachers possess?
3. What type of software is available?
4. Are local, state, or federal funds available for implementing a computer science course in your department (mathematics, science, or business education)?
5. Is emphasis placed on programming or applications?
6. Are computers introduced to students at the high school, junior high, or elementary level?

Further research is needed to answer the following questions:

1. What is the status of certification of computer science teachers in the United States?
2. What is the status of keyboarding as a prerequisite for computer science at the university level?
3. At which grade level is it best to introduce computers to students?

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4. Is there a relationship of student success of owning a computer versus not owning one?

5. Should computer literacy be taught at the junior high level and not in high school?

6. Could an alternative method for certifying teachers to teach computer science be devised?

Summary

Chapter IV included the hypotheses, grounded theories, and conclusions based on the results presented in Chapter III. Recommendations were presented relating to the development of a curriculum for computer science.

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APPENDICES

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Appendix A

Purpose of Study Letter

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A R I Z O N A   S T A T E
U N I V E R S I T Y________________________TEMPE, ARIZONA 85287

College of Business Administration
Department of Administrative Services

April __, 1984

Dear

I am gathering data for my doctoral dissertation in the area of computer science in secondary education. Drs. Sue Cummings and Robert Gryder, chairperson and co-chair of my doctoral committee, have recommended that I contact you for assistance in this study. The purpose of this study is to determine what should be required of teachers to teach computer science as recommended by the National Commission of Excellence in Education. Specifically, what I would also like to know is:

(1) What is "computer science"?

(2) What subject matter should be included in "computer science"?

(3) Who should teach the recommended computer science course?

(4) Who determines or controls educational policy at the local level?

The results of this study will help teachers in the instruction of the recommended course. Complete anonymity will be guaranteed, and results of this study will be provided if desired.

I will telephone you to schedule an interview that will take approximately one hour. A series of questions will be posed and a brief demographic sheet will be provided.

Your cooperating with me in this project will be appreciated.

Sincerely,

Christine G. Jaime
Doctoral Candidate

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Appendix B

Thank You Letter

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Dear

Thank you for the interview on

You highlighted some interesting points in computer education. Your comments are a significant part of my study.

If there were more people like you interested in education, my position as a teacher would be simplified.

Your cooperation in my study is appreciated.

Sincerely,

Christine Jaime

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Appendix C

Letter from Participant

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October 25, 1984

Ms. Christine G. Jaime
623 West Guadalupe Road, #212
Mesa, Arizona 85202

Dear Christine:

I began to answer your questionnaire and discovered I don't have enough specific information into what schools at all levels are teaching under various terms or how they are organized.

From the comments I have had from various educators and others regarding the whole area there is no clear understanding as to terms, definitions, or methods.

A couple of years ago, I asked the Dean of the "Computer Science" school at the University of Arizona for a definition of computer literacy and he couldn't give me one, yet they were advocating such courses for all students in elementary schools.

I leave it to others to figure out what should or should not be called literacy, science, etc.

Best wishes,

/s/

[Participant]

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Appendix D

Demographic Information Sheet

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Demographic Information

NAME Dr. Tom Keller PHONE 965-2689

ADDRESS College of Business DISTRICT —

SCHOOL ASU YEARS TEACHING 11

POSITION Asst. Professor YEARS IN PRESENT POSITION 3

COURSES TAUGHT (if any) Office management, SEX M

records management, CIS 200

PERSONAL INFORMATION (interests, hobbies, etc.)

reading, writing, racquetball

EDUCATIONAL BACKGROUND; MAJOR FIELD Ed.D. Administration

and Supervision with minor in computer systems

PROFESSIONAL ORGANIZATIONS NBEA, ABEA, DPE, OSRS,

AIDS, Pi Omega Pi, AISP

JOURNALS READ MONTHLY Office Administration & Automation,

Harvard Business Review, Infoworld, Business

Week, Modern Office Technology, Mgt. Technology, Inc.,

Today's Office

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Demographic Information

NAME Prudence Lee PHONE 255-4331

ADDRESS 1700 W. Washington DISTRICT

SCHOOL — YEARS TEACHING

POSITION Governor's Aide on Education YEARS IN PRESENT POSITION 2

COURSES TAUGHT (if any) SEX F

PERSONAL INFORMATION (interests, hobbies, etc.) President, Tempe Branch Amer. Association of University Women

EDUCATIONAL BACKGROUND; MAJOR FIELD Public Administration (MPA) BA, Foods + Equipment in Business

PROFESSIONAL ORGANIZATIONS Pi Alpha Alpha

JOURNALS READ MONTHLY Various magazines + journals

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Demographic Information

NAME Dr. William Lewis PHONE 965-3190

ADDRESS ASU, Tempe, AZ DISTRICT —

SCHOOL ASU, Tempe YEARS TEACHING

POSITION Computer science chairperson YEARS IN PRESENT POSITION 4

COURSES TAUGHT (if any) administrative position SEX M

PERSONAL INFORMATION (interests, hobbies, etc.)

EDUCATIONAL BACKGROUND; MAJOR FIELD B.S.E. John Hopkins University, M.A. + Ph.D., Northwestern, Illinois

PROFESSIONAL ORGANIZATIONS ACM, AREE, Sigma Pi

JOURNALS READ MONTHLY Datamation, ACM Monthly

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Demographic Information

NAME Mary Frances Lewis PHONE 967-9194

ADDRESS 1213 E. Loyola DISTRICT Tempe Union High

SCHOOL ______ YEARS TEACHING —

POSITION Board member YEARS IN PRESENT POSITION 6

COURSES TAUGHT (if any) ______ SEX F

PERSONAL INFORMATION (interests, hobbies, etc.)

Children, sewing

EDUCATIONAL BACKGROUND; MAJOR FIELD some college

PROFESSIONAL ORGANIZATIONS ASBA - NSBA

JOURNALS READ MONTHLY Arizona School Board, American School Board Journal, Executive Education

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Demographic Information

NAME Senator Anne Lindeman PHONE ____

ADDRESS Arizona State Senator DISTRICT ____
1700 W. Washington

SCHOOL Phoenix, AZ 85007 YEARS TEACHING ____

POSITION ____ YEARS IN PRESENT POSITION 8 6

COURSES TAUGHT (if any) ____ SEX F

____

PERSONAL INFORMATION (interests, hobbies, etc.) ____

____

EDUCATIONAL BACKGROUND; MAJOR FIELD ____

Nursing - registered; nurse

PROFESSIONAL ORGANIZATIONS ____

____

JOURNALS READ MONTHLY ____

____

____

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ANNE LINDEMAN

6542 West Earll Drive
Phoenix, Arizona 85033

PERSONAL:

Place of Birth:	East Orange, New Jersey - 1932
Marital Status:	Widow of Air Force Lt. Robert Lindeman
Children:	Three sons - Robert, Kurt, Kristofer
Arizona Resident:	Since 1961

EDUCATION:

Elementary and High School in Pennsylvania and Michigan
College in Ohio and Indiana
Graduated from Memorial Hospital School of Nursing, South Bend, Ind.

CIVIC AND POLITICAL ACTIVITIES:

Active in community and civic affairs such as:
- Chamber of Commerce
- P.T.A.
- Arizona Foundation for the Handicapped
- Arizona Baptist Children's Services

Maryvale Chamber of Commerce Woman of the Year--1975 and 1977

LEGISLATIVE BACKGROUND:

As a member of the House of Representatives, 1972-1976, served on the following committees:

- Education, Vice Chairman
- Appropriations
- Government Operations
- Health

Presently a member of the State Senate, serving fifth term and has served and is serving on the following committees:

- Majority Whip, 1983-84
- Senate Parliamentarian, 1979-84
- Education, Chairman, 1979-84
- Appropriations, 1979,84; Subcommittee Chairman 1981-84; Vice-Chairman 1983-84
- Government, 1977-82
- Rules, 1979-80
- Commerce and Labor, 1983-84
- Health, Welfare & Aging, 1977-84
- Legislative Council, 1981-84
- Joint Legislative Budget Committee, 1983-84
- Joint Legislative Reapportionment Committee, 1981

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LEGISLATIVE BACKGROUND: (Continued)

Member, National Child Abuse Advisory Council (ECS) 1976-78

Member, State Vocational Education Advisory Commission, 1977

Member, Committee on Educaton and Social Services, The Western Conference of the Council of State Governments, 1979-80

Member, Education Commission of the States

Chairman - Policy and Priorities Committee, 1982
Vice Chairman, 1983
Coordinator-Arizona State Education Policy Seminars, 1982-84

Legislator of the Year -- Arizona Vocational Education Association, 1981 and 1982

Member, Board of Directors, National Center for Higher Education Management Systems

Member, Board of Directors, Jobs for America's Graduates - 1983

Chairman, Advisory Council, United Student Aid Funds

NATIONAL REPUBLICAN LEGISLATOR OF THE YEAR, National Republican Legislators Association, 1982

Member and Officer of the National Conference of State Legislatures (offices held on separate sheet).

Member, President Reagan's Advisory Council on Federalism, 1982

4/83

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Demographic Information

NAME Jim Love PHONE 839-0292

ADDRESS 500 W. Guadalupe DISTRICT Tempe Union

SCHOOL ______ YEARS TEACHING 25

POSITION ______ YEARS IN PRESENT POSITION 4

COURSES TAUGHT (if any) ______ SEX M

PERSONAL INFORMATION (interests, hobbies, etc.)

fishing, boating, camping

EDUCATIONAL BACKGROUND; MAJOR FIELD business education, educational administration

PROFESSIONAL ORGANIZATIONS ASCD, AASA, ASA

JOURNALS READ MONTHLY Phi Delta Kappa, Executive Educator, School Board Journal, etc.

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Demographic Information

NAME Chuck Riles PHONE 898-2939

ADDRESS 1501 W. Guadalupe Rd. DISTRICT Mesa

SCHOOL Dobson High YEARS TEACHING 18

POSITION Dept. Chairperson - math YEARS IN PRESENT POSITION 3

COURSES TAUGHT (if any) BASIC I, II, PASCAL SEX M

Advanced Placement, Computer science

PERSONAL INFORMATION (interests, hobbies, etc.)

Bicycling

EDUCATIONAL BACKGROUND; MAJOR FIELD Math

PROFESSIONAL ORGANIZATIONS NCTM, CUES

JOURNALS READ MONTHLY Arithmetic Teacher, Mathematics Teacher, Computer Classroom Learning, TLC

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Demographic Information

NAME Tom Santesteban PHONE 257-3700

ADDRESS 3852 N. 29th Ave. DISTRICT —

SCHOOL AZ School Boards Assn. YEARS TEACHING 5

POSITION Associate Executive Director YEARS IN PRESENT POSITION 1

COURSES TAUGHT (if any) K-8 all subjects from SEX M

a L.D. resource base

PERSONAL INFORMATION (interests, hobbies, etc.)

films, reading, travel

EDUCATIONAL BACKGROUND; MAJOR FIELD elementary and special ed.; hold B.S., M.A., doctorate degree in progress.

PROFESSIONAL ORGANIZATIONS

JOURNALS READ MONTHLY American School Board Journal, PDK Journal, various professional literature

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Demographic Information

NAME Dick Sheets PHONE 898-7876

ADDRESS 6402 E Sheridan St DISTRICT Mesa

SCHOOL District YEARS TEACHING 9

POSITION Computer Specialist YEARS IN PRESENT POSITION 2

COURSES TAUGHT (if any) Computer, math (7-9), SEX M
science (7-9), tech. of supv, mgmt at MTCC

PERSONAL INFORMATION (interests, hobbies, etc.) golf, tennis, swimming, football, computer, woodworking

EDUCATIONAL BACKGROUND; MAJOR FIELD B.S.P.E., Master (MAed) Ed. Admin, certified K-8 7-12 CC, Principal Cert., elementary and secondary

PROFESSIONAL ORGANIZATIONS Phi Delta Kappa + MEA /NEA /AEA

JOURNALS READ MONTHLY Electronic Learning, Teachers + Computers, Personal Computer, Math Teacher / Arithmetic Teacher, Educ Comp, Hard Copy, T.H.E. Journal.

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Appendix E

Cover Letter 1

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623 W. Guadalupe Rd.
#212
Mesa, AZ 85202
October 1984

Dear

Once again I appreciate your cooperation and participation in my study.

You were selected because of your expertise in the area of education.

I am asking you to make judgments about selected statements for computer science by means of a three-phase Delphi instrument. The Delphi technique is a means of arriving at a consensus without bringing a "panel of experts" in a face-to-face situation. The technique was developed at the RAND Corporation about 20 years ago for the purpose of making forecasts.

The process is as follows:

1. I will treat the data and return to you the results so that you may revise, delete, or add to the statements.

2. On succeeding phases, or rounds, those individuals whose judgments deviate from what other respondents tend to give are requested to justify their judgments.

3. The justifications are then summarized, returned, and counter-arguments elicited. After the second and the third round (last round), I expect the statements gathered will decrease in number.

4. A conclusion can then be reached concerning emerging curricula for computer science at the secondary school level.

The Delphi technique is highly acclaimed by some researchers.

Please circle your response for each statement on the questionnaire. You are welcome to add any remarks following each statement. Please notify me of any problems you encounter; phone 898-4942 (work) or 892-2304 (home).

Complete the attached questionnaire and return it in the postage-paid envelope. Please return the questionnaire by October 23.

When my study is completed, you will receive a copy of my dissertation.

Thank you for your help.

Sincerely

Christine G. Jaime

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Appendix F

Questionnaire 1

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QUESTIONNAIRE I

Directions: Please circle each statement according to the following scale.

SA = Strongly Agree
A = Agree
N = Neutral
D = Disagree
SD = Strongly Disagree

U = Undecided

		Responses
1.	Teachers who use computers in the classroom can teach anything under the heading, "computer science."	SA A N D SD U

Remarks____________________

2.	Computer science is not clearly defined in A Nation at Risk report.	SA A N D SD U

Remarks____________________

3.	Computer literacy is the same as computer science.	SA A N D SD U

Remarks____________________

4.	Computer science is the study of information storage, processing, interpretation of data, study of equipment, and programs that effectively and efficiently perform data handling tasks.	SA A N D SD U

Remarks____________________

5.	Computer science is the study of design, basic structure of what a computer is, kinds of applications, major functions of a computer, networking, and programming.	SA A N D SD U

Remarks____________________

6.	Computer science is the study of programming, engineering, repair and maintenance of computers.	SA A N D SD U

Remarks____________________

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7.	Computer science is the study of computer awareness and computer literacy.	SA	A	N	D	SD	U

Remarks__________

8.	"Computer information" systems is a better term to use than "computer science."	SA	A	N	D	SD	U

Remarks__________

9.	Computer science is an established field.	SA	A	N	D	SD	U

Remarks__________

10.	Computer science is the teaching of the computer.	SA	A	N	D	SD	U

Remarks__________

11.	Computer science is the teaching of more sophisticated types of equipment.	SA	A	N	D	SD	U

Remarks__________

12.	Computer science is the teaching of programming in various languages.	SA	A	N	D	SD	U

Remarks__________

13.	The basic course in computer science is designed to teach the student to use the computer as a means of learning problem-solving skills.	SA	A	N	D	SD	U

Remarks__________

14.	The direction of a secondary-school-level computer science course is to provide the student with a realistic concept of the power, usefulness, and limitations of computers.	SA	A	N	D	SD	U

Remarks__________

15.	Computer science students are provided with a context from which to consider possible future directions in computing.	SA	A	N	D	SD	U

Remarks__________

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16.	Students work individually to solve problems or work in teams.	SA A N D SD U

Remarks____

17.	The issue of specific knowledge and skills must be dealt with and made concrete concerning course content for computer science.	SA A N D SD U

Remarks____

18.	Realistic concepts of the power, usefulness, and limitations of computers are stressed in a computer science course.	SA A N D SD U

Remarks____

19.	Students are well aware of the broad spectrum of computer applications.	SA A N D SD U

Remarks____

20.	Problem solving, including defining the problem, breaking the problem into subproblems, concept of the algorithm, and graphic representation of the solution is a study topic in computer science.	SA A N D SD U

Remarks____

21.	The basic course is designed to teach problem solving in the most general sense.	SA A N D SD U

Remarks____

22.	Programming methods (including documenting, programing style, manual reading, debugging, and structured programing techniques) is a study topic in computer science.	SA A N D SD U

Remarks____

23.	Programming language (including language syntax, functions and subroutines, input/output, simple sorting, searching, file structures, file manipulation) is included as a study topic in computer science.	SA A N D SD U

Remarks____

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24. Branching and looping is also a study topic in computer science. SA A N D SD U

Remarks

25. Areas of application (including business, health, music, art, engineering, education, research, government, and law) is stressed as a study topic in computer science. SA A N D SD U

Remarks

26. Applications of the computer in word processing, personal computing, electronic funds transfer, information storage and retrieval, arithmetic calculations, and artificial intelligence is a study topic in computer science. SA A N D SD U

Remarks

27. The history of computing (including people and events, trends and predictions, generations of computers, and the effects of computers in our modern world) is a study topic in computer science. SA A N D SD U

Remarks

28. Social and ethical implications (including computer crime, privacy and security, careers in computing, economic effects, benefits to users, and futuristics) is a study topic in computer science. SA A N D SD U

Remarks

29. Readings are assigned for background understanding of the "real world" of computers in science, business, and industry. SA A N D SD U

Remarks

30. Keyboarding is a required skill for computer science. SA A N D SD U

Remarks

31. Elementary algebra or geometry is required for computer science. SA A N D SD U

Remarks

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32. Software is evaluated carefully for student use. SA A N D SD U

Remarks____

33. Software is well written and has good user instructions. SA A N D SD U

Remarks____

34. Computer science teachers need to learn how to evaluate software. SA A N D SD U

Remarks____

35. Availability and compatibility of software is a current problem for computer science teachers. SA A N D SD U

Remarks____

36. A computer science student learns to program. SA A N D SD U

Remarks____

37. Good programming style is emphasized in the classroom. SA A N D SD U

Remarks____

38. Good documentation is required as a regular part of all student programming. SA A N D SD U

Remarks____

39. Structured programming techniques are used in the development of a solution until a program is produced. SA A N D SD U

Remarks____

40. Problems studied range from simple solutions to complex solutions. SA A N D SD U

Remarks____

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41. Students need to learn the fundamentals of the English language before learning to program. SA A N D SD U

Remarks__________

42. University computer science professors do not encourage programming at the high school level because computer students acquire bad programming habits. SA A N D SD U

Remarks__________

43. Students are exposed from three to four programming languages. SA A N D SD U

Remarks__________

44. The programming languages selected are fairly simple and widely used, but powerful enough for meaningful programming. SA A N D SD U

Remarks__________

45. BASIC has enough capability for an introductory computer science course and is available on most systems. SA A N D SD U

Remarks__________

46. A programming language that encourages good habits is taught in computer science. SA A N D SD U

Remarks__________

47. Computer science teachers are short changing students by teaching BASIC. SA A N D SD U

Remarks__________

48. BASIC is a sloppy language to teach programming. SA A N D SD U

Remarks__________

49. Computer science students are aware of other programming languages, such as FORTRAN, COBOL, PILOT, and LOGO. SA A N D SD U

Remarks__________

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50. PASCAL is taught to prepare students for the advanced placement test in computer science. SA A N D SD U

Remarks__________

51. The combination of three programming languages (BASIC, PASCAL, and COBOL) are best suited for the advanced placement test, and not just PASCAL. SA A N D SD U

Remarks__________

52. Computer science teachers teach for the advanced placement test. SA A N D SD U

Remarks__________

53. A computer science teacher requires the use of computer equipment in the classroom. SA A N D SD U

Remarks__________

54. Hard copy capability is required of the computer system selected. SA A N D SD U

Remarks__________

55. One terminal or microcomputer is provided for each 15 to 20 students involved in computing. SA A N D SD U

Remarks__________

56. Each computer science student has at least 45 minutes per day at a terminal or microcomputer. SA A N D SD U

Remarks__________

57. When possible, students use the computer outside of regular class or school hours. SA A N D SD U

Remarks__________

58. Obsoleteness of equipment is a problem. SA A N D SD U

Remarks__________

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59. Computer science is taught by teachers in the business education department. SA A N D SD U

Remarks____

60. Computer science is taught by teachers in the math department. SA A N D SD U

Remarks____

61. Computer science is taught by teachers in the science department. SA A N D SD U

Remarks____

62. Computer science is offered for credit through the math, science, and business education programs. SA A N D SD U

Remarks____

63. A computer science course is not appropriate for all school districts. SA A N D SD U

Remarks____

64. Computer science is a separate department. SA A N D SD U

Remarks____

65. Computer science is not a separate department. SA A N D SD U

Remarks____

66. Computer science is taught only by those teachers interested in teaching computer science. SA A N D SD U

Remarks____

67. Teachers from different departments teach computer science. SA A N D SD U

Remarks____

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68. Computers are integrated in the curriculum to enhance learning. SA A N D SD U

Remarks__________

69. Computers are integrated in all areas of the curriculum. SA A N D SD U

Remarks__________

70. School districts on the local level need to provide more computer in-service training for teachers. SA A N D SD U

Remarks__________

71. Many colleges and universities recognize the need for computer science curricula for the training of teachers. SA A N D SD U

Remarks__________

72. The advent of the advanced placement test in computer science forces the implementation of training teachers for computer science. SA A N D SD U

Remarks__________

73. Certification of teachers in computer science is required as a result of the advanced placement test in computer science. SA A N D SD U

Remarks__________

74. Teachers are not trained and not being trained for computer science. SA A N D SD U

Remarks__________

75. A university computer science course is required for all secondary education, computer-science teachers. SA A N D SD U

Remarks__________

76. A need exists for qualified high school computer science teachers. SA A N D SD U

Remarks__________

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77. All computer science teachers are exposed to LOGO. SA A N D SD U

Remarks_______________

78. Arizona is now certifying teachers for computer science. SA A N D SD U

Remarks_______________

79. The colleges of education need to provide training in computers for teachers. SA A N D SD U

Remarks_______________

80. School districts need to make a financial commitment for more computers. SA A N D SD U

Remarks_______________

81. If computer science becomes a mandatory graduation requirement of all high school seniors in Arizona, the State of Arizona needs to provide funding for equipment, personnel, training, and materials. SA A N D SD U

Remarks_______________

82. Computers are not a panacea for everything. SA A N D SD U

Remarks_______________

83. A need exists to emphasize computer applications, not programming. SA A N D SD U

Remarks_______________

84. Students now entering the ninth grade are computer literate. SA A N D SD U

Remarks_______________

85. Computers are a passing fad. SA A N D SD U

Remarks_______________

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86. School districts are "jumping into" the purchase of computers. SA A N D SD U

Remarks __________

87. Computers are not a passing fad; computers are here to stay. SA A N D SD U

Remarks __________

88. A cultural difference of owning computers is arising for high school students. SA A N D SD U

Remarks __________

89. The computer age has passed; the information age is here. SA A N D SD U

Remarks __________

90. Computer literacy courses are slowly being eliminated in the curriculum as students become more prepared in lower grades. SA A N D SD U

Remarks __________

91. Computer science at the high school level is good for school districts who are not using computers. SA A N D SD U

Remarks __________

92. Computer science should not be taught at the high school level. SA A N D SD U

Remarks __________

93. Computer science is a good start, but not an end. SA A N D SD U

Remarks __________

94. A "turfism" problem exists at many local schools concerning the teaching of computer science. SA A N D SD U

Remarks __________

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95. The fear of computers still remains a problem for some teachers. SA A N D SD U

Remarks__________

96. The role of a teacher in the classroom is changing as a result of the computer. SA A N D SD U

Remarks__________

97. School districts need to become more inolved and flexible in the area of computer science. SA A N D SD U

Remarks__________

98. Politics influences the curriculum. SA A N D SD U

Remarks__________

99. Computer literacy cannot be defined. SA A N D SD U

Remarks__________

100. Computer science cannot be defined. SA A N D SD U

Remarks__________

101. A computer-literate person understands the fundamentals of how to operate the equipment and how to interface with the equipment. SA A N D SD U

Remarks__________

102. The terms "computer awareness" and "computer literacy" can be used interchangeably. SA A N D SD U

Remarks__________

103. A "computer-aware" student understands the basics of computers. SA A N D SD U

Remarks__________

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104. Good software for education is lacking. SA A N D SD U

Remarks___

105. Computer science teachers need to consider the relevancy of topics discussed in the classroom. SA A N D SD U

Remarks___

106. The grade level at which computers are introduced to students is a problem. SA A N D SD U

Remarks___

107. The generation of today is more prepared about computers before entering high school. SA A N D SD U

Remarks___

108. Outlying areas in Arizona are denied access to computers. SA A N D SD U

Remarks___

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Appendix G

Cover Letter 2

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623 W. Guadalupe Rd. #212
Mesa, AZ 85202
November 1984

Dear

Thank you for completing Phase 1 of the study.

In this phase, you are presented the statements again. However, this time your Phase 1 choices are marked in "shocking pink." The Phase 1 choices which the other experts tended to choose are marked in "super green." If your choices and what the other experts tended to choose overlapped, then the choices are highlighted in "turquoise blue."

Please go through all of the statements, again, making judgments just as you did in Phase 1. PLEASE MARK YOUR PHASE 2 CHOICES WITH A BLACK PEN.

IMPORTANT: If your Phase 2 choices do not agree with what the other participants tended to mark in Phase 1, please explain in a few words in the space provided (remarks) why you chose the responses you did. THIS PROCEDURE IS IMPORTANT.

If you will notice, six statements have been deleted, while some statements have been added or revised. Therefore, please review all the items carefully. The new or revised statements are not colored.

Please return the completed questionnaire by December 13. A postage-paid, addressed envelope is enclosed. Phase 3 (the last phase) will be sent to you later. Please phone 898-4941 if any problems.

Thank you for your cooperation.

Sincerely,

Christine G. Jaime

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Appendix H

Questionnaire 2

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QUESTIONNAIRE II

Directions: Please circle each statement according to the following scale.

SA = Strongly Agree
A = Agree
N = Neutral
D = Disagree
SD = Strongly Disagree

U = Undecided

		Responses
1.	Teachers who use computers in the classroom can teach anything under the heading, "computer science."	SA A N D SD U

Remarks____________________

2.	Computer science is not clearly defined in A Nation at Risk report.	SA A N D SD U

Remarks____________________

3.	Computer literacy is the same as computer science.	SA A N D SD U

Remarks____________________

4.	Computer science is the study of information storage, processing, interpretation of data, study of equipment, and programs that effectively and efficiently perform data handling tasks.	SA A N D SD U

Remarks____________________

5.	Computer science is the study of design, basic structure of what a computer is, kinds of applications, major functions of a computer, networking, and programming.	SA A N D SD U

Remarks____________________

6.	Computer science is the study of programming, engineering, repair and maintenance of computers.	SA A N D SD U

Remarks____________________

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7.	Computer science is the study of computer awareness and computer literacy.	SA	A	N	D	SD	U

Remarks____________________

8.	"Computer information" systems is a better term to use than "computer science."	SA	A	N	D	SD	U

Remarks____________________

9.	Computer science is an established field.	SA	A	N	D	SD	U

Remarks____________________

10.	Computer science is the teaching of more sophisticated types of equipment.	SA	A	N	D	SD	U

Remarks____________________

11.	Computer science is the teaching of programming in various languages.	SA	A	N	D	SD	U

Remarks____________________

12.	The basic course in computer science is designed to teach the student to use the computer as a means of learning problem-solving skills.	SA	A	N	D	SD	U

Remarks____________________

13.	The direction of a secondary-school-level computer science course is to provide the student with a realistic concept of the power, usefulness, and limitations of computers.	SA	A	N	D	SD	U

Remarks____________________

14.	Computer science students are provided with a context from which to consider possible future directions in computing.	SA	A	N	D	SD	U

Remarks____________________

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15. Realistic concepts of the power, usefulness, and limitations of computers are stressed in a computer science course. SA A N D SD U

Remarks____

16. Computer science students are well aware of the broad spectrum of computer applications. SA A N D SD U

Remarks____

17. Problem solving, including defining the problem, breaking the problem into subproblems, concept of the algorithm, and graphic representation of the solution should be a study topic in computer science. SA A N D SD U

Remarks____

18. The basic computer science course should be designed to teach problem solving in the most general sense. SA A N D SD U

Remarks____

19. Programming methods (including documenting, programing style, manual reading, debugging, and structured programing techniques) is a study topic in computer science. SA A N D SD U

Remarks____

20. Programming language (including language syntax, functions and subroutines, input/output, simple sorting, searching, file structures, file manipulation) is included as a study topic in computer science. SA A N D SD U

Remarks____

21. Branching and looping is also a study topic in computer science. SA A N D SD U

Remarks____

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22. Areas of application (including business, health, music, art, engineering, education, research, government, and law) is stressed as a study topic in computer science. SA A N D SD U

Remarks______

23. The history of computing (including people and events, trends and predictions, generations of computers, and the effects of computers in our modern world) is a study topic in computer science. SA A N D SD U

Remarks______

24. Social and ethical implications (including computer crime, privacy and security, careers in computing, economic effects, benefits to users, and futuristics) is a study topic in computer science. SA A N D SD U

Remarks______

25. Keyboarding is a required skill for computer science. SA A N D SD U

Remarks______

26. Elementary algebra or geometry is required for computer science. SA A N D SD U

Remarks______

27. Software is evaluated carefully for student use. SA A N D SD U

Remarks______

28. Some software is well written and has good user instructions. SA A N D SD U

Remarks______

29. Computer science teachers need to learn how to evaluate software. SA A N D SD U

Remarks______

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30. Availability and compatibility of software is a current problem for computer science teachers. SA A N D SD U

Remarks ______

31. A computer science student learns to program. SA A N D SD U

Remarks ______

32. Good programming style is emphasized in the classroom. SA A N D SD U

Remarks ______

33. Good documentation is required as a regular part of all student programming. SA A N D SD U

Remarks ______

34. Structured programming techniques are used in the development of a solution until a program is produced in an advanced computer science course. SA A N D SD U

Remarks ______

35. Students need to learn the fundamentals of the English language before learning to program. SA A N D SD U

Remarks ______

36. University computer science professors do not encourage programming at the high school level because computer students acquire bad programming habits. SA A N D SD U

Remarks ______

37. Students are exposed from three to four programming languages in an advanced computer science course. SA A N D SD U

Remarks ______

38. The programming languages selected are farily simple and widely used, but powerful enough for meaningful programming. SA A N D SD U

Remarks ______

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39. BASIC has enough capability for an introductory computer science course and is available on most systems. SA A N D SD U

Remarks__________

40. A programming language that encourages good habits is taught in computer science. SA A N D SD U

Remarks__________

41. Computer science teachers are short changing students by teaching BASIC. SA A N D SD U

Remarks__________

42. BASIC is a sloppy language to teach programming. SA A N D SD U

Remarks__________

43. Computer science students are aware of other programming languages, such as FORTRAN, COBOL, PILOT, and LOGO. SA A N D SD U

Remarks__________

44. PASCAL is taught to prepare students for the advanced placement test in computer science. SA A N D SD U

Remarks__________

45. The combination of three programming languages (BASIC, PASCAL, and COBOL) are best suited for the advanced placement test, and not just PASCAL. SA A N D SD U

Remarks__________

46. Computer science teachers teach for the advanced placement test. SA A N D SD U

Remarks__________

47. A computer science teacher requires the use of computer equipment in the classroom. SA A N D SD U

Remarks__________

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48. Hard copy capability is required of the computer system selected. SA A N D SD U

Remarks ______

49. One terminal or microcomputer is provided for each 10 students involved in computing. SA A N D SD U

Remarks ______

50. Each computer science student should have at least 45 minutes per day at a terminal or microcomputer. SA A N D SD U

Remarks ______

51. When possible, students should use the computer outside of regular class or school hours. SA A N D SD U

Remarks ______

52. Obsoleteness of equipment is a problem. SA A N D SD U

Remarks ______

53. Computer science is sometimes taught by teachers in the businss education department. SA A N D SD U

Remarks ______

54. Computer science is sometimes taught by teachers in the math department. SA A N D SD U

Remarks ______

55. Computer science is sometimes taught by teachers in the science department. SA A N D SD U

Remarks ______

56. Computer science is sometimes offered for credit through the math, science, and business education programs. SA A N D SD U

Remarks ______

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57. A computer science course is not appropriate for all school districts. SA A N D SD U

Remarks

58. Computer science is a separate department. SA A N D SD U

Remarks

59. Computer science is not a separate department. SA A N D SD U

Remarks

60. Computer science is taught only by those teachers interested in teaching computer science. SA A N D SD U

Remarks

61. Teachers from different departments sometimes teach computer science. SA A N D SD U

Remarks

62. Computers should be integrated in the curriculum to enhance learning. SA A N D SD U

Remarks

63. Computers are sometimes integrated in all areas of the curriculum. SA A N D SD U

Remarks

64. School districts on the local level need to provide more computer in-service training for teachers. SA A N D SD U

Remarks

65. Many colleges and universities recognize the need for computer science curricula for the training of teachers. SA A N D SD U

Remarks

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66.	The advent of the advanced placement test in computer science forces the implementation of training teachers for computer science.	SA	A	N	D	SD	U

Remarks______________________________

67.	Certification of teachers in computer science should be required as a result of the advanced placement test in computer science.	SA	A	N	D	SD	U

Remarks______________________________

68.	Teachers are not trained and not being trained for computer science.	SA	A	N	D	SD	U

Remarks______________________________

69.	At least two or three computer science courses should be required for all secondary education, computer science teachers.	SA	A	N	D	SD	U

Remarks______________________________

70.	A need exists for qualified high school computer science teachers.	SA	A	N	D	SD	U

Remarks______________________________

71.	All computer science teachers are exposed to LOGO.	SA	A	N	D	SD	U

Remarks______________________________

72.	Arizona is now certifying teachers for computer science.	SA	A	N	D	SD	U

Remarks______________________________

73.	The colleges of education need to provide training in computers for teachers.	SA	A	N	D	SD	U

Remarks______________________________

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74. School districts need to make a financial commitment for more computers. SA A N D SD U

Remarks____________________

75. If computer science becomes a mandatory graduation requirement of all high school seniors in Arizona, the State of Arizona needs to provide funding for equipment, personnel, training, and materials. SA A N D SD U

Remarks____________________

76. Computers are not a panacea for everything. SA A N D SD U

Remarks____________________

77. A need exists to emphasize computer applications, not programming. SA A N D SD U

Remarks____________________

78. Students now entering the ninth grade are computer literate. SA A N D SD U

Remarks____________________

79. Computers are a passing fad. SA A N D SD U

Remarks____________________

80. School districts are "jumping into" the purchase of computers. SA A N D SD U

Remarks____________________

81. Computers are not a passing fad; computers are here to stay. SA A N D SD U

Remarks____________________

82. A cultural difference of owning computers is arising for high school students. SA A N D SD U

Remarks____________________

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83. The computer age has passed; the information age is here. SA A N D SD U

Remarks ______________________________

84. Computer literacy courses are slowly being eliminated in the curriculum as students become more prepared in lower grades. SA A N D SD U

Remarks ______________________________

85. Computer science at the high school level is good for school districts who are not using computers. SA A N D SD U

Remarks ______________________________

86. Computer science should not be taught at the high school level. SA A N D SD U

Remarks ______________________________

87. Computer science is a good start, but not an end. SA A N D SD U

Remarks ______________________________

88. A "turfism" problem exists at many local schools concerning the teaching of computer science. SA A N D SD U

Remarks ______________________________

89. The fear of computers still remains a problem for some teachers. SA A N D SD U

Remarks ______________________________

90. The role of a teacher in the classroom is changing as a result of the computer. SA A N D SD U

Remarks ______________________________

91. School districts need to become more inolved and flexible in the area of computer science. SA A N D SD U

Remarks ______________________________

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92. Politics influences the curriculum. SA A N D SD U

Remarks ____

93. Computer literacy cannot be defined. SA A N D SD U

Remarks ____

94. Computer science cannot be defined. SA A N D SD U

Remarks ____

95. A computer-literate person understands the fundamentals of how to operate the equipment and how to interface with the equipment. SA A N D SD U

Remarks ____

96. The terms "computer awareness" and "computer literacy" can be used interchangeably. SA A N D SD U

Remarks ____

97. A "computer-aware" student understands the basics of computers. SA A N D SD U

Remarks ____

98. Good software for education is lacking. SA A N D SD U

Remarks ____

99. Computer science teachers need to consider the relevancy of topics discussed in the classroom. SA A N D SD U

Remarks ____

100. The grade level at which computers are introduced to students is a problem. SA A N D SD U

Remarks ____

101. The generation of today is more prepared about computers before entering high school. SA A N D SD U

Remarks ____

102. Outlying areas in Arizona are denied access to computers. SA A N D SD U

Remarks ____

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Appendix I

Thank You Postcards

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November, 1984

Dear ________________:

Thank you for your quick response to Questionnaire I.

Sincerely,

Chris Jaime

December, 1984

Dear ________________:

Again, thank you for your quick response to Questionnaire 2.

Hopefully, some questions will be deleted in this round by other participants (statements that were poorly worded).

One more round is left and that's it! You'll probably be glad to get rid of me.

HAPPY HOLIDAYS!

Sincerely,

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Appendix J

Cover Letter 3

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623 W. Guadalupe Rd.
#212
Mesa, AZ 85202
March 1985

Dear

Thank you for completing Phase 2 of the study; Phase 3 is the LAST phase.

Once again, your responses from Phase 2 are in "shocking pink." The Phase 2 choices the other experts selected are marked in "super green." If your choices were similar to the responses of the other participants, the statements are marked in the resultant colors "pink and green."

If you will notice, four statements were deleted, while nine statements were revised. The revised statements are highlighted in "turquoise blue" to indicate a new response is needed from you. Therefore, please review all the statements carefully. PLEASE MARK YOUR PHASE 3 CHOICES WITH A BLACK PEN.

Please return the completed questionnaire in the enclosed postage paid envelope by March 22, 1985. A quick response is necessary so that I can compile your responses and arrive at a final answer. Please phone 898-4941 if you have any questions.

Thank you for your cooperation in the study. A "treat on me" of $10.00 cash is enclosed for all your help.

Sincerely,

Christine G. Jaime

2 Enclosures
$10.00 cash
Envelope

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Appendix K

Questionnaire 3

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QUESTIONNAIRE III

Directions: Please circle each statement according to the following scale.

SA = Strongly Agree
A = Agree
N = Neutral
D = Disagree
SD = Strongly Disagree

U = Undecided

	Statement	Responses
1.	Teachers who use computers in the classroom can teach anything under the heading, "computer science."	SA A N D SD U
2.	Computer science is not clearly defined in A Nation at Risk report.	SA A N D SD U
3.	Computer literacy is the same as computer science.	SA A N D SD U
4.	Computer science is the study of information storage, processing, interpretation of data, study of equipment, and programs that effectively and efficiently perform data handling tasks.	SA A N D SD U
5.	Computer science is the study of design, basic structure of what a computer is, kinds of applications, major functions of a computer, networking, and programming.	SA A N D SD U
6.	Computer science is the study of programming, engineering, repair and maintenance of computers.	SA A N D SD U

Remarks ______ (after each statement)

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7. Computer science is the study of computer awareness and computer literacy. SA A N D SD U

Remarks_______________

8. "Computer information" systems is a better term to use than "computer science." SA A N D SD U

Remarks_______________

9. Computer science is an established field. SA A N D SD U

Remarks_______________

10. Computer science is the teaching of more sophisticated types of equipment. SA A N D SD U

Remarks_______________

11. Computer science is the teaching of programming in various languages. SA A N D SD U

Remarks_______________

12. The basic course in computer science is designed to teach the student to use the computer as a means of learning problem-solving skills. SA A N D SD U

Remarks_______________

13. The direction of a secondary-school-level computer science course is to provide the student with a realistic concept of the power, usefulness, and limitations of computers. SA A N D SD U

Remarks_______________

14. Computer science students are provided with a context from which to consider possible future directions in computing. SA A N D SD U

Remarks_______________

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15. Realistic concepts of the power, usefulness, and limitations of computers are stressed in a computer science course. SA A N D SD U

Remarks______

16. Computer science students are well aware of the broad spectrum of computer applications. SA A N D SD U

Remarks______

17. Problem solving, including defining the problem, breaking the problem into subproblems, concept of the algorithm, and graphic representation of the solution should be a study topic in computer science. SA A N D SD U

Remarks______

18. The basic computer science course should be designed to teach problem solving in the most general sense. SA A N D SD U

Remarks______

19. Programming methods (including documenting, programing style, manual reading, debugging, and structured programing techniques) is a study topic in computer science. SA A N D SD U

Remarks______

20. Programming language (including language syntax, functions and subroutines, input/output, simple sorting, searching, file structures, file manipulation) is included as a study topic in computer science. SA A N D SD U

Remarks______

21. Branching and looping is also a study topic in computer science. SA A N D SD U

Remarks______

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22. Areas of application (including business, health, music, art, engineering, education, research, government, and law) is stressed as a study topic in computer science. SA A N D SD U

Remarks ______

23. The history of computing (including people and events, trends and predictions, generations of computers, and the effects of computers in our modern world) is a study topic in computer science. SA A N D SD U

Remarks ______

24. Social and ethical implications (including computer crime, privacy and security, careers in computing, economic effects, benefits to users, and futuristics) is a study topic in computer science. SA A N D SD U

Remarks ______

25. Keyboarding is a required skill for computer science. SA A N D SD U

Remarks ______

26. Elementary algebra or geometry is required for computer science. SA A N D SD U

Remarks ______

27. Software is evaluated carefully for student use. SA A N D SD U

Remarks ______

28. Some software is well written and has good user instructions. SA A N D SD U

Remarks ______

29. Computer science teachers need to learn how to evaluate software. SA A N D SD U

Remarks ______

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30. Availability and compatibility of software is a current problem for computer science teachers. SA A N D SD U

Remarks__________

31. A computer science student learns to program. SA A N D SD U

Remarks__________

32. Good programming style is emphasized in the classroom. SA A N D SD U

Remarks__________

33. Good documentation is required as a regular part of all student programming. SA A N D SD U

Remarks__________

34. Structured programming techniques are used in the development of a solution until a program is produced in an advanced computer science course. SA A N D SD U

Remarks__________

35. Students need to learn the fundamentals of the English language before learning to program. SA A N D SD U

Remarks__________

36. University computer science professors do not encourage programming at the high school level because computer students acquire bad programming habits. SA A N D SD U

Remarks__________

37. The programming languages selected are fairly simple and widely used, but powerful enough for meaningful programming. SA A N D SD U

Remarks__________

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38. BASIC has enough capability for an introductory computer science course. SA A N D SD U

Remarks____

39. A programming language that encourages good habits is taught in computer science. SA A N D SD U

Remarks____

40. Computer science teachers are short changing students by teaching BASIC. SA A N D SD U

Remarks____

41. BASIC is a sloppy language to teach programming. SA A N D SD U

Remarks____

42. Computer science students are aware of other programming languages, such as FORTRAN, COBOL, PILOT, and LOGO. SA A N D SD U

Remarks____

43. PASCAL is taught to prepare students for the advanced placement test in computer science. SA A N D SD U

Remarks____

44. The combination of three programming languages (BASIC, PASCAL, and COBOL) are best suited for the advanced placement test, and not just PASCAL. SA A N D SD U

Remarks____

45. A computer science teacher requires the use of computer equipment in the classroom. SA A N D SD U

Remarks____

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46. Hard copy capability is required of the computer system selected. SA A N D SD U

Remarks____

47. One terminal is provided for each two students in computer science on the high school level. SA A N D SD U

Remarks____

48. Each computer science student should have at least 45 minutes per day at a terminal or microcomputer. SA A N D SD U

Remarks____

49. When possible, students should use the computer outside of regular class or school hours. SA A N D SD U

Remarks____

50. Obsoleteness of equipment is a problem. SA A N D SD U

Remarks____

51. Computer science is sometimes taught by teachers in the business education department. SA A N D SD U

Remarks____

52. Computer science is sometimes taught by teachers in the math department. SA A N D SD U

Remarks____

53. Computer science is sometimes taught by teachers in the science department. SA A N D SD U

Remarks____

54. Computer science is sometimes offered for credit through the math, science, and business education programs. SA A N D SD U

Remarks____

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55. A computer science course is not appropriate for all school districts. SA A N D SD U

Remarks ____________________

56. Computer science is a separate department. SA A N D SD U

Remarks ____________________

57. Computer science is not a separate department. SA A N D SD U

Remarks ____________________

58. Computer science is taught only by those teachers interested in teaching computer science. SA A N D SD U

Remarks ____________________

59. Computers should be integrated in the curriculum to enhance learning. SA A N D SD U

Remarks ____________________

60. Computers should be integrated in all areas of the curriculum. SA A N D SD U

Remarks ____________________

61. School districts on the local level need to provide more computer in-service training for teachers. SA A N D SD U

Remarks ____________________

62. Some colleges and universities recognize the need for computer science curricula for the training of teachers. SA A N D SD U

Remarks ____________________

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63. The advent of the advanced placement test in computer science forces the implementation of training teachers for computer science. SA A N D SD U

Remarks ______________________________

64. Certification of teachers in computer science should be required. SA A N D SD U

Remarks ______________________________

65. Teachers are not trained and not being trained for computer science. SA A N D SD U

Remarks ______________________________

66. A minimum of two or three computer science courses should be required for all secondary education, computer science teachers. SA A N D SD U

67. A need exists for qualified high school computer science teachers. SA A N D SD U

Remarks ______________________________

68. All computer science teachers are exposed to LOGO. SA A N D SD U

Remarks ______________________________

69. Arizona is now certifying teachers for computer science. SA A N D SD U

Remarks ______________________________

70. The colleges of education need to provide training in computers for teachers. SA A N D SD U

Remarks ______________________________

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71.	School districts need to make a financial commitment for more computers.	SA	A	N	D	SD	U

Remarks____

72.	If computer science becomes a mandatory graduation requirement of all high school seniors in Arizona, the State of Arizona needs to provide funding for equipment, personnel, training, and materials.	SA	A	N	D	SD	U

Remarks____

73.	Computers are not a panacea for everything.	SA	A	N	D	SD	U

Remarks____

74.	A need exists to emphasize computer applications, not programming at the high school level.	SA	A	N	D	SD	U

Remarks____

75.	Some students now entering the ninth grade are computer literate.	SA	A	N	D	SD	U

Remarks____

76.	Computers are a passing fad.	SA	A	N	D	SD	U

Remarks____

77.	School districts are "jumping into" the purchase of computers.	SA	A	N	D	SD	U

Remarks____

78.	Computers are not a passing fad; computers are here to stay.	SA	A	N	D	SD	U

Remarks____

79.	A cultural difference of owning computers is arising for high school students.	SA	A	N	D	SD	U

Remarks____

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80. The computer age has passed; the information age is here. SA A N D SD U

Remarks________________________________

81. Computer literacy courses are slowly being eliminated in the curriculum as students become more prepared in lower grades. SA A N D SD U

Remarks________________________________

82. Computer science should not be taught at the high school level. SA A N D SD U

Remarks________________________________

83. Computer science is a good start, but not an end. SA A N D SD U

Remarks________________________________

84. A "turfism" problem exists at many local schools concerning the teaching of computer science. SA A N D SD U

Remarks________________________________

85. The fear of computers still remains a problem for some teachers. SA A N D SD U

Remarks________________________________

86. The role of a teacher in the classroom is changing as a result of the computer. SA A N D SD U

Remarks________________________________

87. School districts need to become more inolved and flexible in the area of computer science. SA A N D SD U

Remarks________________________________

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88. Politics influences the curriculum. SA A N D SD U

Remarks ____________________

89. Computer literacy cannot be defined. SA A N D SD U

Remarks ____________________

90. Computer science cannot be defined. SA A N D SD U

Remarks ____________________

91. A computer-literate high school student understands the fundamentals of how to operate the equipment and how to interface with the equipment. SA A N D SD U

Remarks ____________________

92. The terms "computer awareness" and "computer literacy" can be used interchangeably. SA A N D SD U

Remarks ____________________

93. A "computer-aware" student understands the basics of computers. SA A N D SD U

Remarks ____________________

94. Good software for education is lacking. SA A N D SD U

Remarks ____________________

95. Computer science teachers need to consider the relevancy of topics discussed in the classroom. SA A N D SD U

Remarks ____________________

96. The grade level at which computers are introduced to students is a problem. SA A N D SD U

Remarks ____________________

97. The generation of today is more prepared about computers before entering high school. SA A N D SD U

Remarks ____________________

98. Outlying areas in Arizona are denied access to computers. SA A N D SD U

Remarks ____________________

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Appendix L

Thank You Letter

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623 W. Guadalupe Rd. #212
Mesa, AZ 85202
March , 1985

Dear

Thank you once again for responding to the questionnaire. I appreciated your patience and diligence in each phase of the study.

As a participant in my study, you will be recognized in my "acknowledgment section" of the dissertation. You will receive a copy when it is finally published.

I am still very much interested in any meetings and activities or related literature concerning computers. Would you call me at 898-4941 (work) or 892-2304 (home) if you think of some activities that would be of concern to me?

You have been a pleasure to work with!

Sincerely,

Chris Jaime

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BIOGRAPHICAL SKETCH

Christine Chavez Gomez was born in Miami, Arizona, on November 29, 1951. She received her elementary and secondary education in Miami Public Schools. Before attending Arizona State University in Tempe, Arizona, in 1976, she was employed for many years as a legal and analytical secretary in the Miami-Globe area. In 1979 she graduated from Arizona State University with a bachelor of arts degree in secondary education. In August 1979 she was employed as a business education teacher at Mountain View High School in Mesa, Arizona. She received a master of education degree from Arizona State University in 1981. From June 1982 to July 1985 she studied for her doctor of philosophy degree at Arizona State University. She was awarded a graduate assistantship in the Department of Administrative Services of the university, teaching business communications during the 1983-84 school year. She resumed her teaching position at Mountain View High School in August 1984. She is a past recipient of the Delta Pi Epsilon Donald J. Tate scholarship and Treasurer for Pi Omega Pi. She holds membership in the National Business Education Association and Pi Omega Pi, and is editor-in-chief of the Delta Pi Epsilon Newsletter.

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