Principles of technology: a summative evaluation of student achievement in the first year

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Principles of Technology: A summative evaluation of student achievement in the first-year

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A summative evaluation of student achievement in the first year

by

Dolores Hall

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CHAPTER I - INTRODUCTION

Evaluation is part of the decision-making process used daily in almost every aspect of society. Industries examine their materials, processes, personnel, and products to provide information which can be analyzed to make decisions. Citizens evaluate the relative effectiveness of elected government representatives to make judgments for future election campaigns. Employers evaluate the worth of their employees in order to make decisions regarding salary adjustments, promotions, and job terminations. In the schools, students, educators, administrators, staff, curricula, budgets and other elements are evaluated in order to maintain and improve the educational enterprise.

An examination of the definition of the word evaluation is necessary in order to facilitate further discussion. Two definitions of the word evaluation found in the literature were:

(1) A systematic process of collection and use of information from many sources to be applied in interpreting the results and in making value judgments and decisions (Wolansky, 1985).

(2) The systematic process of collecting, analyzing, and interpreting information to determine the extent to which the educational objectives are being met by the program of curriculum and instruction (Gronlund, 1985).

The major theme in each of the definitions of evaluation noted the systematic process and interpretation
of an entity. Authors in the field of educational evaluation have provided additional definitions for the term evaluation. Gronlund (1985) further stated:

Evaluation includes a number of techniques that are indispensable to the teacher.... However, evaluation is not merely a collection of techniques; it is a process, a continuous process that underlies all good teaching and learning (p.3).

Popham (1988) went on to say:

The kind of educational evaluation that everyone is concerned with is formal or systematic educational evaluation. Systematic educational evaluation consists of a formal appraisal of the quality of educational phenomena (p. 7).

Further reference to a definition of educational evaluation was offered by Borg and Gall (1983):

Educational evaluation is the process of making judgments about the merit, value, or worth of educational programs, projects, materials, and techniques (p. 733).

The aforementioned citations applied to education revealed that evaluation is a systematic technique utilized in surveying, measuring, examining, appraising, and comparing the relative attributes of an array of educational endeavors. According to Wolansky (1985) evaluation requires analytical thinking in an attempt to interpret appraisal results in an effort to make decisions regarding ways to improve the teaching-learning process.
Summative Evaluation

Educational evaluation is the systematic process of establishing value judgments based on evidence about a program or product. One function of educational evaluation is summative evaluation. In the case of program evaluation, the summative function of evaluation occurs after the program has been fully developed.

Borg and Gall (1983) wrote:

Summative evaluation is conducted to determine how worthwhile the final program is, especially in comparison with other programs. Summative data are useful to educators who must make purchase or adoption decisions concerning new products, programs, or procedures (p. 758).

Summative evaluation includes the collection and use of data after the educational process or product is completed. Feedback data are intended to be used by the consumer of the educational process or product. It can be said that the purpose of summative evaluation activities is to facilitate consumer decisions concerning the ultimate worth of the educational entity under consideration.

According to Bloom, Hastings, and Madaus (1981) even though Ralph Tyler’s work in curriculum, instruction, and evaluation included evaluation of instruction in progress, historically his main emphasis was on summative evaluation (p. 25). Bloom et al. went on to say that the information collected and analyzed were used mainly to make judgments at the conclusion of the course. Evaluation became largely
summative in nature; stressing grading, selecting, and certifying students, and determining the effectiveness of the curriculum compared with alternative curricula (p. 25).

Summative evaluation data, when provided to decision makers, can assist in making several educational decisions. These decisions include such aspects as revising the present curriculum, adopting new textbooks, as well as purchasing new instructional materials.

Curriculum Development Efforts in Industrial Technology Education

Industrial Technology Education has been in a constant state of change in the United States since its early inception in the secondary schools. The 1960s produced more modifications with wider implications than any of the preceding decades. Acting on the impetus provided by the 'Sputnik' influence, new frontiers began to emerge.

During this period, many curriculum development projects were initiated. These projects focused on improving curricula for the purpose of correcting the deficiencies caused by the vast technology explosion. Hacker and Barden (1983) provided an account of curriculum development projects initiated during this period. To summarize:

(1) The Industrial Arts Curriculum Project (1965): Two courses were developed from the body of knowledge
identifies two curriculum projects: The World of Construction and The World of Manufacturing.

(2) The American Industry Project (1962): Developed a useful conceptual model, produced a significant body of instructional materials, developed a new major field of study for teacher education students and the public schools, and implemented the American Industry approach in a wide variety of school settings.

(3) The Jackson's Mill Curriculum Project (1981): A consortium of twenty-one experts in the field of industrial technology education who developed a universal technical systems model viewing industrial technology education as a study of human adaptive systems. This model provided a breakdown of the inputs, processes, and outputs of communication, construction, manufacturing, and transportation systems (Hales & Snyder, 1982).

In addition to the widely known curriculum projects discussed above, other efforts were also initiated: The Iowa Guide for Curriculum Improvement in Industrial Arts, K-12 (1975) was the first formal attempt to address technological literacy through industrial technology programs in Iowa. The areas of study identified by this guide included (a) graphic communications, (b) energy and power, and (c) production. The curricula developed as a result of this guide were primarily for the middle school
and junior high students. The Iowa High School Industrial Technology Curriculum Project (1986) proposed the use of five content clusters and extended its philosophical base beyond that suggested in the Iowa guide. The content clusters were (a) construction, (b) graphic communications, (c) energy and power, (d) manufacturing, and (e) transportation. Therefore, this document was a supplement to the Iowa guide (p. 4).

The Industry and Technology Education Project (1986) developed content structures and taxonomies for the four industrial and technological systems (communication, construction, manufacturing, and transportation) to accommodate industrial technology programs of different sizes. Through this effort, a document entitled: A Guide for Developing Contemporary Industrial Art/Technology Education Curricula was produced.

The Illinois State Board of Education (1984) published a document entitled: Communication Technology Curriculum Guide for use in developing contemporary communication technology curricula for industrial education programs. Also, The Center for Implementing Technology Education (1986), located on the campus of Ball State University, produced an array of technology education activities. These activities were for use in the study of general
technology, communication, construction, manufacturing, and transportation.

Principles of Technology

The Center for Occupational Research and Development (CORD) in Waco, Texas, and the Agency for Instructional Technology (AIT) in Bloomington, Indiana proposed that a consortium of state and provincial agencies be created (CORD, 1983). The purpose was to develop an adaptable modular system of mediated instruction in applied physics for use in high school vocational programs (AIT, 1983).

A new applied physics curriculum entitled: Principles of Technology was created as a result of the consortium’s efforts. The rationale for the selection of the audience was that vocational high school students were avoiding the study of physics due to their perceived difficulty of the subject matter. Also, that students may not have envisioned a future requiring a knowledge of scientific principles.

Principles of Technology (PT) as defined by the Center for Occupational Research and Development (1985) is:

A high school course in applied physics; it is a course that blends an understanding of basics and principles with practice. In content, (PT) is a two-year course made up of fourteen units; each devoted to the study of an important concept that undergirds technology (p. T-ix).
Principles of Technology, developed for high school vocational programs, is based on the Unified Technical Concepts (UTC) curriculum developed by CORD for post-secondary vocational programs (AIT, 1985). Fourteen concepts or units make up the Principles of Technology course. These concepts include Force, Work, Rate, Resistance, Energy, Power, Force Transformers, Momentum, Waves and Vibrations, Energy Convertors, Transducers, Radiation, Optical Systems, and Time Constants.

First-year, (level-one), units include the technical concepts of Force, Work, Rate, Resistance, Energy, Power, and Force Transformers. Second-year, (level-two), instructional units include the technical concepts of Momentum, Waves and Vibrations, Energy Convertors, Transducers, Radiation, Optical Systems and Time Constants. Each unit consists of four subunits dedicated to the study of a particular technical concept within one of the four energy systems. The four energy systems are mechanical, fluid, electrical, and thermal systems.

Statement of the Problem

Principles of Technology is a recently developed applied physics curriculum in which physics concepts are taught in a laboratory environment using a unique content model (see Appendix B). No broad based summative evaluation of this curriculum has been conducted in the
state of Iowa or the nation. This study was designed to investigate the effects of first year Principles of Technology in learning basic physics concepts in industrial technology education classes in Iowa.

Purpose of the Study

This study was designed to obtain summative data in order to determine whether traditional physics or first year Principles of Technology instruction provides greater student achievement in the acquisition of basic physics concepts. More specifically, this study was designed to obtain summative data relative to whether grade level, school size and gender had an impact on student achievement in first year Principles of Technology in selected Iowa Public High Schools.

Research Questions and Null Hypothesis

The objective of this study was to investigate first year Principles of Technology student achievement regarding basic physics concepts. Achievement was measured by a Technology Test (see 'Definition of Terms' and Appendix A). The following research questions and null hypothesis were formulated based on the stated objective:

1. Is there a difference in the adjusted posttest mean scores regarding basic physics concepts between students enrolled in first year Principles of Technology,
Physics, and the control group, as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates?

**Null hypothesis:** There are no significant differences in the adjusted posttest mean scores of first year Principles of Technology, Physics, and the control group as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]

\[ H_a: \mu_1 \neq \mu_2 \neq \mu_3 \]

2. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test, by gender?

3. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test by grade level?

4. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology,
Physics, and the control group as measured by the Technology Test by school enrollment size?

5. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test by grade level and school size?

Assumptions of the Study

The study was undertaken with the following assumptions:

1. The sample for the study was representative of the population of Iowa public high school students enrolled in first year Principles of Technology.

2. Procedures were taken to establish reliability and validity of the instrument and the data collection process.

3. The data for the study were a correct assessment of the effectiveness of first year Principles of Technology.

4. The nonequivalent control group design was appropriate for the study and yielded valid information.

5. The students responded in a truthful manner.

6. The methods of analyses of the data were appropriate for the study.
7. Instructors teaching first year Principles of Technology classes and those teaching Physics classes taught similar content.

Delimitations of the Study

Interpretation of the findings of this study were limited to the following:

1. The study was limited to a summative evaluation of year one Principles of Technology within selected public high schools in the state of Iowa.

2. The study was limited to students enrolled in grades eleven and twelve.

3. The subjects were limited to those enrolled in first year Principles of Technology classes, Physics classes, and a control group of students not enrolled in Principles of Technology or Physics classes. The control group was selected on the basis of such criteria as Iowa Test of Educational Development (ITED) scores, male-female ratio, and enrollment in Industrial Technology classes.

Procedures of the Study

The study was conducted following these procedures:

1. A thorough review of literature relative to summative evaluation and related studies was undertaken.
2. The proposed topic of the study was identified as: Principles of technology: A summative evaluation of student achievement in the first year.

3. The research proposal was submitted to the graduate advisory committee, with changes made as suggested by the members.

4. The literature search was conducted through use of the ERIC Retrieval System and other available sources.

5. The population to be used was identified through Iowa's State Department of Education: Career Education Bureau.

6. The instrument was developed by a team of experts in the field (Physics and Industrial Technology Education).

7. The instrument was administered as a pretest and a posttest.

8. The data were processed and analyzed at The Iowa State University Test and Evaluation Center.

9. The report was written, revised, and a final draft prepared.

Design of the Study

The population for this study consisted of public high school students in the state of Iowa participating in the assessment of Principles of Technology. The sample for the study consisted of Iowa high school students enrolled in the first year of Principles of Technology classes,
students enrolled in Physics classes, and a control group of students. The study used intact groups. The three groups of students were identified as two treatment groups and one control group.

A nonequivalent control group design as advocated by Campbell and Stanley (1969) was used for this study. This design, called quasi-experimental, was used because the groups constitute naturally assembled collectives such as classrooms.

Analysis of Data

The first step in the statistical analysis was the calculation of the descriptive statistics for both the control group and the two treatment groups.

The second step involved the calculation of the statistical analyses to test the null hypothesis and answer the research questions. An analysis of covariance procedure was used to test for significant differences in the adjusted posttest means, using pretest scores, grade level (junior, senior), gender, and high school enrollment size (small, medium, large) as covariates. A post-hoc comparison procedure was used to detect where the differences in the adjusted means were, as indicated by the analysis of covariance.
Definition of Terms

The following definitions were proposed for the purpose of this study:

**Applied Physics:** The science of matter and energy and of the interactions between the two put into practice or a practical use.

**Control Group:** A group of students similar to the Principles of Technology students but not enrolled in the Principles of Technology course. The control group of students were selected on the basis of such criteria as ITED scores, male-female ratio, and enrollment in Industrial Technology.

**Educational Evaluation:** A systematic process of evaluation that assesses educational activities which provide services on a continuous basis and often involve curricular offerings (The Joint Committee on Standards for Educational Evaluation, 1981).

**First-year Principles of Technology:** The technical concepts of Force, Work, Rate, Resistance, Energy, Power, and Force Transformers taught as instructional units during the first year of the course (CORD, 1985).

**Industrial Technology Education:** Education which allow students to gain an understanding of how processes and practices affect materials and humans in industry. This understanding is achieved by providing practical
experiences in industrial management, personnel, and material goods (Savage, 1988).

**Principles of Technology (PT):** A high school course in applied physics developed by the Center for Occupational Research and Development. Based on the Unified Technical Concepts (UTC), Principles of Technology is comprised of fourteen units, each of which focuses on important concepts that underlie modern technology (CORD, 1985).

**Quasi-Experimental Design:** A group of research designs that are distinguished from true experimental design. They are designs in which random assignment to experimental treatments is not possible because subjects are members of intact groups (Campbell & Stanley, 1969).

**School Enrollment Size:** A classification of the public high schools (grades 9-12) used in the study in which schools with enrollment figures between 100-215 were coded 'small'. Schools with enrollment between 216-400 were coded 'medium', and schools with enrollment between 401 and above were coded 'large'.

**Summative Evaluation:** The end-of-the-year assessment used to determine the effects of a program, project, or procedure. It leads to one of three decisions at the completion of a task—to continue it, change it, or cancel it (DeRoche, 1987).
Technology: The knowledge and study of human endeavors in creating and using tools, techniques, resources, and systems to manage the manmade and natural environment to extend human potential and the relationship of these to individuals, society, and the civilization process (Hales and Snyder, 1982).

Technology Test: A comprehensive, one hundred twenty item multiple response cognitive test. It was the instrument administered as a pretest and a posttest to each group in the study (see Appendix A).

Unified Technical Concepts (UTC): A method of presenting relevant physics for a variety of technologies. It relies heavily upon the natural unity in physics and includes practical applications in four principal energy areas (mechanical, fluidal, electrical, and thermal) (CORD, 1984).

Organization of the Remainder of the Study

A review of the related literature is presented in Chapter II. This review includes a discussion of program evaluation, and applied science and mathematics in Industrial Technology Education. A rationale for Principles of Technology in the Industrial Technology Education curriculum is also included in the literature review.
The methodology and design of the study are presented in Chapter III. It includes a discussion of the population and sample, development of the instrument, collection of the data, and the data analysis techniques employed.

Chapter IV deals with the results of the data analysis and findings. The findings are presented in relation to the research questions and null hypothesis stated in Chapter I.

Finally, Chapter V is a summary of the study. Also included in this chapter are the conclusions based on the findings, recommendations based on the researcher's observations, and recommendations for future study.
CHAPTER II - A REVIEW OF RELATED LITERATURE

Introduction

Today, as industrial technology faces a new era, curriculum revision must be given top priority. In order for the profession to survive, the content must be continuously updated. Following World War II, our civilization witnessed the development of landmark technical developments which impacts us even today. In the 1960s we were referred to as the post-industrial society. Today, we are referred to as the information age (Lauda, 1988). Toffler (1980) and other futurists agree that the current generation lives at the confluence of this transition. Toffler referred to knowledge, as well as the people who generate and use it, as the capital asset of the latest transition; or as he called it, The Third Wave.

In an industrial society a person could practice a skill without having knowledge of the principles involved. Today’s employee, however, is expected to be proactive in detecting problems and determining alternative solutions. Knowledge must precede the acquisition of skills, and the more complex the culture, the more knowledge is needed for production of goods and services. Lauda (1988) supported this idea when he stated that "curriculum developers in industrial technology education must consider the
laboratory their primary focus and consciously address the need for skills and the principles behind them" (p. 12). Lauda went on to say that the discipline of industrial technology education has the distinct advantage of working in laboratories designed to work with technical means. Lauda stressed that "such an environment provides the perfect avenue for accomplishing basic skills utilizing the interdisciplinary approach" (p. 13).

Additional support for curriculum revision and content updating came from Bell (1988) who wrote:

Curriculum is the heart of an educational system, and ours needs major revision in the areas of content, standards, and expectations. The goals should be to provide a sound general education for all Americans, one that prepares them to live freely and perform ably in a rapidly changing, technologically complex, and interdependent world (p. 402).

And Wright (1980) had this to say:

It seems appropriate for the industrial/arts technology profession to encourage and promote a change in content emphasis from a craft/industrial orientation to a modern technology approach.... We cannot afford to continue our primary emphasis upon the craft and tool skills of technology. Our new approach should be interdisciplinary and address the technical and social/cultural issues that are essential contributing factors towards a better understanding of our modern technology (p. 35).

The possibilities for interdisciplinary education with areas such as science and mathematics in cooperation with industrial technology programs are unlimited in scope. This cooperation can provide the opportunity for meaningful
activities to study technology. By investigating, exploring, and manipulating the technical environment in the laboratory, students can be helped to understand technology and its effects on their lives.

While many curriculum development projects have been carried out in industrial technology education, a review of the literature failed to produce a wealth of evaluation studies of these projects. The review of such literature in this study will be treated under three headings:

1. Program evaluation
2. Applied Science and Mathematics in Industrial Technology Education
3. A Rationale for Principles of Technology in the Industrial Technology Education curriculum.

Program Evaluation

The field of evaluation has evolved rapidly in the last two decades, giving rise to a number of different models of the evaluation process and the evaluators' role within it. Program evaluation is often mistakenly viewed as a recent phenomenon. Madaus, Scriven and Stufflebeam (1983) noted that in the United States, perhaps the earliest formal attempt to evaluate the performance of school programs took place in Boston in 1845 (p. 5). These authors pointed out that this event is important in the
history of evaluation because it began a long tradition of using pupil test scores as a principal source of data to evaluate the effectiveness of a school or instructional program.

The few early subscribers to the evaluation process concerned themselves with program worth. From this group, Ralph W. Tyler emerged as the most salient educator who attempted to further formalize the conceptual nature of evaluation. He was an early proponent of behaviorally stated objectives (Madaus et al., 1983). Tyler's approach was to look at evaluation as a process of comparing performance data with clearly defined program goals.

According to Stufflebeam and Shinkfield (1985):

"Tyler saw the purpose of evaluation as providing a check "as to whether these plans for learning experiences actually function to guide the teacher in producing the outcomes desired." This has the flavor of a developmental or formative intent. In reality, the Tylerian approach has been used in a much more summative way (p. 74)."

Nevo (1983) noted that the fallacies of the Tylerian approach were failure to include a decision-making component for program planning and improvement. This approach was also weak in providing a primary reliance on student performance to determine program worth.

Stufflebeam and Shinkfield (1985) concluded that the advantage of the Tylerian approach is that it integrates evaluation with the instructional process. This approach
provides for feedback, and has defined criteria. The determination of the degree to which instructional program goals were achieved resulted in the Tylerian approach becoming known as a goal-attainment model and/or behavioral objectives model.

As a result of the Russian launch of Sputnik in 1957, the federal government enacted the National Defense Education Act of 1958. During this period, a number of new, innovative curriculum projects in mathematics and science were created. As a result, the federal government made funds available to evaluate these curriculum development efforts. Four different approaches to evaluation were used during this period. First, the Tyler approach was used to help define objectives for the new curricula and to assess the degree to which the objectives were being realized. Second, new nationally standardized tests were created to better reflect content and the objectives of the new curricula.

Third, the professional-judgement evaluation approach was used in an effort to rate proposals and to check on the efforts of contractors. And fourth, many evaluators evaluated curriculum development efforts through the use of field experiments. Madaus, Scriven and Stufflebeam (1983) wrote that despite their attempts, many evaluators during
this period began to realize that their efforts were not succeeding.

Program evaluation grew as a discipline with the passage of the Elementary and Secondary Act of 1965. Title I of this act required local educational agencies receiving federal dollars for the education of disadvantaged students to annually evaluate the degree to which the funded projects were achieving their stated goals (Popham, 1988). During the latter part of the 1960s, educators in large numbers were caught up with the conduct of educational evaluations. The federal evaluation requirements of the Elementary and Secondary Act of 1965 soon were emulated by state legislatures. The impact was that even state dollars for education were accompanied by evaluation requirements.

Stufflebeam and Webster (1980) mentioned that the discipline of educational evaluation has developed rapidly during the intervening years, and was influenced by the legislation in 1965. Other reasons for the rapid development of educational evaluation were the "nationwide accountability movement that began in the early 1970s; and, the mounting responsibilities and resources that society assigned to educators" (p. 5).

The decrease in financial support for education which began during the early 1970s ushered in an era of educational accountability. Popham (1975) stated that
"this stepped-up demand for accountability naturally led to a stepped-up need for educational evaluation" (p. 6). Clearly a change in the pattern of evaluation was needed to cope with this new demand for accountability. In addition to determining program worth, evaluators needed to provide information for decision-making as well.

To meet this need, evaluation theorists created a large number of evaluation models. Evaluation models are, as suggested in the dictionary, a "set of plans" or "an example for imitation or emulation" (Webster's Ninth New Collegiate Dictionary, 1985). Alkin and Ellett (1985) contended that prescriptive evaluation models, that is, those that indicate educational evaluation should be conducted in certain ways. These ways can be categorized along three dimensions. These dimensions are (a) ***methodology*** (the techniques used for description and evaluation), (b) ***values*** (the focus on isolating the merit or worth of whatever is being evaluated), and (3) ***uses*** (the purposes or functions of the evaluation) (pp. 1763-64).

Some widely known education evaluation models that have evolved throughout the years, although they are neither exhaustive nor mutually distinctive, are:

1. Goal-Attainment Models (Ralph W. Tyler)
2. Judgmental models emphasizing Inputs
   a. Accreditation model
3. Judgmental models emphasizing Outputs
   a. Goal-free evaluation (Michael Scriven)
   b. Stake's Countenance Model (Robert E. Stake)

4. Decision-Facilitation Models
   a. The CIPP Model (Daniel Stufflebeam and Egon Guba)
   b. The Discrepancy Model (Malcolm Provus)

5. Naturalistic Models
   a. Stake's Responsive evaluation
   b. Eisner's Connoisseurship Model (Popham, 1988).

Although evaluation models differ, each serves the purpose of systematically organizing information. The information is used to assist the evaluator with the choices among the various alternatives available in any type of programmatic evaluation. As pointed out by Ediger, Snyder, and Corcoran (1983) a model does not eliminate all the problems and frustrations of evaluation. However, it does make the task of evaluating more manageable. The success of the evaluation rests on the quality of teamwork between the evaluators and the decision-makers. Perhaps the best known decision-facilitation model is the CIPP Model. This model (CIPP), was designed by Daniel Stufflebeam and Egon Guba. It was conceptualized as a result of attempts to evaluate projects that had been funded through the Elementary and Secondary Act of 1965. The CIPP model believes that the most important purpose of
evaluation is "not to prove but to improve" (Stufflebeam, 1983).

Stufflebeam went on to say that CIPP evaluation is geared more to a systems view of education. That it is concentrated not so much on guiding the conduct of an individual study, but on providing ongoing evaluation services to the decisionmakers in an institution (p. 125). Worthen and Sanders (1987) wrote that the CIPP approach has also been used for accountability purposes. Worthen and Sanders also stated that the CIPP approach provides a record-keeping framework. This framework facilitates public review of educational needs, objectives, plans, activities, and outcomes (p. 83).

The CIPP model distinguishes among four types of educational decisions. These types are (a) planning decisions, (b) structuring decisions, (c) implementing decisions, and (d) recycling decisions (Popham, 1988). These four types of evaluation constitute the heart of the CIPP model:

**Context evaluation:** The primary orientation of a context evaluation is to identify the strengths and weaknesses of some object, such as an institution, and to provide direction for improvement, [planning decisions].

**Input evaluation:** The main purpose of input evaluation is to provide information regarding how to
employ resources to achieve program objectives. The overall intent of an input evaluation is to help the clients consider alternatives. These alternatives are viewed in the context of their needs and environmental circumstances and to evolve a plan that will work for them (Stufflebeam, 1983). The data from this type of evaluation are used to assist in achieving the objectives identified as a result of context evaluation, [structuring decisions].

Process evaluation: Process evaluation identifies defects in the implementation stages. It also provides information for programmed decisions and maintains a record of the process to be used later to aid in the interpretation of the outcomes. This type of evaluation is required once the program is operational "to monitor the actual instructional procedures in order to help the instructional decision-makers anticipate and overcome procedural difficulties", [implementing decisions] (Popham, 1988).

Product evaluation: Product evaluation endeavors to measure and interpret the attainment of program goals at intervals during the program's existence and at its conclusion. Stufflebeam (1983) stated that feedback about what is being achieved is important during a program cycle and at its conclusion. Information gathered from this type of evaluation is used by decision-makers. It is used when
deciding whether to continue, terminate, or modify a particular program, [recycling decisions].

Evaluation is a necessary concomitant of improvement. Whether an evaluation should be comparative depends on the intended uses of the evaluation. Stufflebeam and Shinkfield (1985) identified three main uses of evaluation. These uses are (a) improvement, (b) accountability, and (c) enlightenment. The first use involves providing information for assuring the quality of a service or for improving it. The second main role of evaluation is to produce accountability or summative reports. These are retrospective views of completed projects, established programs, or finished products. The third use is enlightenment. This use attempts to consider all criteria that apply in a determination of value (p. 7).

Evaluation is an integral part of an institution’s regular program. It has a vital role in stimulating and planning changes. Decisions to commence, sustain, install, or abort programs and program improvement efforts almost always will reflect dynamic forces. Evaluation information provides guidance for institutional problem solving. Evaluation information also provides a basis for deciding to abort or institutionalize special projects which can be made on defensible grounds.
Applied Science and Mathematics in Industrial Technology Education

The content of industrial technology education is integrally tied in with most of the disciplines of the secondary school. Even the most simplistic projects developed in industrial technology laboratories usually involve physics, and/or mathematics. Each tool encompasses one or more principles of physics in its operation and function. However, it is beyond tool or machine use where the most significant integration of science and mathematics will occur. The study of industrial technology can interface in meaningful ways with a variety of course offerings.

The increased emphasis on science and mathematics for all students in the schools makes it imperative that industrial technology education have a significant role in student development. The national emphasis on science and mathematics provides the industrial technology profession with enormous opportunities and challenges. Maley (1984) wrote:

"The central issue is that in a period of unprecedented technological explosions in practically all fields, industrial technology education cannot afford to perform outside the mainstream of society. Second, the vital roles of mathematics and science in the technological explosions make it clear that their implications and working should be integrated into the study of technology in industrial technology programs" (p. 3).
The application and interpretation of mathematics and science in the study of industrial technology are natural processes if understanding is the goal. Industrial technology education, in this way, provides the means for increased mathematics and science development on the part of the individual. This application and interpretation also provides the field of industrial technology with an important role in the mainstream of education in a society where the emphasis is on science and mathematics. Support for curriculum update to include mathematics and science in industrial education programs has grown significantly over the past decade. Pautler (1987) stressed: "With contemporary advances in technology in the workplace and the reform movement in education in the United States it would seem that changes are needed in the content and delivery of industrial education". Pautler went on to say that educators in industrial education are always playing "catch up" with technical advances in the field; that changes will continue to occur in industry first with new processes and equipment, and then schools will have to play "catch up" to adopt those changes to the curriculum (p. 82).

Wiley (1988) informed us that scientific advances will penetrate every facet of our world, providing new products and services to enhance the quality of our lives and the
health of our economy. That at a minimum, students will need a good background in mathematics and a general understanding of scientific principles (p. 12). DeLuca (1987) went on to say that as industrial technology faces a new era, curriculum revision has become a major priority. That publications in the field have been devoted to establishing curriculum direction and prescribing technology based activities. This revision in industrial technology education reflects an evolution in the knowledge and skills that are needed to adapt to and improve contemporary life.

As a matter of curricular viability in the present and future, the integration of mathematics and science into the industrial technology education curriculum is imperative. This idea is supported by Maley (1984) who wrote:

As one views the principal contributions industrial technology education can make to the study of technology and the accompanying student development in mathematics and science, there are several important qualities of the nature of instruction in this area on which the profession must capitalize:

1. It is a firsthand experience with understandings growing out of concrete experiences related to mathematics and science.

2. It is a program that has great potential for establishing relevance to the concepts of mathematics and science.

3. It is a program that provides a content base that has a high degree of relevance to the needs of persons living in a technological
4. It is a program that can establish important connections or linkages with the interests of students and the elements of mathematics and science through viable content in a technological age (p. 6).

Science and mathematics have repeatedly emerged as constituents of a high-technology education. Keller (1980) reported that renovation was particularly wanting in areas such as science, technology, and industry. Similarly, Wolf (1983) reported that improvements in high school mathematics and science requirements were needed for all students and particularly those in vocational education.

Educators in the field of industrial technology education such as Hersh (1983) have acknowledged the importance of science and mathematics with regard to technological literacy. Dyrenfurth (1983) has viewed technological literacy as a necessary survival skill. Dyrenfurth defined it as the capacity to use and work with technology intelligently within a broad context of understanding. Technological literacy requires more than a knowledge of mathematics and science, it also requires understanding. Such literacy may entail specific, concrete applications of technology to problems in manufacturing, communication, transportation, and construction.

Further support for the inclusion of science and mathematics into industrial technology programs was found.
Maley (1987b) informed us that industrial technology and vocational education can serve as a point in the school where the student can put it all together in the context of the world beyond school. Maley stressed that such areas of instruction can provide the setting where mathematics and science can be applied in the world of reality. This reality is strengthened with concrete applications of principles and concepts. The principles and concepts of science are used to explain and interpret the phenomena of heat exchange, power transmission, forces, lift, drag, friction and numerous other phenomena. These are the technologies associated with the area of industrial technology education and vocational education (p. 245). In addition to science and mathematics principles and concepts, the industrial technology education and vocational fields abound in several other concepts. These concepts deal with the social and environmental impact of many of the items studied in the laboratory instructional programs.

A Rationale for Principles of Technology in the Industrial Technology Education Curriculum

The world has changed more in the past two hundred years than it has throughout all previous history. The rate of change is continuing at an ever-accelerating pace and is of an increasing magnitude. The industrial
technology curriculum must be adapted to prepare students to cope with these changes.

The roots of industrial technology education reach deep into a history of civilization. A number of educational leaders played significant roles in the evolution and revolution of industrial technology education as we know it today. From John Amos Comenius to present-day professionals in the field, industrial technology has always geared its efforts towards developing new programs. These programs have attempted to incorporate innovative methods, plans, and ideas to meet the needs of students.

Today, concern for the nature of technology has increased as the complexity of technological systems and their impact on humans, society, and the environment have become more evident. Schools at all levels have an important role to play in the process of helping students understand their technological future. One of the keys to helping students understand their technological future centers on the nature of the content. This point was made by Boyer (1983):

The great urgency is for 'technology literacy', the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. The challenge is not learning how to use the latest piece of hardware, but asking when and why it should be used (p. 111).
During the 1960s many efforts were undertaken in order to respond to the challenges presented by Sputnik. Such efforts, and those called for today, resolve around the disciplines of science and mathematics. The industrial technology curricula was no exception. According to Lauda and McCrory (1986) the subject matter area of industrial arts/technology has been involved with the study of technical means since its conception early in this century.... It does present attempts to help students understand tools and materials (p. 25). Lauda and McCrory went on to say that of all the disciplines in the educational system, it has been industrial technology that has a rich heritage in helping students understand their technical heritage. However, industrial technology has been occasionally guilty of being geared to the past and has been represented out of context (p. 28).

Industrial technology education has been working in areas which represent basic activities needed for survival for three-quarters of a century. These areas include construction, communication, manufacturing, production, and transportation. Authorities in the field of industrial technology education have cited problems that have existed, and still exist in most cases, with traditional industrial technology programs. Wright (1980) wrote that the programs have been materials/project oriented, making them involved
with technical processes without conscious concern for the sociocultural context in which they exist (p. 35). Dugger (1980) went on to say that industrial arts/technology has not been involved with all of the technical means in most programs. Absent from most programs are content and instructional strategies that deal with transportation. In The Standards Report, Dugger revealed that most programs were still based on the teaching of woodworking, metal working, and drafting. Lauda and McCrory (1986) added:

Programs have not kept pace with the changing technology. Updating laboratories to reflect contemporary technology is cost prohibitive and alternatives to this problem have not been a high priority for many educators (p. 29).

As a result of the technology explosion over the past decade, a new revolution has evolved. This revolution places greater demands on public education to provide revelant educational programs. Our nation’s high schools are being looked upon as the institutions to prepare individuals for employment, general living, and higher education. Daiber and LaClair (1986) stated that the amount of knowledge present today has been forcast to double again in approximately eight years. The authors went on to say that this exponential growth rate of knowledge has further accelerated new innovations. The acceleration of knowledge has broadened the gap between
classroom subject matter and the technological realm (p. 95).

Because of this gap, there is a need to realign and upgrade content to be congruent with modern technology. This thinking provides a rationale for Principles of Technology. To support this statement, in his guidelines for future industrial technology programs, Maley (1980) encouraged programs that focused on technological alternatives in dealing with identifiable problems of mankind. Maley also emphasized promoting the development and application of speculation, innovation, and problem solving. Ray (1980) responding to the question: "As you look back on the recent curriculum movements in the Industrial Technology profession, what could have been done better"? replied:

"The profession would have profited more had we, earlier, established 'technology' as our subject-matter base. Industrial technology curriculum specialists either did not know of W.E. Warner's ideas, did not understand them, or did not wish to honor them. By focusing in upon our unique knowledge base (the technology of industry), we would have moved well past the 'trade skills and knowledge' influence. We would have moved more rapidly toward the broad-based reservoir of concepts, principles, generalizations, and unifying themes of the 'science of efficient human action or behavior' (technology) in industry (industrial technology)" (pp. 9-10).

A unique feature of the Principles of Technology curriculum in industrial technology education is the use of the interdisciplinary approach to the teaching-learning
process. This approach was supported by Maley (1987b) in developing a project for the state of Maryland entitled: Integrating Math and Science into Technology Education. Maley stated that one of the program’s dimensions centers around the need for an interdisciplinary approach to teach industrial technology education. This comes from the proposition that in order to develop any appreciable understanding of technology or technological literacy, an interdisciplinary approach will be required. Maley stressed that an effective study of industrial technology education will involve mathematics, science, social studies, economics, history and arts (p. 9).

It concert with Maley, Bame (1986) testified:

An interdisciplinary approach is inherent in industrial technology. The humanities, sciences, and technology are interrelated and should be learned in that way. The study of technology can reinforce the study of other disciplines. Concepts and skills in mathematics, the natural and social sciences are used in many ways. Historically, technological advances often preceded a scientific explanation for the act. Today, the theory and practice often go hand-in-hand (pp. 70-95).

Principles of Technology at the high school level is designed to create outcomes related to scientific principles, technical concepts and technological systems. Support for a course with the characteristics such as Principles of Technology can be found in the literature. Title II, Section 251, A (111) of The Carl D. Perkins Act
of 1984 specified that states may use funds for "the conduct of special courses and teaching strategies designed to teach the fundamental principles of mathematics and science. The principles would be taught using practical applications which are an integral part of the student's occupational program" (Vocational Education Act: P. L. 98-524, 1984). Principles of Technology does just that. Batey, Edmondson, Hatch and Mason (1984) noted that too often, students fail to attain the levels of technological literacy they need to interact effectively with their technical environment. Industrial technology educators can and should be at the forefront of the movement to bring both science and mathematics into the classroom (p. 27).

The National Commission on Excellence in Education (1983) has said "Individuals in our society who do not possess the levels of skills, literacy, and training essential to this new era will be effectively disenfranchised, not simply from the material rewards that accompany competent performance, but also from the chance to participate fully in our national life" (p. 7). Policymakers have stressed the importance of more effective science, mathematics, and technology curricula. A report of The Twentieth Century Fund Task Force on Federal Elementary and Secondary Education Policy (1983) suggests that training in mathematics and science is critical to the
economy. That to make informed decisions about issues such as radiation, pollution, and nuclear energy, our citizens must be educated in science. The National Commission On Excellence in Education (1983) cited "the significant movement by political and educational leaders to search for solutions is centered largely on the nearly desperate need for increased support for the teaching of mathematics and science" (p. 12).

Some educators are concerned that an emphasis on technical content will leave little time for studying the arts and humanities. Yet, industrial technology is in the unique position of being able to integrate the technical aspects of science and mathematics with social content areas. The study of industrial technology is unique by virtue of combining technical and social concerns. Boyer (1983) emphasized the importance of technology when he stated: "All students should study technology: The history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised" (p. 31).

Principles of Technology provide students with a foundation for career preparation at the secondary and postsecondary levels. For those students seeking employment upon high school graduation, Principles of Technology provides a firm foundation for entering the job
market. It facilitates on-the-job training, and helps speed retraining as equipment, processes and procedures change in the future.

Summary

The literature reviewed in this chapter focused on program evaluation, applied science and mathematics in industrial technology education, and a rationale for Principles of Technology in the industrial technology curriculum.

Program Evaluation

There is a continuing drive toward educational accountability in this country. Taxpayers want the schools to deliver evidence that society is getting their money’s worth. School boards must be provided with evaluation reports that indicate how well the schools have been operating. Nearly all the literature on evaluation speaks of it as an attempt to serve a decision maker. At its most fundamental level, evaluation involves making judgments as to the worth of some entity. According to Nevo (1986) educational evaluation can serve four functions: (1) formative; (2) summative; (3) socio-political; and (4) administrative.

Summative evaluation refers to appraisals of quality focused on completed instructional programs. The information gathered in a summative evaluation involves
assessing the worth of an overall instructional sequence. This is so that decisions can be made regarding whether to retain or adopt that sequence. The primary concerns of a summative evaluator are documenting or assessing program effects for the purposes of determining their causes and generalizability.

Though it is just one step toward educational improvement, evaluation holds greater promise than any other approach in providing educators with information they need to help improve educational practices. The usefulness of educational evaluation has lead some persons to look to it as a panacea for all the ills of education. Worthen and Sanders (1987) stated that "evaluation alone cannot solve all of education's problems" (p. 8). One of the biggest mistakes of evaluators in the 1970s was to promise results that could not be attained. Stake (1982) noted that "evaluator promises often leap beyond what the proposer has previously accomplished, and also beyond the attainment of anyone in the field" (p. 58).

Program evaluation serves to identify strengths and weaknesses, highlight the good, and expose the faulty. It does not serve to correct problems, for that is the separate step of using evaluation findings. Worthen and Sanders (1987) testified that evaluation is only one of many influences on educational policies, practices, and
decisions. Both its limitations and its benefits must be acknowledged.

Program evaluation at the school district level should be an ongoing process that can be a part of or incorporated into an individual school's evaluation plans. As an ongoing progress, program evaluation can contribute to program and behavior changes. Program evaluation can also promote a positive attitude toward improvement. It can also help educators and learners determine the extent to which each has been successful in the teaching-learning process.

Applied Science and Mathematics in Industrial Technology Education

The Carl D. Perkins Acts of 1984 contained thirty-one words that specifically encouraged strengthening the academic foundations of vocational education. ..."to teach the fundamental principles of mathematics and science through practical application".... This legislative statement is highly significant. The statement is not found in previous Vocational Education laws, and it signals a recognition of the importance of academic principles to vocational education. According to Parks and Henderson (1985), business and industry have supported this notion for some time. The authors also stressed that business and
industry representatives have not requested more academic per se, but applied academics (p. 34).

The transitional function of high schools suggests the need for an interdisciplinary approach to the teaching-learning process. The integration of applied science and mathematics in industrial technology programs at the high school level provide students with a foundation for career preparation. Students at this level will (1) experience the practical application of basic scientific and mathematical principles, (2) make decisions about postsecondary technology careers or service-related fields, and (3) gain an understanding and appreciation for technology in our society and culture.

The Technology Education Advisory Council (1988) stated that the integration of applied science and mathematics in industrial technology education will assist students in: (a) developing basic skills in the proper use of tools, machines, materials, and processes and, (2) solving problems involving the tools, machines, materials, processes, products, and services of industry and technology. New jobs in service industries will demand much higher technical skill levels than the jobs of today. Very few jobs will be created for those who lack adequate science/technical knowledge and who cannot read, follow directions or use mathematics.
Industrial technology has some important roles to play with respect to the development of the student, and helping to live effectively and to contribute in a society so profoundly influenced and impacted by technology. Two identified roles are (a) helping students understand their technological future, and (2) fostering technological literacy through industrial technology education.

A Rationale for Principles of Technology in the Industrial Technology Education Curriculum

The advancements in technologies have modified the industrial and private sector requiring that the nation’s new technologies be taught in public schools. Industrial technology education must respond to the challenges and opportunities in emerging technologies. This can be obtained by preparing students with a broad base of technical concepts and principles and well as with current employable skills. The emphasis on concepts and principles should enable the nation’s future employees to be more employable and flexible in the work force.

The literature reviewed indicated a high degree of support for curriculum revision in industrial technology education. Principles of Technology was designed for those vocational education students in the middle quartiles. Principles of Technology uses a systems approach in content delivery. This approach uses video presentations and
hand-on laboratory exercises. In a practical manner, it teaches how technical concepts and principles apply to the mechanical, fluidal, electrical, and thermal systems that are the foundation of high technology.

Industrial technology has much to offer the future employee both inside and outside the workplace. It can provide unique opportunities not only to learn about, but to practice adaptability skills, technical literacy, occupations, and leisure skills. Henry (1982) stated that a high school graduate should have a broad conceptual understanding of the structure, functions, and mechanics of industry. Additionally, they should possess the fundamental skills of communication, math, and problem solving to be the trainable and adaptable employee of the future.

Incorporating the concepts and principles of technology into the vocational education curriculum has many benefits. It can provide students with the practical, hands-on learning experiences that have been the unique strength of vocational education instruction. It also strengthen students’ mathematics and problem-solving skills as they relate to technical careers.
CHAPTER III - METHODOLOGY

Introduction

This study was designed to investigate student achievement regarding basic physics concepts in the first year of Principles of Technology in industrial technology education. Furthermore, this study was designed to investigate whether grade level (junior, senior), school enrollment size (small, medium, large), and gender had an impact on student achievement in first year Principles of Technology.

The purpose of this chapter is to present the procedures adopted for the study. The procedures have been divided into the following sections:

1. Population and Sample
2. Questions to be Answered
3. Development of the Instrument
4. Collection of Data
5. Analysis of Data

Population and Sample

The population for the study was limited to students enrolled in public high schools in the state of Iowa that were awarded funding through Iowa's State Department of Education: Career Education Bureau (Berryhill, 1988). The funds were awarded for the purpose of participating in the
Principles of Technology Assessment Project (IVAS, 1985). The project was aimed at assessing how well the Principles of Technology objectives were being addressed in Iowa's public high schools. Only high schools that offered first year Principles of Technology were considered in this study.

The sample was made up of the following groups:


Three groups of subjects were identified for a pretest, posttest, and a control group:

Group 1. First year Principles of Technology students
Group 2. Physics students
Group 3. Control group of students.

Questions to be Answered

The following questions and null hypothesis formed the basis for this study:

1. Is there a difference in the adjusted posttest mean scores regarding basic physics concepts between
students enrolled in first year Principles of Technology, Physics, and the control group, as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates?

Null Hypothesis: There are no significant differences in the adjusted posttest mean scores of first year Principles of Technology, Physics, and the control group as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]
\[ H_a: \mu_1 \neq \mu_2 \neq \mu_3 \]

2. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test, by gender?

3. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test by grade level?

4. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology,
Physics, and the control group as measured by the Technology Test by school enrollment size?

5. Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test by grade level and school size?

Development of the Instrument

A team of experts in the field of Physics and Industrial Technology Education met on the campuses of Iowa State University and the University of Northern Iowa during the summer of 1986. The purpose of the meeting was to participate in a series of Principles of Technology workshops conducted during the summer of 1986 (Dugger, 1989). Each participant was selected by the Iowa Industrial Education Cadre based on a set of selection criteria.

During these workshops, participants generated an item bank of questions to be used in the ongoing evaluation of first year Principles of Technology instructional unit objectives. It was during this phase of the process that content validity of the instrument was established. Content validity is the degree to which the sample of test
items represents the content that the test is designed to measure (Borg & Gall, 1983).

At the completion of the six units test evaluations, data were collected and analyzed. Subsequent analysis procedures involved the selection of items for the development of a comprehensive test for year one Principles of Technology. Items were selected based on their difficulty and discrimination indices. Items with a difficulty index between .3 and .8 and a discrimination index between .3 and 1.0 were selected.

The selected items were reevaluated by the project staff and instructors of physics and industrial technology education. Modifications were made as needed. Upon completion of the aforementioned process, a comprehensive test for year one Principles of Technology was developed. The comprehensive test was entitled: Technology Test, (A copy of the test can be found in Appendix A). The Technology Test was composed of test items for year one Principles of Technology instructional units. These units were: Force, Work, Rate, Resistance, Energy and Power. Each unit contained four subunits which were titled mechanical, fluid, electrical, and thermal systems.

The instrument was composed of one hundred twenty multiple response items. Items were written and selected based on subunit objectives from the six instructional
units. The one hundred twenty items were distributed equally across units and subunits. The instrument required approximately 90 minutes of the student’s time at the beginning of the school year (pretest) and the same amount of time near the end of the school year (posttest).

Reliability, as applied to educational measurements, may be defined as "the level of internal consistency or stability of the measuring device over time" (Borg & Gall, 1983, p. 281). There are several methods of estimating reliability, most of which call for computing a correlation coefficient between two sets of similar measurements. These methods were (a) test-retest, (b) alternative form, (c) split-halves, and (d) internal consistency. In this study, the internal consistency method was used because it provides a conservative estimate of reliability.

According to Smith and Glass (1987, p. 106) "The internal consistency method provides information on only one source of error and ignores sources of error from observers, temporary states of the subjects and non-standardized procedures". In this study, Kuder-Richardson Formula 20 was used to estimate the reliability of the instrument. Reliability coefficients vary between values of .00 and 1.00, with 1.00 indicating perfect reliability and .00 indicating no reliability. Moore (1983) stated that a measuring instrument with a
reliability coefficient above .80 generally indicates good consistency of an instrument. The reliability coefficient for the instrument (Technology Test) used in this study was found to be .84.

Collection of Data

A letter was sent to superintendents of districts offering the first year Principles of Technology by the Project Director (see Appendix D). The purpose of the letter was to identify the proper procedures for securing permission to administer the Technology Test to each group of students (see Appendix D). Upon identification of the required permission procedures, agreement forms (see Appendix D) were developed by the Project staff and sent to each participating educational agency for confirmation and approval. The agreement forms also sought to information on group enrollment for mailing purposes. Permission forms were also generated for parents or guardians of students participating in the assessment project (see Appendix E) (Dugger, 1989).

The Technology Test test booklets, color-coded answer sheets, and a cover letter (see Appendix D) were mailed to each identified coordinator at each participating high school in August, 1987. The cover letter contained test instructions, time limits, distribution and collection of test booklets, procedures and mailing instructions.
The instrument was administered as a pretest during the fall, 1987 to the three group of students during their second week of classes. Upon completion of the testing process, testing materials were returned to the Department of Industrial Education and Technology at Iowa State University. The answer sheets were then submitted for scoring to the Center for Test and Evaluation at Iowa State University by the Project Director (Dugger, 1989).

The Technology Test was administered as a posttest during the spring, 1988 to the same group of students upon completion of their yearly instruction following the same procedures used in the pretest administration. Test materials were returned to the Project Director. At this time, answer sheets were once again scored by the Center for Test and Evaluation at Iowa State University.

Analysis of Data

The data were analyzed using the Statistical Package for the Social Sciences (Nie et al., 1983). There were two steps in the data analysis: (a) descriptive analysis and (b) statistical analysis. The descriptive analysis included frequency counts and percentages for the values of individual variables.

In step two, statistical analysis procedures were employed to test the null hypothesis. Analysis of covariance, solved by multiple regression, was the basic
analytical procedure used. The dependent variable was achievement scores. The independent variables were the treatment, and the covariates were: Pretest scores, grade level (11,12), gender, and high school enrollment size (small, medium, large). The analysis of covariance procedure was used to test the following null hypothesis:

**Null Hypothesis**

There are no significant differences in the adjusted posttest mean scores of first year Principles of Technology, Physics, and the control group as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]

\[ H_a: \mu_1 \neq \mu_2 \neq \mu_3 \]

A single asterisk (*) was used in the tables to denote significant differences at the .05 level, and a double asterisk (**) was used to denote significant differences at or beyond the .01 level of significance.
CHAPTER IV - RESULTS AND FINDINGS

The findings and statistical analyses are presented in this chapter. Data reported in this study were analyzed by a number of procedures: Frequencies, percentages, and crosstabulation, and analysis of covariance, solved by multiple regression. The results are discussed in the following sections: (a) Characteristics of the Sample, and (b) Statistical Analysis. The findings and interpretations which resulted from using the aforementioned statistical procedures are discussed in sequence. The Statistical Packages for the Social Sciences (SPSS*) was used to analyze the data.

Characteristics of the Sample

The information collected from six hundred sixty-seven (667) junior and senior high school students in the state of Iowa provided the data for this study. The distribution of their general characteristics are presented. Frequencies and crosstabulation procedures were used to report the results of the analyses for this section.

Group membership

The distribution of the subjects by group membership is shown in Table 1. Table 1 shows that the two major
groups of subjects were members of the Physics group (N = 266), and Principles of Technology group (N = 257).

TABLE 1. Group membership and percentage

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NUMBER</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles of Technology</td>
<td>257</td>
<td>38.5</td>
</tr>
<tr>
<td>Physics</td>
<td>266</td>
<td>39.9</td>
</tr>
<tr>
<td>Control</td>
<td>144</td>
<td>21.6</td>
</tr>
<tr>
<td>Total</td>
<td>667</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Gender

The distribution of the 667 subjects by gender is shown in Table 2. The table shows that 509 (76.3%) of the subjects were males, and 158 (23.7%) were females.

TABLE 2. Distribution of subjects by gender and percentage

<table>
<thead>
<tr>
<th>GENDER</th>
<th>NUMBER</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>509</td>
<td>76.3</td>
</tr>
<tr>
<td>Female</td>
<td>158</td>
<td>23.7</td>
</tr>
<tr>
<td>Total</td>
<td>667</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Grade level

As can be seen in Table 3, the number of subjects by grade level indicates that 262 (39.3%) of the subjects were juniors, and 405 (60.7%) were seniors.
TABLE 3. Distribution of subjects by grade level and percentage

<table>
<thead>
<tr>
<th>GRADE LEVEL</th>
<th>NUMBER</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior</td>
<td>262</td>
<td>39.3</td>
</tr>
<tr>
<td>Senior</td>
<td>405</td>
<td>60.7</td>
</tr>
<tr>
<td>Total</td>
<td>667</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The treatment groups used in the study were (a) first year Principles of Technology students and (b) Physics students. The Principles of Technology group consisted of 257 (38.5%) students who received first year Principles of Technology instruction during the 1987-1988 academic year. Within this group, 219 (85.2%) students were males and 38 (14.8%) were females.

A total of 126 (49.0%) of the students in this group were juniors, while 131 (51.0%) were seniors. The distribution of gender by grade level revealed that 109 (49.8%) of the male students in this group were juniors while 110 (50.2%) were seniors. Females in this group included 17 (44.7%) juniors and 21 (55.3%) seniors. Table 4 shows the distribution of first year Principles of Technology students by gender and grade level.
TABLE 4. Distribution of first year Principles of Technology students by gender, grade level, and percent

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>JUNIOR NUMBER (PCT)</th>
<th>SENIOR NUMBER (PCT)</th>
<th>TOTAL NUMBER (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>109 (86.5)</td>
<td>110 (84.0)</td>
<td>219 (85.2)</td>
</tr>
<tr>
<td>Female</td>
<td>17 (11.8)</td>
<td>21 (14.5)</td>
<td>38 (13.1)</td>
</tr>
<tr>
<td>Total</td>
<td>126 (49.0)</td>
<td>131 (51.0)</td>
<td>257 (100.0)</td>
</tr>
</tbody>
</table>

The Physics group consisted of 266 (39.9%) students. Students in this group received Physics instruction during the 1987-1988 academic year. Within the group, 156 (58.6%) of the students in this group were males while 110 (41.4%) were females.

There were 55 (20.7%) juniors in this group, and 211 (79.3%) seniors. Thirty-four (21.8) of the male students were juniors and 122 (78.2%) were seniors. Females included 21 (19.1%) juniors and 89 (80.9%) seniors. The distribution of Physics students by gender and grade level is shown in Table 5.
The control group consisted of 144 (21.6%) students who received industrial technology instruction (without Physics or Principles of Technology) during the 1987-1988 academic year. Within this group, 134 (93.1%) were male and 10 (6.9%) were female.

A total of 81 (56.3%) of the students were juniors, and 63 (43.8%) were seniors. The analysis revealed that 75 (56.0%) of the male students were juniors and 59 (44.0%) were seniors. Female students included 6 (60.0%) juniors and 4 (40.0%) seniors. Table 6 shows the distribution of the control group by gender and grade level.
### TABLE 6. Distribution of the control group by gender, grade level, and percent

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>JUNIOR NUMBER (PCT)</th>
<th>SENIOR NUMBER (PCT)</th>
<th>TOTAL NUMBER (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>34 (61.8)</td>
<td>122 (57.8)</td>
<td>156 (58.6)</td>
</tr>
<tr>
<td>Female</td>
<td>21 (38.2)</td>
<td>89 (42.2)</td>
<td>110 (41.4)</td>
</tr>
<tr>
<td>Total</td>
<td>55 (20.7)</td>
<td>211 (79.3)</td>
<td>266 (100.0)</td>
</tr>
</tbody>
</table>

Students from fifteen public high schools made up the sample used in the study. The high schools were: Bellevue, Collins-Maxwell, Dike, East Central, Hartley-Melvin, Lincoln Central, Mason City, Midland, Nevada, Sheldon, Sutherland, Tipton, Washington (Vinton), West Marshall, and Western Dubuque High Schools. The researcher obtained high school enrollment data from the Iowa State Department of Education (Gould, 1989). After close examination of the enrollment data, a decision was made by the researcher to group the schools based on small, medium, and large enrollments.

Twelve of the fifteen high schools were included in the study. Table 7 shows the number of high schools and percentage by size. The high school size categories were selected based on the following classification: High
schools with enrollment figures between 100 - 215 were coded 'small'. High schools with enrollment figures between 216 - 400 were coded 'medium'. High schools with enrollment figures 401 and above were coded 'large' (see Table 7).

**TABLE 7. Number and percentage of high schools by size**

<table>
<thead>
<tr>
<th>ENROLLMENT FIGURES</th>
<th>NUMBER OF SCHOOLS</th>
<th>PERCENTAGE BY SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 - 215 (small)</td>
<td>5</td>
<td>18.7</td>
</tr>
<tr>
<td>216 - 400 (medium)</td>
<td>4</td>
<td>24.7</td>
</tr>
<tr>
<td>401 - Above (large)</td>
<td>3</td>
<td>56.5</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 8 gives a summary of the number of subjects per group associated with high schools by size.

**TABLE 8. Distribution of subjects by group and school size by number and percent**

<table>
<thead>
<tr>
<th>SCHOOL SIZE</th>
<th>SMALL SCHOOLS (PCT)</th>
<th>MEDIUM SCHOOLS (PCT)</th>
<th>LARGE SCHOOLS (PCT)</th>
<th>TOTAL NUMBER (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles of Technology</td>
<td>57 (45.6)</td>
<td>73 (44.2)</td>
<td>127 (33.7)</td>
<td>257 (38.5)</td>
</tr>
<tr>
<td>Physics</td>
<td>46 (36.8)</td>
<td>70 (42.4)</td>
<td>150 (39.8)</td>
<td>266 (39.9)</td>
</tr>
</tbody>
</table>
### Statistical Analysis

The remainder of this chapter is organized into the following sections: a) statistical procedure used in testing the null hypothesis, b) research questions and null hypothesis tested, and c) a discussion of the results, along with tables summarizing the results of the analysis.

#### Pretest and Posttest Raw Score Means

Prior to testing the null hypothesis, the researcher used a t-test pairs procedure to test each group’s pretest and posttest raw score means. The researcher discovered that when the posttest arrived at some of the participating high schools, twelvth grade subjects had completed all requirements for the high school diploma and were not available for testing. As a result, some subjects in the **TABLE 8. (Continued)**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SMALL SCHOOLS (PCT)</th>
<th>MEDIUM SCHOOLS (PCT)</th>
<th>LARGE SCHOOLS (PCT)</th>
<th>TOTAL NUMBER (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>22 (17.6)</td>
<td>22 (13.3)</td>
<td>100 (26.5)</td>
<td>144 (21.6)</td>
</tr>
<tr>
<td>Total</td>
<td>125 (18.7)</td>
<td>165 (24.7)</td>
<td>377 (56.5)</td>
<td>667 (100.0)</td>
</tr>
</tbody>
</table>
sample were lost due to this event. To control for mortality, pretest scores for all subjects who did not take the posttest were also eliminated from this study.

The analysis revealed that the pretest mean (Mean = 45.26) and posttest mean (Mean = 79.22) for first year Principles of Technology students was highly significant beyond the .01 level of significance (t = -20.113, P = .000). In order to estimate the magnitude of the improvement (gain) accruing to first year Principles of Technology students as a result of Principles of Technology instruction, the difference between the adjusted posttest means for first year Principles of Technology and the control group (DIFF = 42.40) was divided by the standard deviation of the control group (9.78) to yield a z-score of 4.34 (Glass & Smith, 1979).

The area under a z-score of 4.34 is .4999, indicating a 49.99% improvement in basic physics concepts development associated with receiving first year Principles of Technology instruction. The number of subjects in this group was 141. The results from the analysis are shown in Table 9.
TABLE 9. Summary of means, standard deviation, and
adjusted posttest means for first year Principles
of Technology, Physics, and the control group

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>MEAN</th>
<th>SD</th>
<th>MEAN</th>
<th>SD</th>
<th>ADJUSTED POSTTEST MEANS</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prin of Technology</td>
<td>141</td>
<td>45.26</td>
<td>11.26</td>
<td>79.22</td>
<td>17.66</td>
<td>78.31</td>
<td>-20.11**</td>
</tr>
<tr>
<td>Physics</td>
<td>135</td>
<td>50.57</td>
<td>12.82</td>
<td>66.49</td>
<td>16.51</td>
<td>67.84</td>
<td>-8.20**</td>
</tr>
<tr>
<td>Control</td>
<td>81</td>
<td>37.78</td>
<td>8.62</td>
<td>36.55</td>
<td>9.78</td>
<td>35.91</td>
<td>0.41</td>
</tr>
</tbody>
</table>

**.01 Level of significance.

Physics students pretest and posttest raw score means were found to be highly significant beyond the .01 level of significance (t = -8.20, P = .000). The mean for the pretest (Mean = 50.57) and the posttest (Mean = 66.49) showed a gain of (DIFF = 15.92) points. The number of subjects in this group totaled 135 (see Table 9).

The control group pretest and posttest raw score means indicated no significant difference (t = .41, P = .682). The pretest mean (Mean = 37.78) and the posttest mean (Mean = 36.55) indicated that this group failed to increase their raw scores at the end of industrial technology instruction. The difference (DIFF = -1.23) indicated that subjects in this group obtained lower raw scores on the posttest than the pretest. There were 81 students in this group (see Table 9).
Analysis of Covariance

An analysis of covariance procedure, solved by multiple regression, was used to test posttest achievement differences, using the pretest scores, grade level (junior, senior), gender, and high school enrollment size (small, medium, large) as covariates to adjust for achievement differences.

The use of the analysis of covariance design is to control statistically any initial differences in the students which might have been present and which might confound differences between groups of students (Borg & Gall, 1983). Analysis of covariance was used to test the null hypothesis. The results are presented as they relate to each research question and null hypothesis in the study.

Research question 1

Is there a difference in the adjusted posttest mean scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group, as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates?
Null Hypothesis

There are no significant differences in the adjusted posttest mean scores of first year Principles of Technology students, Physics and the control group as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates.

\[ H_0: \mu_1 = \mu_2 = \mu_3 \]
\[ H_a: \mu_1 \neq \mu_2 \neq \mu_3 \]

Results Based on the results obtained from the analysis of covariance procedure, hypothesis 1 was rejected and found to be highly significant beyond the .01 level of significance \( (F (6, 350) = 65.195, P = .000) \).

There were significant differences in the adjusted posttest mean scores for first year Principles of Technology, Physics, and the control group, using pretest scores, grade level, gender, and high school enrollment size as covariates. The analysis for each individual covariate, however, indicated no significant differences using the covariates grade level (junior, senior), and gender in regards to the adjusted posttest achievement mean scores. A summary of the results can be seen in Table 10.
### TABLE 10. Analysis of covariance for the adjusted posttest means for first year Principles of Technology, Physics, and the control group

<table>
<thead>
<tr>
<th>SOURCES</th>
<th>SUM OF SQUARES</th>
<th>DF</th>
<th>MEAN SQUARE</th>
<th>F VALUE</th>
<th>PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>5114.33</td>
<td>4</td>
<td>1278.58</td>
<td>5.201</td>
<td>0.000**</td>
</tr>
<tr>
<td>Pretest</td>
<td>1795.19</td>
<td>1</td>
<td>1795.19</td>
<td>7.302</td>
<td>0.007**</td>
</tr>
<tr>
<td>Grade Level</td>
<td>0.18</td>
<td>1</td>
<td>0.18</td>
<td>0.001</td>
<td>0.978</td>
</tr>
<tr>
<td>Gender</td>
<td>8.15</td>
<td>1</td>
<td>8.15</td>
<td>0.033</td>
<td>0.856</td>
</tr>
<tr>
<td>Enrollment</td>
<td>3024.90</td>
<td>1</td>
<td>3024.90</td>
<td>12.304</td>
<td>0.001**</td>
</tr>
<tr>
<td>Main Effects</td>
<td>91051.18</td>
<td>2</td>
<td>45525.59</td>
<td>185.182</td>
<td>0.000**</td>
</tr>
<tr>
<td>Group</td>
<td>91051.18</td>
<td>2</td>
<td>45525.59</td>
<td>185.182</td>
<td>0.000**</td>
</tr>
<tr>
<td>Explained</td>
<td>96165.51</td>
<td>6</td>
<td>16027.59</td>
<td>65.19</td>
<td>0.000**</td>
</tr>
<tr>
<td>Residual</td>
<td>86044.68</td>
<td>350</td>
<td>245.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>182210.86</td>
<td>356</td>
<td>511.83</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**.01 Level of significance.

The covariates accounted for .03 percent of the variance in the adjusted posttest scores, the experimental treatment accounted for 48 percent of the variance, and all the various interaction combinations accounted for an additional .008 percent of the variance.

Two interaction equations were eliminated by the regression analysis. These were 1) the interaction of first year Principles of Technology X grade level, and 2) Physics X grade level. A summary of the regression
analysis of adjusted posttest means for first year Principles of Technology, Physics, and the control group can be seen in Table 11.

TABLE 11. Summary of Regression analysis of adjusted posttest means for first year Principles of Technology, Physics, and the control group

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>MULTIPLE R</th>
<th>R SQUARE CHANGE</th>
<th>REGRESSION COEFFICIENTS a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>.1675</td>
<td>.0281</td>
<td></td>
</tr>
<tr>
<td>Pretest scores</td>
<td></td>
<td></td>
<td>-.0202</td>
</tr>
<tr>
<td>Grade level</td>
<td></td>
<td></td>
<td>-.0517</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>-.0574</td>
</tr>
<tr>
<td>School size</td>
<td></td>
<td></td>
<td>-.0341</td>
</tr>
<tr>
<td>Group membership</td>
<td>.7265</td>
<td>.4797</td>
<td></td>
</tr>
<tr>
<td>Principles of Technology</td>
<td></td>
<td></td>
<td>-.0434</td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td></td>
<td>.7262</td>
</tr>
<tr>
<td>Interactions</td>
<td>.7321</td>
<td>.0082</td>
<td></td>
</tr>
<tr>
<td>Prin of Technology X pretest scores</td>
<td></td>
<td></td>
<td>.3380</td>
</tr>
<tr>
<td>Physics X pretest scores</td>
<td></td>
<td></td>
<td>-.0158</td>
</tr>
<tr>
<td>Prin of Technology X gender</td>
<td></td>
<td></td>
<td>-.0333</td>
</tr>
<tr>
<td>Physics X gender</td>
<td></td>
<td></td>
<td>-.0279</td>
</tr>
<tr>
<td>Prin of Technology X school size</td>
<td></td>
<td></td>
<td>-.0573</td>
</tr>
<tr>
<td>Physics X school size</td>
<td></td>
<td></td>
<td>.0057</td>
</tr>
<tr>
<td>Residual</td>
<td>.4840</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aStandardized regression coefficients from final equation.
After conducting a multiple comparison procedure, the \( t \) statistic indicated that the control group adjusted posttest mean was found to be significantly different from first year Principles of Technology \((t = 19.14, P < .01)\) and the Physics group adjusted posttest mean \((t = 14.28, P < .01)\). A significant difference was also found between first year Principles of Technology and Physics students with respect to adjusted posttest raw score means \((t = 5.4, P < .01)\). The results of the multiple comparison procedure are summarized in Table 12.

**TABLE 12. Summary of the multiple comparison procedure**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>ADJUSTED MEANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (Group 3)</td>
<td></td>
<td></td>
<td></td>
<td>35.91</td>
</tr>
<tr>
<td>Physics (Group 2)</td>
<td></td>
<td>*</td>
<td></td>
<td>67.84</td>
</tr>
<tr>
<td>Prin of Technology (Group 1)</td>
<td></td>
<td>*</td>
<td>*</td>
<td>78.31</td>
</tr>
</tbody>
</table>

*Note:* An asterisk (*) denotes pairs of groups significantly different at the .05 level.

**Research question 2**

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology,
Physics, and the control group, as measured by the Technology Test, by gender?

Results As can be seen in Table 10, the analysis of covariance procedure failed to show a significant difference between first year Principles of Technology, Physics, and the control group of students adjusted posttest achievement scores by gender ($F = 0.033, P = 0.856$). The posttest mean for Principles of Technology females was 74.81, whereas the posttest mean for Principles of Technology males was 80.00.

Females enrolled in Physics had a posttest mean of 64.29, and the males had a posttest mean of 66.49. The posttest mean for females in the control group was 34.67, and the posttest mean for males was 36.56. Table 13 shows the posttest means and standard deviation for first year Principles of Technology, Physics, and the control group by gender.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NUMBER</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles of Technology</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 13. (Continued)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NUMBER</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENDER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>74.81</td>
<td>15.23</td>
</tr>
<tr>
<td>Male</td>
<td>120</td>
<td>80.00</td>
<td>17.66</td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GENDER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>54</td>
<td>64.29</td>
<td>15.41</td>
</tr>
<tr>
<td>Male</td>
<td>81</td>
<td>66.49</td>
<td>16.51</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GENDER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>6</td>
<td>34.67</td>
<td>10.40</td>
</tr>
<tr>
<td>Male</td>
<td>72</td>
<td>36.56</td>
<td>9.79</td>
</tr>
</tbody>
</table>

Research question 3

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, students enrolled in Physics, and the control group, as measured by the Technology Test, by grade level?

Results Based on the findings from the analysis of covariance, there were no significant differences in the
adjusted posttest mean scores among first year Principles of Technology, Physics, and the control group by grade level ($F = .001$, $P = 0.978$). The results can be seen in Table 10.

The posttest mean for students in grade eleven and enrolled in Principles of Technology was 87.75, whereas the posttest mean for Principles of Technology seniors was 75.92. Students in grade eleven and enrolled in Physics had a posttest mean of 64.32, whereas the Physics seniors had a posttest mean of 67.45. The posttest mean for students in grade eleven in the control group was 39.11, and the posttest mean for the seniors was 33.03.

Table 14 shows the posttest means and standard deviation for first year Principles of Technology, Physics, and the control group by grade level (junior, senior).

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NUMBER</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles of Technology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRADE LEVEL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Research question 4

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group, as measured by the Technology Test by school enrollment size?

Results As shown in Table 10, there is a significant difference in the adjusted posttest achievement scores for first year Principles of Technology, Physics, and the
control group by school enrollment size \( (F = 12.30, P = 0.001) \). The posttest mean for students enrolled in first year Principles of Technology at small high schools was 83.46. For first year Principles of Technology students at medium and large high schools, the posttest means were 74.94 and 79.81 respectively.

Physics students at small high schools had a posttest mean of 60.16, whereas Physics students at medium and large high schools had posttest mean scores of 65.93 and 68.07 respectively. Students in the control group at small high schools had a posttest mean score of 39.60. Students in the control group at medium and large high schools had posttest mean scores of 39.22 and 35.33 respectively. Table 15 shows the means and standard deviation for first year Principles of Technology, Physics, and the control group by school enrollment size (small, medium, large).

| TABLE 15. Posttest means and standard deviation for first year Principles of Technology, Physics, and the control group by school size (small, medium, large) |
|-------------------------------|--------|--------|------------------|
| GROUP                         | NUMBER | MEAN   | STANDARD DEVIATION |
| Principles of Technology      |        |        |                  |
| SCHOOL SIZE                   |        |        |                  |
TABLE 15. (Continued)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NUMBER</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>28</td>
<td>83.46</td>
<td>18.04</td>
</tr>
<tr>
<td>Medium</td>
<td>38</td>
<td>74.95</td>
<td>21.34</td>
</tr>
<tr>
<td>Large</td>
<td>75</td>
<td>79.81</td>
<td>15.06</td>
</tr>
</tbody>
</table>

Physics

<table>
<thead>
<tr>
<th>SCHOOL SIZE</th>
<th>NUMBER</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>19</td>
<td>60.16</td>
<td>22.77</td>
</tr>
<tr>
<td>Medium</td>
<td>29</td>
<td>65.93</td>
<td>18.35</td>
</tr>
<tr>
<td>Large</td>
<td>87</td>
<td>68.07</td>
<td>13.96</td>
</tr>
</tbody>
</table>

Control

<table>
<thead>
<tr>
<th>SCHOOL SIZE</th>
<th>NUMBER</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>15</td>
<td>39.60</td>
<td>9.42</td>
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<tr>
<td>Medium</td>
<td>9</td>
<td>39.22</td>
<td>11.56</td>
</tr>
<tr>
<td>Large</td>
<td>57</td>
<td>35.33</td>
<td>9.51</td>
</tr>
</tbody>
</table>

Research question 5

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group, as measured by the Technology Test by grade level (junior, senior) and school size (small, medium, large)?

Results Results from the analysis of covariance procedure revealed a significant difference in the adjusted
posttest mean scores of first year Principles of Technology, Physics, and the control group by grade level and by school size (see Table 10). The analysis also revealed that the highest posttest mean score was obtained by a student enrolled in grade twelve and first year Principles of Technology at one of the 'small' high schools.

See Table 16 for a summary of the posttest means and standard deviation for first year Principles of Technology, Physics, and the control group by grade level (junior, senior) and school size (small, medium, large).

TABLE 16. Posttest means and standard deviation for first year Principles of Technology, Physics, and the control group by grade level (junior, senior) and school size (small, medium, large)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NUMBER</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles of Technology</td>
<td>SMALL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junior</td>
<td>27</td>
<td>83.00</td>
<td>78.92</td>
</tr>
<tr>
<td>Senior</td>
<td>1</td>
<td>96.00</td>
<td>0.00</td>
</tr>
<tr>
<td>GROUP</td>
<td>NUMBER</td>
<td>MEAN</td>
<td>STANDARD DEVIATION</td>
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<td></td>
</tr>
<tr>
<td>MEDIUM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junior</td>
<td>26</td>
<td>78.92</td>
<td>19.09</td>
</tr>
<tr>
<td>Senior</td>
<td>12</td>
<td>66.33</td>
<td>24.19</td>
</tr>
<tr>
<td>LARGE</td>
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<td></td>
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<tr>
<td>Junior</td>
<td>27</td>
<td>83.22</td>
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<tr>
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<td>48</td>
<td>77.90</td>
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<tr>
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<tr>
<td>Junior</td>
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<td>MEDIUM</td>
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<tr>
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<td>64.83</td>
<td>15.60</td>
</tr>
<tr>
<td>Senior</td>
<td>17</td>
<td>66.71</td>
<td>20.51</td>
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<tr>
<td>LARGE</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Junior</td>
<td>20</td>
<td>62.05</td>
<td>12.38</td>
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<tr>
<td>Senior</td>
<td>67</td>
<td>69.87</td>
<td>13.99</td>
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<tr>
<td>Junior</td>
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<td>Senior</td>
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<td>39.33</td>
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<td>MEAN</td>
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</tr>
<tr>
<td>MEDIUM</td>
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<tr>
<td>Junior</td>
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</tr>
<tr>
<td>Senior</td>
<td>0</td>
<td>00.00</td>
<td>00.00</td>
</tr>
<tr>
<td>LARGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junior</td>
<td>26</td>
<td>38.81</td>
<td>10.33</td>
</tr>
<tr>
<td>Senior</td>
<td>31</td>
<td>32.42</td>
<td>7.78</td>
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</table>
CHAPTER V - SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Principles of Technology is a recently developed applied physics curriculum in which physics concepts are taught in a laboratory environment using a unique content model. No broad based summative evaluation of this curriculum has been conducted in the state of Iowa.

This study was designed to obtain summative data in order to investigate the effects of first year Principles of Technology in learning basic physics concepts in industrial technology classes in Iowa's public High Schools. Achievement scores was the term used for the composite outcome of knowledge gained and the acquisition of the skills needed in the application of science and mathematics concepts.

A series of student variables such as group membership, gender, grade level (junior, senior), and school size (small, medium, large) were examined for 257 students in first year Principles of Technology, 266 in Physics and 144 in the control group.

The previous chapters included:

1. An introduction outlining the statement of the problem, the purpose of the study, the research questions and hypotheses, methodology, and the analysis techniques employed.
2. A review of literature pertaining to program evaluation, applied science and mathematics in industrial technology education, and a rationale for Principles of Technology in the industrial technology curriculum, and a summary.

3. The methodology used in conducting this research, the procedures followed, the sample selected, and the analysis of the data.

4. The findings as explained in narration and in tables.

The primary purposes of this chapter are to summarize the findings of this research study and draw basic conclusions supported by the findings. Finally, recommendations are presented based on the implications and conclusions of this study.

Restatement of the Problem

Principles of Technology is a recently developed applied physics curriculum in which physics concepts are taught in a laboratory environment using a unique content model. The overall problem of this study was that no broad based summative evaluation of this curriculum has been conducted in the state of Iowa.

This study was designed to obtain summative data to investigate the effects of first year Principles of
Technology in learning basic physics concepts in industrial technology classes in Iowa.

Restatement of the Purpose

The main purpose of this study was to obtain summative data in order to determine whether traditional physics or first year Principles of Technology instruction provided greater student achievement scores regarding basic physics concepts as measured by the Technology Test (see Appendix A).

More specifically, this study analyzed the data relative to whether gender, grade level (junior, senior) and/or school enrollment size (small, medium, large) had an impact on student achievement regarding basic physics concepts, between students enrolled in first year Principles of Technology and Physics classes in selected Iowa Public High Schools.

Conclusions

This section presents a summary and the conclusions of the study as they pertain to the research questions and null hypothesis. Each research question and hypothesis will be restated, followed by a conclusion and discussion based upon findings in Chapter IV.
Research question 1

Is there a difference in the adjusted posttest mean scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group, as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates?

Null Hypothesis

It was hypothesized that there are no significant differences in the adjusted posttest mean scores of first year Principles of Technology, Physics, and the control group as measured by the Technology Test, using pretest scores, grade level, gender, and high school enrollment size as covariates.

Conclusion of Null Hypothesis

An analysis of covariance procedure, solved by multiple regression, was performed to test the hypothesis. There were significant differences in the adjusted posttest mean scores beyond the .01 level of significance. Based on the findings presented in Table 10, the null hypotheses was rejected.

After controlling for initial differences (covariates), the posttest mean score for first year Principles of Technology students was adjusted down from (Mean = 79.22) to (Mean = 78.31), while the posttest mean score for Physics was adjusted up from (Mean = 66.49) to...
The control group's posttest mean was adjusted down from (Mean = 36.55) to (Mean = 35.91) (see Table 9). The results of the post-hoc comparison indicated significant differences in the adjusted posttest means for first year Principles of Technology and Physics students (see Table 11).

Research question 2

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test, by gender?

Conclusion and Discussion

Based on the findings presented in Table 10, there is no significant difference in the adjusted posttest achievement scores between students enrolled in first year Principles of Technology, Physics, and the control group by gender. Although the proportion of females (N = 21) to males (N = 120) was unequal in the first year Principles of Technology group, the analysis indicated that female (Mean = 74.81) students did not perform significantly different from male students. However, the males had a slightly higher mean (Mean = 80.00) than the females.

The proportion of females (N = 54) to males (N = 81) in the Physics group was also unequal. The females (Mean =
64.29) did not perform significantly different from the male students in this group (Mean = 66.49).

In the control group, the proportion of females (N = 6) to males (N = 72) was again unequal. Females in the control group had a posttest mean score of (Mean = 34.67), while the males in this group had a posttest mean score of (Mean = 36.56) (refer to Table 13).

Research question 3

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test by grade level?

Conclusion and Discussion Based upon findings presented in Table 10, it can be concluded that there is no significant difference in posttest mean scores between students enrolled in first year Principles of Technology, Physics, and the control group by grade level (junior, senior). Overall, the highest posttest mean score came from students enrolled in first year Principles of Technology and in grade eleven (Mean = 81.75).

The next highest posttest mean score came from students enrolled in first year Principles of Technology and in grade twelve (Mean = 75.92). A summary of the
posttest means and standard deviation for each group can be found in Table 14.

Research question 4

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test by school enrollment size?

Conclusion and Discussion Based upon the results reported in Table 10, it was concluded that there is a significant difference in posttest achievement scores between students enrolled in first year Principles of Technology, Physics, and the control group according to school size (small, medium, large). The highest posttest mean score came from the 'small' high school students enrolled in first year Principles of Technology (Mean = 83.46).

It was also found that the first year Principles of Technology students at medium (Mean = 74.95) and large (Mean = 79.81) achieved higher posttest mean scores that Physics students at small (Mean = 60.16), medium (Mean = 65.93) and large schools (Mean = 68.07) (refer to Table 15).
Research question 5

Is there a difference in the adjusted posttest achievement scores regarding basic physics concepts between students enrolled in first year Principles of Technology, Physics, and the control group as measured by the Technology Test by grade level (junior, senior) and school size (small, medium, large)?

Conclusion and Discussion It was concluded, based upon the findings reported in Table 10, that there is a significant difference in posttest achievement scores between students enrolled in first year Principles of Technology, Physics, and the control group according to grade level (junior, senior) and school size (small, medium, large). The highest posttest score came from: 1) a student enrolled in first year Principles of Technology, 2) in grade twelve, and 3) attending a small high school (Mean = 96.00).

See Table 16 for a summary of the posttest means and standard deviation for each group according to grade level (junior, senior), and school enrollment size (small, medium, large).

Summary

The conclusions relating to the findings of this study have been presented in this chapter. The stated null hypothesis was rejected and found to be significant beyond
the .01 level of significance. Adjusted posttest achievement scores for the three groups were found to be different for three of the five stated research questions.

Author's Commentary

Based on the findings of this research, the author believes that student achievement in Principles of Technology is probably not limited to students with vast amounts of science and mathematics skills. It is the author's opinion that the Principles of Technology techniques utilized has both relevance and application to other technology courses.

Principles of Technology strengthens applied science and mathematics, as well as laboratory hands-on skills. The author also believes that enrollment in the Principles of Technology curriculum aids the student in becoming technologically literate.

Limitations of the Study

The study was conducted under the following limitations:

1. The population was limited to students attending selected Iowa public high schools participating in the assessment of Principles of Technology.

2. There was no random selection or random assignment of subjects to groups. The research design was limited to the use of the non-equivalent control group design.
3. The test instrument (Technology Test) was used as a paper and pencil test used in the assessment of achievement regarding the acquisition of applied concepts.

Recommendations

The findings and conclusions of this study generated the basis for the following recommendations. The recommendations are presented in two parts. The first part contains recommendations based on the researcher's observations; the second offers recommendations for further research related to this study.

Recommendations based on Researcher's Observations

1. There is a need for educational equity in Principles of Technology programs offered across Iowa. Female enrollment in these programs is not proportionate to male enrollment at this time. It is recommended that all high schools offering Principles of Technology make a commitment to recruit female students into Principles of Technology by making them aware of the options available in technology and by encouraging them to enroll in Principles of Technology.

2. High school mathematics and science requirements have increased throughout the United States. A major cause for this increase is that 'technology'
requires the practical application of these concepts. It is recommended that Principles of Technology credits be awarded as an option to satisfying mathematics or science requirements for the high school diploma.

3. It is recommended that teacher preparation programs in Iowa address Principles of Technology when attempting to meet certification requirements for Industrial Technology Education.

4. High schools must reflect changes in curriculum based on technological changes to meet industrial practices. It is recommended that Principles of Technology become a prominent part of Iowa’s Industrial Technology Education programs.

5. It is recommended that funding and support from federal, state, and local administrators be given to all school districts in Iowa towards the implementation of Principles of Technology. It is further recommended that school districts collaborate with industry (local, state wide) to obtain additional funding and support for their Principles of Technology programs.

6. It is recommended that all educators of Principles of Technology participate in Principles of Technology conferences and workshops to interact
and exchange ideas on a scheduled basis. This concept may be critical to the continued success of Principles of Technology in Iowa.

7. It is recommended that Principles of Technology ideas be infused in all Industrial Technology Education programs in Iowa. It is further recommended that school districts in Iowa initiate in-service to retrain all Industrial Technology teachers in the state.

**Recommendations for Further Study**

The following recommendations for further study are made to strengthen and expand the data collected in this study:

1. A follow-up study of graduates from first year Principles of Technology programs in Iowa should be conducted to identify their progress and impact resulting from enrollment in Principle of Technology.

2. A similar study can be conducted to cover a different geographical area. Further studies need to be conducted to see whether the findings in this study can be generalized to other populations beyond the state of Iowa.

3. This study can be conducted using a different
combination of student characteristics variables for a determination of student achievement in Principles of Technology. Some suggested variables are: 1) quality of instruction, 2) prior industrial technology classes, 3) level of motivation, and 4) cumulative grade point average.

4. This study can be conducted using Principles of Technology educators in an effort to see how their perceptions about teaching Principles of Technology compare with teaching regular Industrial Technology Education classes.

5. It is recommended that a study of this nature be done on a national level using all high schools with Principles of Technology.


Center for Implementing Technology Education. (1986). *Technology education activities*. Department of Industry and Technology. Muncie: Ball State University.


Center for Occupational Research and Development. (1985). *Principles of technology*. Waco: CORD.


The Iowa High School Industrial Technology Curriculum Project. (1986). Des Moines, IA: Iowa Department of Public Instruction.


ACKNOWLEDGMENTS

I wish to express my sincere gratitude to the many individuals who have been instrumental in assisting me in the completion of this research and consequently my doctoral program at Iowa State University.

First, sincere appreciation is given to the members of the Graduate Committee: Dr. Donald J. McKay, Dr. William D. Wolansky, Dr. Clifford Smith, Dr. William Paige, Dr. Trevor Howe, and Dr. John Riley. I thank each of you for your support and guidance during my studies at Iowa State University.

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Special thanks to family members for all their moral support and patience during my educational endeavors at Iowa State; especially Willie and Matilda Hall for being the best parents a person could have (I love you both). To my brothers and sisters, thanks for your everlasting willingness to listen to my problems and your words of encouragement.

Bruce, thanks for all your love, support, and faith during this period of my life. To all my special friends, too numerous to name, thanks for lending an ear or shoulder whenever I needed it.
Appreciation is also extended to Drs. Charles Ramsey, Michael Boatwright, and George A. Jackson. Thanks for all the support and words of encouragement throughout my entire stay in Ames, Iowa.

Finally, I give thanks to God for his guidance throughout the dissertation process. Continue to be with me and bless everyone mentioned above.
APPENDIX A:

TECHNOLOGY TEST
**DIRECTIONS**

Before you begin, make certain that you have the following:
1. Two sharpened #2 pencils
2. An answer sheet
3. A copy of the test

Complete the student information portion of the answer sheet as shown in the example on the right.

---

**BIRTH DATE**

- **MO.**
- **DAY**
- **YR.**
- **A**
- **B**
- **C**
- **D**
- **E**
- **F**
- **G**
- **H**
- **I**
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- **K**
- **L**
- **M**
- **N**

- **Jan.**
- **Feb.**
- **Mar.**
- **Apr.**
- **May**
- **Jun.**
- **Jul.**
- **Aug.**
- **Sep.**
- **Oct.**
- **Nov.**
- **Dec.**

**IDENTIFICATION NUMBER**

- **A**
- **B**
- **C**
- **D**
- **E**
- **F**
- **G**
- **H**
- **I**
- **J**
- **K**
- **L**
- **M**

**SPECIAL CC**

- **A**
- **B**
- **C**
- **D**
- **E**
- **F**
- **G**
- **H**
- **I**
- **J**
- **K**
- **L**
- **M**

---

**NAME (Last, First, M.I.)**

---

**DO NOT TURN THIS PAGE UNTIL YOUR TEACHER TELLS YOU TO BEGIN!**
Directions: Darken the circle that corresponds to the best answer.

1. A fluid system which does work and reuses the same fluid is which type of fluid system?
   a. closed
   b. renewable
   c. open
   d. shut

2. The unit of electrical work is:
   a. ampere
   b. coulomb
   c. volt
   d. joule

3. A circle contains 360° or ____ radians.
   a. $2\pi$
   b. 6.28
   c. either a or b
   d. neither a or b

4. In a thermal system, the transferred energy is ____.
   a. heat
   b. temperature
   c. temperature difference
   d. degrees

5. How many radians are there in 30 degrees?
   a. 0.52
   b. 1.00
   c. 1.91
   d. 9.55

6. The water pressure at a depth of 100 ft. would be:
   (The weight density of water is $\rho_w = 62.4 \text{ lb./ft}^3$ use formula $P = \rho_w gh$)
   a. 43.3 P.S.I.
   b. 62.4 P.S.I.
   c. 6240 lb/ft²
   d. both a and c
7. The unit of frequency, which indicates the number of cycles per second of an AC source, is the:
   a. electrons
   b. ampere
   c. ohm
   d. hertz

8. In rational energy systems, the force-like quantity is called:
   a. scalar
   b. pneumatic
   c. torque
   d. linear

9. How much work, in N-m, is done by a 90 Newton force displacing a load ten meters?
   a. .11
   b. 80
   c. 100
   d. 900

10. A hydraulic cylinder creates a fluid pressure difference of 80,000 N/m² displacing a volume of 0.00012 cubic meters. How many joules of work did it do?
    a. 6.66
    b. 9.6
    c. 12
    d. 19.2

11. When using the System International (SI) measuring system, mechanical force is measured in:
    a. Newtons
    b. Newtons per square meter (N/m²)
    c. pounds
    d. pounds per square foot (lb/ft²)

12. The direction that electron current travels is from:
    a. positive to negative
    b. right to left
    c. left to right
    d. negative to positive

13. "Rate" in a fluid energy system may be:
    a. mass flow (m/t)
    b. current (q/t)
    c. heat flow per elapsed time (H/t)
    d. angular speed (θ/t)
14. Heat added to a substance that causes a change in temperature but no change in the state of the substance is called _________.
   a. latent heat
   b. calories
   c. sensible heat
   d. heat flow

15. A 500 lb wood box is moved along a level concrete floor with a force of 100 lbs. What is the coefficient of friction?
   a. 0.2
   b. 5.0
   c. 600
   d. 50,000

16. A current of 5.2 amperes flows through a 38 ohm resistor. The voltage drop across the resistor is ________ volts.
   a. 197.6
   b. 7.3
   c. 0.14
   d. 0.014

17. Thermal resistance in a material does not depend upon the materials _______.
   a. thickness
   b. area
   c. finish
   d. thermal conductivity

18. When a mechanical, fluid, electrical or thermal system has energy:
   a. the energy is always in the form of heat energy
   b. the energy is always converted to useful work with an efficiency of 100%
   c. all of the energy can be used by the system to do work
   d. the total amount of energy will not change

19. Which of the following statements is false?
   a. When work is done in a system, energy is given to the system.
   b. When a system has energy, part of that energy may be given to another system.
   c. When work is done on a system, only potential energy can be given to the system.
   d. When we expend (use) energy to do work, the work we do may result in a different form of energy.
20. If a 200 lb barbell is lifted a distance of 7 ft. in a constant motion that takes 1.5 sec. How much power would this require in ft lb/sec?
   a. 103.5
   b. 933.3
   c. 35
   d. 14.3

21. The power used by a gasoline pump to raise 63 lbs. of water a distance of 15 ft. each minute is ______ ft·lb/sec.
   a. 56,700
   b. 945
   c. 63
   d. 15.75

22. A 60 watt lamp bulb operating on 110 volts draws a current of ____ amps of current. (Power = Force \times Rate) (P = V \times I)
   a. 0.545
   b. 5.45
   c. 6.6
   d. 66

23. Force is best defined as:
   a. a scalar quantity
   b. a push or pull by one object on another
   c. something that is measured only in degrees
   d. a mass

24. The density of gold is 19.3 gm/cm³. What is the specific gravity of gold?
   a. 19.3 gm³
   b. 19.3 cm
   c. 19.3
   d. not enough information

25. A thermocouple is a device that relates a temperature change to a measurable physical change. The physical change is:
   a. length of solid material
   b. electrical property of a material
   c. temperature, °F as compared to °C.
   d. temperature, °C as compared to °F.

26. An electric stove changes electrical energy mostly into ____ energy.
   a. sound
   b. heat
   c. light
   d. mechanical
27. The difference between angular speed and angular velocity is:
   a. speed is measured in rpm and velocity is measured in radians
   b. speed is revolutions divided by time and velocity is revolutions divided by time in a direction
   c. one is metric and one is English
   d. the number of decimal points is the answer

28. "Rate" in electrical energy systems may be:
   a. mass flow (m/t)
   b. current (q/t)
   c. heat flow per elapsed time (H/t)
   d. angular speed (θ/t)

29. One British thermal unit (BTU) is the amount of heat required to raise the temperature of _____ by one degree Fahrenheit.
   a. 1 gram of water
   b. 1 degree
   c. 1 pound of water
   d. 10 kg of water

30. The pressure drop across a 25-ft. water hose and a 50-ft. water hose is found to be the same. The resistance of the 50-ft. hose is twice that of the 25-ft. hose. The flow rate in the 50-ft. hose must be ____ that of the 25 ft. hose.
   a. twice
   b. the same as
   c. one-half
   d. four times

31. Thermal resistance is the opposition to the flow of ____ energy.
   a. heat
   b. electric
   c. sonic
   d. nuclear

32. A force pushes on an object, causing it to pick up speed as it moves along a horizontal surface. Assume that friction is zero. The kinetic energy of the object may be determined completely by measuring:
   a. the work done by the force to move an object
   b. the speed of the object
   c. the moment of inertia of the object
   d. the density and volume of the object

33. An example of rotational kinetic energy is:
   a. water stored behind a dam
   b. a pendulum at the bottom of its swing
   c. a stretched scale spring
   d. a flywheel that is spinning
34. In the "English system" power can be expressed in ____.  
   a. ft·lb/sec 
   b. ft·lb 
   c. N·m/sec 
   d. hp/sec 

35. In a fluid system, the equation \( P = p \times \Delta v \) illustrates _________.  
   a. pressure = work x rate 
   b. power = pressure x "force" 
   c. pressure = power x work 
   d. power = "force" x rate 

36. A 470 volt source is put across a 4700\( \Omega \) resistive load. What is the power delivered to the load? (\( I = \frac{V}{R} \), \( P = V \times I \)) 
   a. 10 watts 
   b. 47 N·m 
   c. 470 J/sec 
   d. 47 watts 

37. A torque wrench has a lever arm of 0.5 meters. A force of 20 Newtons is applied to the end of the wrench to tighten a bolt. The torque applied is ______ N·m.  
   a. 0.025 
   b. 4.0 
   c. 10 
   d. 40 

38. Your normal body temperature is 98.6° F. If your body temperature was 37° C it would be:  
   Remember \( T^\circ C = \frac{5}{9} (T^\circ F - 32) \)  
   a. too high 
   b. normal 
   c. too low 
   d. not enough information 

39. A weight lifter raises a 125 lb. weight 6 feet. How much work is performed by the weight lifter? 
   a. 20.8 ft·lbs 
   b. 20.8 lb·ft 
   c. 750 ft·lbs 
   d. 750 lb·ft
40. The rate of movement of electrical charge is measured in:
   a. amperes
   b. coulombs
   c. Joules
   d. volts

41. The thermal cooling rate of a heated object is dependent on which of the following factors.
   a. surface area
   b. temperature difference
   c. material thickness
   d. all of the above

42. Glass is classified as an electrical:
   a. insulator
   b. semi conductor
   c. conductor
   d. resistor

43. The potential energy of an object:
   a. increases when its speed increases
   b. changes when its position or shape changes
   c. does not change
   d. decreases with increasing height

44. An inductor has an inductance of 8 henries and draws 15 amps of current. What amount of energy is stored by the inductor? Remember: \( E_p = \frac{L(I)^2}{2} \)
   a. 900 J
   b. 1800 J
   c. 600 J
   d. 300 J

45. Power in electrical systems obeys the unifying equations of work divided by time and ______.
   a. work x time
   b. force x rate
   c. force divided by rate
   d. work divided by force

46. The density of a substance is defined as:
   a. the mass of that substance divided by the volume of that substance
   b. the area of that substance times the mass of that substance
   c. the mass of that substance times the volume of that substance
   d. the area of that substance divided by the volume of that substance
47. Temperature:
   a. is a scalar quantity
   b. is a measure of molecular motion
   c. depends on the presence of absence of heat
   d. all of the above

48. The wheels on a car, from a stop, reach a top rotational speed of 8000 rpm in 2 minutes. What is the angular acceleration in revolutions/minute?

   a. 16000
   b. 8000
   c. 4000
   d. 2000

49. Given a 120 volt heating element which operates at 30 amps, find the quantity of electric charge that goes through the heater during 10 seconds, in coulombs. \( I = \frac{q}{t} \)

   a. 30
   b. 300
   c. 1200
   d. 3600

50. "Starting" friction is also called:

   a. normal
   b. kinetic
   c. static
   d. sliding

51. Fluid resistance in a pipe does not depend upon:

   a. the pipe's length
   b. the pipe's cross-sectional area
   c. the pipe's pressure
   d. the viscosity of fluid in the pipe

52. An example of translational kinetic energy is:

   a. water stored behind a dam
   b. a pendulum at the bottom of its swing
   c. a stretched scale spring
   d. a flywheel that is spinning

53. The change in the potential energy of an object may be found by measuring:

   a. the elastic constant, \( k \), and the object's speed
   b. the work done to raise the object some height above a reference level
   c. the horizontal distance the object moves in a given time
   d. the mass and speed of the object
54. Which of the following is the formula for calculating rotational mechanical power?
   a. \( P = V(q/t) \)
   b. \( P = p(v/t) \)
   c. \( P = F(D/t) \)
   d. \( P = T(\theta/t) \)

55. Mechanical ______ is the rate at which work is done when a force or torque causes the object to move.
   a. work
   b. energy
   c. motion
   d. power

56. The electric meter used by the power company to measure the amount of electricity consumed is actually a/an _________.
   a. voltmeter
   b. ammeter
   c. ohmmeter
   d. electric motor

57. A physical quantity that has both magnitude and direction is called:
   a. scalar
   b. mass
   c. net force
   d. vector

58. The efficiency of a machine can be described as:
   a. distance output/compared to distance input
   b. how well a machine performs
   c. energy input compared to distance output
   d. energy output/compared to work input

59. A forty-five degree (45°) angle is equal to:
   a. \( \pi/4 \) radians
   b. \( \pi \) radians
   c. \( 2\pi \) radians
   d. \( \pi/2 \) radians

60. One coulomb is equal to an electric charge of:
   a. one ampere
   b. \( 6.25 \times 10^{18} \) electrons
   c. one volt
   d. \( 18 \times 10^6 \) electrons
61. A flywheel spinning clockwise completes 180 revolutions in 10 minutes. Its average angular velocity is ______ rad/sec.
   a. 0.30 
   b. 1.88 
   c. 3.00 
   d. 18.0 

62. Given a measured current of 10 amps. How many coulombs per second flows in the circuit?
   a. 10 
   b. 600 
   c. 6 
   d. none of the above 

63. Most thermal systems use a ____ to regulate the amount of heat within a system.
   a. carburetor 
   b. spark plug 
   c. thermostat 
   d. water pump 

64. Two resistors $R_1$ and $R_2$ are connected in series. If $R_1$ is 40 ohms and $R_2$ is 72 ohms, the total resistance ($R_{total}$) of the circuit is ____ ohms.
   a. 1.8 
   b. 25.7 
   c. 32 
   d. 112 

65. Doubling the R-factor of insulation means that thermal resistance of the insulation _________.
   a. doubles 
   b. stays the same 
   c. decreases by one-half 
   d. increases by one-half 

66. The kinetic energy of an object:
   a. is energy of motion 
   b. cannot be used to do work on another object 
   c. is present in a stretched spring that is not moving 
   d. is always equal to the potential energy of the object 

67. In order to calculate the power produced by a hydraulic lift, ____ must be known or found.
   a. fluid density and pressure 
   b. volume of fluid and pressure 
   c. applied pressure, volume of fluid displaced and time for displacement to occur 
   d. fluid pressure, weight of load, and fluid displaced
68. An automobile tire gage reads 30 PSI, (lb/in^2), at sea level. Inside the tire, the trapped air pushes outward on each square inch of tire wall with a force of 44.7 lbs. This 44.7 PSI is:
   a. gage pressure
   b. atmospheric pressure
   c. buoyant force
   d. absolute pressure

69. The gravitational force acting on a 20 kg mass is found by ___ the mass by 9.8 m/sec^2.
   a. dividing
   b. multiplying
   c. adding
   d. subtracting

70. Work is measured when the pressure difference is ___ the volume of fluid displaced.
   a. added to
   b. multiplied by
   c. divided by
   d. subtracted from

71. An electric radiator fan of a car is activated for 2 minutes (120 seconds) and draws a current of 5 amps at a voltage of 12 volts. Find the quantity of charge moved in coulombs. (q = I x t)
   a. 10
   b. 120
   c. 600
   d. 7200

72. A grocery store milk cooler pumps 8.00 kg of Freon through the system in 12.0 minutes. What is the mass-flow rate of the Freon in kg/min?
   a. 96
   b. 4.0
   c. 1.5
   d. 0.67

73. Fluid resistance of a pipe or duct affects both:
   a. flow rate & viscosity
   b. viscosity & net force
   c. flow rate & pressure drop along the pipe
   d. pressure drop & density

74. Thermal resistance is defined as the opposition to:
   a. physical change
   b. the flow of voltage
   c. the flow of current
   d. the flow of thermal energy
Potential energy in electrical systems is stored:

a. When charge flows through an electrical device
b. When a voltage drop occurs across a resistor in a circuit
c. When positive and negative charges are separated from one another in a capacitor
d. When a battery is discharged

Which system uses the equation \[ P = \frac{(\Delta P) \times V}{t} \] for determining power?

a. mechanical
b. fluid
c. electrical
d. thermal

Electrical energy consumption is measured in _______.

a. N\cdot m
b. Joules/sec
c. watts
d. kilowatt-hours

A scalar quantity has:

a. vector
b. direction and speed
c. magnitude only
d. time and angle

A DC current:

a. is needed to operate most appliances
b. moves back and forth in the wires
c. always moves in one direction
d. both a and b are correct

A change in temperature (\(\Delta T\)) would be noted as:

a. \(\circ F\)
b. \(\circ C\)
c. \(\circ F\)
d. \(\circ C\)

By the technical definition of work, which of the activities below is not considered work?

a. moving an I-beam
b. holding an engine with a rope hoist
c. moving water with a pump
d. drilling a hole with an electric drill
82. A student will need the following to measure flow rate of liquid flowing from a pipe:
   a. a graduated cylinder and pressure gage
   b. a one gallon bucket and stop watch
   c. a scale and a gallon bucket
   d. a clock and a calculator

83. A building has a thermal resistance (R_T) of 0.02 C° per (kcal/hr). What is the building's heat-flow rate (Q_H) when the temperature difference (ΔT) from inside to outside is 46 C°, in Kcal/hr?  \[ R_T = \frac{\Delta T}{Q_H} \]
   a. 0.92
   b. 2300
   c. 0.0004
   d. 8300

84. The thermal conductivity (k) for a given material has a constant value. It depends on ________.
   a. the thickness of the material
   b. the type of material
   c. the temperature difference across the material
   d. the surface area of the material

85. A 1180 kg automobile strikes a barrier with a speed of 60 mph (26.8 meters/sec). How much kinetic energy did the automobile possess in M*m? (Remember: \( E_K = \frac{1}{2} m v^2 \))
   a. 115,813
   b. 231,624
   c. 423,762
   d. 848,231

86. Which of the following could be directly operated by fluid power?
   a. a light bulb
   b. an internal combustion engine
   c. airplane landing gear
   d. a microwave oven

87. Voltage is considered a force like quantity because it:
   a. is an electronic storage medium used to hold the monitor program and user programs
   b. forces the conductors to move
   c. moves electrons through a circuit and acts as a prime mover
   d. is not found in electrical circuits
88. In a fluid system, work is done because of a ____ difference.
   a. volume
   b. viscosity
   c. color
   d. pressure

89. Low thermal conductivity in a material means the material is a/an:
   a. insulating material
   b. porous material
   c. conductor material
   d. block material

90. Fluid resistance increases as flow becomes:
   a. turbulent
   b. laminar
   c. both a and b
   d. neither a or b

91. An object has 2000 ft-lb of potential energy at a height 20 ft. By the
   conservation of energy law, this would mean the object possesses ____ as
   it falls past the 5 ft. height above the ground.
   a. 2000 ft-lb of kinetic energy
   b. 2000 ft-lb of potential energy
   c. 1500 ft-lb of potential energy and 500 ft-lb of kinetic energy
   d. 1500 ft-lb of kinetic energy and 500 ft-lb of potential energy

92. An electric motor has a shaft-torque of 3 lb-ft. It has a rotational speed of 1750 rpm. What is the shaft power of the motor in ft-lb/sec?
   (Remember: \( P = T \times \omega / t \))
   a. 5250
   b. 549.5
   c. 87.5
   d. 50.2

93. Which of the following can not be used as voltmeter?
   a. VOM
   b. ohmmeter
   c. digital multimeter
   d. oscilloscope

94. The rate at which a hydraulic cylinder moves is determined by:
   a. the length of the cylinder
   b. the weight limit of the cylinder
   c. the piston area
   d. the flow rate of the fluid used
95. A motorcycle engine runs at top efficiency with 40 pound-feet of torque at 3600 revolutions per minute. How many foot pounds of work is performed by the engine in one minute? ($\pi = 3.14$ exact)

a. 90
b. 960
c. 144,000
d. 904,320

96. "Change of state" is an important principle used in the operation of a

a. radio
b. television
c. refrigerator
d. radiator

97. An electric motor changes electrical energy mostly into______ energy.

a. sound
b. heat
c. light
d. mechanical

98. "Resistance" generated by a solid moving through a fluid is known as:

a. pressure
b. force
c. drag
d. lift

99. What is the fluid resistance ($R_F$) in a pipe when the flow rate ($Q_v$) is 54 gal/min and the pressure difference ($\Delta P$) across the pipe length is 5 lb/in$^2$. (hint: $R_F = \frac{\Delta P}{Q_v}$)

a. $10.8 \frac{\text{lb}}{\text{in}^2} \frac{\text{gal}}{\text{min}}$
b. $10.8 \frac{\text{gal}}{\text{min}} \frac{\text{lb}}{\text{in}^2}$
c. $0.09 \frac{\text{lb}}{\text{in}^2} \frac{\text{gal}}{\text{min}}$
d. $0.09 \frac{\text{gal}}{\text{min}} \frac{\text{lb}}{\text{in}^2}$

100. An example of "gravitational potential energy" is:

a. water stored behind a dam
b. a pendulum at the bottom of its swing
c. a stretched scale spring
d. a flywheel that is spinning
101. The law of conservation of energy implies that:
   a. potential and kinetic energy are always completely changed to useful work
   b. the total energy of a system remains constant, if all forms of energy are considered
   c. losses do not occur when energy is converted from one form to another
   d. all heat energy is wasted

102. Which of the following is correct formulas for finding fluid power?
   a. $P = p \times Q_v$
   b. $P = \frac{W}{t}$
   c. $P = p \times V$
   d. a and b

103. If 24 grams of oil flows by a point in 0.2 seconds, the mass flow rate, in gm/sec, is _____.
   a. 120 gm/sec
   b. 48 gm/sec
   c. 24 gm/sec
   d. 4.8 gm/sec

104. Electrical power is equal to _____ multiplied by current.
   a. amperage
   b. watts
   c. newton
   d. voltage

105. The amount of electrical charge that flows through a conductor in a unit of time is called the:
   a. force
   b. rate
   c. work
   d. resistance

106. A 24 volt source is placed across two resistors in parallel. If the resistors have values of 10 ohms and 15 ohms, the total current flow will be _____ amperes.
   a. 600
   b. 12
   c. 4.0
   d. 0.96
107. The amount of inertia of a body describes how its ____ is distributed around a specified axis of rotation.

a. mass  
b. kinetic energy  
c. rotational speed  
d. potential energy

108. The term "capacitance" refers to:

a. how much charge is stored per unit of voltage across the plates  
b. the total voltage across the plates  
c. how much voltage is developed between the plates per unit of current through them  
d. a capacitor's ability to control current surge

109. Electrical power can be described correctly in all of the following units except _____.

a. joules/sec  
b. watts  
c. volts x amps  
d. kilowatt hour

110. How much potential energy is stored in a capacitor rated at 20 microfarads (20 x 10^-6 F) when the voltage difference is 100 volts? (Remember: \( E_p = \frac{C(\Delta V)^2}{2} \))

a. 0.10 joules  
b. 10.0 joules  
c. 100.0 coulomb volts  
d. 0.01 coulomb volts

111. Static friction is always ____ kinetic friction.

a. greater than  
b. less than  
c. equal to  
d. less than or equal to

112. In the SI system, power can be expressed in ______.

a. J/sec  
b. N·m/sec  
c. watts  
d. all of the above

113. What is the symbol in SI and the English System for electrical resistance, \( R \)?

a. \( \pi \)  
b. \( R \)  
c. \( I \)  
d. \( \Omega \)
114. A force of 25 Newtons is needed to keep a piston moving at a speed of 0.5 meters per second. The power of the piston is \[ P = F \times \frac{D}{t} \] (Remember \[ P = F \times \frac{D}{t} \]).

a. 25.0 J/sec  
b. 50.0 hp  
c. 25.0 N\cdot m/sec  
d. 12.5 J/sec

115. What effect will connecting pipes in parallel have on fluid resistance?

a. fluid resistance remains unchanged  
b. fluid resistance increases  
c. fluid resistance decreases  
d. not enough information given

116. "Inductance" is measured in units of:

a. ohms  
b. henries  
c. farads  
d. watts

117. Torque can best be described as:

a. work  
b. ft\cdot lb of work  
c. rotating force-like quantity  
d. linear force

118. A dragster starting from rest, reaches a top speed of 100 mph. What is its average speed, in mph, during the run?

a. 100  
b. 70  
c. 50  
d. 40

119. The English unit of heat energy in a thermal system is _____.

a. rad  
b. BTU  
c. candles  
d. vector

120. An AC current changes direction at the rate of 3000 times per minute. (1500 alternations per min.) The frequency of the circuit is \[ \frac{1}{3000} \] hertz.

a. 25  
b. 50  
c. 3000  
d. 1/3000
APPENDIX B:

PEDAGOGICAL CONTENT MODEL
## BREAKDOWN OF UNIT 1: FORCE

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T-1b
APPENDIX C:

EVALUATION MODEL
CURRICULUM EVALUATION MODEL

Implement new curriculum at a limited number of selected sites

Develop unit or periodic test appropriate for content covered

Administer tests at all sites and collect & analyze data

Use analysis to prepare a comprehensive course test

Administer comprehensive course as a pre and post test to appropriate groups

Analyze and report results to all interested parties
APPENDIX D:

LETTERS OF CORRESPONDENCE
July 1, 1987

Dear Name2:

High schools that have requested and/or received funding for the "Principles of Technology" program are being contacted by Iowa State University to secure permission to test an instrument developed for use with this program. This instrument will require approximately 90 minutes of the student's time near the beginning of the school year and the same amount of time near the end.

The Assessment Project staff requests that three groups of students be made available to take the 90 minute pretest and the 90 minute posttest. These groups include:

1. Students enrolled in the first year of the "Principles of Technology"

2. A group with similar characteristics (ITED scores, male-female ratio, etc.).

3. Students enrolled in any physics class.

The primary purpose of this research effort is to determine how well the principals of technology program objectives are being addressed in Iowa schools. This letter seeks to identify the probability of securing permission to administer the two tests to the groups identified and to determine the procedure that must be followed to secure permission. Please complete the enclosed form and return in the envelope provided by July 24, 1987.

Thank you for your help in this attempt to improve the educational experiences of Iowa Students.

Sincerely,

Terry R. Smith, Director
Iowa Vocational Assessment System

TRS:jj

Enc.
1. Please correct or complete the following:

School:__________________________________________

Address:________________________________________

__________________________________________

School Phone Number:_________________________

Superintendent:_______________________________

Principal:____________________________________

Principles of Technology Teacher:________________

2. The Principles of Technology...... (please check one of the following)

   ___ will be taught during the fall of 1987.
   ___ will not be taught.

3. --- It is possible... to obtain permission to administer the tests mentioned in the letter.

   --- It is not possible...

4. Please list the procedure that must be used to secure permission if question three indicates a possibility of testing.

Signature_____________________________________

Title_______________________________________
Expected enrollments: (indicate number for each)
A. Principles of Technology________
B. Physics____
C. Other____
Signature________________________
Title____________________________

Note: Tests and permission slips will be mailed before August 31, 1987

SAMPLE PERMISSION SLIP
(please make corrections)

Dear parent or guardian:

Parents of selected students attending ___________ High School are requested to provide permission for their child to take two multiple-choice tests during the 1987-88 school year. Testing will occur during certain science or industrial technology classes.

The purpose of this research effort is to determine how well the Principles of Technology program objectives are being addressed in Iowa schools. This program consists of a 90 minute pretest at the beginning of the school year and a 90 minute post-test at the end of the year. We feel the information gathered will result in better educational programs for Iowa students. Individual scores will be kept confidential.

If you have any questions concerning this project, please call (515) 294-8341. Thank you for your help in this effort.

Principal's Signature:________________________

Name of student:____________________________

Please check one:

___ My child has permission

___ My child does not have permission

Signature of parent____________________________

Date________________________
DATE: May 12, 1988

TO: Principles of Technology Year One Testing Sites

FROM: John Dugger

Enclosed please find test instructions, answer sheets, and tests for the three groups of students. The number of copies provided is based on information that your school has provided.

The attached sheet provides instructions for those teachers who will be administering the test. Please use the same procedure followed last fall.

Thank you again for agreeing to participate in the testing of the Principles of Technology.

JD/pam
jd009

Enclosure
1. Count the tests and answer sheets in your packet and make certain the correct number has been provided. (Call 294-8341 or 294-2870 if you need more tests or have questions.)

2. Obtain a supply of No. 2 pencils.

3. On the day of the test, announce the following:
   a. It is important that you (the students) do your own work for this test. It is designed to determine what you know about certain technology and science ideas. (Distribute the answer sheets)

   NOTE: Color scheme for distribution of answer sheets:
   - Principles of Technology - Green
   - Physics students - Purple
   - Control group - Red

   b. When you get the test, do not turn the page until told to do so. (Distribute tests by placing the booklet in front of each student.)

   c. Look at the top page and use the example to complete the personal information on your answer sheet.

   (When all students have finished this section, allow them to begin the test. Record the starting time.)

   NOTE: If testing exceeds one class, collect all answer sheets and tests and redistribute the following class day. Once 90 minutes of testing is reached, collect all answer sheets and assemble with answer sheets from other classes. All answer sheets should be returned in the envelope provided by June 3, 1988.

4. Destroy all copies of the test booklet.

Thank you.
APPENDIX E:

PERMISSION FORM
Dear parent or guardian:

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If you have any questions concerning this project, please call Dr. John Bugger (515) 294-8341. Thank you for your help in this effort.

Principal's Signature: ________________________________

Name of student: __________________________________

Please check one:    ______ My child has permission    ______ My child does not have permission

Signature of parent: ____________________________     Date ____________________