DEVELOPMENT OF A PHYSICAL SCIENCE CURRICULUM
FOR INTERACTIVE VIDEODISC DELIVERY:
A CASE STUDY

DISSERTATION

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By

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Using a case study approach, this investigation focused on the deliberations and decision-making processes involved in the development of a physical science curriculum to be delivered by interactive videodiscs. The mediating factors that influenced the developmental processes included the participants and their perceptions, their decisions and factors influencing their decisions.

The Curriculum and Instruction Advisory Committee of the Texas Learning Technology Group was selected as the subject of this study which used qualitative data collection methods. Data collection included participant observation of curriculum meetings followed by structured interviews of the participants. Document analyses were triangulated with the observations and interviews to ascertain influences on decision-making processes.

Developmental processes indicated the emergence of staff and committee procedures. Procedures were influenced by school district and personal philosophies, teacher and student needs, and constraining factors such as state
mandates. Other influencing factors included research, tradition, and politics.

Core curriculum was to be delivered by interactive videodiscs and include remediation and enrichment loops along with laboratory simulations. Participants stressed that students perform traditional laboratory experiments in addition to simulations. This curriculum also addressed the possibility of the course being taught by teachers not certified in physical science.
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CHAPTER I

INTRODUCTION

Texas schools are experiencing a sharp decline in the teacher population with increasing numbers of experienced teachers leaving the profession (Vance & Schlechty, 1982; Vance & Schlechty, 1981). In math and science the number of unqualified teachers is growing with half of those hired in 1981 being unqualified to teach the subjects that they were assigned to teach (National Center for Education Statistics, 1983). Aldrich (1983) estimated from a National Science Teachers' Association Survey completed in December of 1982 that of a total of 200,000 mathematics and science teachers, 9 per cent left in 1982-83, 30 per cent are not fully qualified for the subjects they are teaching, and over 40 per cent will retire within the next decade. Along with the decline in math and science teachers there is an accompanying decline in student interest in these subjects and a decline in student learning with Texas high school graduates ranked fifth from the bottom in Scholastic Aptitude Test scores in 1984. In direct opposition to these educational declines, there has been a rise in technologies that may have the power to revolutionize the quality, effectiveness,
productivity, and availability of education. If related educational groups were willing to take the lead in implementing a change in the development and delivery of curriculum, all students would stand to benefit from their efforts. The Texas Association of School Boards has undertaken the task to bring related educational groups together by creating the Texas Learning Technology Group to provide advanced learning technology to Texas school districts.

Researchers readily proclaim that videodiscs and videotex are educational media that improve instructional efficiency, increase student motivation, and increase student achievement (Clark, 1984; Ebner et. al., 1984; McKenzie, 1984; Bobbert, 1982; Deignan et. al., 1980; Ganiel & Idar, 1985). However, research also indicates that students affected by this technology demand attention from curriculum theorists (Chen & Novik, 1984; Hurd, 1986; Yager, 1984; Walker, 1985). Decker Walker (1985) stated

[Students] are children of the television age, now the video age. I find little in contemporary curriculum thought addressing the curricular implications of such technology-related changes in our students. What scant attention curriculum writers have given to technological issues has been polarized and partisan (p. 92-93).

A comprehensive study of the processes required to plan a curriculum for physical science to be delivered by interactive videodisc would assist the education profession
in future endeavors to develop this revolutionary type of curriculum in other subject areas. This study also would increase our knowledge of participants' decision-making processes, perceptions, and philosophies used in curriculum development. The study could provide a planning design for the development of the course materials of a complete, technology-based delivery system using integrated computer, video, and audio technology components along with traditional instructional strategies in physical science.

Statement of the Problem

The problem of this study will be to describe the initial processes used in the development of a technology-based curriculum design for physical science.

Purpose of the Study

The purpose of this study was to describe the processes in the development, the intended dissemination, and the intended application or use of a technology-based curriculum design for physical science in Texas. Specifically, the study examined the deliberations and decisions of the Content, Curriculum, and Instruction Advisory Committee of the Texas Learning Technology Group as a case study of the development of a physical science curriculum design that uses the medium of interactive videodiscs as the major component of the delivery system.
Research Questions

The following research questions were addressed in this study:

1. Who are the major participants in the curriculum development process and what are their roles?
2. What procedures (needs assessment, committee deliberations, specifications) are used to develop the curriculum with a technology base?
3. What types of decisions (objectives, content, scope and sequence) are made by the participants and what are the bases for the decisions?

Assumptions

The major assumptions underlying this study were:

1. The curriculum development processes involve complex decision-making processes.
2. External and internal factors influence the curriculum decisions.
3. The curriculum design reflects the decisions made by the developers.
4. The developers have experience in the field of science education and/or computer technology.
5. The curriculum product reflects the compromises of varying philosophies across the participating school districts.
6. The curriculum product is influenced by the contract guidelines between the participating school districts and the Texas Learning Technology Group.

Limitations

This study was intended to provide a detailed description of the planning processes involved in the development of an interactive videodisc physical science curriculum design. The participants in the development involved curriculum specialists from eight school districts who form the Content, Curriculum and Instruction Advisory Committee, and program designers from American Telephone and Telegraph-Information Systems. Data were collected primarily through interviews, observations, and document analyses. Since both researcher and subject bias cannot be entirely eliminated in naturalistic studies of this type, data and conclusions should be treated as tentative explanations and subject to further study. Further researcher bias might be present due to the researcher's professional involvement in the curriculum development process. Since some of the research was done after the initial organizational contracts had been formulated, the information depended upon respondent recall of various steps of the procedure. Transcriptions of tape recordings and video tapes were used to minimize this particular limitation, but the limitations established by the bylaws and interlocal
agreements could not be eliminated entirely. Appropriate cautions were taken to minimize the effects of all these limitations on the validity by using a variety of data collection techniques, i.e., descriptive field notes, verbatim transcriptions of audio tapes, and document collection in this case study. Since the study was descriptive in nature, its primary goal was to add to the knowledge of curriculum processes and generate an understanding of a technology-based curriculum. The study should not be considered exhaustive or definite but rather a prototype to be revised and refined in future projects.

Definition of Terms

Interactive Videodisc--Computer hardware composed of a central processing unit, videodisc player, and video monitor that allow interactive functions including computer aided instruction, motion video, still frames, and simulations

Curriculum Design--Plan for the development of a course content that generally includes scope and sequence; similar to an architect's blueprint for a building

Curriculum Committee--Members of the Content, Curriculum, and Instruction Advisory Committee of the Texas Learning Technology Group (TLTG)

TLTG--Texas Learning Technology Group; a consortium of Texas school districts who have purchased shares to become members of the group to develop technology based curriculum
under the direction of a board of directors and Texas
Association of School Boards

Courseware—the software and other course-related pro-
ducts such as videodisc images which are developed

Background and Significance of the Study

Educational literature includes much written about the processes involved in planning and developing curriculum. Studies frequently mention structure and content of curriculum documents; however, most discuss only parts of the planning process rather than the process as a whole (Jacko & Garman, 1979). Research suggests that curriculum planning processes need further study (Goodlad, 1981; Barone, 1982) especially in the areas of the participants' role and their decision-making processes. Some research emphasizes the importance of the teacher's role (Cawelti, 1981; Ferguson, 1981; Miller, 1981) while other research indicates that teachers have little expertise or inclination to participate in curriculum planning (Goodlad, 1981).

Decker Walker (1971) stated that there was no in-depth examination of the actual curriculum process because those in positions to record a project's methods render portraits in such broad strokes as to make them useless to other curriculum makers who need to know precisely how such matters as goal-setting and selection and organization of learning activities were handled. Educational literature in
the last three years does not indicate curriculum planning research in the field of science where the selection of activities is especially unique since the participants in the decision-making processes must consider whether the activity would best be learned as an individual hands-on process, a small group process, a teacher demonstration or a simulation. Not only is there an absence of curriculum planning research in science in the literature, there is a striking absence of any educational research in physical science in particular, and little research on a curriculum to be delivered by interactive videodiscs. Walker (1985) notes that the attention of curriculum theorists should focus on students who are affected by the technology of the video age and, also, notes that there is little in contemporary curriculum thought addressing the curricular implications of such technology-related changes in our students. Walker (1985) further emphasizes the need for curriculum theorists to recognize their professional duties "to help schools to build curriculum for our time" (p. 102). He asks the question, "What sort of education should you and I, people of a technological society, choose for ourselves and our children? This is the primary educational issue of our time" (p. 94). Building a technology-based curriculum involves recognizing and recording appropriate decision-making processes (Hurd, 1986; Walker, 1985; Chen & Norvik, 1984). The absence of educational research in the decision-
making processes in science curriculum development and the "technology age" student should add significance to this proposed study.

The positive effects of technology-based curricula on student achievement and material retention have been shown by numerous researchers (Heins, 1979; Ebner, et. al., 1984; Deignan et. al., 1980; Holmgren, 1979; Osbaldston, 1974; Jones & Sorlie, 1976; Okey, 1984); however, Rizza (1981) noted that computer-assisted instructional packages should use a step-by-step process that follows proven guidelines (Rizza, 1981). Weaver (1985) also noted that examining the steps in curriculum decisions and tracing the flow of information are necessary in the examination of the process of curriculum planning; i. e., the curriculum decisions about goals, objectives, and instructional activities. There has been no extensive study of the processes used in the development of a technology-based science curriculum. Tracing the steps and processes of the Curriculum Advisory Committee of the Texas Learning Technology Group could add valuable knowledge to the curriculum development processes and could provide a prototype for future innovative curriculum designs.

A defined set of processes for an innovative, technology-based curriculum design would be beneficial to educators who are increasingly faced with pressures to use computers in the classroom. Instructional computing
innovations in schools now are being promoted from bottom-to-top unlike the top-to-bottom science innovations of the 1960s and 1970s where process/discovery methods demanded by federally funded programs such as the National Science Foundation projects (Project Physics, Man-Made World, Human Sciences) made major contributions to curriculum theory but were vetoed in the classroom by teachers who had been trained in the "purest" form of their discipline and could not master the inquiry-discovery style of teaching necessary for the success of the new courses (Hurd, 1986; Okey, 1984; Hurd, 1970; Hurd & Gallagher, 1968). Okey (1984) notes four interest groups in the current bottom-to-top development of technology-based curriculum designs: students who want to use computers; parents who have accepted the advertised view of the computer as a key tool for success in the future; business, industry, and government officials who see rapid rise of computing in their worlds and recognize the need for educational applications; and school personnel who understand changes in the world and want their schools to address computing problems. Okey further notes that it is a rare school that has not done something about computing.

Science has been singled out as a subject in serious need of reform, but the educational issues are profound, complex, and multi-dimensional lying deep in the changing nature of science; the central problem is the gap existing between school curriculum in science and the demands of
living in a scientifically and technologically driven society (Yager, 1984; Hurd, 1986). With much of the research noting the advantages of narrowing the gap with technology-based curricula (Heins, 1979; Deignan et. al., 1980; Ploeger, 1981; McKenzie, 1984; Ebner, et. al., 1984) some research notes the disadvantages of the "black box" technology including a considerable initial expense and a bewildering array of expensive, often poor quality commercial software. Another top problem listed in a new national study funded by the National Institute of Education and Center for Education Statistics was that teachers do not have time to plan computer-based activities and that for a computer-based curriculum to be effective, an appropriate sequence of activities for all students must be planned (Becker, 1986). Adams (1984) recommends "that computers should do the things that science teachers and books can't do better", but he also notes that "computers can't administer hugs when things go well or badly, and social interaction is still part of the education of the young" (p. 70).

Educators could benefit from a prototype to use in developing the futuristic curriculum in order to reduce costs and to help prevent them from falling into the trap that any new "black box" technology is automatically superior to traditional training tactics (Kearsley et. al., 1983). The historical background and the descriptions of
the developmental processes of the Texas Learning Technology Group's physical science curriculum could serve as a model for future technology-based curricula while adding to the research base of general curriculum development processes.

Methodology

Research on curriculum development includes the examination of the interactions of the people involved in the decision-making processes resulting in the curriculum document. Wilson (1977) notes that human behavior is significantly influenced by the setting in which it occurs, and that studies concentrating on the interactions of educational processes should be qualitative rather than quantitative. Bogdan and Biklen (1982) describe qualitative research as a study that emphasizes inductive analyses, descriptions, and people's perception. They note that qualitative research structures itself as the study proceeds rather than being based on an a priori hypothesis. Miles and Huberman (1984) note that qualitative research is an investigative process in which the researcher makes gradual sense of a social phenomenon through contrasting, comparing, cataloguing, and classifying. Studies of this type may include phenomenological study, case study, or ecological study.

A case study is a detailed examination of one setting, one depository of documents, or one particular event; a
bounded context in which one is studying events, processes and outcomes (Bogdan and Biklen, 1982; Miles and Huberman, 1984). Generally, the researcher selects a single setting or event, begins to collect data, and then reviews the data to determine what direction the study will take. The research of a case study is concerned with a process rather than simply outcomes or products and analyzes data deductively where data are like a funnel, narrowed as it is being collected (Bogdan and Biklen, 1982). Meaning is an essential concern along with participants' perspectives.

The techniques used in qualitative research include participant observation, in-depth interviews, and document reviews. Observation and interview notes are written in detail in field notes, the "written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on the data in a qualitative study" (Bogdan and Biklen, 1982, p. 74). Observation and interview notes may be tape recorded but then must be transcribed and reviewed by the observer. A case study with observation and interview field-notes and document analyses of the Content, Curriculum, and Instruction Advisory Committee of a consortium of eight school districts seemed to be the most useful method for providing the necessary information.
Procedures

Population

Since a naturalistic, descriptive study was selected, the participants in the curriculum decision-making process were the population observed within the context of the curriculum committee. The population was composed of science consultants from eight local school districts along with representatives from American Telephone and Telegraph, Texas Association of School Boards, and Texas Learning Technology Group. Outside participants involved members of other committees on the project and physical science teachers who had a vested interest in the curriculum design. Other than the outside participants the population of the curriculum committee remained relatively stable since new school districts to the Texas Learning Technology Group joined after the initial curriculum was developed. Since the population was dynamic, special attention was focused on describing the participants specifically involved during each phase of the decision-making process.

Data Collection

A triangulated data collection procedure (LeCompte and Goetz, 1982) involving observation, interviews, and document collection was used to build a data base from which to infer decision-making strategies and philosophies along with a brief historical background. Specifically, the researcher
attended all meetings of the Content, Curriculum, and Advisory Committee of the Texas Learning Technology Group beginning in the fall of 1985 and lasting until the official curriculum design for physical science was studied and approved by the committee in the spring of 1986. Detailed field notes of the curriculum committee meetings along with some audiotapes recorded the committee deliberations. Documents collected included curriculum materials from participating school districts and their compilation by American Telephone and Telegraph after the curriculum committee deliberations.

In addition to the data collected from the curriculum committee meetings, data were obtained through structured interviews of the science curriculum specialists representing each school district on the committee and belonging to the Texas Learning Technology Group (TLTG). The Production Coordinator of TLTG and the Executive Director of the Texas Association of School Boards also were interviewed according to the interview schedules. Finally, the Project Manager and the Project Coordinator, who were former physical science teachers, were interviewed as the representatives of American Telephone and Telegraph. The data collected from all of these interviews formed a portion of the triangulation of data along with the observation field notes and relevant documents.
Data Analysis

Data appeared in words rather than numbers and were triangulated through observations, interviews, and documents. Miles and Huberman (1985) described data analyses as a three-step process: data reduction, data display, and conclusion drawing and verification. Working with elaborated field notes, verbatim transcriptions, and curriculum documents totaling over nine hundred forty pages, the researcher reduced the data by repeatedly reading the data noting patterns and designing coding categories to focus not only on the research questions but also upon unanticipated and merging trends that became evident during the coding process. The coding categories were developed through the constant comparative method used in the generation of grounded theory (Glaser and Strauss, 1967). As Miles and Huberman (1984) noted, "Codes are categories;" usually derived from research questions, key concepts, and important themes. Bogden and Biklen (1982) stated that "certain words, phrases, patterns of behavior, ways of thinking, and events repeat and stand out; material bearing on a given topic can be physically separated from other data" (p. 156). Data reduction through coding categories sharpened and focused the data in such a way that final conclusions could be drawn.

The data display portion of the analysis was accomplished through the use of text, tables, and figures.
Tables and figures were utilized to reduce the narrative text to coded characteristics which aided in conceptualizing the themes. Using the constant comparison and analytic induction techniques described in Goetz and LeCompte (1983), merging trends and developing themes were identified, bringing the data analysis to the third step of conclusions and verification. Various data sources helped to cross check the accuracy and increase the validity of the conclusions. The use of primary data in the form of numerous direct quotations from participants provided reliability of the researcher's findings because they can be checked by any reader of the study.
CHAPTER BIBLIOGRAPHY


CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

This review summarizes research focusing on innovations and reforms in science curriculum and curriculum development processes in general. The review is divided into four sections. The first section discusses some history of curricular reforms in science with special attention given to the possible explanations for the failure and/or success of the innovations. The second section covers the call for further reforms in science curriculum in the 1980s in anticipating technological innovations and their benefits to education. The third section discusses curriculum development with emphases on decision-making processes, roles of participants, and influencing factors. The fourth section discusses the methodology involved in the current study.

History of Science Curriculum Reforms

The need for reform of the science curriculum dates back to the 1920s when communities and educators noted the need to reconceive school science education in order to improve its quality. Hurd (1986) discusses the 1928 meeting of the American Association for the Advancement of Science.
Committee which took the position that school science should function more completely in the lives of people in general and promote a moral obligation. The committee concluded that science is essential to the proper balance of general education.

In 1932, a study commissioned by the National Society for the Study of Education recommended that scientific principles and generalizations that have had the largest application in molding the character of our society be emphasized. It also recommended that science curriculum be built around "real problems" that emphasize practical, cultural, and liberalizing values of science. "The effectiveness of any scheme of science education is shown by the place science takes in everyday life" was the general theme in the 1930s as expressed by the physicist J. D. Bernal (1939, p. 6). Technology was also part of the 1930s theme. A five-year long study committee of the Progressive Education Association emphasized the need to develop student awareness of the interaction of science and technology in bringing about social change in the United States (Thayer, 1937). To achieve these goals the committee outlined a science curriculum to emphasize reflective thinking and problem-solving.

In the 1940s, the President's Scientific Research Board recommended that two years of science beyond general
science be required for graduation (Steelman, 1947). The major focus of the reform movement in the 1940s was best expressed in the Harvard report (1945) which recommended a science program "characterized by broad integrative elements taught in a cultural context." Science dealing with problems of society that engaged students in critical thinking was the cry of reformers especially after WWII when achievements in science and technology wrought major changes in U.S. economic and social life.

Interest in improving the science curriculum waned in the early 1950s until the Russian launching of Sputnik I in 1957 renewed the crisis. This crisis in science education identified by the mid-1950s and fueled by the launching of Sputnik I, drew attention to the disparity between existing science courses and the rapid advances in science and technology (Kyle, 1984). The new slogans of reform became "excellence" and "quality." In the late 1950s and early 1960s, the task of reforming science was placed in the hands of research scientists (Kriehbaum & Rawson, 1969). Their efforts were backed by $125 million in federal money for improvement of course content and $500 million for teacher training. This burst of activity resulted in some of the most current, innovative, and spectacular changes in the history of American public school education. The period that followed has come to be known as the Golden Age of Science Education 1955-1974 (Kyle, 1984). Weinberg (1967)
called the renewed interest the "Advent of Big Science," and Machlup (1962) noted that the shift in society would give rise to an economy strongly based on production and use of knowledge and that would require changes in schooling that would place greater emphasis on processing and use of knowledge rather than on its mere accumulation. This rise, and later fall, of the National Science Foundation's role in pre-college science education is well documented (Crane, 1976; National Science Foundation, 1975; Welch, 1979; Jones, 1977).

In the 1960s and 1970s the new courses were written to display science in its "purest" form as a set of research disciplines - doing what scientists do - not on applications of such knowledge (Hofstein & Yager, 1982; Kyle, 1982; Peterson et. al., 1984). The central theme of the National Science Foundation curriculum projects was the presentation of a formal picture of the structure of the separate disciplines with well documented goals: "thinking like a scientist," "the joy of science for its own sake," and the preparation for college (Hurd, 1970; Hurd, 1986; Hurd & Gallagher, 1968). The new curricula were similar because they were developed by teams that included scientists and educators, and all the curricula embodied both scientific processes and the nature of scientific inquiry (Kyle, 1982; Kyle, Shymansky, & Alport, 1982; Peterson et. al., 1984; Shymansky, Kyle, & Alport, 1982). The curricula included
well known projects such as the Intermediate Science Curriculum Study (ISCS), Biological Sciences Curriculum Study (BSCS), Chemical Education Materials Study (CHEM Study), and Physical Science Study Committee (PSSC). Welch (1979) noted that all the NSF curriculum projects were written based on procedures established by one of the first projects (PSSC) where development teams were directed by prestigious scientists, coordinated by advisory boards of prestigious scientists, and actually written by these scientists. The role of teachers was merely to give feedback which actually had little effect on subsequent versions of the curricula.

Other than the composition of the development teams, Duschl (1985) listed two reasons for the failure of the National Science Foundation's curriculum projects: 1) content was a principal weakness since it was already obsolete and dilute and 2) implementation strategies were a second weakness. Hurd (1986) listed another weakness as the inability of teachers to understand the conceptual structure of the curriculum and the inquiry or discovery style of teaching necessary for the success of the new courses. He also observed that teachers felt that the new courses were too abstract for the students; however, he noted that the new courses did make a major contribution to curriculum theory. Aldridge & Johnston (1984) credit the 1960s reforms with updating science by emphasizing significant
concepts with a genuine attempt to give hands-on experience in the methods of scientific observation and discovery.

The long-term movement to reform science education that was revitalized by the Advisory Committee for Science Education of the National Science Foundation in the 1970s recommended relating science and technology to human and social affairs through multidisciplinary curriculum (NSF 71-13, 1970). Technology per se was removed from science, relegating it to industrial arts, health, home economics, and social studies, in order to offer science as it is known to scientists. While there was a burst at the national level to produce new science curricula, state and local schools were introducing their own brand of innovative science programs: earth science, space science, environmental and ecological studies; metric, alcohol, and drug education; and a host of mini-courses (Hurd, 1986).

In 1980, there were more than one hundred thirty-two course titles for science offerings in junior and senior high schools that have helped to sustain a fifty-year effort to establish science as a part of general education (Hurd, 1986). The 1980s have the same reform themes that have persisted for over fifty years but are often overshadowed by political rhetoric and unrelated statistics. Hundreds of studies and reports seem to agree that science in the schools should be reformulated, recognizing that students in the United States live in a modern, technological democracy
with an economy driven largely by science and technology. The reports criticize the current science curriculum and textbooks as too narrow in vision, subject matter, and organization to relate science and technology to human, social and economic affairs (Hurd, 1986; Bybee, et. al., 1984). Section two will synthesize some of the literature seeking renewed reforms to accommodate new technologies and describing the benefits of the utilization of these new technologies in education.

Science Reforms and Technological Innovations

Some of the specific problems that science educators face in the 1980s include students' declining exposure to technical subjects, their decreasing high-order skills, and their growing fear of technology. In addition, a vast number of teachers of science and mathematics are not certified in these subjects. In 1981 50 per cent of math and science teachers were teaching subjects for which they were not certified (Bybee, Carlson, & McCormack, 1984).

The National Science Board Commission report (1983) defined subject matter for science courses as the knowledge needed to fulfill civic responsibilities, improve the students' own health and life, and the ability to cope with an increasingly technological world (Hurd, 1986; Aldridge & Johnston, 1984). However, most of the present courses focus on pure science as did the courses in the 1960s and 1970s.
and are largely devoid of practical application, technology, or the relevancy of science to such problems of society as acid rain, nuclear wastes, disposal of hazardous materials, and improper nutrition. These courses do not prepare students to enter the myriad nonscience occupations that require technological knowledge.

Technology is one part of the study of science that has been central in some science curricula and completely absent in others. The reformers of 1960 were united on the inappropriateness of technology in pure science courses, but one of the clearest moves of the 1980s is technology's emergence as an important part of science (Bybee, et. al., 1984). Its prominence is apparent in the work of the National Science Board Commission and in the reestablishment of the Science and Engineering Education Directorate at the National Science Foundation. Now, many science educators believe that curriculum should focus on science, technology, and society (Yager, 1984). Project Synthesis notes that science programs should provide continuing opportunities for students to be able to:

1. evaluate the long range social impact of new scientific knowledge and technology,

2. prepare for new career opportunities as a result of the impact of new technology, and

3. become involved in first-hand science and technology activities to grow.
National Science Teachers Association's goals for scientific and technological literacy demand reasoning, thinking, and decision-making which are the bases for a general education program (Yager, 1984).

Since science has been singled out as a subject in serious need of reform, researchers have noted that the educational issues are profound, complex, and multi-dimensional lying deep in the changing nature of science. The central problem has been the gap existing between science curriculum in science and the demands of living in a scientifically and technologically driven society (Yager, 1984; Hurd, 1986). While some research notes the advantages of narrowing the gap with technology-based curricula (Heines, 1979; Deignan et. al., 1980; Ploeger, 1981; McKenzie, 1984; Ebner, et. al., 1984), other research notes the disadvantages of the "black box" technology including a considerable initial expense and a bewildering array of expensive, often poor quality commercial software (Kearsley, Hunter, & Seidel, 1983). Another top problem listed in a new national study funded by the National Institute of Education and Center for Education Statistics was that teachers do not have time to plan computer-based activities and that for a computer-based curriculum to be effective, an appropriate sequence of activities for all students must be planned (Becker, 1986). Adams (1984) recommends "that computers should do the things that science teachers and books can't do better" (p. 70),
and he notes that computers cannot provide social interactions between students and teacher that are important in the educational environment (p. 70).

In the mid-1980s, the central crisis and call for further reform in the science curriculum has shifted emphasis from science and society to science and technology. In January 1984 the Exxon Education Foundation (1984) hosted a meeting of some of the nation's top educational leaders. The purpose of the blue ribbon conference was "to explore some of the major issues raised by the current call for science education reform and to make recommendations regarding what steps should be taken to ensure that the needed improvements in elementary and secondary (K-12) science will actually be made in schools across the country" (p. 3). The conferees presented two arguments in favor of a reformulation of the K-12 science curriculum: first, that an understanding of science and technology is the key to participating in the affairs of a world that is likely to continue to change rapidly; and second, that because technological changes occur in all aspects of our lives (at work, in civic affairs, and in personal lives), scientific and technological literacy is necessary for all individuals (Hickman, 1985). Thus, recent technological developments may lead to possible restructuring of our educational systems (Ellis & Kuerbis, 1985; Yager, 1984; Bybee, et. al.,
Educational technology provides new strategies vital to the redesign of science and technology education. Not an end in itself, educational technology is a means to achieve carefully derived goals (Boyer, 1983). A formal, dictionary definition from the Random House Dictionary of the English Language states that technology is "the sum of ways in which a social group provides themselves with material objects of their civilization." American education institutions, constituting a primary "social group" in modern society, have historically done just what this definition suggests: surrounded and provided to the schools the material objects of the society's efforts in technology (Lloyd, 1984). Schools have introduced technological tools such as computers, video discs, and robots. According to a recent survey, 86 per cent of school districts use computers with the average number of computers in schools varying with grade level: the average high school has eleven; the average junior high has seven; and the average elementary school has three and a half (Market Data Retrieval, 1983). A 1983 unpublished survey by Selection Research Incorporated of Lincoln, Nebraska, found that 20 per cent of schools used videodisc players. Other promising information technologies that can be used in education include satellite communications, new broadcast technologies, improved
information services, such as videotext and information networks, and electronic conferences (Office of Technology Assessment, 1982).

Current science teaching is marked by almost a total reliance on textbooks that present science as "fundamental knowledge" (Yager, Aldridge, & Penwick, 1983). Stake and Easley (1978) found that teachers rely on textbooks at least 90 per cent of the time and that the typical method of lesson presentation is "assign-recite-test-discuss." They further suggest that reading is the primary mode of science learning in our schools. Parenthetically, it may be useful to think about the impact on poor readers of this reliance on the textbook (Koballa, 1984). The introduction of a current technological tool, the microcomputer, may provide a means of overcoming the relative rigidity of a textbook. Opportunities exist for the introduction of many different instructional applications of the microcomputer in science education, although current uses appear to center mainly around simulation-type exercises (Beasley, 1982; Cox & Berger, 1981; Mackey, 1982; Steele, Battista, & Krockover, 1982). Overall, computers show great promise as a means of augmenting the classroom instructional process, under the guidance of the teacher (Lloyd, 1984); however, research that specifically addresses microcomputer applications in the science classroom is not abundant.
The significance to students of becoming computer literate is greater in many respects than the average educational institution supposes. Students must now be able to sort, analyze, and synthesize vast amounts of information in a variety of media including print, video, radio and computer (Lloyd, 1984). Technological literacy includes "the necessary abilities to engage in complex thinking, i.e., the possession of an appropriate fund of knowledge and the skills to tap a continuously changing information base" (Hersh, 1983).

Computer technology cannot be expected to solve all the problems associated with education that have been identified in national reports; however, one of the major roles of the classroom computer is to allow students and teachers to work with content in ways that are not possible with conventional means of instruction. Practical examples of abstract concepts such as mathematical probability or chemical reactions can be demonstrated over and over again in endless combinations. Students are free to explore a topic as thoroughly as they like, with no time limits or need for constant teacher-intervention (Lloyd, 1984). Microcomputers are exciting because they make possible greater interaction between the learner and the curriculum, and critical thinking skills on a higher order than rote memorization or simple generalization of concepts can be introduced through their use (O'Brien, 1983). Mandell (1982) suggests that the
powers inherent in microcomputers (rapid calculation, word processing, data storage capabilities, graphics, color, animation) can be used effectively in a variety of instructional modes.

Ganiel and Idar (1985) describe current applications of computers to science teaching as falling into three general categories: subject matter teaching, testing, and interfacing with laboratory instrumentation. These researchers place simulation activities in laboratory instrumentation. A simulation is a dynamic display that is based on a model or a simplified version of the actions and reactions of a system over time (Rowe, 1982). Bork (1982) indicates that as teaching moves to more and more abstract ideas, students' experiences relevant to what is to be learned become fewer and fewer. Simulations are the only type of activity that can provide the environment, and within it, the concrete experiences necessary for the development of insight about abstract concepts.

Computers represent an enormous resource for the enrichment of science education practices. The use of microcomputers may change the relative emphasis on and importance of certain skills (Lloyd, 1984). For example, more emphasis may be placed on problem solving than on memorization. More emphasis may be placed on the students' verbal skills and the precision of language used in science classes since students need to be accurate when
communicating with a computer. Simulations will create an important role for microcomputers to fill, but they will probably never fully replace the real-life laboratory (Gale, 1981). Recent literature discusses the new and future directions for computers in science instruction (Institute for School Development, 1982; Judd, 1983; Walker, 1983).

Educators can take a lead in introducing students to the technological boom in communication and learning. Dynamic developments in electronic communications and microcomputer technology are rapidly altering what teachers do and how they do it (Shane & Talber, 1981). According to the United States Office of Technology Assessment (1982), the so-called information revolution, driven by rapid advances with communication and computer technology is profoundly affecting American education. It is changing the nature of what needs to be learned, who needs to learn it, who will provide it, and how it will be provided and paid for. Strategies are being developed to deal with the future-oriented science curriculum with many questions to be addressed for the successful implementation of a science education system for the future. While microcomputers can help science students simulate natural phenomena in controlled settings, this technology along with technology being currently developed has much broader and deeper application for all aspects of education. Many educators predict computers will revolutionize education; others see computers
as just one more in a long line of educational devices that come into fashion for a short time and then recede into the background. But computers differ from other educational innovations in one capability most critical for effective teaching--interaction. Whereas movies, television, and overhead projectors only present information, computers can interact with the individual student causing him to be continually responding (Vargas, 1986).

Motivation and interaction are key words for one of the latest technological innovations to be experienced in the classroom--interactive videodisc (IVD). Decker Walker (1985) notes that educators may choose among forms of technology, but we may not choose to avoid technology because students in our schools are children of the video age and demand attention from curriculum theorists. Ellis and Kuerbis (1984) describe videodisc technology as a recent development with great potential. The combination of a videodisc and a microcomputer is powerful, allowing moving sequences, still pictures, and text, all on the same disc and under interactive control (Office of Technology Assessment, 1982). One side of one disc can store 56,000 still pictures, one hour of television or film, or an entire encyclopedia. Laser videodisc technology allows rapid random access to any frame or sequence, enabling the user to interact with the video display and branch to different parts of the program based on answers to questions. The
random access feature can either be controlled by the user or be connected to a microcomputer. The power of interactive videodisc technology in the classroom and its effects on curriculum are not yet backed by years of research since it is only currently being developed and implemented.

Ebner, et. al., (1984) describes an investigation of videodisc applications and their adaptations for training programs which focused on a lesson on preparation and administration of intramuscular injections taught at the United States Army Academy of Health Sciences. Results indicate students using videodisc may not learn more but learn faster and retain information longer. Researchers proclaim that videodiscs and videotex are educational media that improve instructional efficiency, increase student motivation, and increase student achievement (Clark, 1984; Ebner et. al., 1984; McKenzie, 1984; Bobbert, 1982; Deignan et. al., 1980; Ganiel & Idar, 1985). Some research has been conducted on the interactive use of graphics (Merrill & Bunerson, 1979; Control Data Corp., 1978; Nievergelt, 1982; Molnar, 1979) that suggest that graphics may not necessarily facilitate learning but may be helpful to expose learners to new concepts, objects, or events for which they have no corresponding visual images. Interactive computer graphics offer largely unknown training application potential.

Some research has been conducted on the psychology of students using videodisc curriculum in relation to student
control of the interactions, boredom with resultant attrition, and stress (Kearsley & Hillelsohn, 1982; Nievergelt, 1982; Spielberger, 1977; Tobias, 1977; Laurillard, 1984). Much of the research has been done in military and industrial training environments rather than in a school environment. Ebner, et. al., (1984) calls for more research that should focus on mediating the role of stress which can result when new educational technology is both unfamiliar and demanding in terms of active involvement. More research should examine specific content of courses, too.

Curriculum Development

The problems of the National Science Foundation curriculum projects of the 1960s and 1970s have been discussed in the literature and seem to indicate that the developmental processes, the major participants (prestigious scientists) in the processes, and the content selection were the major contributing factors to their failure (Duschl, 1985; Peterson et. al., 1984; Kyle, 1982; Hofstein & Yager, 1982; Hurd, 1970; Hurd & Gallagher, 1968). This section of the review of literature will address the processes involved in curriculum development for any subject area but will reflect upon the areas of noted failure in earlier science curriculum projects and describe predictions for development of curriculum for the future.
Historical Background

The first noted study of curriculum was Franklin Bobbit's book, The Curriculum, published in 1918. Since that time curriculum studies have become common with them noting numerous shifts in the responsibility for the source of curriculum development. In the early 1900s, state departments of education mandated what subjects would be taught at the local level. Some local school began their own curriculum development projects. As the local administrators with knowledge of the curriculum moved on to other districts or positions, the curriculum projects died without their leadership (Tyler, 1981).

In the 1960s and 1970s, federal curriculum was developed to ensure that it included knowledge and skills necessary for world survival in the wake of the race for advancements in space technology (Caswell, 1978; Goodlad, 1981; Tyler, 1981). These federally funded curricula evolved from pressure exerted by national, state, and local special interest groups with desires for different curricula (Kirst & Walker, 1971; Caswell, 1978; Rhodes & Young, 1981). Kirst and Walker (1971) note that educators do not consider curriculum development in political terms, and therefore, do not recognize the pressure groups' influences. Kirst and Walker (1971) suggests that curriculum organization is "a process of public policy-making which is necessarily political in character" (p. 482). Stellar (1980) also notes that
curriculum writing is a political process that involves the making of decisions by certain groups to accomplish certain goals. Generally this requires compromise since all groups do not have the same goals (Ferguson, 1981).

Influencing Factors

Outside influences that exert pressure on curriculum planning include the community, testing agencies, textbook publishers, and state and federal departments of education (Oliver, 1982). Testing agencies are a major influence since tests that they develop naturally determine much of the content that will be offered at the high school when college bound students must pass college entrance exams designed by these testing companies. Textbook publishers are another major influence on the curriculum because most teaching comes directly from the content of the adopted textbook along with its teacher's guide, computer test banks, and other supplemental materials. State departments of education influence curriculum by setting and enforcing minimum curriculum standards, and in some states, the department also controls the selection of textbooks. Federal departments of education hold the "purse strings" on many programs, thereby strongly influencing the curriculum offered. The community influence is usually negative according to Kirst and Walker (1971) since they frequently
vote against bonds to fund the curriculum, and community members, although they may be vocal, lack the knowledge to play a crucial role in curriculum decision-making.

Another factor that influences the curriculum is values. Weaver (1985) lists values as an internal influence of the curriculum planning process along with attitudes and district preferences for organization. Kirst and Walker (1971) suggest that the value basis for curriculum is a major concern in curriculum policy-making. They mention the following broad bases for assigning value to certain aspects of curriculum: tradition, community, science, and individual judgment. These bases possess varying amounts of influence depending on what part of the curriculum is being discussed and how strong the feelings of the individual participants are in relation to the bases. However, to arrive at any consensus within the curriculum planning group, certain individuals must be given the power to make curriculum decisions by "exercising professional and presumably expert judgment" (Kirst & Walker, 1971, p. 485). This informal process of curriculum planning is termed "disjointed incrementalism" by Kirst and Walker (1971).

Closely related to values, the viewpoints of the curriculum development team vary depending on their own experiences and philosophies. Thus, curriculum design is influenced by these various viewpoints. Curriculum
orignating from the point of view of a behaviorist, a gestaltist, a psychoanalyst or a cognitive structuralist would each have a different purpose and design because each of these theories is based in different philosophies (English, 1983). These diverse viewpoints affect the selection of curriculum goals and objectives and influence the sequencing of both content and activities (McNeil, 1977; Brandt & Tyler, 1983; English, 1983; Weaver, 1985).

Curriculum Development Models

To coordinate people in the curriculum planning group with their varying values and viewpoints, researchers suggest specific organizational steps in the form of models. Hunkins (1985) suggests that curriculum development should be a broad-based view of the educational system and its place in society, thus necessitating the use of a systematic curriculum development model. Numerous theories and models have been proposed for the steps in curriculum development (Tyler, 1949; Taba, 1962; McNeil, 1977; English, 1983; Littrell & Bailey, 1983; Weaver, 1985).

Some models propose a very structured sequence of steps in the development process often beginning with needs assessment and continuing through specific steps to evaluation (Tyler, 1949; Taba, 1962). Other models are more informal or loosely structured (Kirst & Walker, 1971; Purves, 1975; Barth, 1980). Kennedy (1985) warns that
successful use of a curriculum development model such as Decker Walker's inductively derived model can assist educational practice but cannot be viewed as a general panacea.

Whatever curriculum development model is used, Tyler (1976) notes that after working in the field for more than twenty-five years that the fundamental questions are unchanged. He raises these questions for planning:

What should be the educational objectives of the curriculum?

What learning experiences should be developed to enable students to achieve the objectives?

How should the learning experiences be organized to increase their cumulative effect?

How should the effectiveness of the curriculum be evaluated (p. 62)?

Decision-Making Processes

The answers to these developmental questions require complicated decision-making processes. People engage in a complex process that requires skills that develop as participants practice curriculum decision-making in a group (Jacko & Garman, 1979; Littrell & Bailey, 1981; Weaver, 1985). As curriculum group members make long range curriculum goals and objectives, they establish a "hierarchy" of curriculum planning which delineates the role of each individual in the group and his or her function in the planning process (Littrell and Bailey, 1981).
The factor of group dynamics in curriculum planning affects the decision-making process. Research points out that the participants in curriculum planning must be aware of the viewpoints of various members of the group and be prepared to compromise if necessary in order to accomplish their goals (Czajkowski and Patterson, 1977; Jacko and Garman, 1979; Ferguson, 1981). Jacko and Garman (1979) suggest that curriculum planning be preceded by a study of group dynamics and decision-making skills in order that individuals in the group may participate fully. They also suggest that this understanding could lead to more carefully delineated tasks for group members.

Participants and Their Roles

Research recognizes that group dynamics are important in the curriculum development team, but some studies suggest that there is no consensus about the roles of curriculum participants. In fact, some researchers suggest that most educators are not prepared to plan curriculum (Toepfer, 1976; Regan, 1980). Educators involved in curriculum planning can include teachers, supervisors, principals, and university people. The extent of their involvement depends not only on their position, but also their expertise in curriculum development and the subject area being considered. Group dynamics and decision-making could be affected by the
participants' views of their roles and their views of their abilities.

The teacher's role in the curriculum planning process has been emphasized in research in the last few years. The teachers, not the subject matter specialist or the scholar in the field, have become the curriculum developers, and while this trend has some positive effects on schooling, there are some very negative ones (Madeja, 1981). Jacko and Garman (1979) place teachers on a "continuum of noninvolvement" for a variety of reasons. Goodlad (1981) notes some of these reasons to be the need for teachers to teach, not to develop curriculum, lack of funding for teacher involvement, and lack of skills in curriculum development. Most teachers do not have the time, energy, or interest to spend actually writing curriculum (Young, 1979).

Other researchers emphasize the importance of the teacher in curriculum planning groups. They propose that teacher participation increases the sense of ownership in the curriculum which results in curriculum documents which are more likely to used in the classroom (Ferguson, 1981; Ponder, 1983; Weaver, 1985). Another advantage of teacher participation in planning is that it could add to the teachers' knowledge, professional growth, and professional satisfaction.

A major external participant is the district's local subject area consultant who must be aware of the
organizational structure of the school system and have an understanding of individual and group needs (Czajkowski and Patterson, 1977; Ponder, 1983). These specialists function to link the curriculum committee to administration and other aspects of the educational system, to provide encouragement to the group by monitoring the planning process and lending their expertise to the process (Ponder, 1983; Weaver, 1985). The role of the consultant is complex since research indicates that teachers are reluctant to release their autonomy in curricular matters and strongly resist attempts by district supervisors to control what they do day to day in their classrooms (Goodlad, 1977). However, research gives credence to the role of the consultant as giving strong support to the curriculum planning process with the in-depth knowledge of the disciplines necessary to design and review curriculum (Madeja, 1981).

The participants involved in the complex curriculum planning processes make decisions pertaining to objectives, content, strategies, activities, and the basic format and structure of the document. A special function of curriculum development is to select and organize the content so that desired goals of the curriculum are most effectively achieved (Searles, 1984). Content decisions include selection of materials, where to place them, how to cover them, and where to cover them. Weaver (1985) found that a major portion of the decision-making process was a negotiation
system necessary for a variety of reasons. Some reasons for negotiations were the problems of overlapping materials and selection of materials in the "light of what was good for the district" (p. 331) even if the participants had to give up "pet projects" in order to meet state guidelines or to meet student needs. A major concern and direction of negotiations was always to ensure quality with the participants defining quality as practical in providing teachers a plan to follow in order to teach students the content that a district deemed appropriate.

Science and Curriculum Development for the Future

Early science reforms in curriculum did not acknowledge the need for a specific model of development or the involvement of local educators. The coordinating staffs and decision-makers of the various curriculum projects were, by and large, scientists. Scientists working on the early National Science Foundation curriculum projects set both the standards and the procedures for subsequent curriculum projects (Duschl, 1985). Curriculum in the future needs to address the failures of these previous efforts. Educators have a responsibility to not let tradition, departmental structures, and other restraints dictate the program students will receive (Cawelti, 1981).

The mission for educational leaders is to examine the school curriculum that is, and plan for the curriculum that
will be—there is a certainty that the year 2000 will not be much like the year 1980 (Oliver, 1982; Larson, 1983). The future holds new technological advances as becoming commonplace, and the secondary school curriculum will need to emphasize skills in the use of new technologies and skills that include a high tolerance for ambiguity and the ability to examine and create alternatives (Larson, 1983).

Secondary curriculum must become more interdisciplinary, integrated, and holistic in its design where learning "how" will take precedence over learning "what" and teachers will become managers of learning rather than transmitters of knowledge (Larson, 1983). In considering science for the 1980's, McNeil (1981) suggests that when science becomes an accepted basic, a multidisciplinary approach will serve two purposes. First, it brings new depth to the discipline, and second, it reminds us of science's relation to the political, economic, and social affairs of humankind.

In planning for future curriculum, Shane and Talber (1981) present six approaches to curriculum planning that suggest such options as returning to some of the values and practices that have been discarded, adopting changes that are mandated by a changing society, creating new education designs, adopting new approaches to learning experiences, or selecting any combination of these options. Some practical recommendations made by McNeil (1981) for improving traditional science courses for the future include developing new
materials that deal with new areas of modern science, tying instructional activities to ongoing scientific enterprises in the community, and having the local community serve as a learning laboratory. In the learning laboratory, science projects dealing with social implications are taught by or at local agencies and include topics such as pregnancy, drinking, stress, environmental and consumer health; combining skills from the natural sciences, humanities, and social sciences—a multidisciplinary approach.

Science curriculum planning in the future indicates the need for a multidisciplinary approach and a knowledge of new technology, mainly the microcomputer. To meet the demands of an increasingly complex world, the classroom of the future will become a learning environment which coordinates space, work surfaces, group and individual interaction, audio-visual presentations, printed material, and electronic media (Oliver, 1982). Within that integrated classroom will be the microcomputer with its instructional software, serving as one of the most powerful of teaching tools available to educators since it personalizes individual learning, combines vital immediate feedback with infinite patience, and captures the learner's attention.

Methodology

After selecting a topic in inquiry, the researcher faces the dilemma of selecting a methodology that most
appropriately answers the research questions. Patton (1980) relates a paradigm of choices noting that the issues of methodology are issues of strategy and that strategy is best which matches research methods to the questions being asked. Borg (1979) describes some research methods available in education that include historical research, correlational research, causal-comparative research, survey research, observational research, and experimental research. Until recent years, research has been dominated by the largely unquestioned, natural science paradigm of hypothetico-deductive methodology that assumes quantitative measurement, experimental design, and multivariate, parametric statistical analysis to be the epitome of "good" science (Patton, p. 19).

Qualitative research has emerged in recent years as another viable educational research method. A single, encompassing definition of qualitative research is difficult to find. Long recognized in the field of anthropology and sociology where the researcher spends time in a natural setting, making observations, studying attitudes, describing events, examining documents, and talking to people in their own environment, qualitative research has come to be accepted in the educational setting as well. Wilson (1977) notes that human behavior is significantly influenced by the setting in which it occurs, and that studies concentrating on the interactions of educational processes such as
curriculum planning should be qualitative rather than quantitative. He further adds that "the National Institute of Education is encouraging this kind of approach, and many researchers involved in the evaluation of educational programs and in the processes of innovation are finding these approaches useful" (p. 246).

One of the most important aspects of the qualitative method is the setting in which the research is conducted. Goetz & LeCompte (1984), Patton (1980), Bogdan and Biklen (1982), and Miles and Huberman (1984) emphasize that qualitative studies are done in a natural setting that results in well-grounded, rich descriptions and explanations of processes occurring in local contexts. They note that qualitative research structures itself as the study proceeds rather than being based on a priori hypothesis. Miles and Huberman (1985) state that qualitative research is an investigative process in which the researcher makes gradual sense of a social phenomenon through contrasting, comparing, cataloging, and classifying. Studies of this type may include phenomenological study, case study, or ecological study.

A case study is a detailed examination of a bounded context in which one is studying events, processes, and outcomes (Bogdan and Biklen, 1982; Miles and Huberman, 1984). A case can include a wide range of settings. Stake (1978) lends support to the qualitative research methodology,
particularly the case study, which he says "proliferates rather than narrows" (p. 7). Furthermore, he claims that case studies will often be the preferred method of research because they may be more in harmony with the reader's experience and, thus, to that person a natural basis for generalization.

Comparing quantitative and qualitative measurement, Patton explains that where quantitative studies rely on standardized instruments which limit the scope of the data, qualitative data collections are open-ended narratives which purposely disallow the standardized categorization of program activities or the experiences of people. He further notes that a naturalistic, qualitative research method causes the researcher to enter into the research without predetermined hypotheses. The researcher collects qualitative data consisting of detailed descriptions of situations, events, people, interactions, and observed behaviors; direct quotations from people about their experiences, attitudes, beliefs, and thoughts (primary data); and excerpts or entire passages from documents, correspondence, and records (Patton, p. 22). The detailed descriptions, direct quotations, and case documentation of qualitative measurement are raw data that provide the depth and detail necessary for qualitative research.

Goetz and LeCompte (1984) elaborated the role of the qualitative researcher as being one which analyzes phenomena
in naturally occurring settings. They noted that the researcher emphasizes the interaction between variables within natural contexts. Credibility of qualitative research is enhanced by examining all factors in the environment as opposed to the exclusivity of experimental research which deliberately eliminates variability by controlling certain factors. The eclectic approach to collecting data allows the qualitative researcher to cross-check the correctness of data collected in other ways. This use of data gathered in different ways and from several sources is called triangulation.

Triangulation prevents the investigator from accepting too readily the validity of initial impressions; it enhances the scope, density, and clarity of constructs developed during the course of the investigation. It also assists in correcting biases that occur when the ethnographer is the only observer of the phenomenon under investigation (Goetz and LeCompte, p. 11).

Bogdan and Biklen (1982) suggested that although the research design should be an evolving process especially during the field work stage of qualitative research, the use of interview schedules is helpful in multi-subject studies where consistency of data is a concern. In Patton's (1980) description of three basic approaches to interviewing, he says that the basic purpose of carefully considered interview schedules is to minimize interviewer effects by asking the same questions to each respondent. He also notes that interview schedules make data analysis easier because of
organizing differences and similarities in answers and that they are politically wise because producing an exact interview form to show decision-makers and information users reduces the likelihood of data being attacked. Interviews also provide direct quotes for primary data.

Bogdan and Biklen (1982) suggest that research does not necessarily need to be a uniquely scientific enterprise. Rather, it should be practical and include common sense understanding. They criticize educational researchers for modeling research efforts after hard science, pointing out that researchers in sciences such as physics and chemistry do not define science as narrowly as those who try to imitate them. Part of the scientific attitude is to be open-minded concerning method and evidence according to Bogdan and Biklen. They further add that the "researcher's goal is to add to knowledge not pass judgment on a setting. The worth of a study is the degree to which it generates theory, description, or understanding" (p. 24).
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CHAPTER III

RESEARCH METHODOLOGY

This case study was designed using the qualitative techniques of participant observation, in-depth interviews, and document collections. The purpose of this design was to allow the researcher to enter the setting of the Curriculum and Instruction Committee. Entering the setting allowed the researcher to become close enough to the people and situation to understand the depth and detail of what was occurring. Being within the setting permitted the researcher to capture what took place and what people said—the perceived facts, and to obtain a pure description of people, activities, and interactions including direct quotations that were spoken or written (Patton, 1980). A qualitative approach allowed the researcher to describe the role of the committee members, note their decisions, and describe and further understand factors that influence those decisions without making any judgments or having a preconceived mind-set.

Procedures

Once the research topic and methodological design have been determined, the researcher needs to have an overview of
the approach to be taken. Miles and Huberman (1984) pose the question, "Prior to fieldwork, how much shape should a qualitative research design have" (p. 27)? They make a case for tight, prestructured qualitative designs and for loose, emergent ones and predict that most qualitative research lies between the two extremes. A conceptual framework explains, either graphically or in narrative form, the main dimensions to be studied, the key factors or variables, and the presumed relationship among them (an overview). The conceptual framework of this study is as follows in Figure 1.

![Conceptual Framework of Study](image-url)

Fig. 1--Conceptual Framework of Study
This study was conducted using the case study approach with qualitative data collection and analysis procedures. The primary goal of the study was to describe the procedures and processes of the curriculum committee involved in the development of a technology-based curriculum design for physical science. The qualitative case study approach provided suitable methods to record curriculum development processes in this study for the following reasons:

1. Descriptions of decision-making processes of a committee was the focus of the study. Decision-making involved interactions of the participants that could only be described by qualitative methods.

2. The ecological context of the curriculum meetings was critical to the understanding of the procedures and processes. Participant observations and a phenomenological approach provided the methods for obtaining meaning within the context of the committee proceedings.

3. Detailed information was sought on several interrelated factors, some of which emerged during the study and could not be predicted at the beginning of the study; therefore no a priori hypotheses could be stated.

4. Data would consist of transcripts, fieldnotes, and documents for which qualitative content analysis was best suited.

The research design for this study was the collection of data from several sources in several methods. Data were
triangulated through the use of participant observations, verbatim transcriptions, and document analysis in order to increase the internal validity of the findings (Denzin, 1978). Specifically, the researcher attended all curriculum meetings of the Content, Instruction, and Curriculum Committee of the Texas Learning Technology Group beginning in the fall of 1985. A number of curriculum documents including textbook analyses, districts' document compilations, minutes, and curriculum designs were collected at the meetings. Finally, committee members from eight different school districts, state agency participants, and a commercial designer were interviewed in the spring and summer of 1986 to add to the data base from which to infer the decision-making processes and procedures and the perceptions of the participants concerning their roles in the process and the probable use and dissemination of the curriculum design. The independent variables in the study were the factors influencing the procedures and decision-making processes; the dependent variable was the curriculum design. Figure 2 shows a flowchart of the procedure for this study.

The researcher's entry into the context of this study was facilitated by the fact that she had known and professionally worked with most of the participants for a number of years. Participants from TLTG and AT&T were not acquainted at the beginning of the study. The purpose of the study was explained to the participants, and all
Fig. 2--Flowchart of Procedures of the Study
consented to being interviewed. However, fictitious names were used to insure their anonymity. Official permission to complete the study was received in January 1986 from TLTG; however, the researcher had discussed the study with a TLTG representative at the first curriculum committee meeting in October 1985.

Subjects
The subjects for this case study were science consultants/coordinators from eight different school districts, two representatives from state agencies, and one commercial software designer who formed the curriculum committee or had a major influence on the curriculum design. The science consultants were representatives of local school districts which had purchased shares to become members of the Texas Learning Technology Group. The purpose of this group was to design a physical science curriculum delivered by interactive videodiscs. These science curriculum specialists were involved actively in the curriculum planning processes in their districts and had previous experience in teaching science. Most of the science consultants had little computer experience, and none had developed a computer-delivered curriculum.

One of the state agency representatives had extensive experience in developing science education computer programs as did the commercial software designer. The commercial
designer was also a former physical science teacher. The second state agency representative had practical computer experience but no experience in curriculum development for the computer. This representative was not an official member of the curriculum committee but influenced the curriculum by his position as the initiator of the entire project focused on physical science. He always attended curriculum committee meetings and made comments about purposes, progress, and deadlines. However, he did not stay at the curriculum meetings for extended periods of time since it was necessary to stay abreast with the other project committees which met on the same days.

Data Collection

Following the procedures outlined by Bogdan and Biklen (1982), Goetz and LeCompte (1984), Patton (1980), and others for the collection of qualitative data, this study used participant observations, in-depth interviews, and document collections. This procedure for collecting data in different ways and from several different sources is termed triangulation of data (Denzin, 1978). Patton (1980) terms triangulated data from a variety of data sources and the use of multiple methods as a "methodological mix." Goetz and LeCompte (1984) particularly emphasize the importance of multiplicity of data sources since "data collected in one way can be used to cross-check the accuracy of data gathered
in another way" (p. 11) and thus increases validity and reliability. The triangulated data was used to build a database from which to determine decision-making strategies, influencing factors, and philosophies along with a brief historical background of TLTG.

The participant observation source of data was recorded in field notes and audiotapes when possible. Field notes, "the written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on data", (Bogden and Biklen, p. 74) were taken during TLTG overview meetings, curriculum committee meetings, technical meetings, and teacher/principal meetings. Field notes included descriptions and impressions of the surroundings along with descriptions and impressions of the participants and committee proceedings. When it was feasible, audiotapes also were made of meetings to enhance the researcher's field notes of observations of the ongoing deliberations and decision-making processes. The state agency also audiotaped meetings. Transcriptions of these tapes were collected when possible.

The second source of data was structured interviews (Appendix A) designed to answer the research questions and to capture particular perceptions of the committee members and a brief history of the Texas Learning Technology Group. Even though the structured interview schedule was used, the researcher asked probing questions as the need arose. Many
times pertinent topics emerged naturally and were pursued in order for the researcher to gain deeper understanding and insight. For example, teacher needs and overall opinions of the project frequently arose. Each science consultant from the local participating school districts, the project manager of TLTG, and a representative of the Texas Association of School Boards, were interviewed in their ecological settings. The representative of American Telephone and Telegraph Information Systems was interviewed after a curriculum meeting since it was impractical for the researcher to travel to New Jersey when the representative attended all curriculum meetings in Texas. Audiotapes were made of each interview. Verbatim transcriptions of these tapes allowed comparisons in the analysis phase. Interviews also provided direct quotes for primary data in this study.

The third source of data was document collections. The documents included a compilation of original curriculum documents from the participating school districts and the final curriculum documents which indicated what decision-making processes and deliberations occurred during the study. Other documents included textbook analyses, courseware specifications, and a unit prototype. Correspondence from the Texas Learning Technology Group and American Telephone and Telegraph-Information Systems were collected in order to arrange processes and events chronologically. Minutes of the curriculum meetings transcribed by TLTG were
collected to enrich and cross-check the fieldnotes. Thus the documents collected included various curriculum documents, correspondence, and minutes from meetings all of which were used as official documents in the search for the "true picture" (Bogdan and Biklen, p. 100). The data collection phase of the study spanned nine months from the initiation of the Texas Learning Technology Group project in October of 1985 until the curriculum design was approved by the group and the first videodisc prototype of the curriculum was produced in June 1986. Original documents were collected back to April 1985.

Data Analysis

Data appeared in words rather than in numbers and were collected in a variety of ways: observations, interviews, and documents. Miles and Huberman (1984) describe data analysis as being a three-step process: data reduction, data display, and conclusion drawing and verification. Working with elaborated field notes and verbatim transcription of tapes, the researcher reduced the data by reading and rereading them, looking for patterns and designing coding categories (Appendix B) to focus not only on the research questions but also upon unanticipated and merging trends that became evident during the coding process. As Miles and Huberman (1984) note, "Codes are categories; usually derived from research questions, key concepts or
important themes. They are retrieval and organizing devices that allow the analyst to spot quickly, pull out, and then cluster all the segments relating to the particular question, hypothesis, concept, or theme. Clustering sets the stage for analysis" (p. 56). Following Miles' recommendations codes were devised to prompt the researcher's memory regarding obvious categorizations. For example, the code SEQ was used for sequence of topics, SM for state mandates, and TN for teacher needs. Each major category was divided into more specific subcategories as they emerged from the data. The final elaborated list consisted of twenty-nine coding categories that were organized into eight clusters. Bogdan and Biklen state that "certain words, phrases, patterns of behavior, ways of thinking, and events repeat and stand out; material bearing on a given topic can be physically separated from other data" (p. 156). Data reduction is a form of analysis that sharpens, sorts, focuses, discards, and organizes data in such a way that "final" conclusions can be drawn and verified (Miles, p. 21).

The second step in Miles' process of data analysis is data display which he defines as "an organized assembly of information that permits conclusion drawing and action taking" (p. 21). Data display may be accomplished through the use of narrative text, matrices, graphs and charts. The most frequent form of display in qualitative research in the past has been narrative text, but as Miles notes, "text is
terribly cumbersome. It is dispersed sequential rather than simultaneous, poorly structured, and extremely bulky. Under these circumstances, it is easy for a qualitative researcher to jump to hasty, partial, unfounded conclusions" (p. 21). For these reasons, whenever possible, graphic displays were created and used during the analysis of data.

The third step in data analysis is conclusion drawing and verification. Miles emphasizes the importance of finding meaning in the data. Meaning in this study was sought through constant comparison and analytic induction techniques described by Goetz and LeCompte (1984). The constant comparison technique combines inductive category coding with simultaneous comparison of all social incidents observed. Goetz and LeCompte describe constant comparison as the "discovery of relationships that begins with the analysis of initial observations, undergoes continuous refinement through data collection and analysis, and continuously feeds back into the process of category coding" (p. 183). The constant comparisons with previous events leads to new typological dimensions as well as new relationships. Analytic induction notes the patterns, themes, and categories that come from the data; these emerge out of data rather than being imposed on the data prior to data collection and analysis. Analytic induction involves scanning data such as transcribed interviews, searching for categories of occurrences and relationships among categories.
The researcher looks for natural variation in the data. For researchers, "the study of natural variation will involve particular attention to variation in program processes and how participants respond to and are affected by the programs" (Patton, p. 306).

Thus, various data sources and various analysis techniques helped to cross-check accuracy and increase the validity of the conclusions. The use of primary data in the form of direct quotations from participants should provide reliability in the researcher's findings because they can be checked by any reader of the study.

Summary

Qualitative research methods are emerging as valid techniques in the field of educational research. Qualitative research fills gaps left in research done in quantitative methods. By expanding the potential for gathering pertinent information in a natural setting where students, teachers, and administrators are interacting, the qualitative researcher can increase the base of knowledge and link characteristics of the participants with processes which could not be done through quantitative methods. By use of the qualitative case study approach the procedures and processes of the TLTG curriculum committee were correlated with participants' perceptions of their roles in the processes. Factors affecting the processes emerged and were
cross-checked through qualitative techniques. A set of procedures for the development of an interactive videodisc curriculum in cooperation with private industry was noted.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

RESULTS

The data collected in this case study were focused on the Curriculum and Instruction Committee of the Texas Learning Technology Group. A brief historical background of the Texas Learning Technology Group is important because of its influence on the processes of the Curriculum and Instruction Committee and the resultant curriculum in this study.

The Texas Learning and Technology Group (TLTG) was first conceived as an idea in early 1985 in Washington, D.C. at a meeting with the National Science Center for Communications and Electronics Foundation (NSCCEF) that was being hosted by the National School Board Association. The goal of NSCCEF is to advance the state of education in math and science in America's schools through technology. At the meeting there was considerable concern about the lack of use of technology in education and a lack of qualified science teachers. Consequently, a decision was made by persons from NSCCEF and the Texas representatives of the school board association to "actually do something about these problems and stop just talking about how to integrate technology into education."
The National Science Center for Communications and Electronics Foundation agreed to provide a $500,000.00 grant to Texas if Texas school districts would raise $500,000.00 in matching funds (The Texas Learning Technology Group, March 1986, p. 7). Therefore, the Texas Association of School Boards representatives began to lay the groundwork for the project by visiting the larger school district in the state to seek support. The Texas Association of School Boards (TASB) hosted an orientation meeting in May, 1985, at the Infomart in Dallas. Then they visited local school districts in June and July 1985, to receive agreements from the districts that they would purchase shares at $75,000.00 each to join the Texas Learning Technology Group and help develop a physical science curriculum delivered by interactive videodisc technology. By the end of September 1985, the Texas Association of School Boards organized a group to be named Texas Learning Technology Group to establish the by-laws, to seek legal advice on operations, and to organize the project. The fifteen member Board of Directors of TLTG was appointed as follows:

Two by the Chairman of the State Board of Education
One by the Speaker of the House of Representatives
One by the Lieutenant Governor
One by the Governor
Five by the President of the Texas Association of School Administrators

Five by the President of the Texas Association of School Boards

In addition to the fifteen board members, two State Board of Education members serve in advisory positions.

Advisory Committee members were appointed by the local school districts who joined Texas Learning Technology Group. The advisory committees included the following:

Curriculum and Instruction
Technical Standards
Evaluation and Testing
Teacher Training/Administrative

The advisory committees first met on October 21 and 22, 1985, in the American Telephone and Telegraph (AT&T) facilities at Infomart in Dallas. American Telephone and Telegraph had been selected as the commercial vendor for the TLTG project due not only to their sophisticated production facilities and Bell Laboratories, but also to their management team, some of whom were former physical science teachers. The company also employed an excellent course designer who had a commitment to education.

Thus, the Curriculum and Instruction Committee began work to develop a physical science curriculum. The responsibilities of this committee were stated to be to develop the curriculum structure in terms of objectives, content,
sequence, activities and hours spent on topics. The committee was to design instructional activities and strategies with AT&T and to make any necessary reconciliation/trade-off decisions. AT&T was to advise the committee whether activities could be adapted for computer presentation.

With this historical and political background the results of this study will be presented in this chapter in five sections. The first section will describe the participants and their perceptions of their roles in the project. The second section will present a chronology of events leading to the procedures and types of decisions made by the participants. The third section will describe developmental procedures and processes. The fourth section will relate the factors influencing the decisions. The fourth section will detail the resultant curriculum design and possible dissemination.

Participants and Perceptions of Their Roles

The Curriculum and Instruction Advisory Committee was composed of science consultants or directors from eight local school districts. AT&T and TLTG personnel always met with the curriculum committee. The members of the committee who were interviewed for this study appear in Table I. Descriptions of each member came from the perceptions of their roles in the TLTG project as revealed in their interviews. The committee advised representatives from American
TABLE I

CURRICULUM COMMITTEE PARTICIPANTS
WHO WERE INTERVIEWED

<table>
<thead>
<tr>
<th>Organization</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>District A</td>
<td>Weldon</td>
<td>Relevency and Application</td>
</tr>
<tr>
<td>District B</td>
<td>Laura</td>
<td>Generalist</td>
</tr>
<tr>
<td>District C</td>
<td>Susan</td>
<td>Objective-Oriented</td>
</tr>
<tr>
<td>District D</td>
<td>Pam</td>
<td>Designers' Collaborator</td>
</tr>
<tr>
<td>District E</td>
<td>Dan</td>
<td>Reflection of District</td>
</tr>
<tr>
<td>District F</td>
<td>Ray</td>
<td>Curriculum Model Designer</td>
</tr>
<tr>
<td>District G</td>
<td>Mike</td>
<td>Enlightened Colleague</td>
</tr>
<tr>
<td>TLTG</td>
<td>Carter</td>
<td>Coordinator/Researcher</td>
</tr>
<tr>
<td>TASB</td>
<td>Billy</td>
<td>Master Planner</td>
</tr>
<tr>
<td>AT&amp;T</td>
<td>Gene</td>
<td>Student Protector</td>
</tr>
</tbody>
</table>

Telephone and Telegraph, who designed the software, and representatives from Texas Learning Technology Group, who were the liaisons between the groups. Since all four advisory committees frequently met on the same days, members of the other committees sometimes attended the curriculum meetings. Their influences will be discussed in section three of this chapter. The detailed descriptions of the participants below indicate that these people attended all curriculum meetings, were involved in all major decisions, and became known as "the" curriculum committee.
Weldon: District A - Relevancy and Application

Weldon is the science coordinator in District A where he is responsible for about one hundred ninety-five teachers in twenty-two schools. He also is in charge of operating a media materials center (K-12), advising the secondary health program, and chairing a major committee in the district concerned with adolescent sex, drug, and alcohol problems and education. Weldon's sense of humor is apparent in his statement concerning what his colleagues tell him about his committee chairmanship, "you get all the fun because you get all the drugs, sex, and alcohol."

Weldon's experience with developing computerized educational programs is "more learned on the job than actual formalized training." He has done much reading and hands-on computer practices and learned simple, basic programming techniques. He views the application of computer programs as being more important than knowing how to write programs since "the real test comes from being used out in the [school] buildings and how it's going to be used. So, I try to concentrate on getting that kind of experience." Weldon has had some formalized training from IBM Educational Division.

Weldon was told about the computerized physical science proposal of Texas Learning Technology Group by an assistant superintendent in his district. He was given a prospectus on the project and asked to write a report on its pros and
cons. He felt that if his district understood some of the potential financial implications that the project held promise for putting the use of computers in the science program. He thought the project would place educational computers in proper perspective in terms of getting beyond just the simple use of a book or simply computer assisted instruction type of programs. The project could use the computer as a laboratory interfacing device. He was very persistent throughout the curriculum development processes in emphasizing that the computer be used as a laboratory interfacing device because he felt that was the way to develop programs at this time and to give students practical applications.

Weldon described his role in the TLTG curriculum development process as being related to "what we do in any curriculum planning process." He felt that his role was to identify the content and to work out the various parameters that are going to impact that particular content; in this case, how interactive the activities were to become. He felt his role was one to react and to suggest things that might be useful and motivational for the students and to determine how to evaluate whether or not the students will understand the curriculum. Weldon emphasized throughout the development process the importance of relevancy of content as indicated in his comments.
Relevency is an often batted around term which in effect, is application in terms of relating it to the kind of world that the student is living in. I think that's part of your role as a valid curriculum planner, and also decision-making.

Thus, Weldon was an advocate of relevency and application in each phase of curriculum development.

Laura: District B - Generalist

Laura is the secondary science consultant in District B. She is responsible for coordinating the curriculum and science teachers in seven secondary schools. District B lies in a growing suburban area with primarily middle and upper middle-class neighborhoods. Laura was reluctant about expanding on the interview questions probably since she had only been in her present position for one year, and the tape recorder seemed to make her nervous and fearful of saying something inappropriate.

Laura had no previous experience in developing a computerized science curriculum and learned about the TLTG physical science project through her assistant superintendent. He brought her a booklet on the curriculum project in late September or early October of 1985. She said that at that time "the board had already voted on it, and we were already committed to the project. I was already assigned to this committee before I ever even received any written information."
Laura described her role in the curriculum planning process as having input in deciding the overview, scope, and sequence. She felt that determining prerequisites, or the lack of them, was part of her role. She stated that she thought the committee "made some important decisions in terms of who this student is that we are going to train."

When questioned about who the student is, she described him as a prototype student who is "a normal, average physical science student," not necessarily in the ninth grade, and not necessarily gifted or below level in intelligence. She related that she had contributed her district's curriculum guides to the project designers and helped to map the format of what items would be delivered, in what way they would be delivered, and what prerequisites would be necessary for a particular topic. Her concern to represent her district, while considering other districts, was obvious in her following statements.

I think, as a representative of my school district, the primary consideration I had was getting a product that this district could use. But, realizing that there were many school districts involved and they were dealing with a different child and a different set of circumstances, we had to consider that, too. We wanted a product that was useful in many different areas.

She indicated that the curriculum committee's role was hampered because "I don't think we know enough about the technology." Laura almost always brought a physical science teacher from her district with her to the curriculum
meetings. Laura had been a biology rather than a physical science teacher.

**Susan: District C - Objective Oriented**

Susan is the Program Director of Science for grades kindergarten through twelve in a large metropolitan school district. She coordinates science curriculum for ninety-two schools. She is responsible for evaluating teachers and actually checking the cost control of the science departments for all the different schools. She holds a doctorate degree in chemistry. Susan was also reluctant to expound on the interview questions saying that the tape recorder made her "a little bit nervous."

Susan said that she had no experience in developing any computer related educational materials until she worked on the Texas Learning Technology Group project. She learned about the TLTG project in a meeting with her assistant superintendent and a staff member from TLTG. During this meeting in October 1985, she was asked to serve on the curriculum committee representing District C.

Susan felt that one of her major roles in curriculum planning was to make decisions on the objectives because, "I feel that the objectives of the course will be the most important part in making decisions on how the course will look in the end." She also acknowledged the importance of
her role as a person to evaluate the various processes produced by technology.

**Pam: District D - Collaborator with the Designers**

Pam is the Director of Research and Evaluation for a district that has thirteen elementary schools and five secondary schools. She was a chemistry teacher prior to her current position, "so, by virtue of the nature of the Learning Technology project, and from the research standpoint that we would be looking at in terms of its value, impact, and all that sort of thing, that's why I became involved with it."

Pam has had experience with educational computing ever since District D first bought computers. She has been involved with the instructional computing program since its inception in her district approximately five years ago. She has worked with computer-assisted instruction and programming oriented to applications in finding more efficient ways to do things.

Pam learned about the TLTG project when her assistant superintendent gave her "a large volume of material and said, 'read it'." She received the information in the fall of 1985 and became interested in the project. Although she envisions "an awful lot of equipment" with the interactive videodisc presentation of physical science, she thinks that it will be very interesting and will "prick the students'
interest" by presenting some things that "we've not been able to do" and "giving us some zippy ways of seeing things that we could just talk about in a very plain way." She feels that this new type of curriculum is needed because it is an efficient way of delivering instruction to the students while allowing the teacher to have more time with small groups. She further thinks this curriculum will introduce students to lab work in a more appealing manner and will address different learning styles in different ways from what is now available in the regular classroom instruction base.

During the months of curriculum planning, Pam changed her mind about who would use the interactive videodisc curriculum as demonstrated in her comments.

Well, when we first looked at it, my first thought was that districts that perhaps had difficulty in identifying certified personnel, or well-trained personnel, would use it. But, I don't feel that way any more. I think it's going to take a well-trained teacher to do it, and to do it successfully.

She felt that the school district might have to be mid-sized to utilize the program. She was afraid that high costs would disallow its utilization by small school districts and could possibly affect the extent to which larger districts could use it. She stated that "large districts have a way of having [computer programs] here and there, but not everywhere."
Pam believed that a major role of the curriculum committee members was to bring together for the first time some ideas on what physical science was supposed to be all about—the content. She felt that her role was important in giving the commercial vendor, American Telephone and Telegraph, a set of constraints. She believed that if the designers had developed the curriculum from a purely textbook standpoint, or a purely theoretical standpoint, that they would have followed a progression that would not necessarily have fit once it was tried in the classroom. For example, she suggested that scientific methodology and measurement be a strand throughout the curriculum. The committee members supported this redundancy of these particular topics, and the developers listened and accepted the idea. Another important role was that of sequencing the topics. She stated that, "I think we definitely had some influence on sequencing, and when you come down to the essential elements and what is essentially physical science, it's there." After content, constraints, and sequencing she mentioned the role of determining depth and the need for various levels of remediation and extensions within the curriculum. Pat was a strong supporter of the commercial designers since she felt that her role was important to them as indicated by their careful listening, documenting, and incorporating her ideas and those ideas of the other participants into the final curriculum design. She added,
I think as an advisory body they listened. I was very pleased, more than once, to see specific things that we told them come back and be included. Because very often, somebody that's doing something like that, particularly someone at the level of expertise that those people are, they listen politely, but then they go on and do their thing. I don't really think they did that.

Pam described the designers as a strength of the project.

**Dan: District E - Reflection of District**

Dan is the Director of Science and Health for a large urban district. He is in charge of curriculum development for science and health in grades K-12 in one hundred eighty schools.

Dan has a computer that he uses regularly in his office but has had no previous experience in developing a curriculum to be delivered by a computer. He has worked with a teachers' user group that met monthly to write programs to be used in their classrooms. He currently is organizing staff development for computers and interfacing devices to be placed in each chemistry department at the twenty-three senior high schools in the district.

Dan learned about the TLTG in the fall of 1985 from his boss who met with him to discuss their district's involvement. He assumed that the curriculum would be packaged as a set of videodiscs, computer software, and a teacher's manual. He was unsure that this interactive videodisc curriculum is needed and thought that "the
computer and videodiscs have been touted to have a lot of promise and very well may have a lot of promise." He did feel that someone needed to try out this curriculum to verify its promise since "you obviously want to do things better." He felt that any "regular physical science teacher" could use the program.

Dan indicated that in addition to deciding the objectives and content that his major role was to reflect the physical science curriculum of his district and his "experience [regarding] what ought to go into a physical science curriculum." Other than the objectives and content, he also felt that the format and sequencing of topics were major decisions. His overall feeling about the project was that it was "no big deal."

**Ray: District F - Curriculum Model Designer**

Ray is the secondary science consultant in a suburban district with eleven secondary schools. He is responsible for the development of curriculum for eighteen courses as well as the development of district exams for these courses.

Although Ray has had no experience in developing computerized curriculum, he was interested in the project when his superintendent explained it in September 1985. He felt pleased with the project since he noted that a great deal of time had gone into designing it. He envisions the curriculum being delivered in a classroom adapted to
individual students with monitors and student carrels but admitted that "it's hard to conceptualize." He was unsure of the need for the program, believing that "the same outcomes could be achieved without technology through teacher training [in the use of] a reteach model for mastery of objectives" and to make more effective use of their time. However, he noted that the TLTG curriculum could be a pattern or "a model of teaching toward mastery of certain objectives and then having a way to allow individualized reteaching of those objectives if mastery is intended." His real concern was not with the type of curriculum but whether it is really cost efficient. He envisioned the participating TLTG districts to use the program initially, but then, "if there's a way that the cost can be itemized . . . it will be used by other groups for teacher shortage or . . . to get more mileage out of the teachers that they have." He also indicated that the project could be used very well as "just a curriculum model." He further expanded the idea of a model by stating that

the kind of design process of the curriculum, what we call the global objectives and the specifiers, I think that, in itself, was a good process to arrive at a unified curriculum mode.

He thought that if the districts involved would follow a common curriculum like the one being developed, they would have a complete course.
Ray described his role as two-fold. He encouraged teachers to become actively involved in the process through district meetings to get their input, and he brought a physical science teacher to most curriculum meetings. His second role was to influence what objectives were in the units and actual ways to teach units. He stated, "I think I was involved in just about every level of the planning process . . . every stage from objectives to specific content."

Mike: District G - Enlightened Colleague

Mike is the science coordinator for a suburban school district. He is responsible for coordinating all science courses in grades kindergarten through twelve. In addition to his science responsibilities K-12, he coordinates health in grades K-7 and outdoor education. Outdoor education involves the organization, budgeting, and maintenance of an outdoor environmental center.

Mike was introduced to the TLTG physical science project by his assistant superintendent in September 1985. He thought the curriculum was needed and would be used by the physical science teacher whom he has found over the years to be a "frustrated biology teacher: a person whose major training has been in another field." He hoped that the curriculum would make a "real good utilization of video, so that you're able to visualize and see all the different
aspects of the physical science curriculum." He voiced concern that the presentation of content be varied so that students do not look at a computer monitor all the time but realized that it would require a special teacher with "quite a bit of training and a desire to teach in that manner." He felt that students using the curriculum would be general physical science students "running the gamut of intellectual abilities because of the enhancement activities and the remedial loops that will be in the program."

Mike described his role in the planning process to be the one to ensure his district's curriculum needs were met. As he served with his colleagues from other school districts, he was enlightened as to "how close the different school districts were in what they taught and objectives they had to meet." Also, he described his role as a decision-maker in the area of selecting objectives and the content to be taught.

**Gene: American Telephone and Telegraph Subcontractor - Student Defender**

Gene is the president and owner of a company who designs training and is the major subcontractor of American Telephone and Telegraph for the TLTG physical science curriculum project. His company designs training without bias as to the format whether it be videodisc, videotape, or instructor-led. His objectives are "simply to look at a
learning problem, a budget, and between the trade-offs of the two, design training that would result from that."

Gene has considerable experience with computerized instructional materials and was a former physical science teacher. On his master's degree thesis he worked with tutorial programs called LAP's, Learning Activity Packets, which were self-paced. After graduation he used computers in industry in the form of spread sheets and other industrial applications. When he entered the training field, he used computers in the development of programmed instruction which was part of computer-based training, the umbrella term for CAI (computer-assisted instruction) and CMS (computer management system). He has been using computers for the last sixteen years for the delivery of education.

Gene learned about the TLTG physical science project when a description soliciting designers was posted on a board at AT&T in early 1985. He was a contractor to AT&T designing videodiscs for other clients at AT&T, and when he read the posting, he wanted to do it. "TLTG had not begun its bid process but had done a solicitation of about a hundred companies" to ask if any of them were interested. "So, that's how I met the project, and from the first time I read about it, I wanted to do it."

Gene thought that this type of curriculum was needed due to a "change in society towards information processing
and technology." He believes that computers are here to stay and thinks that educational programs delivered by interactive videodisc will increase the effectiveness of learning. According to Gene, the design of the TLTG physical science program will include a teacher component, a student component, and a group component and is designed to be used by any physical science teacher nationwide. He believed that the teacher component and the group work station could measurably improve education as much as all three components. He felt that the individual work station against a cost-work model might not justify itself. His intuitive feeling is

that this great thing called individualization has strings to it. I don't know if there is enough research and enough evidence to take away from something that's in a sense proven, but I'm not sure if it isn't proven by default rather than by specific techniques.

When asked what his role was in the curriculum planning process, he said it was to protect the student. He related that as owner of the company with personnel designing the program and coordinating other subcontractors that were producing and programming the project that he had roles in all phases of the project. However, he felt his major role was to protect the student. He believed that from a business point of view, the bottom line is the "target population" which is the main part of the whole project.
The target population in this project is the physical science students who are most often ninth graders, and Gene stated that he was "surprised in all of our meetings that no one protects them, is concerned about them, perhaps, reflects an understanding of them, and I think that's one of my major roles." Gene has a ninth grader and was previously a ninth grade physical science teacher with great interest in the student.

Carter: TLTG Representative
Coordinator/Researcher

Carter is a staff member of the Texas Learning Technology Group. His responsibilities include both curricular and technical aspects of the physical science project. Thus, he states that "my title could be anywhere from Technical and Curriculum Consultant to Production Coordinator." He was employed by TLTG immediately following his graduation with a doctorate in August 1985.

Carter's experience with a computerized science program involves his development of a non-calculus, introductory physics computer program using the concepts of learning theory in his dissertation. He applied learning theory and artificial intelligence techniques and wrote a two-week physics program using computer language lists.

Carter first learned about the TLTG physical science project through his major professor at the university in
July 1985. The professor had received some documentation on the Texas Learning Technology Trust, as it was originally named, and after talking to the director of TASB, suggested that Carter call about the job opening. He accepted the job in early September 1985.

Carter felt that this type of curriculum, designed with three facets: lecture, group activity, and individualized instruction, was needed for three basic reasons. First, he believed it was needed because of "teacher weaknesses as far as being content experts." Second, it was needed "to move instructional technology up to where our technology is." He stressed that we are still teaching in non-individualized methods and need to move into individualized areas. Third, he felt that this system would alleviate the paperwork burden for teachers and allow them to be freer to attend to student needs. With the three reasons for needing this curriculum, he noted three groups who could effectively use it. He reasoned that teachers could use it for teaching, teachers could use it for training, and students could use it for learning.

Carter stated that his major role in the curriculum planning process was "to maintain a flow of information between Texas Learning Technology Group, the school district curriculum advisers, and AT&T designers." For example, if the designers called him to develop a way to teach a certain concept that they were unable to find in the
curriculum materials, he would suggest an interactive videodisc way based on his past experience. So, he states that "it's a fun position to be in, sort of an in-between of all the activity." In his role he has also interfaced with university personnel who were considered science education or curriculum experts. His role included tapping into current research through the universities and the Association for the Development of Computer-Based Instructional Systems. Carter used his research knowledge to maintain the flow of information between all participants in the curriculum development processes.

Billy: Texas Association of School Boards - Master Planner

Billy is the Executive Director of the Texas Association of School Boards. In this position he oversees a variety of programs dealing with school district type problems.

Billy's experience with computers in education goes back to the late sixties when he taught math using an IBM 360/30 at the high school level and then later at the community college level. His other computer-related experiences involve their use in the learning process. He, along with the TASB Board, has researched ways to change the instructional system through telecommunications systems. Their research has concluded that computer hardware is not
the main problem of educational computers but rather the availability of comprehensive software designed to provide a full year course.

Billy related his role in the initiation of the Texas Learning Technology Group. He discussed the prospects of integrating computers and technology into education with professionals in education and technology from throughout the United States. After his discussions his role was to lay the groundwork within Texas for support of a technology-based curriculum by visiting with local school district superintendents. After obtaining verbal agreements from local districts, he organized a group "to establish the by-laws, do the legal work on how to do it, and organize it." He summarizes his role as "basically . . . coordination and facilitation, providing the leadership. It won't work without somebody taking the initiative in the beginning." He further extended his role to making local school boards, superintendents, and administrators aware of the capabilities of technology, and then, to work to get the resources to provide this kind of system.

The researcher was the participant representing the eighth local district on "the" curriculum committee. As a committee member, she was able to record and to relate to the decision-making and perceptions of the other participants. She has known the other curriculum specialists in all the other local districts, except Districts B and D,
for the last eight years as she has collaborated with them on local, state, and national science conferences and projects.

Chronology of Events

**October Session**

The first of eight curriculum sessions was held at the Infomart in Dallas over a two day period. After a full day of meetings focused on an overview of technology and discussions of the project's mission, plans, and procedures, the participants divided into advisory groups on the second day. In addition to the curriculum committee members of the Curriculum and Instruction Advisory Group, there were three physical science teachers from three different local school districts, a Texas Education Agency representative, and seven other persons from other TLTG Advisory Committees in attendance. Bill, from District F, volunteered to chair the committee.

A series of questions entitled "Issues for Content, Curriculum, and Instruction Group" (Appendix C) was distributed to the curriculum committee by Texas Learning Technology Group. However, some concern was raised by the previous project overview in the area of the contract specifications for American Telephone and Telegraph to design an eighty-hour course. Committee members held "the position that the course needs to fill the whole school year." It
was agreed, with approval by TASB, that AT&T would design a
document for the delivery of one hundred sixty hours of
physical science. Gene then charged the committee to advise
AT&T as to what should be contained in this one hundred
eighty hour course.

A representative from District F then questioned, "Is
the electronic part the 'core' of the course?" Much
discussion ensued revolving around the fact "that the goal
is to eventually raise the educational levels of all the
students in the state, realizing that there will be superior
teachers who wish to be the performer." The task to answer
the core question in depth was given to the committee for
later resolution.

The meeting turned then to the series of distributed
questions. The five questions under "Focus: Prerequisites"
took little time since the general consensus was that there
be no prerequisites. However, question 1.2 relating to the
level of math required of the students led to the discussion
of whether we should include introductory physical science
in this course. Comments included the following:

_Weldon_: These are two separate courses.

_Laura_: There are separate essential elements for
each course.

So, a major decision at this point was that the
project would address the regular physical science course.
Focus: Individual versus Group Instruction.--
Discussion of this section proved difficult for the group due to a lack of technological knowledge. The term "IVD" had to be defined for the committee. Humor prevailed when one participant defined it as "something that's contagious." Carter defined it as meaning interactive videodisc and gave an extended description of the technology involved. Gene concluded the focus on this section of questions by saying,

It is difficult to have the course deliver each topic as either of the three [large group, small group, or individual], but it is likely that there will be elements of each of these depending upon the nature of the topic to be delivered."

Focus: Scope of Content.--In question 1.10 the committee responded that state mandates determined physical science to be a full year course composed of one semester of physics and one semester of chemistry but do not determine the sequence. Some of the participating school districts insisted that they teach physics first semester while others teach chemistry first semester. Discussion turned to what specific units, chapters, and topics from existing TEA-approved textbooks would be included in the curriculum for each semester. The committee members failed to negotiate an answer to this question and were reminded by Gene of their role which was to design the curriculum to deliver this course, and "let's put first the need to envision what this curriculum should look like." He further
emphasized that the committee concentrate on designing the ideal course through a "design then shrink" concept. Confusion about the role of the committee resulted in a decision that each school district would send their course outlines and curriculum documents to AT&T who would analyze and incorporate them within an "essential elements first" environment.

Once the decision on content analyses was made, a general discussion of physical science, its content and strategies, and student and teacher needs ensued. It was suggested that the committee seek what had been traditionally difficult to teach, the weakness of the course, and determine what could be taught best in an electronic format. Laboratory simulations and major concepts were envisioned as appropriate to be delivered electronically with the computer system controlling the learning environment. AT&T software designers initially felt the system would control learning environment while the teacher handled remediation and enhancement activities. The consensus of the committee reversed this idea with the following comments:

Ray: There are enough poor teachers that we should strive to have the system handle the presentation and remediation.

Dan: Teachers may introduce the concept, but the computer should teach the core and handle the remediation loop. This will free the teachers.

Mike: Poor teachers are the reasons we need the system to handle the core and remediation.
Bill: Look where this project is going. Look all over the state. Our incoming teachers are not getting any better. We need the system to present content accurately.

Carter: There are many abstract concepts involved here, and the system is ideal for these abstract concepts. Books with their static pictures have trouble with these.

Software designers agreed with the committee to produce core materials along with remediation and enhancement materials. Discussion was finally redirected to the series of printed questions to be answered at the current meeting.

Focus: Sequencing Topics.—Since much of science does not require linear sequences, it was decided that the sequences not be preset but would be flexible. Carter suggested that "there could be an overall structure, like a pyramid, in which the student enters in at prerequisite topics, then progresses according to performance. This would still provide for unitization of topics." Ray emphasized the desire for flexibility to rearrange units since the course is presently taught in units. He felt that the project should still "try for a baseline core with basic enrichment and remediation handled by the computer, including scoring, with fringe remediation handled by the teacher." With flexible, modular sequencing decided, the discussion centered on support materials.
Focus: Support Materials.—Gene introduced the discussion posing questions about the need for a textbook, student workbooks, teacher guides, lab manuals, or videotape demonstrations. He suggested that the committee "finish this question out to its logical conclusion: What is the relationship between the textbook and this course?" During the discussion, the idea that the textbook becomes a supplemental or reference source repeatedly emerged. Program designer, Jeff, interjected at one point,

The electronic medium can't handle it all. We are trying to get a feel of how you want this system to play in the classroom. We still have to talk about what other materials you would suggest to support the system.

The textbook as a supplement was the only consensus reached at this time. Discussion then turned to learning theory.

Focus: Learning Theory.—Two questions in this section focused on the six major models of information processing and cognitive tests. Committee members were reluctant to discuss these two questions probably due to a lack of knowledge in the area. AT&T designer, Carla, suggested that the system could be developed to handle different styles of questioning, and Gene proposed that students might be tested to determine "what kinds of learning styles we will be dealing with." No decisions resulted, but a feeling that the project not become overly complicated arose along with
the idea that an all-inclusive approach to learning theory would be difficult within the TLTG budget. Discussion then turned to labwork.

Focus: Labwork. There was an early consensus that lab must definitely be some fraction electronically delivered as noted in the following comments.

Susan: The system should be required to deliver the lab dependent upon the nature of the subject involved.

Steve: Hazardous labs and expensive lab experiments could be performed quite well via electronic means.

Weldon: The electronic method could serve to compress time.

Carla then asked the group to define lab. General consensus was that lab meant "hands-on" experiences, and that even though simulations could be the best method for some labs, it was necessary for students to complete traditional hands-on lab activities.

Focus: Human Factors.—Since time to close the meeting was near, Gene moved to the questions centered around human factors and interactivity. He asked, "Just who is this ninth grader?" The student was described as usually enthusiastic, and "if they're interested, they'll sit forever." A teacher, Kathy, stated,

Ninth-graders seem to come into the course with high expectations for science, and they start to let down when they have to take notes and listen
to lectures. We'll have to look at ways to present the material that is not watered down, but is exciting to them while educational.

Other descriptions of this student suggested that he was not always trustworthy and was becoming socially aware which encouraged the question about the length of time he could be expected to sit in front of a computer terminal. The program designer, Jeff, answered that there was no definite answer and that testing needed to be done in this area. Mildred, from the Teacher Training Advisory Committee, suggested that "we take advantage of their need to socialize while at the terminal" to which Carter asked the group to recall the model of classroom instruction developed by Trump (1962). Trump's classroom model consists of large group discussion, small group interaction, and self-paced, individualized instruction and has been used as a model for this project's classroom design.

Wrap-up.--When asked if there were other matters before the wrap-up, several questions were raised. One concerned laboratory interface devices. Weldon stated,

We have neglected to talk about the ability of the computer to act as a laboratory interface. There are products available to allow laboratory apparatus such as pH meters, light meters, temperature probes, and toy cars to be attached to a computer. This interface allows the computer to also perform as a laboratory tool.

It was agreed that interfacing was inexpensive, could utilize an installed base of microcomputers, and could take the
drudgery out of the laboratory. When the question about the need for a Texas flavor was asked, it was readily agreed that the designers should use a wide ethnic spectrum in the reproduction of the course since Texas has students from many other states and countries, and they watch national-scale television daily. In the final wrap-up, committee members agreed to take the focus questions to their districts and to address the issues individually in order to allow the project staff the best chance of accurately measuring the attitudes and positions of the districts.

The second meeting was scheduled for November 12, 1985, in Arlington. Table II summarizes the decisions and directions of the curriculum committee at the October 1985 meeting.

**TABLE II**

**OCTOBER MEETING**

**SUMMARY OF CURRICULUM DIRECTIONS**

| Content | - Critical information and essential concepts to be instructor-independent  
|         | - Second critical use of computer to be for remediation and enhancement activities with at least two loops of each.  
|         | - Curriculum committee to determine specific content for one hundred eighty hour course through objectives  
| Sequencing | - Units to be modularized and as prerequisite-free as possible, and when they are not, computer will control the sequencing  
| Evaluation | - Testing for mastery to include pretest, post-tests, and within tests |
November 12 Session

The second curriculum meeting held in District X was attended by science consultants/coordinators from school districts, three physical science teachers, three designers from AT&T, and two staff members from TLTG. Carter immediately distributed a summary of the October meeting which everyone read intently without casual visiting. Gene noted that AT&T had received curriculum documents from only four district and needed them to help determine the core of the course. Some district representatives had brought their documents to the meeting. Gene then charged the committee with answering all of the nine pages of focus questions that had been distributed at the October meeting. Dan asked, "Do AT&T and TASB believe that we've answered the questions enough and are now backtracking?" Gene responded that all questions needed to be answered with prerequisites and sequence of the utmost importance. With this charge, the committee divided into three groups with each group responsible for answering a set of questions as follows:

Group 1  Prerequisites (1.1 - 1.5)

Individual versus Group Instruction (1.6 - 1.9)

Scope of Content (1.10 - 1.16)

Group 2  Sequencing Topics (1.17 - 1.22)

Support Materials (1.23 a and b)
Labwork (1.24 - 1.26)
Instructional Strategies (1.27)

Group 3 Instructional Strategies (1.28 - 1.31)
Learning Theory (1.32 - 1.33)
Remedial & Enrichment Activities
(1.34 - 1.37)
Instructional Flexibility (1.38 - 1.39)
Texas Orientation (1.40 - 1.42)

The Special Interest Group: Student Testing (2.1 - 2.7) and the Special Interest Group: Human Factors (3.1 - 3.6) were not assigned. Each group answered their questions and discussed problems arriving at the answers, then the entire committee reconvened for discussion.

Group 1 noted that students working through units are at various levels with individualization increasing the variation. The group then suggested that time limits be placed on the units with enrichment activities for those students who finish rapidly and extensions or remediation activities for those who are slow to grasp a concept. Varying philosophies emerged on the discussion of individual instruction versus group instruction with a consensus that student interactions might be lost with 50 per cent individualization with the computer. A final suggestion was made by Ray, "Why not let large group video instruction introduce all major concepts?"
Group 2 related the need for sequencing by semester to be a local district option allowing each district to decide whether to teach the physics semester or chemistry semester first. However, the need for chemistry to follow a prescribed sequence was noted. Physics could be sequenced with more flexibility and stand-alone units (Fig. 3). Once the sequence was determined, the group stressed that units must be divided into objectives, subobjectives, and activities. Within the activities both traditional, wet labs and simulations were proposed to be the strategy for a minimum of two hours per week. AT&T staff members had prepared analyses of the scope and sequence of the five TEA-approved textbooks which Groups 1 and 2 used in their decision-making processes. Appendix D contains sample analyses from two textbooks and Appendix E contains a summary of the analyses of all five textbooks.

Group 3 used an AT&T analysis of curriculum documents from four districts (Appendix F) to discuss possible remediation and enhancement activities. It was suggested that AT&T determine what activities would be best suited for electronic delivery. This suggestion resulted in a misunderstanding between AT&T staff and members of the curriculum committee. Gene restated that AT&T must be given the curriculum, that methodology was not their responsibility, and that teachers must be given the ability to select activities. Dan remarked that "everyone is disturbed
Fig. 3--Instructional Sequence for the Physical Science Curriculum.
with how monumental the task is." Other committee members voiced their concern and stress about a lack of time "to do a good job and keep up with their district job" and meet the December 18 deadline for the curriculum to be delivered to AT&T. Gene reiterated that it is TLTG's job to bring a curriculum to the AT&T staff who will electronically produce it and help determine whether an activity would be delivered through videodisc, text, or laboratory.

It was finally decided that "the" curriculum committee, composed of only one representative from each participating district and no outside people, would determine objectives, subobjectives, and time limits at the next scheduled meeting on October 22. The reduced committee would work from a compilation of district curriculum documents to be furnished by AT&T.

This meeting proved difficult and stressful partly due to the attendance of people from school districts who had not joined the Texas Learning Technology Group. Members from participating districts felt that these people should not influence curriculum decisions if they were not using the final product. TLTG staff personnel emphasized that the greater the input from many districts, the greater the possibility of producing a successful program. Stress was also apparent in the area of timelines and job responsibilities. The curriculum had to be written by December 18 so that AT&T could meet a February 12, 1987, deadline to deliver the
design document to TLTG. The curriculum committee had not realized the impact of its responsibilities on the entire project, and that the other committees could not proceed without the curriculum determined. Table III summarizes the directions taken by the curriculum committee at the November 12, 1985 meeting.

TABLE III

NOVEMBER 12 MEETING

<table>
<thead>
<tr>
<th>Content</th>
<th>Sequence</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>-General concepts determined</td>
<td>-Prescribed sequence for chemistry semester</td>
<td>-Remediation and enhancement loops programmed</td>
</tr>
<tr>
<td>-Introductory concepts required at beginning of school year</td>
<td>-Modular, flexible sequence for physics semester</td>
<td>-Importance of student interactions noted</td>
</tr>
<tr>
<td></td>
<td>-Introductory unit always first</td>
<td></td>
</tr>
</tbody>
</table>

November 21 - 23 Session

All focus group committees met in District X November 21 - 23 (Agenda, Appendix G). A brief history and overview was given to all committees on Thursday morning, November 21. In the overview Billy stressed that the items of foremost importance were "establishing a good curriculum and an effective teacher training program. The architecture of the product should be structured around the curriculum
elements." He further stated that AT&T was not to write the curriculum and that the courseware must drive the hardware. He noted that 7,000 studies were used as a data base to avoid pitfalls of early curriculum reforms in science. Gene reiterated that historical science curriculum reforms failed because they were designed in isolation then given to the teacher who was told to implement them. He stated that the committees might say to AT&T, "Go out and design a program, and we'll implement it," but that leads to failure. For these reasons AT&T developed the rationale for its position to insist that the members of committees accept their responsibilities in the project.

On the second day, the curriculum committee met after the overview and a presentation on Bell Laboratories' research on adaptive instruction. Adaptive instruction was described as tailoring the form that instruction takes according to the individual learner's characteristics which is ideally suitable for artificial intelligent tutoring systems. Curriculum committee members had received a compilation of local school districts' curricula from AT&T on November 18. Each unit was analyzed, by school district, according to the following:

Global objective
Related sub-objective
Sequence of unit
Time (in hours) spent on the unit
During the morning break, members expressed concern and stress that so many people were observing committee proceedings and suggested that they not be allowed to participate for the remainder of the morning and that the curriculum committee move its meeting to another building in the afternoon. The location was changed for the afternoon.

One of the first decisions reached by the curriculum committee during this meeting was that "Ninth Grade" should be removed from the title of the project and allow the local school districts to determine grade level. Consensus was that "ninth grade" in the title added nothing but caused roadblocks.

Discussion centered for the remainder of the day on the global objectives and related sub-objectives for each unit compiled by AT&T from the participating district's curriculum documents (Appendix H). Beginning with the first global objective in the sixty-six page document, the committee discussed every global objective and sub-objective within the fifteen units. An example of the procedures used to develop one unit would illustrate the procedures for the remaining fourteen units.

Unit Title: Work, Simple Machines, Potential/Kinetic Energy contained eight global objectives and eighty sub-objectives representing the curriculum of the eight different school districts. After the group read and discussed all these objectives, they decided on one global objective
with twelve sub-objectives for the unit entitled simply "Work." The time allotted for this unit ranged from 2.5 hours in one school district to 20 hours in another district. It was decided that ten hours would appropriately cover the topic. The range of sequencing was from the unit being taught as the second topic in first semester to the fourth topic in the sixth six-weeks. The committee decided that "Work" should be the second unit in the physics semester. Table IV illustrates the unit differences before and after the curriculum decisions.

The committee followed the same procedure for each of the fifteen units, and during mid-afternoon, Dan stated, "we've hooked onto a process." The process followed these steps:

1. Everyone read through all the objectives for a unit.
2. Bill would call for suggestions on a specific statement of the global objective for a unit.
3. Discussion and statements were carefully worded until everyone agreed upon a specific statement.
4. Bill would call for suggestions on a specific list of sub-objectives.
5. Discussion and reading ensued with additions and deletions to one of the district's sub-objectives until everyone agreed on appropriate list.
### TABLE IV

**EXAMPLE: DETERMINING CURRICULUM OBJECTIVES AND SEQUENCE**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Original</th>
<th>After Curriculum Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Work, Simple Machines, Potential/Kinetic Energy</strong></td>
<td><strong>Work</strong></td>
</tr>
<tr>
<td><strong>Global Objective</strong></td>
<td>Eight variations</td>
<td>Develop an understanding of force, work, and power, and how work is made easier and power is increased by use of machines</td>
</tr>
<tr>
<td><strong>Sub-objectives</strong></td>
<td>Eighty-eight variations</td>
<td>The student will:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Define work as &quot;force times distance&quot; and be able to solve problems using this formula</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Be able to list the six simple machines and give an example of each</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Given ten household items, be able to identify what type of simple machine it illustrates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Define mechanical advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Tell how to calculate mechanical advantage in the inclined plane and the lever</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- List the three parts of a lever (fulcrum, effort, and resistance) and tell where each is located in the three classes of levers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Recognize that the mechanical advantage of a pulley is equal to the number of supporting strands.</td>
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<tr>
<td></td>
<td></td>
<td>- Describe the wheel and axle as a variation of a first class lever</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Describe and inclined plane and tell how a wedge and screw are variations of it</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- State the relationship between work input and work output as defined by efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Solve mathematical problems related to work, mechanical advantage, and efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Explain why work output is always less than work input</td>
</tr>
<tr>
<td><strong>Sequence</strong></td>
<td>Range: first unit in first semester to fourth unit in sixth six-weeks</td>
<td>Second unit in physics semester</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>Range: 2.5 hours to 20 hours</td>
<td>10 hours</td>
</tr>
</tbody>
</table>

6. Review of sequence that had been determined at a previous meeting.

7. Discussion and determination of time required to teach the unit.
When the committee completed this session late in the evening, members felt that they had accomplished the task. Humor was maintained as expressed by reoccurring puns such as, "Is 'Heat' a good unit title?" The response was, "I don't think it's so hot!" A great pressure was removed after this session which ended with a curriculum designed for one hundred eighty-two days with fifteen days for an introductory unit, eighty-two days for the chemistry semester, and eighty-five days for the physics semester. During the Saturday, November 23, meeting with metroplex area teachers and principals, there was little concern about the curriculum. They were interested in an overview of the project, use of the equipment, teacher training, and their role in the classroom. Table V summarizes the curriculum decisions and directions at the November 22, 1985, meeting.

**TABLE V**

**SUMMARY OF CURRICULUM DIRECTIONS**

<table>
<thead>
<tr>
<th>November 22 Meeting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
</tr>
<tr>
<td>- Agreed on fifteen units</td>
</tr>
<tr>
<td>- Established global objectives for each unit</td>
</tr>
<tr>
<td>- Established sub-objectives under each global objective</td>
</tr>
<tr>
<td><strong>Sequence</strong></td>
</tr>
<tr>
<td>- Verified design for introductory unit first for either semester</td>
</tr>
<tr>
<td>- Verified precise sequence for chemistry</td>
</tr>
<tr>
<td>- Verified flexible sequence for physics</td>
</tr>
<tr>
<td>- Determined time allotment for each unit</td>
</tr>
</tbody>
</table>
December 12 Session

The fourth curriculum meeting was held in District E with five members from the regular curriculum committee, one teacher, one TEA representative, one university professor, and TLTG and TASB staff present. Carter distributed copies of the fifteen physical units including global objectives, related sub-objectives and sequence of each unit along with the time spent on the units. Two units, Chemical Reactions and Chemical Bonds, serve as a sample of the distributed materials (Table VI). These materials were used in making curriculum decisions during the meeting. Each person briefly read the copies and agreed on the sequence presented and that the following should be added to all unit objectives: 1) Scientific Method, 2) Science, Society, and Technology, and 3) Careers. The committee felt that these concepts were important as strands throughout the course and usually were taught continuously rather than as separate units.

Committee members decided that the number of hours listed for a unit should be flexible and used only as an estimate for designing the program. Another concern about listing the hours was voiced by Weldon who said,

Don't present this to teachers as one hundred eighty-two hours but rather as a percentage of the course. Hours will be confusing because class periods are usually fifty-five minutes and frequently interrupted by announcements and assemblies.
TABLE VI

SAMPLE OF UNIT ORGANIZATION

UNIT TITLE: Chemical Reactions

GLOBAL OBJECTIVE: The student will gain an understanding of conservation of matter and energy chemical reactions and how those reactions take place.

RELATED SUB-OBJECTIVES:

The student will:

- define, describe, and give examples of decomposition, synthesis, and displacement reactions.
- write balanced chemical equations for synthesis, decomposition, displacement and double displacement reactions.
- learn to use the Law of Conservation of Mass to solve problems involving unknown amounts of reactions or products.
- distinguish between exothermic and endothermic reactions.
- explain the role of catalysts in chemical reactions.
- demonstrate the proper writing of equations.
- demonstrate the proper use of equipment and materials.
- conduct activities using metric units to make measurements and solve problems.

TIME (IN HOURS) SPENT ON THE UNIT: 15 HOURS

UNIT TITLE: Chemical Bonds

GLOBAL OBJECTIVE: The student will gain an understanding of how elements (atoms) combine to form compounds (molecules).

RELATED SUB-OBJECTIVES:

The student will:

- name common compounds.
- define terms associated with compounds and bonding.
- recognize formulas for compounds.
- distinguish between atoms and molecules and be able to explain how atoms combine.
- contrast the transfer and sharing process of bonding.
- use oxidation numbers to write formulas for compounds.
- name binary compounds and recognize diatomic molecules.
- identify and write formulas for compounds containing poly-atomic ions.
- demonstrate the usefulness of models to show how atoms will combine.

TIME (IN HOURS) SPENT ON THE UNIT: 10 HOURS
Another concern about time was the building of a percentage of time near the end of the semester for tests. Four days at the end of each semester was suggested as an appropriate time allotment.

The remainder of the meeting was spent reviewing each unit, checking for content and wording of each global objective and related sub-objective, and verifying time allotments. The following list would indicate some of the revisions in the content and document the procedure used:

**Unit: Measurement (page 1).** In the last Related Sub-objective of the first global objective, change wording to read "give appropriate data, construct a graph (strike "line")." In the fourth related sub-objective of first global objective, add conclusion/analysis of results.

**Unit: Motion and Force (page 2).** Combine Related Sub-Objectives 8, 9, and 10, relating to Newton's laws to read: "State Newton's laws and give examples."

**Unit: Work (page 3).** Change 7th Related Sub-Objective to read "recognize that the ideal mechanical advantage of a pulley is equal to the number of supporting strands."

**Unit: Electricity & Magnetism (page 4).** Change 1st Related Sub-Objective to read "explain static electricity and cite various examples of static charges in nature."

Change 10th Related Sub-Objective to read "describe the behavior of magnets and magnetic fields."

Change 2nd Sub-Objective to read "recognize how the electroscope detects the presence of static electricity."
Unit: Heat (page 5). Change 14th Related Sub-Objective to read "describe thermal pollution."

Change 6th Related Sub-Objective to read "describe specific heat."

Change 11th Related Sub-Objective to read "describe the concept of absolute zero."

Unit: Sound and Waves (page 6). Change 3rd Related Sub-Objective to read "define the term sound and describe the characteristics of sound."

Unit: Light (page 7). Delete 1st Related Sub-Objective. (Observe the properties of light.)

Change the 15th Related Sub-Objective to read "Define laser light and describe its properties."

Unit: Nature of Matter (page 8). (No comments.

Unit: Atomic Structure and the Periodic Table (page 9). Change 5th Related Sub-Objective to read "Describe the arrangement of electrons in atoms in various orbits and relate the neutron, etc".

Change 2nd Related Sub-Objective to read "Describe parts of atom based on location, mass, and charge."

Delete 4th Related Sub-Objective which reads "Prepare selected elements in laboratory."

Change 12th Related Sub-Objective to read "Identify elements using flame test."

Unit: Chemical Bonds (page 10). In the 8th Related Sub-Objective, delete the hyphen from the word poly-atomic."

After the committee completed the revisions, math skills of students were discussed. Weldon suggested that math skills could be covered in a remediation loop by means
of a Math Skills Help Box on the computer screen. It was noted that the Math Skills Help Box should cover only what is needed for the particular part of the physical science course on which the student is working at the time. Ray expressed that the math skills be incremental in presentation and deal with specific skills, for example, the addition of decimal fractions. The AT&T designers noted the recommendations and agreed that programming math skill remediation would note be a problem. Table VII summarizes the curriculum decisions made at the December 12, 1985, meeting.

**TABLE VII**

**SUMMARY OF CURRICULUM DIRECTIONS**

**December 12 Meeting**

<table>
<thead>
<tr>
<th>Section</th>
<th>Details</th>
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<tbody>
<tr>
<td><strong>Content</strong></td>
<td>- Added three strands to all unit objective; 1) scientific method, 2) science, society, and technology, and 3) careers</td>
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</table>
| **Sequence** | - Determined that math skills be covered in remediation loop and be incremental  
- Revised content and wording of global objectives and related sub-objectives in each of fifteen units  
- Agreed on specific sequence of units  
- Decided that designated time allotments be only estimates for design |
| **Prerequisites** | - Decided science experts and program designers should determine |
The fifth meeting was actually a co-chairpersons meeting held in Dallas; however, four members of the curriculum committee attended in order to answer questions specifically addressing curriculum design.

Gene opened the meeting by stating the objectives and methodology for the two-day session. The objectives were "to provide AT&T with a common set of guidelines and viewpoints for the design of TLTG's physical science curriculum, and to provide AT&T with guidelines and viewpoints for the factors which will effect the delivery, use, teacher training, and evaluation of TLTG's physical science curriculum." He then outlined the following methodology:

1. In the following order, the chairpersons of each focus group will present its considerations for the: curriculum, teacher training, technical hardware, and evaluation.

2. Using the Curriculum Focus Group's design as the starting point of discussion, any disagreements between groups will either be resolved, or identified and left for AT&T to resolve.

3. To complete the work of the session, AT&T will raise any questions or issues on which it needs closure.
He reiterated the importance of closure on all curriculum issues and distributed a series of issues (Appendix I) for each focus group to consider. The lists of focus group issues contained notations as to which ones were at issue due to a lack of agreement among focus groups, indicated by "+" and on which issues AT&T needed to comment, indicated by "**".

The curriculum committee was asked to clarify eighteen issues. First, prerequisites were discussed in regard to reading and math skills. The decision was made that as a curriculum requirement, designers could presume that the physical science students would have a minimum grade level of 7.0 on math, science, and reading. AT&T agreed to document its assumption of the capability of students and prepare a prerequisite test to measure these assumptions. Bill noted that parents could influence a student's entrance into the physical science program even though the student did not meet the prerequisites. It was decided that prerequisites would not rule students out of a course.

The content, composed of fifteen units, raised no issues; however, the lock step design and flexible sequence posed some questions. Ray asked that lock step design be defined in relation to a flexible sequence. Lock step design meant that students must remain together within the bounds of a unit but may not be at the same point within the unit. If a student were to master the core material of a
unit, he would enter into enrichment activities. The
teacher could sequence the units as desired within the
constraints of prerequisites with the physics units being
more flexible than the chemistry units. It was decided that
the curriculum would follow a quasi-lock step design.

Remedial activities formed the fifth area of concern.
Not all focus groups agreed that the remedial activities be
in two distinct loops with repetition considered to be one of
the two loops. The groups had not agreed upon where to pre-
sent math remedials. The decision was made that there would
be one electronically delivered remedial loop per sub-
objective. Repetition would form the second loop. The
teacher would have to control remediation after the
program's remedial loops on a sub-objective. The group
agreed that math remedials would be designed in relation to
the unit topic and that a pop-up calculator would be used.
The designer also agreed to furnish a resource list of
available math programs for remediation.

Core information was the sixth curriculum issue.
Designers wanted to verify whether all core information was
to be delivered electronically in individualized settings
and was to include all of the state's essential elements.
Gene defined core information as all basic concepts
required to meet the objectives of the course. The group
agreed that core information would be presented electron-
ically to cover all state-mandated essential elements.
Another decision was that instruction of the core would be delivered in a combination of ways including individualized, small group, and large group methods.

Enrichment activities, those beyond the core activities for all students, posed no issue; however, laboratory activities created an issue. State mandates require 40 percent of science courses to be laboratory activities. TLTG had received permission from the state education agency to meet the 40 percent requirement via 20 percent traditional, wet laboratory activities and 20 percent computer simulated laboratory activities. There was a conflict of philosophies as noted when a committee member said that simulated laboratory activities could not replace traditional, wet activities. Another committee member insisted that laboratory interface devices were essential to the design of the curriculum. Finally, an agreement was reached that computer simulated laboratory activities would provide 20 percent of the required 40 percent lab-oriented activities, and the amount of laboratory activity would be unit dependent rather than a set number such as two laboratory activities every week. Laboratory interface devices would be an option in the program to allow the use of the computer as an electronic thermometer, pH meter, or other laboratory device.

The discussions turned to testing after a review of the curriculum requirements for course materials: that they be
nonsexist and across ethnic groups, that there was no need for Texas orientation, and that alternative activities must be provided. The program was to provide a test bank for teachers to select test items or use random selection except for the final semester test. The final test was to be standardized for evaluation purposes. The issue arose on setting the mastery level at 70 per cent or allowing the teacher to set mastery level. It was decided that the program design should allow teachers to set mastery level and should allow four days of curriculum time for testing with teachers being able to alter testing time upward. Pretests to allow students to "test out" of the core curriculum and enter enhancement activities and prerequisite tests to identify required entry level skills and knowledge were agreed to be part of the curriculum design.

Design considerations, issue thirteen, reiterated AT&T's role to design a complete curriculum covering two semesters to be delivered by both electronic and nonelectronic components. Designers were to design instruction based on science skills with a combination of activities that used inquiry methods sparingly. Committee members expressed the need to design some "what would happen if . . . " exercises to encourage inquiry, application, and synthesis. The issue of whether the course should be 50 per cent individual delivery and electronic delivery with 50 per cent other modes was resolved. The percentage of the
course to be delivered electronically would be determined by the course designers.

On the issue of what strands should be woven throughout the course, the major issue focused on a math strand. The group decided that math did not need to be designed into every unit but only as needed for a specific unit. The strands required for each unit then would include scientific method, career opportunities, and science, society, and technology.

Designers agreed that the program would be independent of a textbook and would accept generic software packages. AT&T was asked to design the software to allow other software packages to be linked to it. The generic software packages could include word processing programs, spread sheets, and an electronic calculator.

The last two issues for the curriculum committee were teacher support and teacher control. To give teachers needed support, the committee suggested a computer management system in which the computer scores alpha/numeric responses, clocks student time on the computer, and tracks progress of the student at all times. The group also suggested a computerized grade book with built-in security. The group agreed with designers that the course should remain under teacher control with the teacher being allowed control of the following:

Adjust programmed 70 per cent mastery level
Sequence curriculum that has no prerequisites
Select a combination of activities
Select test items

Near the close of the meeting Billy summarized the complexities that the curriculum committee was seeking to be designed. He stated, "When the money issue comes up, there will be priorities." Curriculum decisions and directions of the December meeting are summarized in Table VIII.

This curriculum meeting marked the deadline for district input into the design. AT&T was charged now to complete the curriculum design document and to deliver it to TLTG by February 12, 1986. The curriculum design was delivered to TLTG on February 12.

March 12 Session

The meeting on March 12, 1986, was held in Hurst for the cochairmen of the Technical and Curriculum committees. However, the researcher and two other curriculum committee members attended with two members of the Technical Committee and Carter from TLTG. The purpose of this brief meeting was to scan the official curriculum design delivered to TLTG by AT&T on February 12, 1986.

After general statements about the document far exceeding the committee members' expectation, discussion focused on costs and budgeting. Bill asked what costs
| **Prerequisites** | -None other than presumption of a minimum grade level of 7.0 in math, science, and reading |
| **Content** | -Fifteen required units over two semesters  
-**Core information**—basic concepts to meet objectives of course  
-Presented electronically in combination of ways—individual, large group, small group  
-Address all state-mandated essential elements  
-After first unit, all answers in metric measurements  
-Strands required in each unit—scientific method, career opportunities, and science, society, and technology  
-Math eliminated as a strand  
-Nonsexist, across ethnic groups, no Texas orientation  
-Remedial and enhancement activities |
| **Sequence** | -Lock step design: all students within same unit, not necessarily at same point in unit  
-Teacher control of sequence within constraints of unit prerequisites  
-Physics units flexible  
-Chemistry units prescribed |
| **Strategies** | -Remedial Activities electronically delivered  
-One remedial loop per sub-objective  
-Remedial math in relation to unit topic  
-Pop-up calculator  
-Enhancement activities—electronic and nonelectronic  
-After core material mastered  
-Under teacher control  
-Laboratory Activities  
-20 per cent computer simulations  
-20 per cent traditional, wet experiments  
-Interface devices optional |
| **Testing** | -Test bank of items  
-Teacher selection or random generation  
-Unit and semester tests  
-Final test standardized  
-Teacher control of mastery  
-Allotment of four days of curriculum time  
-Pretest—mastery allows student to directly enter enhancement activities  
-Prerequisite test  
-Identifies required entry skills and knowledge  
-Provides coaching and/or remedial activities |
needed to be budgeted for the 1986-87 school year which led into a discussion of what equipment the local school district wished to purchase. Estimates on cost were as follows: Teacher Workstation - $5,500.00, Group Workstations - $35,000.00, and Individual Stations with computer-managed instruction - $90,000.00 plus the cost of the Teacher Workstation or approximately $100,000.00. Steve indicated that budgets need not include cost for equipment until the summer of 1987.

Discussion turned to general opinions and questions about the total TLTG physical science program. Ray, from the Technical Committee, stated, "We need to get teacher feedback on the room layout, especially the group workstation. The kids will play with the computers." Carter noted that the districts would need to try various classroom arrangements to verify what really works since the program is new and untried. Bill then asked who would be selected to run the pilot program, "an effective teacher or pilot with some poor teachers?" Carter replied that TLTG had no recommendations except they would like some poor teachers in order to better evaluate the pilots. He made it clear that selection of teachers remained with local districts. Bill noted that "we can find a poor teacher to run the equipment but may not be able to manage students." Dan commented that the implication was that the program is teacher-proof. Carter indicated being teacher-proof was the intention of
the design, but the teacher had to be able to run the computer system. It was recommended that a teacher be selected who works well with small groups and possesses traditional organizational skills.

Group interaction was emphasized in the curriculum development processes. Emphasis on group interaction was important from the first curriculum committee meeting. Group interaction was the foundation for design of the group workstations in the dynamic classroom arrangement (Fig. 4). However, Carter felt that small group workstations formed the weakest link in the design since small groups of students could rotate into the teacher workstation to work as a larger group then move into individual workstations. Using the teacher workstation for small group activities would reduce the cost by approximately $35,000.00. Carter reiterated that "price is the toughest part of the project."

A technical committee member noted that the purpose of the project was to plan a classroom for the twenty-first century, but it would be difficult to implement based on economics unless the State could sell it to other districts and states. He also stated that tutorials for minorities would extend the use of the computer systems in his district, but it was still a "hard sale."

A general feeling emerged that the entire curriculum committee and some teachers needed to review the curriculum design. The design delivery was noted as being radically
### T.L.T.G. Project

Classroom / Hardware / Bundle(s)

![Dynamic Classroom Arrangement Diagram](image)

#### Equipment
- 3 B2/400
- 21 Hard Disc Players
- 21 Video Disc Players
- 21 Image Capture Boards
- 18 12" Color monitors
- 3 19" Color Monitors
- 1 25" Color Monitor
- 1 Network
- 18 Headphones
- 1 Printer
- 21 Keyboards

#### Bundle Options
- ① Teacher
- ② Group Activities
- ③ Individual

*Fig. 4—Dynamic Classroom Arrangement*
different from traditional delivery of lecture, activities, and tests. A review of the design would orient the teachers to the new delivery methods. Carter stated that time prohibited an extensive review of the curriculum design since AT&T was designing a prototype unit to be delivered in June 1986, and teacher training was beginning in August 1986. He noted that the teachers would be given a choice of numerous activities, all of which were submitted by local teachers. Dan concluded that the lock step plan was important in the design and a review of the entire document was unnecessary; however, a curriculum meeting should be planned for all members to see the efforts of their work, the curriculum design document.

April 28 Session

The curriculum meeting held on April 28, 1986, was directed toward reviewing and analyzing the prototype covering the unit Electromagnetic Spectrum, a two hundred fifty-six page document. Six staff members from AT&T, five staff members from TLTG, one from National Science Center for Communications and Electronics Foundation, one from the state education agency, two TLTG trustees, and several Technical Committee members attended in addition to the Curriculum Committee.

The interim chairman of the TLTG board gave an introduction in which he warned that the physical science project
was so comprehensive that the board wanted to be sure that nothing of importance was overlooked. He noted the number of committed people involved, the number of hours the curriculum committee had worked, the complexity of the effort, and the prospects for its future in education. He revealed that the board had approved the curriculum design in February 1986, and that the program was more expensive than had been anticipated. However, the board had given TLTG approval to coordinate efforts between AT&T and a publishing company to produce testing and supplemental printed materials. He charged the curriculum committee to carefully review the prototype on the electromagnetic spectrum since it would be used in teacher training sessions in August 1986 in fund raising efforts.

A second board trustee stressed obtaining teacher's cooperation and a solid course content. He said that teachers should be willing to accept this innovative approach if the delivery system is easier than traditional delivery, has advantages over traditional methods, and has solid course content with "continuity and flow." He proposed that "exciting technology is available now on the cutting edge in education today." He further noted that the "teacher makes the difference" even if the content is imaginative and that the future in education is "to stretch gifted students and bring along the slow ones." He
concluded that the curriculum committee should "give us your best suggestions to make the product acceptable."

The Electromagnetic Spectrum Prototype was demonstrated and explained briefly before questions were addressed. Some questions included the following:

Dan: How do you ensure that the core is taught when students may be working in groups or individualized stations?

Gene: Students repeat the teacher's core curriculum whether in group or individualized stations to ensure that the core is taught.

Dan: Don't you think the students may group themselves by learning style?

Jeff: Yes, the computer will push the student into his style.

Ray: Instead of group stations, could we have all individual stations?

Gene: Group learning theories and styles are important. You don't want all individual stations. Students need group interactions.

After the question exchange Gene noted that scheduling of the variety of designed activities might prove to be a weakness. He noted that the number of activities would exceed the class allotment "so students won't be sitting around." The pilot programs would address scheduling and the problem involving activities for the units.

Gene and Carter summarized several points before the remainder of the meeting specifically addressed the prototype design. Gene emphasized the importance of two factors in the TLTG physical science project: group work
stations and teachers. He pointed to these factors as differences between this project and other projects. He said, "We're not chasing individualized instruction. We're chasing group instruction where the teacher opens and closes each unit. The teacher remains in control unlike other projects. We're not removing the importance of the teacher."

Carter reviewed the three modes of the dynamic classroom and charged the committee with giving feedback during the development of the prototype. He emphasized the need for input on video programs since TLTG was charged to provide AT&T with video according to contract.

The following five questions formed the bases for specific discussion of the prototype:

- Is it required/beneficial for students to receive a copy of the lesson objectives as part of the introduction?
- Is the preset criteria level, 100 per cent for pretest and 70 per cent for post-test, realistic? acceptable, etc.?
- What percent, if any of lab exercises can be guided inquiry versus validation?
- Tests Items: the number of test items, the design of the test item bank, two different test item banks, items for SST career.
- Is the introduction/wrap-up sequences (of content), for the teacher workstation, acceptable as a "template" for all discs?

General committee consensus was that daily objectives were not needed by the student, but a teacher's manual to provide the objectives should be available. Everyone agreed on the
second question that students should master 100 per cent of the pretest in order to directly enter enhancement activities rather than the core curriculum. The 70 per cent mastery on post-test was agreeable unless teachers wished to change mastery level upward. On the question of laboratory activities, members felt the experiments should balance inquiry and validation methods.

The question on test items caused more discussion than the other questions. The tests originally were to be designed to have four questions for every objective with multi-forms of the tests available. The answers were to incorporate all levels of thinking skills. The discussion of how many answers should use higher levels of thinking skills led Carter to conclude, "This gets into philosophical questions with no apparent resolution. Let's charge AT&T with making four questions per objective and making the test bank robust enough to allow the teacher to tailor the test."

An AT&T designer asked "if it were feasible and agreeable for AT&T to design six questions per objective and let the teacher tailor the test?" The committee members concurred and decided that the pretest need not be unique from the post-test if distractors were rearranged to produce a different test form. The group also concluded that application of science should be tested but not the career topics.

The final question on acceptance of a "template" for all discs received little comment since Gene stated, "We
must make templates. We can't make fifteen different designs for fifteen units." Committee members agreed that an introduction/wrap-up sequence of content could serve well as a template for all discs. Also, it was noted the mix of video and computer was striking during the prototype demonstration. A designer commented, "The focus is to teach, not to entertain although parts may be entertaining."

When the official curriculum meeting adjourned, a reduced curriculum meeting began. Four members of the curriculum committee met with three AT&T designers, one TLTG state member, and one state education agency representative. The meeting had been prearranged to review the content of the prototype in a page-by-page methodology. In the review, three areas were addressed: 1) male, female, and minorities appropriateness, 2) correct answers with no apparent response pattern, and 3) correct content and spellings.

Some corrections were made in content and spelling. One example of a correction would be the definition of "refraction." The original definition was "refraction is the term used to describe the bending of waves around an object." The corrected definition was "refraction is the term used to describe the bending of waves as they pass from one substance into another." In each topic reviewed, the group read a description of video on the computer screen, the narrator's script presenting content, each question referring to content in the script, and all choices for
answers to each question including both correct and incorrect responses (Appendix J). Students who respond incorrectly would receive unique feedback to tell them why an answer is incorrect. Incorrect responses would receive feedback in screen text only, but a correct response would receive a clever animation on the screen as a reward. The prototype review in this manner was so tedious and time-consuming that, after two hours, Carter divided the remainder of the one hundred seventy-eight page section among the committee members. The participants were asked to review the material in the established methodology and report any corrections to TLTG within three days. All participants willingly accepted their assignments and felt that this methodology should be used to review all content units. However, there was an apparent need for the number of science educators reviewing content to be greatly increased. Table IX summarizes the curriculum decisions during the April session.
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<td><strong>APRIL MEETING</strong></td>
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| **Objectives** | - Daily objectives for students unnecessary  
|                | - Daily objectives for teacher in manual  
|                | - Narrative text on screen with video presents concepts |
| **Content** | - Series of questions covering concepts  
|            | - Incorrect responses explain reasons for incorrectness  
|            | - Correct responses rewarded with clever animation |
| **Activities** | - Multiple choice and true-false questions on content  
|               | - Laboratory experiments - balance guided inquiry and validation |
| **Sequence** | - Introduction/wrap-up for each lesson |
| **Test** | - 100% mastery on pretest before enhancement activities  
|           | - 70% mastery on post-test unless teacher adjusts upward |
Developmental Procedures & Processes

Two different sets of procedures or modes of methodology emerged from the results of this study. One emerging methodology dealt with procedures used in curriculum meetings by staff members of TLTG and AT&T and will be titled "Staff Procedures." The second methodology manifested itself within the procedures of the local science specialists meetings, which will be titled "Curriculum Committee Procedures." Even though both sets of procedures were interwoven, they will be discussed individually with references to their interactions.

Staff procedures followed a pattern at each curriculum meeting. Reviewing and analyzing the results found that meetings were introduced by the project manager from AT&T and/or the project coordinator from TLTG. Frequently, the director of a state agency or a TLTG board member would comment during the introductory phase or overview of the meeting. Printed agendas were sent to committee members prior to meetings with extra copies available at meetings. After the review, staff personnel would distribute a printed summary of the previous meeting if appropriate, then distribute a series of questions or issues to be addressed at the current meeting. Staff members began discussions by reviewing questions and issues. They initiated deliberations and functioned as arbitrators during committee
discussions. At the end of meetings, these people summarized meeting decisions and projections for future meetings during the wrap-up. Staff members also functioned as researchers for the committee providing detailed analyses of district curriculum guides and state approved textbooks and surveys of research on learning and human factors. The emerging pattern for staff procedures (Fig. 5) facilitated committee deliberations and decisions, thereby increasing productivity which was essential to meet timelines designated in contract specifications.

Curriculum committee procedures were not as well defined as staff procedures during the curriculum planning process. After listening to meeting overviews, committee members generally asked questions about the entire project and expectations for the committee. Time was spent individually reviewing printed materials if the information had not been sent to members prior to the meeting. Discussion of printed information was followed by addressing questions and issues presented by AT&T and TLTG staff. Deliberations and decision-making resulted from discussions or unresolved questions were deferred to later meetings if no decisions could be determined. Figure 6 represents the procedures of the curriculum committee resultant from this study.
Overview

Distribute Printed Information

Initiate Discussion for Decisions

Wrap-Up

History

Purposes

Agenda

Prior Decisions

Current questions/issues

Research/analyses

Review questions/issues

Review research/analyses

Solicit decisions

Arbitrate differences

Summarize decisions

Respond to questions

Project future questions/issues

Fig. 5.--Pattern of Staff Procedures
Fig. 6.-Curriculum Committee Procedures
Interrelationships between staff procedures and curriculum committee procedures were apparent upon analysis of results (Fig. 7). The overview set the tone for the curriculum meeting. Curriculum discussions, deliberations, and decisions were based on the printed information supplied by staff members. The final wrap-up at each meeting not only summarized decisions that had been made but also proposed issues that were to be decided at future meetings. Staff members and committee members cooperated in following these procedures without the committee realizing a set of procedures at the time. However, AT&T staff had extensive experience in conducting developmental meetings and apparently realized the need to follow an orderly

![Diagram of Overall Committee Procedures]

Fig. 7.-Overall Committee Procedures
progression in order to meet deadlines of the development timelines.

Since the foundation of the entire project was the curriculum design, curriculum decision-making processes were important. Curriculum committee decisions impacted the hardware, software, testing, and evaluation of the project. During committee deliberations a decision-making process emerged as seen in Figure 8. Decisions concerning specific curriculum design began with selection of units to be taught, then unit sequence, objectives, prerequisites, strategies, and evaluation methods. Time to be spent on the units was determined then along with the possibilities of presenting certain topics electronically. A review of curriculum decisions frequently led to more discussion and deliberating on specific content design.
Courseware decisions impact hardware decisions

Eight district curricula combined into one original by deliberating and deciding

1. units of content
2. sequence of units
3. content objectives
4. prerequisites
5. strategies/activities
6. evaluation methods

Assign time allotments for each unit

Decide appropriate electronic media to each topic

Review Curriculum

Fig. 8—Decision-making Process
Factors Influencing Decisions

Factors influencing curriculum decisions of prerequisites, objectives, content, sequence, and strategies in this study will be described in four categories. The categories will be as follows: philosophical, human, limiting, and other factors (Appendix B). Interaction of these influencing factors in all types of curriculum decisions (Fig. 9) will be noted as will consistencies of other research done in different settings.

Fig. 9--Factors Influencing Curriculum Decisions
Philosophical Factors

Influences grouped under philosophy include values and experience. Values refer to the values and philosophy of individual participants in the curriculum planning process, the values and philosophy of the participants' local school districts reflected through them, and the values and philosophy of science educators in general. Experiences refer to the personal experiences of the participants as former classroom teachers and as science curriculum coordinators.

Each curriculum decision-maker approached the planning process from his/her own perspectives as has been shown in other studies (McNeil, 1977; Kirst & Walker, 1971; English, 1983; Weaver, 1985). Weldon stated,

I think each one of us on that curriculum committee certainly approached the task from our own perspectives as people who reviewed it on a day-to-day basis. And, you are going to take a look at factors like the receptivity of your own teaching staff.

Participants related that their past experiences as classroom teachers and as curriculum coordinators affected their decisions.

A second major influence on decisions was the philosophy of the participant's local school district. Participants felt that they were representatives of their districts with responsibility to "get a product that my school district could use." Ray stated that a major influence on his role as curriculum developer was the target
population, "particular needs of the population of our
district . . . to make sure that there's a match" between
the physical science project curriculum and the population.
An AT&T designer also noted the value of the realization of
who the target population was. Even though participants
valued and reflected the philosophies of their districts,
they showed commitment to developing "a product that was
useful in many different areas" as Laura stated. Committee
members addressed specific needs pertaining to their
district but wanted to be realistic in designing an aca-
demically strong course that would be motivational and
practical, consistent with other research in different
settings (Weaver, 1985; Searles, 1984; Ponder, 1983). In
line with a practical, strong curriculum, the participants
found no value to adding a Texas flavor to the curriculum
but did value the utilization of a wide ethnic spectrum of
both males and females in the production of the course.
Values and philosophies of the participants were closely
related to and interwoven with their concern for human
factors.

Human Factors

Human factors influencing the curriculum planning pro-
cess in this study included student characteristics and
needs, teacher characteristics and needs, and other groups' input. Research on human factors in association with
computer delivered instruction also influenced curriculum design. Human factors were a tremendous portion of this whole curriculum and were mentioned in all interviews and curriculum meetings.

Student needs stemmed from student characteristics. Committee members characterized the student as a fifteen to sixteen-year-old who "will sit forever if they're interested," who "are becoming socially aware, "and who come in "a wide range, especially when it comes to being trustworthy" according to committee members. Due to the wide range of students taking physical science, usually at the ninth grade level, prerequisites were set at a reading, math, and science level of grade 7.0. Dealing with different children from different sets of circumstances influenced the content decisions that the core be delivered at a level acceptable to an average student to include remediation and enhancement loops within the program. As Pam spoke of the "nature of the students," she noted that the program should "prick the students' interest . . . show them . . . really impress in some zippy ways . . ." Two participants not only wanted to motivate the students through electronic delivery, but also to increase relevance of physical science through application. To focus on relevancy, Weldon wanted the curriculum to "apply to the student's everyday life, in terms of their experience base, and their impression of the world at their level." Decision
makers also addressed students' different learning styles in planning activities delivered in different modes to reinforce concepts.

Student needs focused on learning environment in dealing with the student's interaction with the computer system. Human factors and student needs involved how many students ideally would use a computer. If one student were assigned to a computer, the ideal individualized learning environment would be achieved, but the social aspect of learning would be lost. AT&T designers and TLTG staff members caused the curriculum committee members to realize the importance of meeting student needs in this unique learning environment. Staff members cited research on cooperative learning (Humphreys, Johnson, and Johnson, 1982) and use of graphics and density of text (Hathaway, 1984; Cohen, 1983) in helping participants determine scope, sequence, and strategies of the project. Attention continuously focused on how the curriculum could be designed to allow the student to interact with the computer system in the most fluid, easy way. Student needs were a strong influence on all decisions.

Teacher characteristics and needs were the second group of human factors influencing the planning process. Teacher characteristics focused on weaknesses. Susan found her decisions on the kinds of activities "were affected by the quality of teachers who would be using the program . . .
Many of our teachers are not as well qualified as they should be." Weldon noted teacher characteristics as a deciding influence when he stated that physical science "is an area where we don't have the best trained cadre of teachers . . . ." In every meeting, it was reiterated that "incoming teachers are not getting any better" and as one participant said, "Poor teachers are the reason we need this system to handle the core and remediation." Ironically, one committee member stated that the teacher selected to pilot the program needed to be "energetic and enthusiastic and want to try something new . . . very self-motivated."

Decisions did address teacher needs. Giving teacher support through training and materials was important to curriculum planners. Curriculum decision makers reinforced the production of supplemental teacher manuals, prompts on computer screen, a computerized grade book and scanner, and a flexible test bank. Bill stated that the program must "allow creative teachers to be creative" by allowing them to add personal script and exercises to the core curriculum. The curriculum was designed to allow teacher control of mastery level, sequencing when not defined by prerequisites, and selection of activities. Teachers surveyed wanted the program to handle scoring and time-consuming tasks. A teacher need addressed but not resolved by the curriculum committee was teacher appraisal. Pam noted teacher appraisal as a major concern by stating, "I can see problems
down the line, particularly when . . . the entire team of people, including those who will be doing the appraising, are not aware of what's supposed to be going on in class. The teacher . . . is going to be in a rather vulnerable position." However, since appraisal was not a specific curriculum problem, this teacher need was forwarded to TLTG staff to discuss with appropriate groups.

Other groups formed the third area of human factors. Other groups included people who visited curriculum committee meetings and voiced their opinions on content, objectives, prerequisites, strategies, activities, and testing. Members of the other TLTG focus groups: Technical, Evaluation and Teacher Training Groups, frequently attended curriculum meetings held in conjunction with their group meetings. There were no noted differences in these peoples' comments and the comments from curriculum committee members. They reinforced curriculum participants viewpoints on such matters as the technical feasibility of using the micro-computers as scientific interface tools, percentage of curriculum to be delivered electronically, and feasibility of enhancement and remediation loops within the core curriculum. University professors who commented during curriculum meetings influenced the group to set prerequisites at grade level 7.0 and to determine that a separate math unit was not necessary which was in opposition to the opinions of university personnel. Curriculum committee
members decided that a math strand would run through the entire curriculum in appropriate units. The state education agency helped especially with laboratory activities and allowing 20 per cent of the activities to be simulations. Participants were aware of other groups which used technology successfully train their personnel. Groups which use technology for educational purposes encompass industry and military services. Other group influences were positive unless the group became too large to make decisions at which time curriculum committee members requested a reduced meeting in a location away from other committee meetings.

Limiting Factors

Limiting factors placed constraints, or parameters, on the curriculum design. Constraints encompassed contractual specifications, state mandates, time, costs, and school environment which includes schedules, space, facilities, and equipment. The constraints dealing with time, costs, and school environment were intertwined in their influences.

Each local school district participating in the curriculum planning process had signed an agreement with TLTG, and TLTG had signed an agreement with AT&T. These contractual agreements provided a framework of specifications and timelines for the development of a physical science curriculum and the project as a whole. AT&T was contracted to develop a design for a physical science course from a
single, unified curriculum given to them by TLTG and the participating districts. The specification that AT&T would be given a single curriculum necessitated clarification on the role of the curriculum committee. Eight participating district supplied eight different curriculum documents from five state approved textbooks to AT&T whose staff members analyzed them. These analyses formed a basis for curriculum decisions. AT&T had originally agreed to design an eighty-hour course, but that specification was revised to one hundred sixty hours at the recommendation of the curriculum committee. The unified physical science curriculum was to be furnished to AT&T by December 18, 1985, to allow them to develop an electronically delivered design of the curriculum by February 1986. The time specification posed a stressful problem for committee members, but the deadline was met.

State mandates which limited curriculum decisions were the essential elements and the 40 per cent hands-on laboratory activities prescribed by House Bill 246. The state essential elements had been written generally so that local school districts could create their own physical science curriculum with essential elements forming a minimum framework. Thus, each participating school district taught separate but similar curricula including essential elements as prescribed by the state. The single unified curriculum of this study included all essential elements delivered in several modes (Appendix K). The State education agency
allowed half the mandated 40 per cent hands-on type laboratory activities to be computer simulations. The 20 per cent laboratory simulation influenced the types of activities recommended by the curriculum committee. The State constraints through mandated curriculum formed a framework from which to create the single physical science curriculum. Time has been mentioned as a source of stress to curriculum committee members in meeting specified deadlines, but time was a limiting factor in the school environment along with space, facilities, and equipment. Ray expressed concern about the timeline saying,

It's short, in fact, unless everyone involved really stays on top of it to make sure that the materials themselves are reviewed for accuracy and making sure we don't count certain things out that could be very effective ways to teach, we may ignore those . . . because of the time element.

Determining the sequence and amount of time required for each unit in the curriculum was a major decision, also. Total unit time had to fit into fifty-five minute class schedules. Weldon noted positively that "the electronic method can serve to compress time." Another committee member felt that what equipment and laboratory facilities were needed affected his decisions. A teacher noted that lab experiments that require expensive equipment or materials could "easily be done [through simulations] by a small school with a limited budget" using this program. Providing
space for the equipment necessary for delivery of this curriculum caused the committee to propose a variety of activities that could be used in groups and/or individual workstations.

Costs were a major influence and concern. Selection of laboratory activities depended on expenses. Hardware to deliver the curriculum was considered a large initial expense, but it was noted that it could possibly reduce expenditures on other laboratory equipment and expensive, often hazardous chemicals. Curriculum committee members felt that computer features such as a touch screen and pop-up calculator would be beneficial to students, but Weldon voiced a question that was repeatedly asked, "Look at the economic side of the issue. Is the payoff there enough to justify the cost?" The group also recommended teacher aides such as classroom progress monitoring and grade sheet scanning, but the costs placed limitations on some recommendations. The curriculum committee dreamed about imaginative ways to present the content, but the question of costs always placed limits on reality.

Other Factors

Other factors that influenced curriculum decisions included textbooks, research, and current weaknesses in physical science or science in general. Textbooks held no
specific influence on the unified curriculum since participating districts used different textbooks from the list of five state-approved books. The analyses of five physical science textbooks completed by AT&T staff reinforced the participants' view that major concepts in physical science are the same without regard to textbook. Textbook differences occurred in sequences, concept emphases, activities, and supplemental materials. A committee member summarized the feelings of the group on textbooks, "The textbook becomes a reference or a back-up system." Interactive videodisc presentation of physical science was lauded as a positive attribute when compared to textbooks with their static pictures and extensive text that must be read by students. Another current weakness of the physical science course was the abstract concepts involved and our inability to "show them" as Pam proclaimed which has made physical science "traditionally difficult to teach." The participants sought activities to teach concepts electronically and to present laboratory activities "that are difficult to set up or repeat" according to Wayland. Activities presented in a simulation mode were supported by research at Western Washington University in which Gerhold (1985) stated, "one irony is that computer simulations are often closer to true science than laboratory activities, which are constrained by time, budget, and safety limitations to be cookbook exercises." Research also supported participants' notion
that group activity learning was important for the age group. Humphrey, et. al., (1982) determined that interaction between students may have a greater impact on students' achievement than curriculum programs or teacher behavior. TLTG and AT&T staff members continuously presented curriculum planners with research in areas of discussion as they arose. Thus, current weaknesses in the physical science course were an influencing catalyst for the planning process with research and textbooks possessing some influence upon the decisions.

Curriculum Design

The curriculum design with courseware and hardware specifications for the Texas Learning Technology Group's physical science project was submitted by AT&T on February 12, 1986. The design document was developed by AT&T Information Services and is the property of the Texas Learning Technology Group. The curriculum is a one hundred sixty hour, two semester curriculum which can be taught in grades eight through ten. The design was the culmination of the focus groups' meetings in the fall of 1985. This section will review specific curriculum-related areas of the one hundred eighty page document in relation to the deliberations and decisions of the Curriculum, Content, and Instruction Focus Group referred to as "the" curriculum committee in this study. Curriculum design will be divided
into four sections as follows: initial specification changes, scope and sequence of content, instructional strategies, and participants' perceptions of weaknesses/problems, strengths, and dissemination.

**Initial Specification Changes**

Since the conception of the project and during negotiations with the focus groups, AT&T, and TLTG, three major curriculum issues were re-examined and changed. These issues were as follows: number of hours of content, individual progression through the curriculum, and percentage of individual instruction.

At the beginning of the project, a goal was to reduce the current one hundred sixty hour curriculum to eighty hours. At the first curriculum meeting that goal was abandoned for two reasons. First, committee members felt that some students could not learn that fast no matter how good the materials. AT&T staff members agreed that compressing a one hundred sixty hour course into eighty hours was not "do-able." Second, schools would have difficulty filling the "found" time. One participant stated, "The course needs to fill the whole school year." In addition, while AT&T knew that time would be saved in going from the non-electronic to an all electronic format, they were not convinced that

-50 per cent time would be saved

-an all electronic format was affordable to the majority of school systems
-an all electronic system would be successful

neither the student nor the teacher would accept
an all electronic system (Manz, p. 4).

The decision was made that the one hundred sixty hours could be used to first teach better and then teach more by enriching the content which would stay within current expectations of public school educators.

The second major issue involved the original goal which was to allow the student to advance through the curriculum as fast as possible. Teachers and curriculum committee members voiced concern about "how to manage students at varying levels within a single classroom." The rapid progression concept was abandoned

because of the potential administrative nightmare for the student, teacher, and school. We were concerned that:

the teacher burden might become so negative that the teacher would inhibit/resist the system

"ultimate individual learning" was not best for the student, i. e., there are not only peer pressures involved, but a great deal of learning - BETTER and MORE - would come from teacher and group activities rather than from individual activities (Manz, p. 4).

The resolution to this issue was to develop a quasi-lock step curriculum that would allow students to receive enrichment activities after they complete the core material. In describing the lock step design, one curriculum participant described that "students
begin and end a module together but work at various
levels within the module." AT&T noted that students would
"learn BETTER and MORE from group and teacher activities,
when combined with individual instruction, than if they only
receive individualized instruction--no matter how good that
individual instruction is" (Manz, p. 5).

Scope and Sequence of Content

The physical science curriculum was designed to cover
one semester of physics and one semester of chemistry in one
hundred sixty hours of instruction. Content was divided by
the curriculum committee into fifteen units of instruction
including eight units of chemistry, six units of physics,
and one introductory unit. Content was then built upon a
global objective for each unit with varying numbers of sub-
objectives under each. The term "core curriculum" was used
to indicate critical elements that all students would be
expected to master and included the Essential Elements for
the Physical Science Curriculum - Chapter 75.64
(Appendix K) provided by the Texas Education Agency. By
agreement with the curriculum committee, AT&T designed
programs to insure that all core concepts were presented
electronically. Of the one hundred sixty hours of instruc-
tion, approximately 60 to 65 per cent of the content would
be delivered electronically which includes 50 per cent lab
simulations. The remaining 35 to 40 per cent was planned to
be delivered via laboratory exercises and traditional
teacher-led lectures and demonstrations. Specifically, from
the curriculum design (Manz p. 7), the major components of
instruction were designed as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Total Curriculum Percentage</th>
<th>Electronic Curriculum Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Workstation</td>
<td>20%</td>
<td>80% - 100%</td>
</tr>
<tr>
<td>Group Workstation</td>
<td>20%</td>
<td>80% - 100%</td>
</tr>
<tr>
<td>Teacher-Led</td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>Laboratory (including simulations)</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>Testing</td>
<td>10%</td>
<td>70% - 90%</td>
</tr>
</tbody>
</table>

When determining the instructional sequence of the
units in the overall curriculum, the "Introduction to
Physical Science" unit was designed to stand alone and must
precede either semester. Once completed, teachers may elect
to teach either the physics or chemistry curriculum for a
semester. Through discussion and negotiations, committee
members determined that physics units may be flexible in
sequence; however, chemistry units were to follow the
prescribed curriculum.

**Instructional Strategies**

The major components of the instructional delivery
system are the Student Workstation, Group Workstation, and
Teacher/Large Group Workstation. In addition to core
content being delivered through these workstations, 20 per
cent of laboratory activities will be delivered via this
method which directed special attention to these activities during curriculum meetings.

Student Workstation activities were designed to include 20 per cent of the total curriculum. Students work on an individual basis at their own workstation and "proceed through computer-assisted instruction designed to teach, test, tutor, and reinforce content relating to one or more objectives" (Manz, p. 7). Both student and computer know what content needs to be learned because a pretest was electronically scored at the beginning of the unit. The student first receives instruction on concepts that need to be learned, and the student may review information indicated as mastered at the pretest level. Activities at the Student Workstation include the following:

- Presentation of core material of the unit that covers all objectives

- Two remediations of the course material that includes one repetitive loop and one non-repetitive loop

- Post tests enabling students to demonstrate mastery of unit objectives and subsequently generate test results automatically transferred to the electronic grade book stored at the Teacher Workstation.

- Enrichment activities that more advanced students can participate in, expanding on the unit objectives (Manz, p. 27).

Each one of the areas of activities above resulted directly from curriculum committee deliberations. Test questions were to be designed to incorporate all learning levels: knowledge, comprehension, application, analysis, synthesis,
and evaluation, and to assess the student's understanding as appropriate to the unit objectives determined at the December curriculum meeting.

The Group Workstation was designed to deliver 20 percent of the total curriculum to a small group of two to seven students. Students "participate in computer-supported instructional activities designed to introduce, reinforce, and enhance the objectives of each unit in the curriculum" (Manz, p. 8). The core of each instructional unit would be delivered on videodisc through audio and visual materials. Group exercises and activities to reinforce core concepts were designed to be longer and more thought-provoking than the individual activities. The average individual exercise was programmed to last approximately five minutes; group exercises would run fifteen to twenty minutes. Students would receive prompts to talk among themselves to solve problems. In addition to providing learning activities directly related to core concepts, activities at the Group Workstation promote enhancement and enrichment; i.e., "enable students to apply scientific principles to unique situations, and to explore science, society, and technology issues" (Manz, p. 8). The curriculum committees' decisions that the Group Station teach the core concepts with reinforcing exercises and enhancements along with the strands of careers, science, society, and technology were followed closely in its design (Fig. 10).
In summary the Group Workstation was designed to provide the following:

- A review of the core material of the unit
- Group problems and situations that students solve together, at times with additional paper materials, and other times by exploring the videodisc.
- Applications of the important concepts of the unit

- Science, society, and technology or career opportunities if applicable to the unit

- Simulated laboratory experiments using videodisc and the student lab book

- Other enhancement activities relative to the core material

The Teacher/Large Group Workstation would allow the entire class to participate in teacher-led activities. Curriculum designed for delivery via this mode would include a unit overview and unit wrap-up. A pre-lab section could be used in the middle of the lesson template of overview and wrap-up which the curriculum committee agreed would best serve the delivery of content in all units. The overviews were designed to be delivered via interactive videodisc for each unit of the curriculum. The intent of the overviews was to provide a stimulating and motivating vehicle for the introduction of objectives and content of the unit. Specific purposes of overviews were to prepare students for the unit by providing a global understanding of the instructional objectives included in the unit, to stimulate curiosity, and to promote the methodology of scientific inquiry. After the overview, a pre-lab section could be inserted. Pre-lab sections were programmed for the Teacher Package to contain information pertinent to every laboratory activity in the curriculum.
"This information can either be referenced by just this teacher for lab preparation purposes, or can serve as a lab introduction for the entire class" (Manz, p. 54). The curriculum committee had requested the pre-lab section especially for teachers who are frequently ill-prepared to coordinate content and laboratory activities, and to mix chemical solutions and make other preparations for laboratory activities. The unit wrap-up was planned for interactive videodisc delivery and to promote group discussion. In the wrap-up, students would be provided with demonstrations illustrating concepts introduced within the unit. Demonstrations would be broad in scope so that unit concepts would be related to both society and the world as a whole. Group discussion of the following would be promoted by the wrap-up:

- key concepts introduced within the unit
- careers
- science/society/technology issues
- student questions and comments entered into the system during individual instruction (Manz, p. 8).

An example of a unit wrap-up taken from the design document follows. It illustrates the career strand requested by the curriculum committee and a topic mandated in the essential elements.

People having careers utilizing physical science principles are interviewed in this unit activity.
Students might be "introduced" to different people who have been interviewed and then asked to select one person who seemed most interesting to them. The video plays a short segment where the person describes their area of expertise. The screen then fills with a list of questions that students could ask the person. Upon choosing a question, students cause the program to branch to the appropriate response. In this way, students can participate in a mini-interview of the person concentrating on the areas that interest them most. Possible careers that may be explored in this unit on matter are: science writer, mineralogist, steel work, and lab technician (Manz, p. 55).

In summary, the Teacher/Group Workstation would deliver core curriculum concepts via interactive videodisc. The core would always consist of a unit overview and unit wrap-up, the template for all units (Fig. 11). A pre-lab activity could be selected for the teacher alone or for the entire class.

Laboratory activities were instructional strategies of special concern in curriculum meetings and in the design document. Forty per cent of science courses must be laboratory investigations, by state mandate, and curriculum committee members insisted that "wet" labs were necessary for student understanding of major concepts. A Texas Education Agency representative asked the committee to reflect on the meaning of "wet lab." She noted that "a wet lab is a place with water, gas, and electricity. 'Wet lab' needs to be changed to hands-on lab activities; they must involve manipulation of scientific equipment."

Participants understood that wet lab meant manipulative,
Core Concepts

Introduce in Overview or Review in Wrap-Up

Questions & Answers

Key Point Review

Lecture w/Still Frames

Questions & Answers

Summary

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Fig. 11.--Sample of Design Outline - Teacher/Group Workstation
hands-on activities and repeatedly used the terminology.
The curriculum was designed to continue 20 per cent wet labs
and to create 20 per cent computer simulations. Computer
simulations were planned for small groups of students at the
Group Workstation. Figure 12 depicts a design outline for
lab simulations. The simulation takes forty-five minutes to
perform. It begins with a situation and carries the
students through an experimental setup, manipulation,
conclusion, and applications.
The simulations take advantage of computer technology by the
following:

- Reinforcing scientific concepts that are
difficult to illustrate or impossible to repeat
on a local basis

- Demonstrating experiments that are either too
expensive or impossible to repeat on a local
basis

- Illustrating experiments generally regarded as
unsafe for most students to perform (Manz, p. 9).

Prior to beginning each laboratory activity, teachers can
utilize information provided in the Teacher's Guide and/or
electronic support package to:

- Select from a variety of experiments

- Review the objectives of the experiment

- Review procedures for equipment setup

- Reinforce safety procedures

- Review the prerequisite skills and knowledge for
  the lab activity
Traditional laboratory experiments are an integral component of the Dynamic Classroom. Students are able to practice and obtain the "soft" skills that cannot be as easily learned in laboratory simulations delivered through electronic means. Wet lab activities constitute approximately 20%-30% of the unit.

Students participate in the wet labs as a whole class activity, referred to at other times in this document as a large group activity.

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Fig. 12--Sample of Design Outline - Lab Simulation
-Refer to information about conducting demonstrations (Manz, p. 9).

Participants viewed laboratory strategies as a key to the success of the project. Computer simulations and teacher aids would be especially beneficial "looking at . . . a declining pool of science teachers" (Weldon) "who are not as well qualified as they should be" (Susan).

Testing as an instructional strategy and evaluation was discussed at most curriculum meetings. Curriculum participants determined that the teacher could control mastery level except during the pilot program which will be a standard 70 per cent. Testing in the curriculum design has two components: pretest and post-test. Pretest items may be selected from the computer's test item bank or authored by the teacher. The pretest assesses each student's understanding of the unit objectives. Once at the Student Workstation, students proceed on a recommended instructional path through the lesson as determined by pretest performance. After completing instruction at the Student Workstation, all students are required to take a unit post-test. "Those students performing satisfactorily on the post-test receive enrichment activities as directed by the teacher. Students failing to achieve mastery receive remediation, specific to the non-mastered objective(s), as directed by the teacher" (Manz, p. 10).
Participants' Perceptions: Weaknesses/Problems, Strengths, Dissemination

Participants' perceptions of weaknesses or problems with an interactive videot disc curriculum were not focused on the curriculum itself. The major weakness of the project repeatedly was costs. Billy noted money as a major problem saying, "It's a sophisticated system that will require . . . a large investment in hardware." Ray commented that "the cost factor is the one that's going to be most difficult to overcome." Mike reiterated "that cost is probably the biggest weakness because I have faith in the curriculum." Teacher training and facilities were the two most frequently cited problems after cost. Billy noted that "there'll be problems figuring out how to train people to use [the program] effectively." Another participant commented that some teachers would "want to try something new and those are very self-motivated. The borderline cases are those that do what they have to do, period." Participants felt that teacher training would "have a great deal to do with the success" of the program. Facilities presented a problem in most districts. Participants tended to "worry about being able to meet all the needs of laboratory" (Mike) and provide space for computer systems to run the interactive videot disc portion of the curriculum. Carter posed this question, "If we had to ask for a complete separate lab for the delivery area of the electronic
portion, can the school provide a lab room?" Each district will have building and facility concerns to address.

Costs, teacher training, and facilities were the three major problems perceived by the participants; however, some participants cited computer maintenance, eye-strain, and teacher utilization as problems. Computer down-time and maintenance personnel will have to be addressed by each district. Billy suggested that "maintenance systems . . . be developed." One participant was concerned about "the eye-strain involved in looking at a video monitor" for long time periods. Closely related to the amount of time a student sits in front of the computer screen, teacher utilization of the program was considered a problem. Susan felt that if the curriculum were not "utilized the way that it was planned, that it would become a complete substitute with the teacher . . . not giving any input at all." Ray stated that "I'd be fearful . . . that the teacher could become very removed from the [curriculum], and put the kids on the screen, and say, 'there it is.'" Therefore, student and teacher needs were being considered when addressing potential problems of the program.

Strengths and advantages of the physical science program outnumbered the weaknesses and related to the curriculum more directly. Laura reflected the feelings of the participants in stating, "The primary strength . . . is that you get a good, solid base of information. We, then,
don't have to worry about new teachers who might be weak in subject matter." Some other participants' comments that follow support the perceived strengths of the curriculum:

Mike: We've developed a very complete curriculum. . . . It should be very helpful for the teacher. The media will lend itself as a motivational factor for the students.

Ray: One advantage is that it allows you to illustrate things that would be difficult to otherwise . . . things for time reasons . . . things that were probably not safe to do or too expensive to do.

Carter: You're going to have the best system scientifically based on research and supported by other people's experiences.

Another strength of the curriculum was the "interesting applications that can be done with no other technology" (Weldon). The program was cited as reflecting "current thinking in the science educator community" (Dan) in regard to the use of computer technology. Using current technology was perceived as being not only motivational but also more efficient. The program was designed to use computers as "data gathering devices" which would be more cost and time efficient. Weldon suggested that the program offered a "potential teacher savings to the district if we can use the people on staff more efficiently." The caliber and efficiency of the people developing the curriculum were cited as strengths. Dan stated that "there really were some talented people there. There was a log of good experience and
background at the table, and they were fairly prompt people." Pam noted the abilities of the program designers to listen when she said, "I was very pleased, more than once, to see specific things that we told them come back and be included." The ability of the curriculum committee to work cooperatively was a major strength. The participants, with the exception of two, had known each other professionally for a number of years. The two other participants had not been in their current curriculum positions as long as the others. Politics were mentioned as a strength also. One participant stated that "the politics behind the program may mean more for its success than a lot of other things. Well, it has the potential for success because it has a lot of the right kinds of . . . movers and shapers interested in it being successful." Participants reflected positive attitudes in their comments toward the project's strengths and their roles in its development.

Dissemination and packaging of the curriculum were first mentioned during the November meeting. A TLTG board member stated in his overview that the "timelines are tied to a contract with AT&T and TLTG, and we want to take [the curriculum] to the state to be approved as a textbook program." Timelines presented at the December meeting designated January 1987 as the date to present the entire product to the legislature. The physical science textbook
will be adopted in 1987 according to the state adoption cycle. In November discussion involving how to package the program arose. The participants agreed that the program should have the "capacity to be unbundled to a lower level system or bundled to a higher level." With the curriculum developed in bundles, school districts could purchase portions to function in only one component or all three components of the system; i.e., Student Workstation, Group Workstation, Teacher Workstation. At this time Billy also mentioned the possibility that "we may use lease agreements so we can update the equipment."

In the interviews of the curriculum committee participants, there was a division of answers pertaining to the probable dissemination methods. The two noted divisions were a narrow local dissemination method and a broad state/national method. Four participants fell into the local distribution option and six into the state/national method.

Participants who felt the dissemination question was difficult to answer believed the product would be distributed at the local level. Susan stated, "It's difficult to answer at this time because there does not appear to be any clear cut procedure for dissemination of the material." She felt that the local district science consultants would receive the materials from TLTG and distribute them to the schools within their districts. Laura commented that "it'll take a real salesmanship job. I think . . . whoever is
in charge of this will have to go the big districts first. They'll be the ones who have the money to spend." Then, she felt that smaller districts would be interested in the curriculum after it was a "proven success." The two other participants in this group were concerned with teacher training in relation to a dissemination procedure. Pam said,

I think it will have to be disseminated with strong teacher training activities to support it. You can't just . . . ship everything to them in a box and say, 'Here it is.' I don't think that's possible. It's not worked with any computerized learning situation ever before . . . [The program can be] used virtually in any school district, any size, anywhere, where the funds are there to support it. There's a possibility of it going national, but . . . it's tied to the Texas essential elements.

Ray assumed that the materials would be disseminated through the teacher training session, and he was "hoping that there will be a close tie between the proper training, and materials won't just be released." He felt that someone within the district should coordinate the program and be responsible for ensuring that it be used properly.

The six participants who held a broad view of dissemination generally believed that districts throughout Texas would use the program initially, but that nationwide distribution was planned. One participant felt that there would be "a publicity type campaign throughout all school boards in Texas. The Texas Association of School Boards will be
the disseminator. They have some nice publications on the whole project. They're primarily using it for funding." He also mentioned dissemination through "normal channels such as CAST [Conference for the Advancement of Science Teaching] and NSTA [National Science Teachers Association]. Lots and lots of people are interested." The two members from state agencies projected distribution through the state textbook adoption process which had been mentioned in the initial meetings. One participant explained that "[our] goal is to distribute it, by having the state adopt it through the textbook process. The state will purchase the program. Local districts will purchase the equipment." The other state agency member said, "I'm assuming that we'll have to work out a process similar to what the textbook process is or through regional service centers . . . We're not tied in stone, but there will be a dissemination system established. There'll be some requirement for training--how to use this new type program." Three other participants believed that "it'll be sold nationwide. Physical science is not different in Texas from anywhere else" (Dan). These three participants did not mention local and state dissemination. A National sales force would include a publishing company or AT&T according to two participants. Mike also thought "being that . . . the Texas Association of School Boards has been a major group that put together the
TLTG, that will help in disseminating the successes throughout the nation." He was concerned that nationwide distribution might be difficult in making "sure that they listen to what Texas has to say in regard to physical science." However, the opinion has been noted that physical science is the same anywhere. Table X depicts the participants' perceptions of possibilities on how the program will be disseminated.

TABLE X

PARTICIPANTS' PERCEPTIONS OF DISSEMINATION

<table>
<thead>
<tr>
<th></th>
<th>Local Districts</th>
<th>Statewide</th>
<th>Nationwide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susan</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laura</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ray</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pam</td>
<td>Yes</td>
<td>Yes</td>
<td>Maybe</td>
</tr>
<tr>
<td>Weldon</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Carter</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Billy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mike</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Dan</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Gene</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>
The specific procedure for dissemination had not been detailed at the time of this study. Billy stated, "We don't know those answers. Until we get a product we're comfortable with, those decisions are on down the road." Data indicated preliminary plans for dissemination included the state textbook adoption cycle, but other states and the National Science Teachers Association were interested in the project.


CHAPTER V

CONCLUSIONS AND INTERPRETATIONS

Summary

This case study examined the deliberations and decision-making processes of the Content, Curriculum, and Instruction Advisory Committee of the Texas Learning Technology Group during the development of a physical science curriculum design that uses the medium of interactive videodiscs as the major component of the delivery system. The need for study in this area involving curricular implications of technology-related changes in education was indicated by prior research (Yager, 1984; Walker, 1985; Hurd, 1986). The topic for this study was selected because it afforded the opportunity to study the development of a curriculum to be delivered in an innovative method, interactive videodisc, and in an area that lacks research, physical science.

Qualitative data collection procedures included participant observations recorded in field notes and audiotapes of curriculum meetings, document analyses, and interviews with the participants. Field notes and audiotapes of meetings were made to ascertain the roles of the
participants, the developmental procedures, the types of
decisions, and the factors affecting the decisions during
curriculum meetings held over a seven month period.
Participants were interviewed near the end of the develop-
mental process to obtain their perceptions of their roles,
and the final product along with its probable dissemination.
The resulting data base consisted of nine hundred forty-
eight pages of transcripts and documents such as textbook
analyses, curriculum document analyses, minutes from
meetings, Texas Learning Technology Group's documentation,
the curriculum design, and the prototype.

There has been a marked decline in qualified science
teachers accompanied by a decline in student interest in
science. In direct opposition to these educational
declines, there has been a rise in technologies that may
have the power to revolutionize the quality, effectiveness,
productivity, and availability of education. For these
reasons the Texas Learning Technology Group was formed to
develop a motivating, technology-based physical science
curriculum which served as the basis of this study.

The committee formed to develop the curriculum in the
study was unique in composition. While other curriculum
planning research has usually focused on groups composed
entirely of local district personnel such as teachers and
subject area consultants or groups composed of subject area
experts such as scientists and college professors, this study combines the knowledge of subject area specialists from eight different local districts. The subject area specialists were also curriculum specialists with background knowledge and experience in specifically developing science curriculum in their local districts. The science curriculum specialists joined efforts with state agencies' personnel and commercial design personnel to form a curriculum planning committee unlike traditional committees.

Walker (1985) noted that curriculum theorists should focus their attention on students who are affected by the technology of the video age and address the curricular implications of technology-related changes in our students. Development of the technology-based physical science curriculum in this study provided the local district participants with their first experiences in addressing technology-related changes in education. Participants found that selection of objectives, content, and activities were all related to their presentation in electronic media. Determining whether to deliver the content and activities electronically or traditionally were among the unique decisions faced by the planning committee. How many hours to spend at the computer terminal or in interactive class discussions and activities was a special concern in the developmental processes. Knowing that science has been singled out as a subject in serious need of reform, the
curriculum planners in this study realized that the educational issues were complex and that a major problem was the gap existing between school curriculum in science and the demands of living in a scientifically and technologically driven society. Participants felt that there were advantages of narrowing the gap with technology-based curriculum and worked to design a curriculum to incorporate motivational computer activities that reinforced core concepts delivered also by the computer.

The curriculum committee developed a curriculum structure in terms of objectives, content, sequence, activities, and hours spent on topics. Strategies were developed in cooperation with videodisc designers which necessitated reconciliation between the committee and designers on exactly what content was appropriate for electronic delivery. The participants enjoyed autonomy during the development and noted that the commercial designers utilized the recommendations of the committee as evidenced by document revisions. The participants' decisions formed the final curriculum with the designers accepting the curriculum in its entirety.

The designers functioned only in computerizing the curriculum developed by the TLTG curriculum committee, offering assistance in suggesting activities that would display well on the computer, and supplying necessary technical knowledge. The commercial designers and TLTG staff
members also organized agendas for the curriculum committee that included research publications, printed issues and questions, and analyses of textbooks, districts' curriculum documents, and state mandates. The committee used these analyses for the basis of decisions. Thus, program designers and the TLTG project coordinator became the motivating forces for the work of the curriculum committee. These motivational people and the local districts' curriculum documents played major roles in determining content and meeting timelines for development.

Recognizing that there were many interacting factors which influence curriculum planning processes and procedures, data analysis consisted of the use of a categorical coding system of the transcripts and documents to identify and describe the roles of the participants, the types of decisions, the factors influencing decisions, and the traits of the curriculum design. Comparative analysis (Glaser and Strauss, 1967) and analytic inductive analysis (Goetz and LeCompte, 1984) of transcripts and documents resulted in the emergence of twenty-nine coding categories to describe the procedures and influences during the curriculum planning process. The codes emerged not only from the research questions but also from obvious but unexpected repetitions in the content of the transcriptions.

Data were displayed in figures and tables, and comparisons were made between data in the coded transcriptions
and the resultant documents. The use of numerous direct quotations from the individuals interviewed as well as the graphic display of data provides any reader with the opportunity to validate the findings of the study and to confirm the reliability of the work.

Findings and Tentative Explanations

The research questions addressed in this study serve as the framework for the following discussion of the findings. In addition, the intended dissemination and intended application of this technology-based curriculum design will be discussed as established in the purposes of the study. The roles of the participants, procedures, and decision-making processes are separated for conceptual clarity, but it should be noted that they are all interrelated.

Participant Roles

All participants in the curriculum planning processes felt that their major role was to determine what they believed were standard curriculum decisions. These standard decisions included determining objectives to be taught, specific content, scope and sequences, and teaching strategies and activities. In one participant's words,

We were doing the whole process, from the time the objectives were agreed upon to actually what content and ways to teach things... I think I was involved in just about every level of the planning process.
Curriculum planning was a major responsibility of each participant within their local school district where they served as science curriculum specialists which gave them experience not only in curriculum planning but also in science itself. The commercial designer participants were not as familiar with specific curriculum planning as the local district participants, but they had experience as former physical science teachers. The TLTG project coordinator was not experienced in curriculum planning but had knowledge in science content, particularly physics. With the background experiences of the participants, they felt comfortable with the role of deciding objectives, content, scope and sequence, and strategies.

When making curriculum decisions for this physical science project, participants expressed the importance of reflecting their district's philosophy by addressing needs of the student population within their district. Committee members sought curricular activities for slower students as well as high achievers. They insisted upon as much flexibility in sequencing as possible so that teachers in their districts could continue to teach in a sequence similar to what they had taught in the past. Addressing student needs and teacher needs was important in all curricular decisions; however, the participants realized the need to develop a unified, consistent curriculum that could be used by other districts and states. Ray noted that the population
influenced his decision-making role as shown in his comments:

What group would [the curriculum] be intended for? What population it'd be influenced by? My particular needs of the population of our district, for one, to make sure there's a match there. But then also, broader than that, and probably more importantly, is it realistic to design a good course to fit all populations?

Developing a uniform curriculum that would satisfy local districts' needs and be a sound academic physical science curriculum in general was the major role of the project according to the participants' perceptions.

In making a consistent, sound curriculum several participants emphasized the importance of relevancy and application. Content and activities selected by the committee members stressed relevancy to the student and tried to encourage students to apply major concepts to everyday experiences. Members felt that their role as decision makers included application of physical science concepts in terms of relating them to the kind of world in which the student is living. Hence, the decision was made to run strands on science, society, and technology and careers throughout the curriculum. The importance of relevancy and application were noted also when participants selected "what would happen if . . . ." activities. Relevancy and application appeared as major concerns since the abstract concepts taught in physical science currently are not presented in relevant, practical ways.
Several participants acknowledged their feelings that the composition of the curriculum committee itself was important. Participant roles and pride were affected by membership in the committee which they felt was composed of talented, knowledgeable people. Support among the committee members was apparent during long, tedious hours of deliberations and negotiations and short timelines. Other researchers (Lieberman & Miller, 1984; Weaver, 1985) have found that the "social context is a critical component of school improvement." Personal interactions generated a pride in the project with committee membership composed of "some talented people" in which there was "respect for the other people that were there." Local district participants had known each other for several years and had worked together on state and national science projects and curriculum conferences. Commercial designers and the TLTG project coordinator worked well with the group after initial misunderstandings about the extent of the curriculum committee's role. They were considered to be the "technical experts" and a necessity for the success of the project.

Some participants developed a major interest that they pushed throughout the curriculum development process. Weldon, for example, insisted upon making the content relevant and applicable to the student's life. In the name of practicality, he continually asked that activities incorporate "laboratory interfacing devices going beyond some of
your simpler CAI kinds of stuff." Other participants voiced their opinions that interfacing capabilities were feasible but not a necessity. Laura and Dan noted the importance of the curriculum reflecting their districts' philosophies. Susan was quite vocal during the formulation of objectives which she considered as her major role. However, she was outspoken on sequencing topics and time allotments for those topics, also. Other committee members generally agreed with Susan probably due to her experiential background and extensive knowledge of the content area. Colleagueship was apparent in this committee as "ownership" of the curriculum evolved.

Two members volunteered to cochair the committee to facilitate proceedings, but no single committee member took a leadership role. Two factors might explain why no one became the dominant leader. First, all participants were knowledgeable in the areas of science and curriculum development processes; therefore, they felt secure in expressing their opinions and respected the opinions of other members. Negotiations were characterized by persuasive agreement rather than heated debate. Second, TLTG and AT&T staff introduced the agenda for meetings, supplied resources, and expedited negotiations on differences. Staff members facilitated the planning process, but the local district representatives made the actual curriculum decisions.
In summary, participants felt that their major role was to design a curriculum content based on specific objectives with a semi-flexible sequence and motivating activities. In developing the curriculum content they felt that they should ensure that the philosophy and needs of their own districts were embraced and that relevancy and applications were included in an academically uniform curriculum.

**Decision-Making Procedures, Processes, and Influences**

**Procedures and Processes.**—The commercial designers and the group formed by the state agency, called TLTG, were instrumental in organizing and motivating the curriculum committee members. The participants in the curriculum planning process were charged with determining the curriculum, but many of the time-consuming tasks were completed by AT&T and TLTG. Thus, staff procedures and curriculum committee procedures emerged with interrelationships apparent in this study.

In staff procedures, TLTG and AT&T personnel followed an emerging pattern that included an overview, distribution of printed materials, initiation of discussion for decision-making, and a wrap-up. The overview established curriculum priorities for each meeting and set the tone and pace for the day. Overview time allowed participants to clarify their roles and voice concerns about previous curriculum
decisions or "unfamiliar technical aspects of delivery" of the curriculum. Distribution of printed materials by the staff included curriculum documents that had been written at the preceding meetings, current issues, research, and analyses. The curricula from participating districts were compiled and compared by AT&T according to curriculum objectives, topics, sequences, and time allotments. AT&T also analyzed the five state approved textbooks according to the same criteria. Committee members requested that AT&T staff "handle these time-consuming tasks. We have district responsibilities and don't have time to analyze all of these." These analyses and compilations served as a data base for the curriculum committee. Without the analyses timelines for the project could not have been met.

In initiating discussions for decisions, staff members began discussing compilations and analyses of district curriculum objectives and textbook sequences. As participants negotiated objectives, sequencing, and activities down to the specific wording of statements, participants commented,

Staff: All right, what is the final wording of this objective?

Staff: Is there agreement on this?

Staff: Enrichment loops have to be done for every unit. Do we want to do it now on this one where we haven't done it?
Susan: We're here, so we might as well do it.
The staff members became the motivators, or prime movers, in the process. Their role as the "movers" probably emerged due to their outside objectivity in getting the job done within time constraints. Staff members were experienced in brain-storming sessions and program development within short timelines. The staff's wrap-up reiterated the decisions of the current meeting and projected issues and questions for the next meeting.

Curriculum committee procedures were determined overall by staff procedures. However, discussion of printed materials and decision-making followed an emerging pattern. Negotiating curriculum decisions involved district and personal philosophies based on the individual's experience. For example, in determining the objectives from districts' curriculum compilations, committee members negotiated to use five of eight objectives in one unit with two of the remaining three objectives used for enrichment and one objective moved to another unit. This example shows that participants agreed that all eight objectives were important, but general consensus was that three of the eight objectives would not be appropriate as major objectives on that particular unit. Similar trade-offs emerged throughout the process for the completion of the curriculum document.
Influences.---Prerequisites for the physical science course were initially determined to be non-existant by the committee. Committee members felt that any student registered for physical science should be able to complete the TLTG electronic course. However, the software designers influenced the participants to set prerequisites because they needed minimum student reading and math skills in order to design computer activities which would reinforce the core curriculum and form the bases for remedial and enhancement loops. Even though physical science is taught normally at the ninth or tenth grade level, participants based their decision of the prerequisite grade level 7.0 on past experiences and knowledge of lower level students in the course.

Content decisions began with a decision to offer fifteen units of content. AT&T analyses of five textbooks influenced this decision along with participants' knowledge of the curriculum within their own district. Global and sub-objective decisions were found to be closely related to the objectives in the eight curricula of the participating districts which had been compiled by AT&T personnel. Participants noted that all districts covered the same topics in various sequences and emphases; therefore, development of the TLTG unified curriculum involved determining how to word the objectives and how to combine them in a suitable manner. This study found that a decision-making
process emerged whereby participants read all the compiled variations of the global objective for a unit, suggested a specific statement of the objective, and discussed and reworded the objective until the majority agreed. Then, the participants discussed lists of subobjectives for each global objective in the same manner. In discussing content, participants occasionally were asked what textbook their district used. As Susan stated, "We use Prentice, but I add objectives of my own." In determining objectives, participants discussed and rediscussed them in such detail that designers would question "so, what is global objective number five? What are the sub-objectives under it?" Weaver (1985) also noted these negotiation system during meetings termed "hash sessions" or brain-storming sessions. Participants who had specific experience in teaching physical science influenced the wording of objectives and content. State mandated essential elements and research on science reforms influenced content by stressing minimums and encouraging strands of specific topics that would run throughout the curriculum.

Even though research shows that teachers are dependent on the textbook for their curriculum, no specific textbook was used as the basis for this project. Reviewing the scopes and sequences of the five state-adopted textbooks, participants noted that "physical science is physical science. It's the same wherever it's taught." Noted
differences in the textbooks were the sequences of topics and the emphases of topics as shown by the "size of the unit." Content and sequencing decisions were based on what the participants considered the usual, or standard, physical science course based on their knowledge and experience rather than a specific textbook. However, participants insisted that printed materials be developed for "back-up" and supplemental materials. Recognizing the teacher's dependency on a textbook and down time of computers, participants recommended four printed components: teacher guide, student lab guide, textbook, and summary notes. The printed components had not been developed at the time of this study.

Experience, local district philosophy, and state mandates influenced participants in deciding strategies. Remedial and enhancement activities were planned originally to be handled by the teacher. Participants decided that the computer should handle these strategies because the curriculum would be used by weak, often uncertified teachers. Simulated laboratory activities were decided to be effective only if students also performed traditional manipulative labs. "Hands-on experience can never be replaced by the computer" was the consensus of the participants based on their experience and philosophy and state mandates.

A quasi-lock step curriculum design allowed sequencing flexibility which was deemed an important teacher need by
the participants. Teacher needs influenced decisions to allow flexibility whenever possible even in determining mastery level on test bank items, selecting test items, and sequencing units based on prerequisite units. Participants were influenced by teachers' needs to be "creative and to perform before the class." Participants and commercial designers had entered the project to develop a teacher-proof program with the role of the teacher changing to a manager. Due to the influence of teacher needs and participants' experience, participants developed a "more accurate, efficient curriculum that doesn't have to rely on the competency of the teacher." The curriculum could "be used to train teachers--help the teacher brush-up on content or train a new teacher." The teacher remains important in this quasi-lock step curriculum design.

This study indicates the importance of the composition of the curriculum committee on decision-making processes. Participants were able to use their knowledge in two fields of study, science and curriculum development. Further knowledge came from their experience as former science teachers. Experiential knowledge greatly influenced all decisions since participants personally recognized student and teacher needs. Experiential knowledge is continually updated by the participants whose job responsibilities require visitations to science classrooms on a weekly, if not daily basis. Interaction between the committee members
required negotiations and compromises to make final decisions. The importance of these interactions became apparent in both the emerging staff/committee procedures and the decision-making processes.

**Dissemination and Application of Curriculum**

Intended dissemination of this physical science curriculum that could be used by any physical science teacher and student in Texas and the United States can only be a prediction at the time of the study. Findings indicate that state, and ultimately national, dissemination is planned. During the November 1985 meeting the overview noted the importance of the curriculum being approved by the state as an alternative textbook program. Timelines for the project reflect the need for unit prototypes to be developed in time for delivery to the state legislature in January 1987. In January 1987, the state will begin the adoption cycle for physical science textbooks. National dissemination plans are reflected in the proposals to contract a publishing company to produce tests and supplemental teacher manuals and activity books. Other states have contacted TLTG about joining the group also. Initial dissemination likely will be through the state textbook adoption cycle; later dissemination cannot be determined at this time.

The curriculum was designed to be taught by any physical science teacher to any student with a 7.0 grade level in
math and reading. Care was taken to include all traditional topics at various levels of difficulty which would enable slow learners, gifted students, and regular students to complete the course.

Implications

Some specific points can be made from this study and applied to the structuring of future curriculum planning projects.

1. Composition of the curriculum planning committee should be planned carefully. Participants who share working experience and mutual respect seem to cooperate to make decisions more quickly and efficiently.

2. Curriculum decision-makers should have training in not only their specific academic area but also in curriculum planning. If participants realize from the beginning what types of decisions are expected, they may be able to plan more effectively, realizing that topics and objectives normally precede the other curriculum planning decisions. Knowledge of the content area also is essential in the planning process. The curriculum participants in this study possessed knowledge in both areas.

3. Expertise in a highly technical medium such as interactive videodisc should be supplied to curriculum participants. Curriculum developers may possess experience and knowledge in content areas and curriculum planning but may
know little about current technology. Technical personnel need to communicate with educators about how curriculum can be delivered via technological devices. Technical personnel with past teaching experiences would be advantageous in technology-based curriculum development as it was in this study.

4. Agencies with sufficient resources should become involved in technology-based curriculum. Comprehensive curriculum planning requires time and money that individual teachers and districts may not have. Agencies such as states, voluntary consortia, regional laboratories, and private industry could supply resources sufficient for developing curriculum to be delivered by technological innovations to students faced with living in a technological world. This project combined resources of money, time, and talent from a variety of agencies and districts.

5. Teacher and student needs must be considered especially in computerized curricula. Teachers who enjoy creating and delivering course content should not be changed to managers of computer programs. Teachers need to maintain a controlling role in the classroom. Students need to have interactions with their teacher and other students. Sitting at an individualized computer workstation for extended periods would not allow these interactions. Developers of computerized curricula should recognize and accommodate
teacher and student needs. Meeting teacher/student needs was a major thrust of the TLTG physical science project.

6. Costs of developing and implementing an interactive videodisc curriculum should be considered. This project was initiated with a $500,000.00 grant to be matched by the state. In order to implement the curriculum, a school district would have to budget a minimum of $6,000.00. Costs of software and supplemental materials cannot be estimated at this time. The initial capital outlay must not be ignored in technology-based curriculum.

Recommendations for Future Studies

There are some indications from the findings emerging from this study that further examination of participants from other school districts should be conducted. Eight local school districts belonged to Texas Learning Technology Group when curriculum development began. These eight local districts planned the curriculum. Other districts have joined the group since the initial curriculum development. Further research could ask the additional districts' participants about their perceptions of the curriculum, their knowledge of its development, and their acceptance of it. The key to this extended research of additional participants lies in qualitative research techniques.

Another emerging area of research questions is whether the curriculum is transferred to videodisc in the way
curriculum planners designed it. Are all units developed in the quasi-lock step design programmed adequately? Are math and reading prerequisites used for the units? Are suggested activities designed as computer activities? Do the laboratory simulations reinforce concepts in appropriate ways? Are wet lab experiments indicated in the program? Careful examination and comparison of the curriculum document and completed software would necessitate extensive research.

Teacher needs addressed by curriculum planners could be further detailed. Are the computer programs designed to allow the teacher to control mastery level on tests? Can the teacher regulate a semi-flexible sequencing of units? Are teacher aids in the form of manuals and special software available? Are teachers receiving district support with their problems? Are teachers receiving sufficient computer training? Is the role of the teacher changing in a technology-based curriculum? How is the teacher being evaluated on her performance and classroom management in this innovative learning environment? All these questions on teacher needs should be addressed as education progresses into technological curriculum designs.

Students' needs should be addressed, also. Curriculum planning participants in this study felt that students should interact with each other in the learning process. Research should focus on the amount of group and individualized activities allowed with this computer program. How
long can a student comfortably focus on the computer screen? Are remedial loops and enhancement loops used by the student, and are the loops at the appropriate level? These questions could result in several studies; however, no study should overlook other possible factors affecting student needs.

Finally implementation and dissemination of this curriculum could form the bases for a number of future studies. How is a technology-based curriculum implemented at the local school district level? How many pieces of equipment are being used in a classroom? What kinds of facilities are being planned? How is the curriculum being disseminated to local school districts and to other states? How is the curriculum being publicized? Both quantitative and qualitative research studies could be designed to answer these questions.

Educators must meet the challenge of increasing technology and realize the necessity to prepare students to meet technological challenges. Comprehensive curriculum planning for technological innovations require time and money that many local school districts cannot afford. To meet the challenge educators need to cooperate with industry at the local, state, and national levels in providing the impetus to develop innovative curriculum. Curriculum planning must focus on talented people, open communication, and proper timing. Furthermore, curriculum planning cannot afford to
stray too far from the practical needs of users. Curriculum planning, regardless of how brilliantly structured, is a failure if it does not result in improved learning opportunities for students. It is the firm belief of this researcher that the time for technology-based curriculum has arrived, and improved methods of qualitative research are a key to the educator's illumination of this innovation. More and better qualitative research combined with improved quantitative techniques is needed to document the development, implementation, and benefits of technology-based curriculum.
CHAPTER BIBLIOGRAPHY


APPENDIX A

INTERVIEW SCHEDULES

Introduction

Due to several factors including a decline in the number of qualified science teachers and a decline in students' interest in science, the Texas Association of School Boards has formed the Texas Learning Technology Group (TLTG). The TLTG and the National Science Center for Communications and Electronics Foundation have partnered to develop a physical science course using a technology-based delivery system.

The purpose of this study is to describe the procedures and processes involved in developing the physical science curriculum design of this project. The study is intended to research the processes and document the procedures so that they may be used in future innovative endeavors involving interactive computer programs.

I would like to ask you a few questions concerning the development of the curriculum design for the interactive videodisc physical science program. The questions pertain specifically to the curriculum design and do not consider implementation, teacher training, or technical aspects of the project.
Interview Questions

Science Curriculum Specialists and Technical Curriculum Designers

I. Experience

1. Briefly describe your current position.

2. Have you had prior experience with developing a computerized educational program? If so, please briefly describe the experience.

II. Factual/Opinion

1. How did you learn about the TLTG physical science project?

2. How do you think the final product will look?

3. Why do you feel this type of curriculum is needed?

4. Who will use it?

5. What do you perceive as your role in the curriculum planning process? (Probes)

6. What kinds of decisions did you have to make in the curriculum process? (Probes)

7. What factors affected your decision?

8. How will the curriculum be disseminated?

9. What strengths and problems do you perceive with this approach?
State Agencies' Representatives

I. Experience

1. Briefly describe your current position.

2. What previous experiences led to your participation in the development of a computerized science program?

II. Factual/Opinion

1. How did you first learn about the TLTG physical science program, or what was your role in the initiation of the TLTG physical science program?

2. How do you think the final product will look?

3. Why do you feel this type of curriculum is needed?

4. Who will use it?

5. What do you perceive as your role in the curriculum planning process? (Probes)

6. What kinds of decisions did you have to make in the curriculum planning process?

7. What factors affected your decision?

8. How will the curriculum be disseminated?

9. What strengths and problems do you perceive with this approach?
Sample Interview

Interview Schedule for State Agencies' Representative

Interviewer: What kinds of decisions did you have to make in the curriculum process?

Carter: OK. The one I just mentioned was a decision that the curriculum drives the test. And, of course, this gets in the area of writing your objectives and all that, you know. There are a lot of schools of thought that would say, "You don't have to have this beautifully defined objective first," even though that's what we've done. We talked to some professors over at UT and other places that have said, "Objectives are maybe not the best way to approach this. Maybe you ought to look at the student needs to learn thus-and-so." We've listened to people talk about that, and Carla and I have written our own mental set of objectives the student will become excited about, and that's not in any normal objectives you'd set for physical science. And so, we've had to address this whole question of, "What is your guiding force?" And it's been sort of verbally agreed that we would aim to affectively--well, make affective changes in the student as well as cognitive. Hopefully, we can do both here. I'm just going to mention about the objectives. We did go ahead and write out the course in terms of major objectives for each unit, and subobjectives, for each of the fifteen units which you've got. So, these objectives will all be met, but it'll be sort of fun for us to try to add in some affective into those cognitive items that are listed.

Interviewer: Now, clarify what you mean by "affective". What do you want to do?

Carter: OK. Cause a student to become a self-motivated learner for science.
Interviewer: So you think the IVD will cause this to happen?

Carter: We really believe so. If they can go manipulate things on the moon, that might cause them to get more excited about going to the moon or something. That's just one little thing that could happen.

Interviewer: What factors affected your decisions? You know objectives and affective versus cognitive. What has caused you to make these decisions?

Carter: That is a good question. Let me make a note of it. OK, factors. Current educational research—I'm plugged in to, as I mentioned earlier, the Association for the Development of Computer-Based Instructional Systems, ADCIS for short—there's a lot of research that I'm trying to tap into and make known to the other people about what is currently being studied, and what are the current results. Just as an example, just a simple item is how you reinforce right answers and wrong answers. That could change the student's whole outlook on the course, and it would be very good to have good supporting research that would support what you implemented. And so, right in that booklet I showed you, there is a method on how to approach responding to right and wrong answers. The "beep" or "no beep" for attention is something that's involved in human factors. So human factors is a tremendous portion of this whole curriculum, how the student interacts with the system. And so, if you're looking at human factors, you get into, should you have one student at the machine, or two, three, or whatever. Or, should you have combinations for them. Well, if you have one student at the machine, you have the ideal individualized learning experience, but you're losing the social aspect of learning, which seems to be quite important to ninth graders. So, we've had to look at the human factors of what the best environment is for a student to learn in. Also cost. You've got to remember that one. Ideally, we want to have the student interact with the machine the most fluid,
easy way possible. That could be a touch screen. However, that costs possibly $1,000.00. Can we still have the same interaction or quality of interaction with the keyboard? And there are several other crossfactors. Of course, just the cost of individualized learning vs. group instruction, you know. Let's see. I think that's about the three basic factors there. Let me just mention pedagogical theory. I know I've mentioned educational search, but pedagogical theory has got to be sound. So, we're constantly reading up on what the theories are on educational science.

Interviewer: What strengths and problems do you perceive with this approach?

Carter: Well, strengths are, you're going to have the best system scientifically based on the research and supported by other people's experience. The problems are, you might end up, if you let money influence it too much, a low quality systems compared to what you could have. If you let human factors drive the thing too hard, you'd have too expensive of a system. If you read all the educational research, you'll have conflicting ideas, in many cases on how to approach certain problems. I'm sure there's a lot of disagreement in the community on exactly how many students per work station is best. So, while we're going to try to handle this, we're bound to be making mistakes, maybe not mistakes, but correctable avenues of approach here. An so, that could be a problem, if we try to read too much and implement everybody's theory. So, we do have to balance it out with—Oh! another factor. Sorry. Let me back up. Another factor is what the schools physically have as far as your facilities. That's a factor, and we might, ideally, ask for a whole lecture hall and combine four classes, so that part of them at one time can go to the lecture hall, and part of them can go to a lab room. But we can't do that because of facilities. So the school environment had to affect the decision, you know. If we had to to ask for a complete separate lab
from the delivery area of the electronic portion, can the school provide a lab room? So, that was a factor. Is that all the questions?

Interviewer: That's all!
## APPENDIX B

### CODING CATEGORIES

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**Influencing Factors**

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<td>OG</td>
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**Limiting Factors**

<table>
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<tr>
<th>SM</th>
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<tr>
<td>C</td>
<td>Cost</td>
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<tr>
<td>T</td>
<td>Time--curriculum and procedure</td>
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<td>SE</td>
<td>School environment, space, and facilities</td>
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<tr>
<td>E</td>
<td>Equipment</td>
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### Other Factors

<table>
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<tr>
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<tr>
<td>CW</td>
<td>Current weakness in course, teacher, or science field</td>
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<tr>
<td>TR</td>
<td>Tradition</td>
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<tr>
<td>PL</td>
<td>Politics</td>
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<td>TX</td>
<td>Textbooks</td>
</tr>
<tr>
<td>R</td>
<td>Research</td>
</tr>
</tbody>
</table>
APPENDIX C

ISSUES FOR CONTENT, CURRICULUM, AND INSTRUCTION GROUP

Ninth Grade Physical Science Project
First Advisory Group Meeting

Special Interest Group: Content, curriculum, Instructional Activities

Focus: Prerequisites

1.1 What science courses, if any, are prerequisite to this course?

1.2 What entry level math and reading skills are expected of students?
   1.2a What is the range of extremes?

1.3 How should the students be screened for the necessary prerequisite?

1.4 What actions should be taken when students do not meet the necessary prerequisites?

1.5 What strategies can be incorporated into this course to deal with students who do not possess prerequisites?

Focus: Individual vs. Group Instruction

1.6 Will the IVD course be used in a large group, small group, and/or individual setting?

Trade-off: large group => more cost-effective but decrease in the degree of learner-based instruction.
           individual => less cost-effective but increase in the degree of learner-based instruction.
1.7 What is an appropriate set of percentages of delivery time for each setting, if the course is delivered as a combination of the above?

1.8 How will teachers use the IVD material in a group setting?

1.9 How will IVD and instructor-led versions of the course be treated in granting credit?

Focus: Scope of Content

1.10 What is current 9th grade physical science structure?

a. is it 1 semester of groundwork and 1 semester of modern physical science?

b. is it 1 semester of chemistry and 1 semester of physical science?

c. other:

1.11 What units, chapters, and topics from existing TEA-approved textbooks will be included in the course?

1.12 What other subjects, principles, and concepts should be included?

1.13 Which units, chapters and topics must be completed (mastered) for students to complete the course?

1.14 What resources are available for use in developing the course?

1.14a Which resources may be preferable or undesirable?

1.15 Who will have final approval of course content and instructional strategies?
1.16 How will compatibility with the approved science curriculums be guaranteed?

**Focus: Sequencing Topics**

1.17 What chapters will be required or optional?

1.18 Will the sequence of chapters be prescribed or flexible?

1.19 Will students be "locked out of" chapters after a certain period of time or after a set number of trials through courseware?

1.20 If so, what happens next?

1.21 If so, can anyone "unlock" students? Who?

1.22 Will all students see material written for each chapter, or only some sections.

**Focus: Support Materials**

1.23 What text(s) will be used to support the IVD course?

1.23a How closely will the instruction be related to the text?

1.23b What other materials will be needed to support the course?

- student workbooks
- teacher guides
- lab manuals and materials
- exercises and handouts
- videotape demonstrations, lectures, etc.
- enrichment or remedial materials
Focus: Labwork

1.24 How will lab exercises be developed, administered, and taught?

1.24a What percentage should be interactive videodisk delivery?

1.24b What percentage of this can make use of "SCI-LAB" type technology?

1.25 Will a separate laboratory be associated with the IVD course?

1.25a If so, is it near enough to the delivery area to make transition feasible during the class period?

1.26 How many lab exercises will be available each week or month?

Focus: Instructional Strategies

1.27 Which parts of the content are best taught with each instructional strategy?

self-paced instruction on IVD
self-paced instruction without IVD
small group work (with or without an instructor)
hands-on labwork or experiential activities
videotape or audiotape
computer-assisted instruction (non-video)

1.28 Will all students use the same "mix" of instructional strategies when taking the course?
1.29 Will all students take the same content, labs, exercises and texts?

1.30 What level of mastery will be required to grant credit for the course?

1.31 How will mastery be determined? - Bloom's taxonomy?

Focus: Learning Theory

1.32 Of the approximately six major models of information processing: inductive thinking (Taba), inquiry training (Suchman), science inquiry (Schwab), concept attainment (Bruner), advance organizer (Ausubel), and developmental (Piaget), which one(s) should be used in the transmission of information to the student?

1.33 Should we have cognitive style map tests performed on randomly selected ninth graders to determine important parameters for the delivery format? In essence, we need to determine the percentage of the course in which the student will be performing certain activities, such as interacting with authority figures on the screen, viewing the simulation of events, reading text on the screen or in books, working with other students, etc.

Focus: Remedial and Enrichment Activities

1.34 What remedial activities are presently being used in science education?

1.34a What activities should be used in this course?

1.35 What enrichment activities are presently being used in science education?

1.35a What activities should be used in the IVD course?
1.36 Should enrichment and remedial activities be designed into the course and/or designed by the supervising teacher?

1.37 What amount of remediation will be available to students?

Focus: Instructional Flexibility

1.38 How will the instruction be adapted to the individual differences among students, teachers, and school districts?

1.38a student abilities; reading and math skills, maturity levels, ability to work independently, etc.

1.38b teacher experience with content and technology

1.38c school district budget instructional needs, staffing, demographic dispersion, etc.

1.39 To provide the ability to accommodate both weaker and stronger students, how should the branching structure be developed so as to provide learner-based instruction, while at the same time, keep all students on a reasonably uniform pace?

Focus: Texas Orientation

1.40 Should the course have a dominant Texas flavor? (e.g. examples used in video and content)

1.41 Will this course be used outside of Texas? If so, by whom?

1.42 How similar is Texas science curriculum and requirements to that of other states?
Special Interest Group: Student Testing

Focus: Student Testing

2.1 Will students be pre-tested on material?

2.2 How will post-tests be designed and administered?
   multiple versions of post-tests
   random selection from item pool
   administrative reports needed on student progress
   (individual vs. group reports, item analysis, number of attempts, student instructional time reports, etc.)
   testing intervals - end of chapter, end of unit, review, etc.
   scoring of tests
   does post-test match pre-test?

Focus: Student mastery of Material

2.3 What criteria will be required for mastery?

2.4 Will all students have the same mastery criteria?

2.5 How much time may students spend on remediation?
   2.5a on total course?

2.6 What proportion of students are expected to master (pass) the course?

2.7 Will students learn as well on IVD course as on instructor-led course?
Special Interest Group: Human Factors

Focus: Session Duration

3.1 What is the optimum time for a student to be working at a workstation?

3.2 Should workstation breaks be included in the courseware?

Focus: Interactivity

3.3 What is an appropriate level of interactivity between the student and the computer?

Focus: Input/Output

3.4 What are the possible user interfaces to the courseware?
   Mouse?
   Keyboard?
   Light pen?
   Joystick?
   Touch screen capability?
   Barcode reader?

3.5 What are the possible courseware interfaces to the user?
   Analog color monitor?
   Monochrome monitor?
   Printer?
   Plotter?
   Speech synthesis or recognition?
3.6 What is the appropriate reading level?

Font size (optimum, adequate)?

Protecting of hardware - control of knobs
APPENDIX D

EXHIBIT F

UNIT AND CHAPTER TITLES

PRENTICE-HALL TEXTBOOK

UNIT 1: DIVERSITY OF MATTER

Chapter 1: General Properties of Matter
Chapter 2: Special Properties of Matter
Chapter 3: Classification of Matter

UNIT 2: COMPOSITION OF MATTER

Chapter 4: Structure of Atoms
Chapter 5: Bonding of Atoms
Chapter 6: Families of Atoms

UNIT 3: CHEMISTRY OF MATTER

Chapter 7: Chemical Reactions
Chapter 8: Acid-Base Chemistry
Chapter 9: Carbon Chemistry

UNIT 4: MECHANICAL ENERGY AND MOTION

Chapter 10: Force, Work and Power
Chapter 11: Motion
Chapter 12: Energy: Forms and Changes

UNIT 5: ELECTRICAL ENERGY AND MAGNETISM

Chapter 13: Electricity
Chapter 14: Magnetism
UNIT 6: HEAT ENERGY AND WAVES

Chapter 15: Heat
Chapter 16: Sound
Chapter 17: Light

UNIT 7: PHYSICAL SCIENCE: PRESENT AND FUTURE

Chapter 18: Physical Science and Technology
Chapter 19: New Directions in Physical Science

HOLT, RINEHART AND WINSTON TEXTBOOK

UNIT 1: MATTER AND ENERGY

Chapter 1: Science and Measure
Chapter 2: Property, Changes and Composition of Matter
Chapter 3: Structure of Atoms and Molecules
Chapter 4: The Kinetic Theory of Matter
Chapter 5: Acids, Bases, and Salts
Chapter 6: Nuclear Reactions

UNIT 2: CHEMISTRY IN OUR WORLD

Chapter 7: Common Fases of the Atmosphere
Chapter 8: The Chemistry of Water
Chapter 9: Environmental Pollution
Chapter 10: Chemistry and the Home
Chapter 11: Metallurgy
Chapter 12: Fossil Fuels
Chapter 13: Organic Compounds
Chapter 14: Rubber and Plastics
Chapter 15: Natural and Synthetic Fibers

UNIT 3: MOTION, FORCES AND ENERGY

Chapter 16: Motion and its Causes
Chapter 17: Using Force and Motion
Chapter 18: Forces in Solids, Liquids, and Gases
Chapter 19: Work, Energy and Power
Chapter 20: Heat Energy
Chapter 21: Engines
UNIT 4: WAVE MOTION AND ENERGY

Chapter 22: Wave Motion and Sound
Chapter 23: The Nature of Light
Chapter 24: Color

UNIT 5: ELECTROMAGNETIC NATURE OF MATTER

Chapter 25: Electrostatics
Chapter 26: Current and Circuits
Chapter 27: Sources of Electric Currents
Chapter 28: Magnetism and Electromagnetism
Chapter 29: Electronics

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APPENDIX E

TEXTBOOK ANALYSES SUMMARY

Results

1. The number of chapters and units varies somewhat as does the sequencing of content, however, 5 general categories can be defined:
   - Properties and Classification of Matter
   - Chemistry of Matter
   - Mechanical Energy and Motion
   - Electrical Energy and Magnetism
   - Wave Motion and Energy

2. The sequence of the first three categories is the same in both Prentice-Hall and Holt, Rinehart and Winston. The last two categories however, are reversed.

3. Prentice-Hall provides metric system enabling knowledge as needed throughout the text, while Holt, Rinehart and Winston begin with a chapter devoted to the metric system.

4. Properties and Classification of Matter includes the following:
   - Definition of Matter
   - Mass vs. Weight
   - Law of the Conservation of Mass
   - Volume vs. Density
   - Phases of Matter (Solid, Liquid and Gas) and relationship to temperature
   - Elements, Mixtures and Compounds
   - Structure, Bonding and Families of Atoms
   - The Periodic Table and relationship to atomic structure

5. Chemistry of Matter includes the following concepts:
   - Chemical reaction rates
   - Acids, Bases and Salts
   - Acid/Base Indicators
   - Writing Chemical Equations
- Carbon/Organic Chemistry
- Practical Applications

6. Mechanical Energy and Motion includes the following:

- Work, Force and Power (Definitions and Calculations)
- Speed vs. Velocity (Definitions and Calculations)
- Laws of Motion
- Simple Machines
- Relationship between energy and motion
- Types of Energy and Interconversion
- Units of Measurement
- Practical Applications

7. Electrical Energy and Magnetism includes the following:

- Conduction and Induction
- Current, Voltage and Resistance
- Types of Circuits (series, parallel)
- Properties of Magnets
- Natural vs. Induced Magnetism
- Electrical Current and Magnetism
## APPENDIX F

**CODE FOR THE SAMPLE CURRICULUM ANALYSIS REPORT**

(Districts coded as Documentation/Curriculum Guides Received)

<table>
<thead>
<tr>
<th>CODE</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
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</tr>
<tr>
<td>2.</td>
<td>X</td>
</tr>
<tr>
<td>3.</td>
<td>A</td>
</tr>
<tr>
<td>4.</td>
<td>F</td>
</tr>
</tbody>
</table>

The --- symbol indicates information not available in the curriculum materials provided.
Sample Curriculum Analysis Format

I. Title of Subject/Topic

Measurements

II. Global Objective

1. The student will demonstrate the proper use of both the English and the metric systems of measurement.

2. The student will demonstrate the safe and proper use of metrically calibrated equipment.

3. The student will exhibit the ability to use a variety of measuring instruments to measure the quantities of length, mass, time, temperature and electric current; express those quantities in the proper metric units; and use the measurements to determine derived quantities such as velocity, force, work, power, energy, etc.

4. The student will develop skills in making measurements of mass, volume, length, and temperature using metric units of measurement.

III. Related Sub-objectives

1. Students will:

   - Identify units of time measurement
   - Identify metric units for length
   - Identify metric units for area measurement
   - Identify metric units for volumetric measurement
   - Identify relationships between mass and volume
   - Distinguish between mass and weight

2. Students will describe the general properties of matter (mass versus weight, volume, density). (Graph)

3. ---
4. Students will:
   - Explain the importance of a measurement standard
   - List the units (of the SI system) used to measure length, volume, mass and temperature
   - Conduct activities using metric units to make measurements and solve problems
   - Correctly use a balance to determine the mass of objects provided

IV. Instructional Sequence of this subject/topic in relation to the other subjects included within the group (e.g., ___ of ___)
   1. ____
   2. Presented in first six weeks—appears as .3 of 6 in the matrix
   3. Optional—appears within first topic of course outline (Mechanics)
   4. Presented as Unit II (of 7) in the topical outline

V. Time (in hours) spent on the subject/topic
   1. 10
   2. 5 (assumed)
   3. 2.5 - 5
   4. ___

VI. Lists of Supporting Material/Media—include basal and supplementary text chapters/pages; titles of films, film strips, audio tapes, etc.; copies of transparencies, puzzles, model constructions, etc.
   1. ___
   2. ___


National Science Teachers Association Factsheet 1-19 (Energy Topics), Washington, D. C., MSTA, 1976


Focus Lab Manual

Appendix B to District Curriculum Guide

VII. Prerequisite skills/knowledge required for the subject/topic

1. ---

2. ---

3. ---

4. ---

VIII. Activities (Lab Investigations, Field/Library Investigations, etc.). Are these required or suggested? NOTE: Texas required 40% of the curriculum be composed of lab activities--exclusive of demonstrations.

1. ---

2. ---

3. ---

4. Suggested Activities:
- Perform Lab Investigation: Distance and Volume—#5 in Lab Manual
- Measure distances (metric) using a map
- Measure mass with a balance

IX. Remedial/Enhancement Activities to supplement the subject/topic

1. ---
2. ---
3. ---
4. Have students make a display of items found at home which use metric units to indicate length, volume or mass.

X. Evaluation Tools (include copies of local, state, and national tests)

1. ---
2. ---
3. Standardized quizzes provided by textbook publisher
4. ---

XI. If applicable, list concepts within this subject that are perceived by students as being most difficult/troublesome. Indicate tasks or activities used to alleviate the difficulty.
APPENDIX G

TEXAS LEARNING TECHNOLOGY GROUP

Advisory Committee Meetings

November 21, 22, 23, 1985

AGENDA

Thursday, November 21, 1985:

Arlington ISD Food Service Center (one block south of main Arlington ISD office building) 1206 W. Arkansas at Davis Street

11:00 A.M. - 3:00 P.M. Technical Committee Meeting
12:00 Noon - 1:00 P.M. Lunch Break (Provided)
3:00 P.M. - 4:00 P.M. Teacher Training Committee Meeting (Committee Chairmen only)

Friday, November 22, 1985:

(Same location as above)

9:00 A.M. - 9:30 A.M. Project Overview
9:30 A.M. - 12:00 Noon Curriculum Committee Meeting
12:00 Noon - 1:00 P.M. Lunch Break (Provided)
1:00 P.M. - 2:30 P.M. Teacher Training Committee Meeting (Full Committee Meeting)
2:30 P.M. - 4:00 P.M. Evaluation Committee Meeting
Saturday, November 23, 1985:

Arlington ISD Office Building - 1203 W. Pioneer Parkway
(Intersection at Davis Street)

9:00 A.M. - 12:00 Noon Project Overview
(Continental Breakfast Provided)
APPENDIX H

UNIT ANALYSIS

UNIT TITLE: Work, Simple Machines, Potential/Kinetic Energy

GLOBAL OBJECTIVE (A) AND RELATED SUB-OBJECTIVES (B):

1. A. The student will develop an understanding of the mechanisms of each of the simple machines -- the lever, the pulley, the wheel and axle, the screw, the wedge, the belt and pulley, and the inclined plane.

B. The student will:

- identify types of simple machines
- recognize advantages of simple machines
- distinguish relationships between force and distance and simple machines

A. The student will be able to describe the difference between kinetic and potential energy by citing examples of each.

B. The student will:

- identify two alternative sources of energy
- distinguish between kinetic and potential energy

2. A. Discuss the relationship between work, time, power, distance and force and be able to solve simple power and work problems.

B. The student will be able to:

- describe how engines operate
- discuss the relationship between work, time, and power
- work simple power problems
A. Identify the six types of simple machines and classify them as multiplying force, speed and distance, or changing the direction of force.

Define effort and resistance, work input and work output, and solve simple mechanical advantage problems.

B. The student will be able to:

- describe mechanical advantage and how it is calculated
- be able to name the six kinds of simple machines including three types of levers
- classify simple machines as multiplying force, multiplying speed and distance, or changing the direction of the force
- match a given job with the appropriate simple machine
- define effort and resistance and work input and work output

A. Define, recognize, and calculate potential and kinetic energy.

B. The student will be able to:

- define energy
- describe how energy is measured
- name the forms of energy
- define kinetic and potential energy
- identify the positions at which a falling ball exhibits its maximum kinetic and maximum potential energy
- describe the energy conversion that takes place in combustion engines
- define the law of conservation of energy

A. Name the forms of conventional energy (heat, light, mechanical, sound, electrical, magnetic) and alternate energy sources (nuclear, solar, geothermal).

3. A. Describe examples of simple machines and determine the mechanical advantage of each; explain the law of conservation of energy and identify the energy transformations in examples of energy chains.
B. Work and Power
  .Machines
  .Mechanical advantage
  .Efficiency

A. Name and describe a variety of energy sources that can be used in electrical energy production; state the physics principles involved in the use of each; and state some of the advantages and disadvantages of each.

B. Energy
  .Energy forms (potential and kinetic)
  .Energy conservation
  .Energy transformations
  .Energy sources (optional)
    .Solar
    .Wind
    .Hydroelectric
    .Geothermal
    .Nuclear fission
    .Nuclear fusion
    .Other

A. State correct, conceptual definitions for the physical quantities included in the study of mechanics.

8. A. The student will be able to demonstrate knowledge of energy.

B. The student will:
   -define energy and cite examples of energy
   -observe examples of potential and kinetic energy in a system

A. The student will be able to demonstrate knowledge of work and machines.

B. The student will:
   -identify simple machines
   -identify first, second and third class levers
   -define the ideal mechanical advantage of a lever
   -observe the difference between first, second and third class levers
   -identify varieties of inclined plane as a wedge and a screw
- test various inclined planes, pulleys, block and tackle in the laboratory
- determine the mechanical advantage of an inclined plane from experimental data
- compute IMA for various simple machines
- compare the mechanical advantages for various simple machines
- calculate the efficiency of simple machines
- classify simple machines used in daily activities
- define work and its unit of measurement
- solve problems regarding work, energy, and power
- explain why work output is always less than work input
- determine horsepower for individual students
- contrast the operation of internal and external combustion engine

INSTRUCTIONAL SEQUENCE OF THIS UNIT IN RELATION TO THE OTHER UNITS WITHIN THE CURRICULUM (e.g., ____ of ____)

1. ---

2. Shown as the first two and last two topics in the 4th six-week period

3. Shown as part of Mechanics - the first topic in the physics course (second semester)

4. Shown as unit 3 (of 7) in Semester I.

5. This unit is taught in conjunction with Unit 4 - Motion & Force. Both are taught as the first topic in Semester I.

6. Appears as topics #2 and 3 (of 9) in the first semester

7. Shown as topic #4 (of 4) in 6th six-week period

8. Appears as part of topic #6 and all of topic #8 (of 11) in topic outline
TIME (in hours) SPENT ON THE UNIT

1. 20 hours
2. ---
3. 2.5 - 5 hours
4. ---
5. This unit is taught in conjunction with Unit 4 - Motion & Force. Total time is shown as 20 hours.
6. ---
7. 10 hours
8. 13 hours
APPENDIX I

CURRICULUM FOCUS GROUP

CURRICULUM REQUIREMENTS:

* = Not all focus groups are in agreement
** = AT&T Comments

1. Global Prerequisites to Curriculum
   Beginning of seventh (7) Grade reading and math*
   Prerequisites do not rule students out of course

2. Content
   All units are required
   (SEE ENCLOSED DOCUMENT)

3. Lock Step Design*
   Students will remain together within a unit*
   Once core material is mastered, student will go into enrichment activities

4. Flexible Sequence
   Teachers will sequence as desired within the constraints of prerequisites
   Physics units will be more flexible than chemistry units
   (SEE ENCLOSED DOCUMENT)

5. Remedial Activities
   Two distinct "loops" or activities**
   Repetition is not one of the two remedial activities
   Math remedial is in relation to unit topics*
   Under control of the teacher
8. Laboratory
   Laboratory interface is a must **
   No SCI-LAB materials
   Must provide materials to support the teacher
   At least two "wet" labs a week**
   Amount of lab is unit dependent

9. Course Materials
   Nonsexist and across ethnic groups
   No need for a Texas orientation
   Must provide alternative activities

10. Testing
    Test bank for teacher to select test items
        Random question generation possible
        Unit and semester tests
        Final test is standardized
        Teacher can control mastery level*
            Start test criteria at 70% level*
        Allow four days of curriculum time for testing
            Allow teacher to alter testing time upwards

11. Pretest
    Allows student to "test out" or core and go into
        enhancement activities

12. Prerequisite Test
    Identifies required entry level skills and
        knowledge
        Curriculum and individual units**
        Provide coaching and/or remedial activities

13. Design Considerations
    AT&T to design complete curriculum
        Electronic and non-electronic components
        Two semesters of instruction
    Use science skills as backbone of instruction
    OK to design instruction to test outcomes
    Mix activities:
        Include individual, group, class activities
        OK to use peer teaching/tutoring
    Core materials
        Should be individualized and electronic**
    After first unit, all answers are in metric
    Instruction time to be described in terms of % of
    course
    Overall, 50% of course should be individual and
        electronic, 50% other modes**
    Use inquiry method sparingly
Design some "what would happen if _ _ _ _ _ _" exercises
Inquiry, application, synthesis

14. Threads (Required for each unit)
   Math*
   Scientific method
   Career opportunities
   Science, society, and technology

15. Text Book
   Text book is a resource to the courseware
   Curriculum design is dependent of the textbook

16. Separate Software Packages
   Work processing
   Spread sheet*
   Calculator* **

17. Teacher Support
   Teacher grade book
   Teacher guidance to setup labs
   Teacher must know where students are at all times
   Teacher must be able to interpret what was done
   Add a clock so that time of computer will be known

18. Teacher Control
   Course must remain under teacher control
   Teacher can adjust 70% criteria level*
   Teacher can sequence curriculum
   Teacher has choice of activities
   Teacher can select test items
APPENDIX J

SAMPLE DESIGN FROM ELECTROMAGNETIC SPECTRUM PROTOTYPE

All three color circles are on the screen. All intersect. White light appears at intersection of all three circles.

Narrator 1

There it is. In the center of the screen where red, green, and blue light are mixed, you have made white light.

In the process of mixing the primary colors you have also made the three complementary colors of light.

Mixing red and green made yellow
Mixing green and blue made cyan.
Mixing blue and red made magenta.

FREEZE FRAME - PRESS TO CONTINUE

QUESTION:

The primary colors of light are

1. red, blue and yellow.
2. blue, green and black.
3. green, blue and red.
4. red, blue and white.

Enter your choice and press RETURN

FEEDBACK:

1:
Sorry. These are the primary colors of PIGMENT and they are not the same as the primary colors of light.

Press RETURN to try again
2:
No. Blue and green are primary colors of light but black is not. Black is the color that indicates the absence of all colors of light.

Press RETURN to try again

3:
AUDIO SUGGESTION: That's right! (Red, green and blue are the primary colors of light)

4:
No. Remember, white is the combination of all colors of light. It is not a primary color like red and blue.

Press RETURN to try again

FAILURE:

No. Red, blue and green are the primary colors of light. When these lights are combined in equal amounts, they make white light.

Press RETURN to continue

PREVIOUS NARRATIVE:

Need to distinguish between the primary colors of pigment and light. Also, to be sure and cover yellow light as the red and green lights combine.
## APPENDIX K

### ESSENTIAL ELEMENT GRID

<table>
<thead>
<tr>
<th>Essential Element</th>
<th>Student Work-Station</th>
<th>Group Work-Station</th>
<th>Teacher/Group Work-Station</th>
<th>Laboratory Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Demonstrate safe use of physical science laboratory equipment and chemicals.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>2. Observe physical and chemical properties of matter.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>3. Observe the effects of forces on matter.</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Explore magnetic and electrical interactions.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>5. Classify chemicals according to similarities of properties.</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>6. Describe physical and chemical interactions.</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
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<td>7. Discuss the factors that affect the motion of objects.</td>
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<td>8. Measure physical and chemical quantities.</td>
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<tr>
<td>Essential Element</td>
<td>Student Work-Station</td>
<td>Group Work-Station</td>
<td>Teacher/Group Work-Station</td>
<td>Laboratory Activities</td>
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<tr>
<td>9. Plot data on graphs and other displays</td>
<td>x</td>
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<tr>
<td>10. Formulate a physical science hypothesis.</td>
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<tr>
<td>11. Predict the outcome of a physical science activity from trends in data using extrapolation or interpolation.</td>
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<tr>
<td>12. Compare models of atoms and machines.</td>
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<tr>
<td>13. Compare and contrast chemicals according to properties.</td>
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<td>x</td>
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</tr>
<tr>
<td>14. Compare objects according to properties.</td>
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<tr>
<td>15. Clarify operational definitions used in explaining precipitation, acid-base indicators, force meters, electroscopes and simple machines.</td>
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<tr>
<td>Essential Element</td>
<td>Student Group Work-Station</td>
<td>Group Work-Station</td>
<td>Laboratory Work-Station</td>
<td>Teacher/Student Group Work-Station</td>
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<td>16. Identify the variables remaining constant, the variables being manipulated, and the variables responding in physical science investigations.</td>
<td>x</td>
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<td>17. Manage an experimental apparatus to test a physical science hypothesis.</td>
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<td>18. Analyze the use of chemicals in everyday activities of the home and industry.</td>
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<td>19. Apply alternative sources of energy to work.</td>
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<tr>
<td>20. Evaluate the application and career implications of physical science principles and the finding of research.</td>
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</table>

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