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PRINCIPLES OF TECHNOLOGY TEACHER COMPETENCY PROFILE

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled PRINCIPLES OF TECHNOLOGY TEACHER COMPETENCY PROFILE, submitted by Peter B. Hansen, in partial fulfillment of the requirements for the degree of Master of Education in Vocational Education.

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DEDICATION

This thesis is dedicated to my wife Rachel, who sacrificed much during the course of the research. Her loving support, encouragement, and words of wisdom helped me to ensure that this study could be successfully completed.

ABSTRACT

The major purpose of this study was to validate a modified DACUM profile of the competencies required of a teacher selected to teach Principles of Technology at the secondary school level. Secondary objectives of the study were: to have Principles of Technology teachers in the United States review and modify a revised Principles of Technology teacher competency profile; to determine the competencies required of a teacher of Principles of Technology through analysis of a validated competency profile; and to construct a recommended Principles of Technology teacher competency profile.

Two instruments were used to collect data for analysis in this study: (a) a two-page questionnaire, which was designed to collect demographic data from study participants; and (b) a revised Principles of Technology teacher competency profile. The revised profile comprised 15 general areas of competence encompassing a total of 162 specific competency statements. The instruments were mailed to a random sample of 20 urban and rural Principles of Technology teachers in the United States. This sample was taken from a population of all Principles of Technology teachers in the United States.

Of the 20 instruments posted, 14 were returned for a return rate of 70%. An analysis of the demographic data revealed that the average Principles of Technology teacher surveyed taught in an urban setting; had taught Principles of Technology since the implementation of the course in 1985; possessed a minimum of a bachelor's degree; had work experience in a trade, technical, business, medical/chemical, or teaching environment prior to teaching Principles of Technology; had completed from one to four mathematics and one to four physics courses while an undergraduate student; and had learned how to teach Principles of Technology from on-the-job experience, Principles of Technology teacher training workshops, and through undergraduate studies.

The results of the study found that 7/15 (46.7%) of the bands on the revised teacher competency profile needed revision. These changes included the addition of eight new competency statements, and revisions to the wording of two competency statements. Changes to each band are highlighted on the recommended Principles of Technology teacher competency profile through shading of the new or revised competency statement(s).

The study concludes with several recommendations made to selected educational groups in the province and with the observations that were made while the research was being conducted.

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The assistance of the Curriculum Design Branch, Alberta Education is very much appreciated as well. In particular, the researcher would like to thank Mr. J. Pallas for his invaluable cooperation during the course of this study.

The researcher thanks Alberta Principles of Technology teachers Les Kiffiak and Craig Donaldson for their insight and assistance during the pilot study phase of the research. Much of the credit for the recommended Principles of Technology teacher competency profile belongs to them.

Without the cooperation of vocational education administrators in the United States and their Principles of Technology teachers the study would not have been possible. The author would like to acknowledge these professionals for their cooperation.

The author would also like to thank personnel from The Training Group who assisted in the production of the competency profiles. The contributions of Robert Buffel and Janet Toma are especially recognized.

A considerable amount of library research was required to lay the foundation for this study. The assistance provided by the librarians of the H. T. Coutts Library of the University of Alberta, and the librarians of the Northern Alberta Institute of Technology, is acknowledged.

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The Problem

Introduction

In recent years secondary school vocational education has laboured under a considerable amount of pressure for change. Indeed, some school administrators have been questioning the viability of vocational education courses at the secondary school level. This has resulted in considerable debate among vocational and other educators regarding the justification for and content of secondary school vocational education programs. Perry (1989), for example, noted that "at least 43 states [in the United States] in the past four years have re-examined their vocational education policies" (p. 128). Four key factors have helped initiate this intensive re-evaluation of secondary school vocational education: (a) the "back to basics" movement, sparked by the 1983 report A Nation at Risk on the status of the American public school system (National Commission for Excellence in Education, 1983); (b) the call for technological literacy; (c) emphasis on "generic", or transferable work skill development; and (d) vocational education's dismal record of keeping pace with technological change.

In response to these pressures, school administrators from state, provincial, and local school jurisdictions looked for ways to improve their secondary school vocational education programs to meet the challenges posed by the reform movement of the 1980s. Between 1983 and 1985 a consortium was formed by 33 provincial and state educational agencies to pilot-test and implement a senior high school course called "Principles of Technology" (PT) (Agency for Instructional Technology [AIT], 1985a). Principles of Technology is a secondary school vocational education course which concentrates on the principles, not specifics, of technology. The course was designed to academically challenge students while simultaneously providing them with the opportunity to learn fundamental concepts and principles related to modern technology. According to Jordan (1986), the course can be described as "physics and math in work clothes" (p. 40) because of its unique application of scientific and mathematical principles to problem-solving.

A major difficulty that secondary school vocational educators have faced has been the selection of the Principles of Technology teacher. These employers have had no standard reference to assess the specific qualifications of potential teachers of Principles of Technology. Those responsible for the design of the Principles of Technology course recommended that the teacher selected to teach Principles of Technology should be "a vocational teacher with industrial experience and a strong background (two or three college courses) in physics." (AIT, 1985a, p. 7). These developers were aware that "this type of person is atypical and, in most instances, alternate selections must be made" (AIT, 1985a, p. 7). It is evident from the material emanating from AIT that teachers with different types of backgrounds may be suitable to teach Principles of Technology. Nowhere have the developers of PT or the implementing agencies made an effort to delineate the competencies required by a teacher who will teach Principles of Technology.

Problem Statement

An accurate and concise identification of the competencies required of a Principles of Technology teacher has not been undertaken nor reported in the literature that reports the findings of educational research.

The major problem of this research was to validate a modified DACUM[1] chart which illustrates the competencies required of a teacher selected to teach Principles of Technology at the secondary school level.

Supporting Objectives

The major problem of this study had the following supporting objectives:

1. to have selected, practicing Principles of Technology teachers from member agencies of the consortium serve as members of a team to validate the revised Principles of Technology teacher competency profile.
2. to modify the competency profile by incorporating the recommendations made by the members of the validation team to produce a recommended Principles of Technology teacher competency profile.

Need for the Study

The primary factor which helped establish the need for this study was the lack of available published information on the competencies required of a teacher assigned to teach the Principles of Technology. A review of the literature indicated that there has been some effort directed toward the identification of vocational education teacher competencies, which is related to this investigation.

Duenk (1987) reported the essential components of an off-campus vocational education teacher certificated program as consisting of: (a) an introduction to vocational/ technical education; (b) methods of teaching vocational subjects; (c) laboratory management; (d) curriculum development in vocational/ technical education; and (e) evaluation in vocational/ technical edu-

[1]DACUM is a contraction of Developing a Curriculum. The DACUM process is fully described in Chapter 2. This description is provided for the benefit of the reader.

cation. Specific teacher competencies were then developed from these broad categories of instruction. Principles of Technology teacher competencies were neither identified nor discussed.

Norton (1987) described the work of the National Center for Research in Vocational Education (NCRVE), based in Columbus, Ohio in developing and implementing vocational education teacher training materials. The NCRVE employed the efforts of approximately 1000 vocational education instructors, supervisors, and teacher trainers in the identification and verification of 384 teacher competencies at both the secondary and postsecondary school levels. Principles of Technology teacher competencies were not directly identified in this listing, although there were similarities between the competencies required by these two types of teachers.

Vocational education teachers with science (and specifically physics) and mathematics backgrounds were recommended as potential teachers of the Principles of Technology course (Hammer & Thode, 1989; McKinney & Kohan, 1986; AIT, 1985a). The specific competencies required by a teacher to teach PT have not been identified by the agencies that developed the course or in the literature that reports the findings of educational research.

The void of data on PT teacher competencies could be partially attributed to the fact that the curriculum for Principles of Technology was designed by non-educational agencies and that it is a relatively new course; the program was first implemented during the 1985-1986 school year in several schools of members of the consortium, both in the United States and in Canada. Additionally, educational researchers have not made any serious attempts to accurately identify competencies that are required of a teacher to successfully teach Principles of Technology. This helped establish a need for the study.

The researcher noted that in the five years the course had been implemented the research efforts to identify Principles of Technology teacher competencies by either the developers of the PT course materials, or by those who implemented the course were nonexistent. Secondly, the researcher found that a concise description of technology teacher competencies, in the form of a Principles of Technology teacher competency profile, or a listing of competencies for these teachers, did not exist. Finally, it was observed that school administrators who were implementing the PT course were experiencing difficulty in assigning teachers with the appropriate qualifications and background to teach Principles of Technology. Donaldson (personal communication, 1990) attributed this to the shortage of objective data to assist in this task.

The above reasons helped to establish a need for the study.

Significance of the Study

Preliminary research completed to provide background information for this study showed that neither a listing nor a profile of competencies required by teachers of Principles of Technology existed. At the conclusion of this study, when the recommended competencies of a teacher of Principles of Technology have been identified and charted, the profile should have significance for:

1. teachers who have been identified or selected to teach Principles of Technology. These individuals may find it helpful to compare the competencies they possess against those on the profile to identify competencies where they were deficient and initiate remedial action so they can more effectively and efficiently teach the course content.
2. those responsible for the implementation and administration of the Principles of Technology in a school jurisdiction. These school

administrators may find the recommended profile useful as a model to compare the competencies on the chart with the competencies of candidates selected to teach Principles of Technology.

3. teacher education program planners, who may have responsibility for preparing PT teachers. These individuals might find the recommended profile useful as they design and develop a program of study to prepare Principles of Technology teachers.
4. the curriculum developers of Principles of Technology (the Center for Occupational Research and Development [CORD], and AIT). A Principles of Technology teacher competency profile will enable these agencies to more effectively describe the competencies that are needed by a PT teacher to prospective (or existing) member agencies of the consortium. The profile may also prove to be helpful for determining the content of inservice teacher training workshops that either agency may wish to conduct.

Limitations of the Study

This study was limited to:

1. those teachers, both urban and rural, in consortia schools in states of the United States, who were responsible for teaching the Principles of Technology. No other teachers were involved in the research.
2. the recommended competencies listed on the Principles of Technology profile identified by teachers in participating schools, which are not generalizable to teachers in other schools.
3. the ability of participants in consortia schools to validate and accurately interpret, with complete understanding, the general areas of competence and the competency statements that form the bands on the profile they

were asked to validate. Other teaching competencies required of a teacher do not appear on the profile nor were they included as part of this investigation.

4. another limitation was the ability of those involved in the study to identify from bands on the chart competencies that were required to teach Principles of Technology.
5. a final limitation was the ability of the researcher to correctly understand and interpret all of the comments made by validators on the revised competency profile to initiate modifications for the recommended profile.

Definition of Terms

Operational definitions are used for terms that appear throughout the study. These terms are defined so that the reader develops a common understanding with the researcher for the context in which the term is used in the research. These terms are study specific.

Competencies: valuable accomplishments for which an employer or customer is willing to pay; consist of a complete unit of work performed on the job; may be broken down into several procedural steps; represent a typical assignment given to a worker on the job; result in a finished product or service or change in the work environment (Blank, 1982).

Some researchers go to great lengths to differentiate between terms such as "job tasks", "competencies", "worker skills", or "operations", while others are content to use these terms synonymously. Blank (1982) contends that "Whether you use the term 'task' or any other term is really unimportant. The key to effective program planning is how these outcomes are identified, stated, and learned - not what they are called" (p. 60). For the purposes of this study, the terms "competency" and "competencies" will be used exclusively to describe worker skills within the three domains of learning.

Competency Profile: a competency profile is defined as a modified form of a DACUM chart which graphically illustrates the general areas of competence and the competencies that are necessary for successful Principles of Technology teacher performance. A profile consists of several bands, with a band consisting of a single general area of competence and from 3 to 30 specific competency statements. For the purposes of this study, the terms "chart", "profile", and "competency profile" will be used interchangeably.

NOTE: The competency profile used in the study is referred to with descriptive names throughout the report, depending on the phase of the research in which it is being used. To help clarify its status during the various phases of the research, the following profile descriptors will be used:

(a) The "Initial" Profile

This term will be used for the competency profile developed solely by the researcher to begin data collection.

(b) The "Revised" Profile

The profile after modification following the recommendations made by Principles of Technology teachers in Alberta during the pilot test.

(c) The "Recommended" Profile

The profile after changes suggested by United States Principles of Technology teachers have been evaluated and incorporated in the final draft of the profile.

Competency Statements: statements which describe the competencies required for successful completion of a general area of competence. These statements may describe simple physical actions to sophisticated processes like problem-solving; they always reflect what is actually done on the job under typical working conditions (Mitchell, 1983b). Competency statements are introduced with an action word (verb), have an object that receives the action, and may or may not contain qualifiers (Blank, 1982).

General Areas of Competence: broad categories of employee responsibility; they serve as broad headings under which related competencies can be organized (Mitchell, 1983b).

Principles of Technology: a secondary school vocational technology education course which explores the fundamental principles of technological systems, from a mechanical, electrical, fluidal, and thermal perspective (AIT, 1985b).

Principles of Technology Teacher: A secondary school teacher assigned to teach Principles of Technology.

Validator: a Principles of Technology teacher who will validate general areas of competence and competency statements on a competency profile by reviewing, confirming, refuting, or modifying, and if necessary identifying missing competencies to be added to the profile. "Validate" here does not refer to the classical definition of validation as those responsible for instrument design might use the term. Validation of a DACUM chart is part of a process that leads to a competency profile being placed in the hands of an instructional designer for organizing course content.

Population and Sample

The population for this study consisted of all practicing secondary school Principles of Technology teachers in selected member states of the United States that were part of the consortium that financed the project. To identify states for participation in the study a random selection was taken from a mailing list of consortia representatives obtained from the coordinator of Principles of Technology, Curriculum Design Branch, Alberta Education. The list, published in 1986, included the names, titles, and addresses of state and provincial vocational education coordinators and teachers who formed the consortium of agencies which funded the Principles of Technology project. This list was chosen for two reasons: first, it was readily accessible to the researcher, and second, it provided names and addresses of individuals who could help identify Principles of Technology teachers who could serve on the profile validation team.

A stratified random selection of twelve Principles of Technology consortium agencies was taken from the mailing list for participation in the study. To perform this selection, the researcher arbitrarily divided the agencies identified on the list into small, medium, and large K-12 school enrollments, based on school enrollment data for the 1980-1981 school year. "Small" school enrollments were considered by the writer as those state or provincial agencies having up to 400,000 students; "medium" school enrollments consisted of those states or provinces enrolling 400,001 to 1,000,000 pupils; "large" school enrollments were those listing more than 1,000,001 students. All states and provinces identified on the 1986 Principles of Technology consortia member list were stratified using these criteria and became eligible for participation in the study, with the exception of Alberta. Alberta was excluded because the Principles of Technology teachers in that province participated in the pilot study.

To perform the random selection of vocational education coordinators, the researcher separated all of the state and provincial educational agencies on the list into three groups: small, medium, and large school enrollments. Four educational agencies were randomly selected from each of the three groups, for a total of 12 agencies. All of these agencies were located in states of the United States.

The vocational education coordinator in each of the 12 states was requested to provide the researcher with the names of two practicing Principles of Technology teachers in that state to serve as validators of the revised PT teacher competency profile. This would have created a sample of 24 PT teachers from 12 states. Because two states were unable to participate in the study, the sample of PT teachers was reduced to 20 in 10 states. Complete details of how these teachers were involved in the investigation can be found in the section labeled "Methodology".

Instrumentation

Two instruments were used in this study to collect data. The first instrument was a two page questionnaire designed to collect demographic data from the participants. The revised Principles of Technology teacher competency profile, which is a modification of a DACUM chart, formed the second instrument. How each instrument was developed is described in the following paragraphs.

The two page questionnaire was developed by the researcher after reviewing the works of Moore (1983), Sax (1979), Oppenheim (1966), and Rummel (1964). From that review, the researcher learned the procedures to be followed to design, develop, and evaluate a research instrument, including how to: (a) word questions to ensure clarity and reliability; (b) design open ended and closed ended questions; (c) sequence questions appropriately; and (d) ensure the professional appearance of the instrument. The researcher also learned from this review that mailed questionnaires have inherent advantages and disadvantages. The low cost, ease of handling and processing, consistency (each respondent receives the same set of questions exactly the same way), ease of contacting a specific person, the assurance of anonymity, the relative ease of sampling a large number of respondents, and absence of interviewer bias were the chief advantages of the mailed questionnaire. The most serious weakness of this type of instrument stems from the possibility of a poor response rate (Rummel, 1964). Oppenheim (1966) notes that response rates for a questionnaire often fall somewhere between 40 and 60 percent, and claims that the figure seldom exceeds 80 percent. Sax (1979), on the other hand, states that it is possible to improve response rates through the use of appropriately worded reminders, in the form of follow-up letters or telephone calls. Other weaknesses of a mailed instrument include: it must be very easy to complete; it is a very impersonal form of data collection, which offends some; it suffers from a total lack of control over how it is completed (it may not necessarily be completed in the order anticipated by the researcher, which may introduce some bias); respondents may not actually complete the questionnaire, but pass it on to someone else for completion (thereby confounding the validity of the findings); or, respondents may not be able to complete the questionnaire properly.

The second instrument developed was a modified DACUM profile of Principles of Technology teacher competencies. DACUM is a contraction of Developing A Curriculum, a type of occupational analysis system frequently used in vocational and technical education to identify instructional content of an occupation to be taught (National Network for Curriculum Coordination in Vocational and Technical Education, 1988). DACUM chart development is normally a group process, in which a skilled DACUM coordinator guides a selection of practitioners from a specific occupational area through activities required to build a chart referred to as a competency profile. A DACUM chart, or competency profile, consists of "bands", each of which includes a single general area of competence, and any number of competency statements. Bands on a DACUM chart are seen as a row of horizontal rectangles of two different sizes. The larger rectangles represent general areas of competence; these are followed by smaller rectangles which contain competency statements. There are commonly 8 to 12 general areas of competence on a DACUM chart, with 6 to 30 competency statements for each general area of competence (Norton. 1985).

The Principles of Technology teacher competency profile was developed by the researcher following a thorough review of the DACUM profile development procedure. Because it was financially impossible for the researcher to form a DACUM committee of Principles of Technology teachers in the United States, the decision was made that the researcher would develop the initial profile. This profile was used in the pilot study as described in the section labeled "Pilot Study". The initial profile was developed from a content analysis of Principles of Technology textual materials, as well as analyzing supplemental instructional material used in the course. To identify additional competencies for the initial profile, the researcher reviewed these learning resources: (a) Principles of Technology support materials; (b) articles from the professional literature that were directed at Principles of Technology; and (c) three related DACUM charts for vocational/ industrial teacher/ administrators (Norton, 1987; Norton & Harrington, 1987; Ontario Institute for Studies in Education, 1986). See Appendix A page 137 for a list of vocational education teacher competencies developed by the National Center for Research in Vocational Education.

Finally, the researcher was able to formulate other competencies from interviews and work with Principles of Technology teachers, and from personal experience teaching several Principles of Technology classes in a school where the course was being implemented.

After general areas of competence had been identified, they were grouped together with competency statements to form bands on the initial Principles of Technology teacher competency profile. The overall arrangement of the general areas of competence and the competency statements within the bands of the profile was based on whether or not a particular sequence of teaching duties appeared in the texts and learning resources. If a sequence of teaching duties was deduced, the competency statements within a general area of competence were arranged to correlate with that sequence. If no sequence of teaching duties was evident, the researcher organized general areas of competence and competency statements according to the arrangement illustrated on other competency profiles, or by logical deduction. The pocket on the inside back cover of this report contains a copy of the initial profile.

Since the questionnaire and the Principles of Technology teacher competency profile were of an untested design, a pilot study was conducted.

Pilot Study

For the pilot study, the questionnaire and the initial Principles of Technology teacher competency profile were reviewed by selected teachers in Alberta who were responsible for teaching Principles of Technology. These teachers were excluded from the major data collection phase of the research. These teachers were chosen because of their teaching experience with Principles of Technology and their accessibility to the researcher.

The major purposes of the pilot study were to determine:

1. If the instructions for the questionnaire and the profile were explicit and easy for the participants to follow;

2. If the competency statements were properly phrased;
3. If the competencies required of a Principles of Technology teacher were adequately represented on the profile;
4. If revisions were necessary to the questionnaire, the profile, or to the instructions that were to be used with the validators;
5. If there were any ambiguous or unnecessary statements on the profile; and
6. The amount of time it took to complete the validation of the profile.

To identify Principles of Technology teachers who could participate in the pilot study, the researcher collaborated with personnel from the Curriculum Design Branch, Alberta Education. Two PT teachers who met the following criteria were nominated for participation in the pilot test: (a) must be a practicing PT teacher in the province; (b) must demonstrate a commitment to the success of the course in the school system; and (c) must have been a participant in the project since 1984. Teachers who met these criteria were contacted by telephone to request their cooperation in the research by reviewing the initial competency profile. Both teachers agreed to participate in the pilot study. Each pilot study teacher was mailed a research package that included a covering letter, the questionnaire, the initial profile of PT teacher competencies, and a stamped, self-addressed return envelope. The purpose of the covering letter was to explain the role of the participant in the research, and to request they report the length of time it took for them to complete the questionnaire and review and modify the profile. Since both teachers returned the pilot test materials by the deadline date, a follow-up procedure was not employed. The time frame from initial mailing to return of the instruments ranged from three to six days.

Following receipt of the questionnaires and the initial competency profiles, the researcher reviewed each instrument to determine if changes were necessary in the materials. Both instruments were modified according to the recommendations made by those teachers who participated. Some of the questions on the questionnaire were refined to more adequately gather the required data, and the directions for completion of the instrument were clarified. The profile itself was modified extensively, going from 10 bands of 82 competency statements on the initial profile to 15 bands encompassing 162 competency statements on the revised profile. Minor changes in the wording or sequence of some competency statements were also incorporated into the revised profile, which was used for the main study. A copy of the revised profile can be found in the pocket on the inside back cover of this report.

Pilot study participants indicated that the minimum amount of time needed to complete the instruments was 40 minutes, while the maximum was 60 minutes. Using these two extreme time limits, the researcher established an average time of 50 minutes as the time needed to complete the research materials.

Methodology

The following methodology was used to collect data for analysis and bring the study to a successful conclusion.

To collect data for the literature review and instrument development, the researcher conducted a library search using both manual and electronic means.

While conducting the literature review, the following reference materials were consulted: The Education Index, The Canadian Education Index, The Alberta Education Index, Resources in Vocational Education, Technical

Education Abstracts, Dissertation Abstracts, Education Theses, and selected government documents. In addition, the following computer based databases were used: Vocational Education Curriculum Materials (VECM), Applied Science and Technology Index (ASTI), Canadian Business and Current Affairs (CBCA), The Education Resources Information Center (NEW ERIC), The Ontario Education Resources Database (ONED), Dissertation Abstracts (DISS), and Resources in Vocational Education (RIVE). NEW ERIC was searched using the SPIRES network at The University of Alberta, while ONED, DISS, and RIVE were searched using the Bibliographic Retrieval System (BRS) information technologies database.

Key words were used to conduct the search of both ERIC and NEW ERIC databases. These key words were obtained from the Thesaurus of ERIC Descriptors (Oryx Press, 11th Ed., 1987). The following keywords were used to identify published information related to this study: Vocational Education; Technical Education; Secondary Education; Teaching Skills; Pretechnology Programs; Technological Literacy; Technological Advancement; Emerging Occupations; Futures (of Society); Science and Society. In addition, the term "Principles of Technology" was used as a search item, as both an identifier and a title. The computer database searches yielded 398 hits, of which 76 were selected for use in this study.

The instruments used to collect data for the study were the two-page questionnaire and the revised Principles of Technology teacher competency profile. The development of these instruments is fully described in the section labeled "Instrumentation". The questionnaire and the initial competency profile were pilot tested with secondary school teachers in Alberta responsible for teaching Principles of Technology prior to being used with PT teachers in the United States who served as profile validators.

To identify the research sample the writer corresponded by mail with the 12 selected state consortia member vocational education administrators to ask them to cooperate in the study by identifying two outstanding Principles of Technology teachers in their state who might serve as validators for the Principles of Technology teacher competency profile. Identification of the 12 states selected for the main study is fully described in the section entitled "Population and Sample". The letter additionally requested that these administrators provide the researcher with the names and addresses of the individuals they would nominate as potential members of the validation team and return the information by the deadline date stated in the letter. The researcher assured the 12 consortia member administrators that the information collected would guarantee anonymity for the research sample, and that all research information would be destroyed upon completion of the study. The writer also guaranteed that research ethics would be strictly adhered to throughout all phases of the study, and that participants could withdraw from the study at any time without prejudice. A copy of this letter can be found in Appendix B, page 141. A telephone follow-up procedure was employed two weeks after initial mailing of the letter to increase the rate of return.

All 12 state vocational education administrators responded to the request for PT teacher names and addresses. Of the 12 states contacted, one was unable to participate in the study, and a second state was dropped from the research by the writer. The state vocational education administrator from New Jersey explained that it would be impossible to identify PT teachers in that state because he had no idea which schools were actually teaching the course. He stated that participation in Principles of Technology by New Jersey schools was strictly voluntary; individual school principals had freedom to choose whether or not to offer the course. This state educational administrator claimed that it would therefore be impossible for him to identify two outstanding PT teachers in New Jersey, and that the state would have to withdraw from the study. The state vocational education administrator in Mississippi, on the other hand, claimed that his state no longer used the PT curriculum materials. Mississippi had instead taken the original Principles of Technology materials and used them as a basis for the development of a state course in technology education called "Diversified Technology". Since this major modification of the PT curriculum had taken place, and the state was no longer a member of the consortium, the researcher made the decision that these teachers would not be as able to contribute accurate information on PT teacher competencies and were thus excluded from the study.

All of the ten remaining state vocational education administrators identified a minimum of two Principles of Technology teachers they considered to be outstanding PT teachers. (A complete listing of the states which were contacted during the study can be found in Appendix C, page 144.) This resulted in a total of 20 teachers nominated to serve as validators of the revised profile of PT teacher competencies. In some cases the state administrators identified five or six nominees to serve as PT teacher competency profile validators. In these cases the researcher selected the first two teacher names that appeared in the list.

The 20 teachers nominated to become validators of the revised competency profile were contacted through correspondence and asked to participate in the study by completing the two research instruments. The researcher prepared a covering letter to explain to the participants their role in the study, and to request their cooperation by completing the questionnaire and validating the revised PT teacher competency profile. The letter was accompanied by a questionnaire, a revised Principles of Technology teacher competency profile, directions on how to validate the profile, and a self-addressed stamped envelope for return of the completed questionnaire and profile. Included in the content of the letter was a deadline date for the return of the profile and questionnaire. Copies of this correspondence can be found in Appendix D, page 148.

The research instruments were mailed to PT teachers in the United States during the latter part of May 1990. By June 30, 10 of the 20 teachers (or 50% of the research sample) returned completed instruments. Since the school year ended June 15th, it was not possible to immediately employ a follow-up procedure with the 10 remaining delinquent teachers. The shorter school year in the United States may have contributed to the moderate rate of return. A second reason may have been that Principles of Technology teachers were probably in the process of establishing final grades for students and closing their classes and laboratories for the year when the instruments arrived.

In late August 1990 the researcher mailed a second set of materials to these 10 teachers in an attempt to collect data. The research package mailed to these individuals was identical to the first, with the exception that the cover letter had been modified. A copy of this letter can be found in Appendix E, page 154. Included in the cover letter was a revised deadline date for return of the completed materials. Four teachers responded to this follow-up request.

In total, 14/20 (70%) of the teachers contacted returned completed instruments. Of these teachers, 11 (78.6%) were from urban environments, and 3 (21.4%) were from rural settings.

Analysis of the Data

Returned questionnaires and profiles were reviewed by the researcher to determine their completeness and were divided into either a rural or an urban grouping, based on the responses on the questionnaire. Each question on the questionnaires was analyzed for completeness. Profiles were examined for modifications, additions, and/or deletions recommended by members of the validation team. Three evaluation criteria were established to determine the number and type of modifications needed to be made to the profile. These criteria were: (a) at least one-fifth (20%) of the respondents had to agree on the suggested change; (b) any safety-related changes were considered important enough to warrant immediate adoption; and (c) any obvious omissions from the Principles of Technology teaching methodology or instructional materials were similarly considered to be important enough to be adopted without challenge. Using these criteria the profile was modified and was titled as the "recommended" profile, and released as public domain.

To illustrate respondent perceptions, charts and tables were constructed from the collected data. From these data, findings, conclusions, and recommendations were made. Observations made by the researcher while conducting the various phases of the study are also reported.

Organization of the Thesis

The purpose of the first chapter was to describe in detail the research design through the following sections: introduction, statement of the problem, supporting objectives, need for and significance of the study, limitations, operational definitions, population and sample, instrumentation, pilot study, methodology, and analysis of data.

The second chapter will begin with a review of the forces acting to put pressure on secondary school vocational education in the early 1980s, and the introduction, origins, and implementation of the Principles of Technology course. Included as content of chapter two is a brief discussion of how authorities define the term 'curriculum'. The chapter concludes with a description of the implementation of PT in Alberta, the DACUM process and product, and research related to the study.

The third chapter provides an analysis and presentation of the data collected from the questionnaires and competency profiles. These data are organized into tabular form for ease of interpretation and analysis.

The fourth chapter concludes the report with a summary of information collected, and conclusions, recommendations, and observations made by the researcher while conducting the study.

CHAPTER II

Review of the Literature and Related Research

Introduction

The previous chapter briefly examined some of the key factors that have forced secondary school vocational education into an intensive re-evaluation of its purpose within the school systems of North America. These included the "back to basics" movement, technological literacy, transferable (or "generic") skill development, and the inability of secondary school vocational education to keep pace with technological changes taking place in industry. Principles of Technology was described as a secondary school vocational education course designed to address some of the concerns that were raised by these issues. Included as content of that chapter was the problem with which the research was concerned. The content of chapter one also described the research population, the development of the initial modified DACUM chart of Principles of Technology teacher competencies, and the research methodology that was used to collect data for analysis.

This chapter begins with an examination of the forces that have acted to initiate change in secondary school vocational education, and describes the role that the Agency for Instructional Technology (AIT) and the Center for Occupational Research and Development (CORD) have played in helping vocational/ technical education teachers and administrators. A section of this chapter looks at the term 'curriculum' and how it is defined by authorities in this field of study. The origins of the Principles of Technology (PT) are traced from the development and implementation of the Unified Technical Concepts (UTC) Physics curriculum in postsecondary technician training programs to the changes made to that program to make it suitable for secondary school vocational education students. Details are provided on the nature and composition of the consortium that financed the PT project, and how the project's materials were pilot tested and revised. The latter part of this chapter describes how Alberta Education became a member of the Principles of Technology consortium and how this course was implemented in selected secondary schools of the province. A brief description of the DACUM process and product, along with a review of related research, concludes the chapter.

The Changing World and the Changing Workplace

In the 1980s the interaction of several phenomena placed a considerable amount of pressure on schools in general, and on secondary school vocational/ technical education in particular. These phenomena included: (a) a growing, world-wide economy and global competitiveness; (b) the changing nature of work as a result of the introduction of new technologies; (c) the changing nature of jobs as industrialized nations moved from goods-producing industries to service-producing industries; (d) changing demographics, resulting in a greater number of older, well-educated workers in the workforce, and declining secondary school enrollments; and (e) pronounced fiscal restraint (Bjorkquist, 1985a; Pratzner, 1984).

As the world changed, secondary vocational/ technical schools were seen in the eyes of their critics as stagnating. The plethora of investigations and studies on secondary education completed during this period concluded that a return to the academic "basics" would help get schools and their graduates "in shape". A new basic, by the name of "technological literacy", gained greater acceptance as a fundamental skill to be acquired by all students. Researchers additionally claimed that "generic" cognitive and psychomotor skill development, versus specific occupational skill training, was not only desirable but essential. The increased attention on the vocational/ technical secondary school highlighted vocational education's poor record of keeping pace with technological change. At the least, these analysts called for fundamental changes in the focus and direction of secondary school vocational education; at most, the complete dismantling of secondary school vocational education.

A Nation at Risk and the 'Back to Basics' Movement

During the 1980s there were many reports published in the United States about the condition of school systems and their graduates. Few reports related positive comments to tax-payers; most described the school curriculum as offering far too many frivolous course options to students who demonstrated a marked disdain for "hard" subjects like physics, mathematics, and chemistry. It was believed that poor academic performance would undermine worker flexibility, creativity, and efficiency in an increasingly technological society. Poorly-educated, inadequately-prepared graduates, it was believed, would be unable to adapt to the changing nature of work in a technologically-advanced society.

A Nation at Risk acted as a catalyst for the tide of publications and evaluations that were to follow April, 1983, the date the report was released. This publication reported the findings of the National Commission for Excellence in Education. The commission was established to "present a report on the quality of education in America" to the United States Secretary of Education (National Commission for Excellence in Education, 1983, p. ii).

The dominant theme of A Nation at Risk was a warning that a "rising tide of mediocrity" was threatening the educational foundations of the United States, and that Americans were guilty of "committing an act of unthinking, unilateral educational disarmament" (National Commission for Excellence in Education, 1983, p. 5). Assessing the world as a global village filled with determined, well-educated, and highly motivated competitors, the commissioners asserted that "knowledge, learning, information, and skilled intelligence are the new raw materials of international commerce" (National Commission for Excellence in Education, 1983, p. 7). The report further admonished:

> The people of the United States need to know that individuals in our society who do not possess the levels of skill, 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. (National Commission for Excellence in Education, 1983, p. 7)

The authors of A Nation at Risk identified a weak curriculum, excessive student freedom in course selection, minimal time spent in class and on homework, and inadequately-trained and poorly-paid teachers as but a few of the factors contributing to the poor showing of the American educational system (National Commission for Excellence in Education, 1983).

To address these problems, A Nation at Risk made several recommendations. The first of these focused on the secondary school curriculum. The commissioners recommended that all students seeking a high school diploma be required to take the "New Basics": four years of English, three years of mathematics, three years of science, three years of social studies, a half-year of computer science, and two years of foreign language study for the college-bound (National Commission for Excellence in Education, 1983). Their second recommendation was that schools, colleges, and universities "adopt more rigorous and measurable standards, and higher expectations", and that "four-year colleges and universities raise their requirements for admission" (National Commission for Excellence in Education, 1983, p. 27). The authors also recommended that more time be spent on learning the New Basics, and that teacher salaries and training be upgraded.

The fall-out from the release of A Nation at Risk was predictable: some educators pronounced the report a bold step in the right direction, others interpreted it as an affront to vocational education because of the increased emphasis on academic courses at the apparent expense of electives such as vocational/ technical education (Feldman, 1987; Gardner, 1986; Glines, 1986; Dugger, 1985; Lotto, 1985; Rosenaur, 1984). Lotto (1985) reported that:

> In the wake of numerous studies and commission reports, U.S. secondary education is in the grip of a back-to-basics movement... 44 states have stiffened high school graduation requirements to include more mathematics, science, foreign language, English, social science, and computer education. Forty-two states have initiated reforms in curriculum content, and 20 have moved to extend the school day or year. (p. 568)

Five years after the release of A Nation at Risk, Pratzner (1988) reported that "one consequence of the school reform and excellence movement is that the role of vocational education at the secondary school level has been seriously questioned. A major reexamination is underway" (p. 49). And Perry (1989) stated that "at least 43 states in the past four years have re-examined their vocational education policies. The results: Schools are experimenting with new teaching methods that integrate basic academics and hands-on learning" (p. 128).

Indeed, many industrial arts and vocational education teachers and administrators reacted to the perceived need for increasing academic content by advocating the integration of requisite academics and hands-on learning through technical education courses in the secondary school curriculum. Technical education teachers were encouraged to offer increased academic skills that would "allow students to continue to grow throughout their lives career-wise, on the job, and as citizens" (Peckham, 1988, p. 15). The new focus for vocational/ technical education was to be on "strategies and instructional methods that bring the principles of mathematics and science together with the study of technological accomplishments" (Maley, 1985, p. 7). It was recommended that new curricular packages, focusing on "principles of technology rather than on the previously separate materials-oriented aspects of the industrial arts" were needed (Jones, 1986, p. 22).

Technological Literacy

Riding on the coat-tails of the back-to-basics movement were those who advocated the need for technological literacy, a term defined by Dyrenfurth (1983) as "the capacity to use and work with technology intelligently within a broad context of understanding" (p. 43). Both technical and science educators began referring to technological literacy as one of the new "basics". "We need to introduce technology as a school subject for all [Canadian] secondary schools", concluded Orpwood (1984, p. 10). Rumberger (1984) tangentially made reference to technological literacy when he suggested:

> Technology is an important force that will increasingly shape the nature of work in the future. To be better able to understand this force and to ensure the maximum benefits from it, students will need an increased understanding of technology, not simply for their jobs, but for their lives as adults. (p. 34)

Lauda (1985) was more emphatic in addressing the issue of technological literacy when he related that literacy to mathematics and science:

> The call for scientific and technological literacy is evident. Such literacy calls for more than an esoteric knowledge of mathematics and science, or an esoteric knowledge of technology; but rather a holistic view toward problem-solving in a corporate venture. (p. 6)

Science educators such as Chen and Novik (1984) asserted scientific and technological literacy to be an essential part of the education for all when they stated:

> Coping with the evolving radical changes and ensuring that man is becoming familiar with and overcoming the language barrier implies that scientific and technological literacy must be an essential part of every man's education. Thus, the main objective of science education should be extended beyond the scope of scientific discipline to its applied aspects, namely technology and its interphase with society. (p. 424)

Todd (1985) summarized the argument of the need for a populace that was technologically literate when he stated:

> People who understand technology can help invent new products as well as implement new technical systems to produce and distribute the products and services. On a more immediate basis, however, a technologically literate populace would be better prepared to consider proposed technological changes and their social impacts on a more rational basis. (pp. 24-25)

"Technologic literacy", according to Ost (1985), "is not a new component of education. It is, however, a new element of basic education" (p. 690). Adams and Merz (1989) claimed that "Americans must be literate in technology if we are to protect our habitat and define our lifestyle . . . becoming technologically literate will enable our students to make wiser choices" (p. 27).

Academic excellence and technological literacy were two forces that helped redirect secondary school vocational/ technical education in the 1980s. There was seen to be a need for greater integration of and emphasis on the academics of mathematics and science in the vocational education curriculum. Helping students to become technologically aware of the world around them was also recognized as being an important element of that curriculum. These factors, however, helped spark renewed debate over whether occupationally-specific skill training should be taught in the secondary school system.

Occupationally-Specific vs. Generic Skill Training

Traditional vocational education programs, such as those in trades and industry or business and office, had become "dysfunctional" in the early 1980s because of their emphasis on specialized skill training, and were in need of "complete revamping and restructuring" (Pratzner, 1984, p. 9). But vocational education educators have never been in agreement over the level of skill to be taught in the secondary schools: one group believes strongly that the level of skill to be taught should be occupationally-specific. The other group takes the position that "generic" or transferable skills should be taught (Pratzner, 1984). Generic skills are skills "with common characteristics, which because of their similarity, have high transfer possibilities" (Taylor, 1987, p. 3).

Narrow skills training, argued Pratzner (1984), was unrealistic and unfair to students: "The more specialized skills are, the less transferable they are to other occupations and to other uses. Thus, heavy emphasis of highly specialized job skills at the secondary school level can significantly reduce or restrict students' work-related options" (p. 4). Bjorkquist (1985a) added that "uncertainty about employment and retraining will be part of most workers' futures. Specific job preparation will be less likely to prepare an individual for a lifetime career" (p. 11). Pratzner (1984) identified several other factors that mitigated against specialized skill training, including: ubiquitous fiscal restraint, obsolete equipment and facilities, the difficulty of retaining quality instructors, declining enrollments, and a lack of clear evidence of labour market benefits of secondary school vocational training. A focus on the teaching and acquisition of transferable work skills, such as technological literacy, and skills in analyzing and solving problems, learning-to-learn, decision-making, and critical thinking (Pratzner, 1988) would enable workers to retrain more easily. Employees with these new skills, it was thought, would be more adaptable and flexible and less susceptible to being displaced by new technologies.

In reporting the results of a survey of over 100 businesses in Michigan, Robertson (1985) stated "the day of the narrowly-defined job is over" (p. 5), and that job skills in general were being broadened. Businesses surveyed in the Robertson (1385) study identified a series of basic skills that were valued more than specific occupational skills. These basic skills were: fundamental reading, writing, speaking, and computational skills; employability skills (attendance, effort, willingness to work); technical literacy skills (use of computers and keyboards, familiarity with common software and basic manufacturing processes and materials); and analytical and problem-solving skills. "Employers basically believe they can and should train a person to use technology," reported Robertson (1985); "they would rather not teach basic skills" (p. 6).

"Learning", asserted Glines (1986), "will ultimately supplant work as the central ethic" (p. 7). Crohn (1983), in commenting on the changes needed in secondary school vocational education, claimed that the teaching of complex skills (such as problem-solving, reasoning, analyzing, and conceptualizing) posed a great challenge to educators:

> These 'learning-to-learn' skills are those which our sources say are more important in helping students cope with a changing work environment. We came to the conclusion that individual needs require both a broad and a specialized curriculum with particular emphasis on the reinforcement and application of basic skills. The emphasis must be on providing a foundation that will enable people to learn over their lifetimes as new knowledge is needed. (p. 9, emphasis in original)

Pannabecker (1989), Perry (1989), the Texas Education Agency (1989), Chambliss and Chiariello (1988), Cuetara (1988), Feingold and Atwater (1988), Mansell et al., (1988), Peckham (1988), Groff (1987), and Bjorkquist (1985a, 1985b) concur with the need for generic work skills for employees of the future.

The growing emphasis on the teaching of transferable work skills in high schools helped place secondary school vocational education programs under pressure to modify and adapt to the realities of the changing nature of the workplace and requisite worker skills.

The Problem of Obsoleteness

Technological backwardness has long been a problem faced by secondary school vocational education. With increased attention being paid to vocational education in the light of the above reforms, this problem became even more acute.

The obsolete hardware sitting in vocational schools today "serves as a mute witness to the stagnation which now threatens the existence of many programs" (Foster, 1985, p. 26). Secondary school vocational education teachers have seldom been able to teach students with contemporary equipment and processes because of the cost of keeping technologically up-to-date (Pratzner, 1984). The Texas Education Agency (1989) observed that vocational/ technical education had often provided unrealistic learning conditions for its students, using obsolete equipment and outdated procedures. "In too many cases," the Agency concluded, "[vocational education] deserves the criticism it receives" (Texas Education Agency, 1989, p. 6).

Two educational agencies that have had a history of working with vocational/ technical education teachers over the past 25 years to help resolve crises such as those faced by vocational education schools in the eighties are the Agency for Instructional Technology (AIT), and the Center for Occupational Research and Development (CORD).

AIT and CORD

The Agency for Instructional Technology, located in Bloomington, Indiana, is a nonprofit organization comprised of American and Canadian educational agencies that was established in 1973 to strengthen education through the use of television and other technologies (AIT, 1983). From April 1973 to July of 1984, this organization was known as the Agency for Instructional Television; prior to that it was known as National Instructional Television, which began operating in 1962. The major function of AIT is the collaborative development of program projects involving state and provincial educational agencies.

Like AIT, the Center for Occupational Research and Development (CORD) is a nonprofit organization that was established in 1974 to conduct research and development activities in occupational education and training (AIT, 1985a). Prior to 1974 this agency was known as the Technical Education Research Center - Southwest. Projects that CORD accepts are contracted projects that are funded by either a state or provincial agency, or through industrial support from the private sector. The results that are developed from CORD projects are used in these diverse educational settings throughout the world: technical institutes, vocational high schools, community colleges, and industrial training programs (AIT, 1985a). Since 1975, CORD has developed over 36,000 pages of instructional materials for technicians to be used with 14 curriculum projects (AIT, 1985a). The home office of CORD is Waco, Texas.

Unified Technical Concepts (UTC) Physics

Unified Technical Concepts Physics (or "UTC Physics") was developed by CORD in 1978 for use with postsecondary technician training programs from a grant awarded by the United States Office of Education (Baker, personal communication, 1986). CORD developed and implemented UTC Physics to address a number of major shortcomings that were identified from the traditional approach used to teach physics in postsecondary technician training programs. The first shortcoming identified by CORD using the traditional approach to teach physics was the lack of emphasis by the physics instructor on the analogous, unifying relationships that thread through the separate physics disciplines of mechanics, heat, fluids, and electricity (Baker, personal communication, 1986). Traditionalists who taught physics to technicians normally presented material in a set of rigid "compartments" (such as heat, sound, and mechanics), without placing emphasis on the similarities and unifying principles between each of the fundamental systems. To illustrate:

> The student may identify the physical concept of rate with speed (**ft/sec, miles/hr**), as it is usually introduced in mechanics, and not identify the rate analogies of **calories/sec** in thermal systems, **cubic feet/sec** in fluid systems, and **coulombs/sec** in electrical systems. (CORD, personal communication, 1986, p. 2, emphasis in original)

A second shortcoming that CORD identified was that in traditional physics training used to prepare technicians undue time was spent on formula derivation and proofs, an unnecessary skill for a number of technicians. CORD believed that technicians would derive greater benefit from the hands-on application of essential technical principles that were related to useful devices and instruments the learner would find in the scientific and industrial world (CORD, personal communication, 1986).

To help with a solution to these problems, CORD designed UTC Physics as an adaptable, modular system of instruction which emphasized the hands-on application of analogous physics concepts. Curriculum materials for UTC Physics consisted of three textbooks in the form of modules. One textbook contained the physics "concepts" modules, while the other two textbooks were classified as "applications" modules. These curriculum materials were prepared by CORD staff using contributions from university faculty who had expertise in physics, engineering technology faculty, and practicing technicians and engineers from industry (CORD, personal communication, 1986).

The 13 UTC Physics concepts modules stressed the unifying principles of basic physics concepts found in the four major energy systems - mechanical, fluid, thermal, and electrical (CORD, personal communication, 1986). The learning content for these modules was organized from simple to complex and was presented to students to ensure that fundamental physics concepts were learned before the more advanced concepts were attempted. In order of presentation, the 13 modules were titled: Force, Work, Rate, Momentum, Resistance, Power, Energy, Force Transformers, Energy Convertors, Transducers, Vibrations and Waves, Time Constants, and Radiation.

Each UTC module begins with the development of the essential physics relevant to the concept under study. Then, "the basic physics concept is identified as a unifying principle that is extended to a variety of problems in mechanical, thermal, fluid, and electrical systems" (CORD, personal communication, 1986, p. 2). This pattern of defining and explaining each concept, and then demonstrating its application as a unifying concept in the four major energy systems, continues throughout the remaining modules.

The two remaining textbooks contain the applications modules, which consist of 111 hands-on student laboratory exercises (CORD, personal communication, 1986). Each application module is designed to illustrate contemporary applications of the concept described in the concept module. This reinforcement is accomplished through the use of up-to-date laboratory equipment (such as shock absorbers, prony brakes, strain gauges, venturi meters, transducers, and electric motors), to reinforce the concepts to be learned (CORD, personal communication, 1986). There are an additional 59 UTC Physics laboratory exercises available from CORD for institutions who may need further applications experiences for their students.

In commenting on this unique approach to technical physics education developed by CORD, McKinney and Kohan (1986) said:

> Perhaps the most interesting aspect of the UTC curriculum was the manner in which the key elements of technology - electrical, mechanical, fluidal, and thermal principles - were presented. Rather than being presented as isolated concepts, the key elements of technology in the UTC curriculum were presented together as analogous phenomena. (p. 12)

From 1978 to 1980 CORD pilot tested UTC Physics at various technical institutes throughout the United States to determine: (a) student reaction to the curricula; (b) whether the unification concepts were grasped by students; (c) whether UTC students performed better in more advanced technology courses; (d) the effectiveness of retraining employed adult technicians; (e) if deficiencies existed in the modules; and (f) how long it took to teach UTC Physics (Baker, personal communication, 1986). It was found from the pilot test that the UTC Physics system of instruction used to teach physics concepts when compared to traditional methods of physics instruction for technicians, was especially effective in: (a) generating student interest; (b) helping students retain technical principles; and (c) ensuring relevance and applicability of content to the technician's field of work (AIT, 1983). UTC Physics is currently being used in the United States in technical institutes where associate degrees for technician training programs are available (Baker, personal communication, 1986; AIT, 1985a).

Curriculum Defined

The Agency for Instructional Technology and the Center for Occupational Research and Development frequently use in their descriptive literature the term 'curriculum' when they are actually making reference to a course such as UTC Physics or Principles of Technology. This misuse of the term 'curriculum' by these agencies needs to be clarified.

Authorities who have written on curriculum design and curriculum theory provide definitions for the term "curriculum" (Unruh & Unruh, 1984; Tanner & Tanner, 1980; Lett, 1975; Cay, 1966; and Taba, 1962). According to Unruh and Unruh (1984), curriculum is defined as "a plan for achieving intended learning outcomes: a plan concerned with purpose, with what is to be learned, and with the results of instruction" (p. 96). The definition for the term curriculum presented by Tanner and Tanner (1980) places emphasis on the knowledges and educational experiences the learner will become involved with to increase the learner's control of both knowledge and experience. To these authors, curriculum is defined as "that reconstruction of knowledge and experience, systematically developed under the auspices of the school (or university), to enable the learner to increase his or her control of knowledge and experience" (p. 43).

Lett (1975) considers curriculum as a charter given to a school to offer an education to the learner (p. 33). As a charter the curriculum has a context that is both societal and cultural. An earlier writer on curriculum development (Cay, 1966), provides the following definition for the term curriculum:

Is school experience involving interaction between those who teach and those who learn. "Curriculum" is the professional education term that covers all school experiences like an umbrella. It consists of a preconceived design of educational experiences that should lead to designed goals, eventually benefiting the individual and society. (p. 1)

It should be evident from these definitions that leading curriculum writers provide a variety of definitions for the term curriculum. Some of these definitions are generic and all-encompassing while others are more specific. A noted authority on curriculum design, Taba (1962) in Curriculum Development Theory and Practice took the position that all curricula are composed of certain elements:

A curriculum usually contains a statement of aims and of specific objectives; it indicates some selection of organization of content; it either implies or manifests certain patterns of learning and teaching, whether because the objectives demand them or because the content organization requires them. Finally, it includes a program of evaluation of the outcomes. (p. 10)

Implied in Taba's (1962) definition and that of the authorities previously quoted are two types of learning experiences which benefit both the learner and society. These experiences can be either curricular or extra-curricular. The former, curricular, includes all those experiences that the learner is exposed to in a formal classroom setting. Extra-curricular learning experiences include all those that are acquired external to the classroom setting, for example, sports activities, club activities, riding the school bus, etc. Acceptance of the global definition implies that a curriculum includes all forms of education, academic, vocational, as well as technical (Finch & Crunkilton, 1989, p. 10).

Pautler (1978) categorizes a vocational education curriculum as the entire group of programs offered at a high school, a technical institute, or a college (p. 55). A program is considered by this author to be comprised of a series of courses a learner must complete to achieve a degree of expertise in pursuit of a certain specialization, for instance plumbing or electrical certification. A course, according to Pautler (1978), is classified as "one segment of a program" (p. 55).

It should be evident from the above discussion that Principles of Technology would be considered by curriculum theorists and curriculum specialists as a "course" and not as a curriculum. However, for the purposes of this study, the terms curriculum and course will be used when referring to Principles of Technology.

Prospectus: Principles of Technology

The success of the UTC Physics curriculum at the postsecondary level spurred interest in the development of a similar course for secondary students (McKinney & Kohan, 1986). In June 1983 AIT and CORD distributed an invitation to educational administrators at the state department level in the United States and at the provincial department level in Canada asking them to participate in financing and developing the "Principles of Technology" project by becoming part of a consortium. The invitation, in the form of a Prospectus (AIT, 1983), presented a rationale for the Principles of Technology curriculum, identified the background and major components of the course, and described the financial and administrative structure of the project.

According to the Prospectus both the Agency for Instructional Technology and the Center for Occupational Research and Development were to cooperatively manage the Principles of Technology project. The functions of AIT were to provide for overall fiscal responsibility for the project, responsibility for the development of the video and information materials, and liaison between state and provincial educational agencies (AIT, 1983). CORD had responsibility for development of the curriculum, including print-based and laboratory materials, conducting leadership training workshops, and monitoring the use of project materials and providing technical assistance to teachers and administrators during the pilot tests (AIT, 1983).

Fiscal Information

The Prospectus reported the developmental cost for the Principles of Technology project would be $2.5 million in United States dollars (AIT, 1983). It was anticipated that this sum could be raised if between 30 to 35 state/provincial educational agencies participated in the project. The fee that each participating agency would contribute was determined by the following formula: to a base amount of $40,000 an additional 5.5 cents was added for every kindergarten to grade 12 student enrolled in school in that state or province for the 1980 - 1981 school year (AIT, 1983). CORD/ AIT do not explain why the 1980 - 1981 school year was selected in determining the amount of funding consortium members would have to contribute; neither is this information available in the literature.

The project budget was broken down into nine major expense categories: Project Initiation - $115,785; Instructional Design - $628,725; Consortium Meetings - $82,165; Production - $1,146,020; Communications - $16,185; Information/Promotion - $52,290; Utilization - $142,550; Sets of Materials - $217,875; Contingency - $93,375; bringing the total budgeted dollars for development of the Principles of Technology to $2,494,970 U.S. (AIT, 1983).

The Argument for Principles, Not Specifics, of Technology

The major thrust of the Prospectus was that existing secondary school vocational education programs were no longer adequate to prepare students for entry into the world of work or in meeting the needs of employers in the last two decades of the twentieth century. These agencies also saw classical secondary school vocational education programs as being too narrow in their focus on specific skill training. Vocational education programs in the early 1980s prepared students to become occupation specific in a trade or in one area of technology only (such as "Brake Technician" or "Tune-Up Technician"). The authors of the Prospectus took the position that operators and technicians of the future must become multi-skilled individuals who could "understand the entire system with which they work and the technical principles that govern the behaviour of each device within that system" (AIT, 1983, p. 1).

The second reason given for the inadequacy of contemporary secondary school vocational education was that rapid technological change would continue to characterize the workplace of the eighties and into the future (AIT, 1983). As a consequence of these technological changes, workers would find it necessary to continually learn new skills in the operation and maintenance of new equipment and processes. These authors claimed that an understanding of the fundamental principles and concepts that underlie modern technologies would enable workers to "adapt and retrain more easily than those who have only a narrow specialization" (AIT, 1983, p. 2), since these principles would not become obsolete as equipment and technologies change.

CORD/ AIT believed that a curriculum which focused on fundamental technical concepts and principles, rather than on a specific technology, was needed in high school vocational education programs of the future. These authors described this shift as moving away from the standard competency-based, occupation specific curriculum normally found in vocational education programs, to one which was founded on lasting, broad-based concepts and technological principles.

CORD/ AIT recognized that to incorporate these concepts and principles of technology into a secondary school vocational education program would involve innumerable challenges. A major concern that was identified was the related capital and maintenance costs of implementing this program into a school. A second concern was curriculum-related: would the developed curriculum be sufficiently academically challenging to satisfy the critics of secondary vocational education? If these concerns were to be properly addressed, the agencies felt that a technology-based curriculum would have to have these characteristics: (a) adapt to the budgetary constraints of a typical school district or secondary school; and (b) make certain that the curriculum would be academically challenging to students while reinforcing mathematics and science capabilities, the Achille's heel of secondary school education. To ensure quality learning experiences for students, the curriculum designers decided to employ practical, hands-on learning experiences, and exercises to help build and strengthen mathematics and problem-solving skills as they related to technical careers (AIT, 1983).

After identifying the need for a technology-based high school vocational education curriculum, and addressing the major concerns regarding implementation of such a curriculum, the agencies next proposed that a consortium of state and provincial agencies be formed to help finance and participate in the development of the Principles of Technology curriculum and eventually implement the course in their state or province. "From an economic stand-point," stated McKinney and Kohan (1986), "the consortium, in association with CORD and AIT, was a feasible strategy for the initial development of the Principles of Technology curriculum" (p. 24). The course materials to be developed were to consist of both teacher and student learning manuals (modules[2]), supporting videotapes, and supplemental course materials. The two developing agencies of the Principles of Technology felt that using UTC Physics as a starting point, developmental costs could be minimized by using the conceptual base and instructional methodologies that had been proven in postsecondary institutions throughout the United States (CORD, personal communication, 1986; AIT, 1983).

To adapt UTC Physics and to make it suitable for secondary school vocational education, the following changes were considered by CORD when it began to redesign the curriculum from UTC to Principles of Technology:

> 1. The analytical and quantitative level of the presentation, as well as the means of presentation, would be adapted to the ability and interests of secondary school vocational education students.
>
> 2. The lab activities would be shortened and modified to meet time and equipment limitations of typical secondary schools.
>
> 3. The volume and technical level of available print materials would be adapted to the reading level and technical proficiency of the secondary student.
>
> 4. The level of the material, the pace at which it is presented, and the means of presentation would be matched to the requirements of typical high school vocational education teachers. (AIT, 1983, p. 9)

Teaching Principles of Technology

The 13 modules for Principles of Technology were to include the following physics concepts: Force; Force Transformers; Work; Energy Convertors; Rate; Transducers; Momentum; Vibrations and Waves; Resistance;

[2]The developers of Principles of Technology use the terms "modules", "units", and "manuals" when referring to the print-based curriculum materials. For the purposes of this report, this interchangeability will be maintained.

Time Constants; Power; Radiation; Potential and Kinetic Energy (AIT, 1983). These learning packages were not assigned identification numbers in the Prospectus, even though they were referred to as "Modules 1 - 6" and "Modules 7 - 13" within this document (AIT, 1983, p. 12-13). A specific teaching sequence was also not provided.

The content of the Prospectus described how a student could learn the physics concepts found in the 13 modules. It was estimated a student could acquire the concepts from these modules in one hour of instruction per school day in the Principles of Technology distributed over two school years (AIT, 1983). The Prospectus further advocated that four weeks of instruction be devoted to the topic of each module. The focus of each week would be on one of the four major energy systems (mechanical, electrical, thermal, and fluidal) as each system and its subsystems relate to the technological concept under study (AIT, 1983). To illustrate, it was determined that teachers would need four weeks to present the materials in the module "Force". During the first week, Force would be examined as it applies to mechanical energy systems. In the second, Force would be studied in electrical energy systems. Force in thermal and fluidal energy systems would be undertaken in the third and fourth weeks of the classroom experience. See Figure 1.

According to the Prospectus, the topic for each week was to be further subdivided into a series of student-specific learning activities which were integrated with the supporting videotape. Topics were to be introduced in the first class of the first week using videos and class discussions. A seven-minute video on the mechanical application of the concept to be learned was to be shown in the next class and was also followed by a discussion period. The next class focused on a teacher-led hardware demonstration of the concept and con-

	Monday	Tuesday	Wednesday	Thursday	Friday
WEEK ONE	**5-Minute Video: Concept Intro** **7-Minute Video: Mechanical Application of Concept** Discussion	Hardware Demonstration on Mechanical Application of Concept Discussion	Problem-Solving (Math) Lab	Hands-On Lab: Mechanical Application of Concept	Hands-On Lab: Mechanical Application of Concept
WEEK TWO	**7-Minute Video: Fluidal Application of Concept** Discussion	Hardware Demonstration on Fluidal Application of Concept Discussion	Problem-Solving (Math) Lab	Hands-On Lab: Fluidal Application of Concept	Hands-On Lab: Fluidal Application of Concept
WEEK THREE	**7-Minute Video: Electrical Application of Concept** Discussion	Hardware Demonstration on Electrical Application of Concept Discussion	Problem-Solving (Math) Lab	Hands-On Lab: Electrical Application of Concept	Hands-On Lab: Electrical Application of Concept
WEEK FOUR	**7-Minute Video: Thermal Application of Concept** Discussion	Hardware Demonstration on Thermal Application of Concept Discussion	Problem-Solving (Math) Lab	Hands-On Lab: Thermal Application of Concept	Hands-On Lab: Thermal Application of Concept **Video Review of Concept**

Figure 1
Principles of Technology 4-Week Presentation Strategy

tinued classroom discussion of the mechanical application of the concept. A problem-solving mathematics laboratory, focusing on the solution of problems related to the concept being taught, followed these classes. The fifth and sixth classes were to consist of student hands-on laboratory experiments that employed the mechanical application of the concept under study. The remaining three weeks were structured similarly, with the exception that during the first session the seven-minute video substituted for the overview video, and the concept was taught in relation to the three remaining energy systems. A final concept review video, shown on the last day of the four-week period, helped summarize what was to be learned, and reinforced the "interrelationships among concepts and principles and systems" (AIT, 1983, p. 8). The final concept video was also designed to explore career opportunities in related technological fields.

A large part of the Principles of Technology curriculum was to be devoted to student laboratory exercises. The two agencies that were to develop the curriculum felt that a laboratory presented the best possible learning environment where the student could learn and reinforce technical concepts and principles that were previously learned, and gain valuable experience in solving practical problems:

> It is by this hands-on learning that students gain a fundamental understanding of the concepts, principles, and systems they are studying. Through the lab experiences they will develop their comprehension of the underlying similarities and differences among systems, and through applications in the lab they will develop practical problem-solving skills. (AIT, 1983, p. 7)

Teacher modules (called "Teacher's Guides") were designed to assist teachers in the planning of lessons, organization of laboratory sessions, and evaluation of student performance. The teacher modules contained information for teachers in the form of "Teaching Paths", which outlined teaching resource materials, described class goals and activities, and offered notes about the video portions under discussion. Additional notes were included to help teachers set up and organize laboratory sessions. McKinney and Kohan (1986) noted that a teacher module provided "suggestions for teaching each class session. The guide [module] is not a set of rigid rules or a substitute for teacher ingenuity, but it is a useful tool for implementing the Principles of Technology course" (p. 24).

The instructional video supplements content found in the student and in the teacher modules to introduce and demonstrate applications of technical concepts and principles, highlight interrelationships of systems, and familiarize students with career opportunities in technological industries. One master set of videotapes would be provided. "The video segments introduce ideas presented in the text. Through the video programs students are taken to the workplace settings where technicians are employed. The video segments were designed as a tool for putting variety into the classroom teaching pattern" (McKinney & Kohan, 1986, p. 25).

Principles of Technology Project Deliverables

According to the terms of the project contract, each state and provincial educational agency that became part of the consortium for the Principles of Technology project would receive a master set of the curriculum materials, at no additional cost, for unrestricted duplication and distribution within that agency's jurisdiction for a ten year period following delivery of these materials by AIT (AIT, 1983). These curriculum materials included master sets for student and teacher manuals as well as instructional videos. The student modules formed the bulk of the curriculum; these focused on instruction in and application of the physics concepts and principles in the course. Average length of the student modules was 135 pages (Baker, personal communication, 1986).

According to the Prospectus, a variety of information materials were to supplement the above print- and video-based components of the course (AIT, 1983). Brochures and pamphlets would be made available to help publicize Principles of Technology; support materials for teachers, mostly centering on the acquisition and upkeep of laboratory equipment, were to be produced as well (Baker, personal communication, 1986; AIT, 1983).

Operational Aspects

The Prospectus described that although CORD intended to use the UTC Physics program as the basis for developing the Principles of Technology program, it also recognized that "newly developed curriculum materials and procedures usually need modification before meeting their full potential" with a learner (AIT, 1983, p. 12). Several different means of evaluating and revising curriculum materials were included in the project plan. These included: pilot testing of instruction in representative classrooms; the use of questionnaires sent to representatives of participating agencies, subject specialists, and teachers; consortium meetings, where member agencies could review project materials (AIT, 1983).

The anticipated Principles of Technology completion schedule proposed in the Prospectus was that modules 1 through 6 would be pilot tested at the beginning of September, 1984 (AIT, 1983), with all six modules scheduled for general use in September 1985. The authors of the Prospectus neglected to distinguish which modules were being referred to. To prepare those who would teach PT, it was planned to have a number of workshops for these teachers so they would become familiar with the instructional content, the methodologies used to effectively teach that content, and pilot test procedures. Modules 7 through 13 were to be pilot tested during the 1985-1986 school year, with full implementation in September, 1986 (AIT, 1983). The schedule was to follow this schema:

Activity	Dates
Funding	June 1983 - June 1984
Instructional Design	
Modules 1 - 6	October 1983 - June 1984
Modules 7 - 13	July 1984 - June 1985
Revisions	December 1983 - June 1986
Pilot Testing	
Modules 1 -6	
Teacher Workshop	June 1984
Testing Period	September 1984 - June 1985
Modules 7 - 13	
Teacher Workshop	June 1985
Testing Period	September 1985 - June 1986
Consortium Meetings	January 1984 January 1985
General Use	
Modules 1 - 6	September 1985
Modules 7 - 13	September 1986. (AIT, 1983)

The literature does not report and there is no evidence of publication of materials from either AIT or CORD for the period June 1983 (when the Prospectus was distributed) to the summer of 1985. Information published by these agencies after the summer of 1985 and by independent researchers was used to synthesize the following chronological description of the implementation and pilot testing of the Principles of Technology curriculum.

Curriculum Development/ Pilot Testing Principles of Technology: 1984 - 1986

Pilot Test: Year One (1984-1985)

Initial Principles of Technology module development work began in November of 1983 (AIT, 1987), using the UTC Physics curriculum as its foundation and following the developmental plan outlined in the Prospectus. At some point during this early developmental stage, CORD changed some of the names of the modules (as they were described in the Prospectus), gave the modules identification numbers, and added a fourteenth module, called "Optical Systems". The precise rationale for and timing of this decision cannot be identified in published literature. What can be learned is that all materials published after the Prospectus refer to these modular units:

1. Force
2. Work
3. Rate
4. Resistance
5. Energy
6. Power
7. Force Transformers
8. Momentum
9. Waves and Vibrations
10. Energy Convertors
11. Transducers
12. Radiation
13. Optical Systems
14. Time Constants. (AIT, 1985b)

Pilot testing of the first PT module (Force) began in September of 1984 (AIT, 1987). The purpose of this formative evaluation was to determine how well the PT materials were working, and to identify specific problems with the curriculum (AIT, 1987). AIT had responsibility for conducting the pilot test of the Principles of Technology materials. This was done in cooperation with CORD (McKinney & Kohan, 1986).

The first-year PT pilot test was preceded by a one-week try-out of the test procedures at a vocational school in Oklahoma in May 1984 (McKinney & Kohan, 1986). A preliminary version of the Force module was used for this test, which involved one teacher and nine students. After the test was completed, AIT concluded that the try-out was useful in "identifying positive indications about the curriculum and evaluation procedures as well as in identifying some legitimate concerns" (McKinney & Kohan, 1986, p. 13). Neither of these results were reported in published literature.

Each member agency of the consortium designated two schools in their jurisdiction to act as pilot test sites. Prior to conducting the pilot test, approximately 60 pilot test teachers were oriented to the Principles of Technology curriculum and pilot test procedures by CORD staff during meetings that were held in Dallas, Texas in June 1984 (AIT, 1987; McKinney & Kohan, 1986). A total of 72 sites, all in the United States, were mailed pilot test curriculum materials in mid-August 1984 (AIT, 1987). Curriculum materials included copies of teacher and student module 1 (Force), its video supplement, pre- and posttests, computerized scoring sheets for the tests, a student attitude questionnaire, and a teacher questionnaire (AIT, 1987). All completed evaluation materials were to be returned to the Agency for Instructional Technology, where they were scored and analyzed by AIT staff (McKinney & Kohan, 1986). It should be noted that not all members of the consortium participated in the pilot test. Alaska and Ontario decided to forego the test; Washington state dropped out of the project by November of 1984 and was excluded from the process. Kentucky and Georgia joined the project too late to participate (AIT, 1987). Alberta, which joined the consortium in 1983, did not participate in the pilot test because test sites had either not been selected or were not ready to begin teaching (Pallas, personal communication, 1990). Some members did not participate because of laboratory equipment delivery or acquisition problems. AIT had no control over test site selections (McKinney & Kohan, 1986). Pilot test teachers either volunteered for the opportunity to evaluate the PT materials or were selected by state vocational program administrators (Selland, 1986).

By November 28th, 1984, AIT had accumulated the results of the pilot test of the Force module (module 1) and its accompanying video segments (AIT, 1987). Thirty-one sites had returned evaluation instruments for assessment by AIT staff. Analysts noted the following from the results of the pilot test (note that these are not verbatim from the text):

1. Many teachers reported problems with obtaining the recommended Principles of Technology laboratory equipment. This was traced to either a lack of school funding for the equipment, or delivery problems by suppliers.
2. Almost half (44%) of the pilot teachers had one or less college physics classes; 97% had two or more college math classes; 29% had five or more college math classes.
3. Teacher mathematics backgrounds had no statistically significant effect on student performance.
4. Teacher physics backgrounds had a statistically significant effect on student performance; the more physics classes completed, the greater the students' scores.
5. Students and teachers were generally positive about the Force unit.
6. Statistically significant learning gains occurred.
7. Fifty- to sixty-minute class periods were thought to be the ideal length for any particular session.
8. The majority of teacher problems centered around the labs. Even if teachers were able to obtain the lab equipment, there were still those who experienced difficulty in understanding and conducting the labs (AIT, 1987).

Pilot testing of modules 2 (Work) through 7 (Force Transformers) continued on a month by month basis throughout the 1984 - 1985 school year.

Pilot test materials for the Work unit were mailed to teachers in mid-September 1984; materials for the Rate (module 3) unit were mailed to teachers in mid-October 1984; and so on. The evaluation materials and procedures were identical to those used in the pilot testing of module 1. The moderate participation rate of the pilot test sites (about 50%) continued, due mostly to problems in obtaining "the necessary instructional equipment and/or school funds to purchase program start-up equipment" (McKinney & Kohan, 1986, p. 14). Other reasons for non-participation in the pilot test included long delays in teaching the materials due to normal school routines, and teacher attrition from either dropping out of the pilot test or from illness (AIT, 1987).

In commenting on the laboratory equipment problem towards the end of the first year of the pilot test, AIT (1987) claimed that "it should be pointed out that most of the [hands-on laboratory] problems reported were with simply getting the equipment. Once teachers have the equipment, most of the labs seem to work satisfactorily" (p. 485). Selland (1986) reinforced this assertion by stating:

> If there's one recurrent theme during the pilot test [in Idaho], it's that the necessary lab equipment for the Principles of Technology hasn't been shipped quickly enough. Equipment manufacturers haven't been able to produce the equipment fast enough to keep orders filled to specification. However, PT teachers have been resourceful in making do. (p. 49)

In January of 1985 AIT extended an invitation to the National Center for Research in Vocational Education (NCRVE) to become involved in the pilot testing of PT modules 1 through 7 (McKinney & Kohan, 1986). NCRVE staff were asked to help AIT design and assess a formative evaluation system that would provide "specific revision feedback about the effectiveness of the overall learning system, including the printed materials, lab activities, learning kits, displays, and audio-visual materials" (McKinney & Kohan, 1986, p. 11).

Since the pilot study and course evaluation materials had already been designed and implemented, NCRVE staff were limited to assessing the existing evaluation system and suggesting improvements to it. After performing their assessment, NCRVE staff cautioned that "the first-year evaluation design was a pilot test that utilized a one-group pre-test posttest design as a means of measuring criteria performance. Threats to the internal validity of this design were numerous" (McKinney & Kohan, 1986, p. 30). These threats included: history; testing procedures; the Hawthorne Effect; instrumentation; plus other threats (McKinney & Kohan, 1986).

With respect to improving the formative evaluation process, NCRVE researchers suggested that a series of case studies would help to provide more insight about the successes and failures of implementing PT in a school. "Case studies", stated McKinney & Kohan (1986), "[would provide] the curriculum developers with greater depth of information about the enormously complex settings in which local schools were attempting to implement PT" (p. 10). Three case studies were conducted by AIT researchers during the 1985-1986 school year (i.e., year two of the pilot test) as a result of this recommendation (AIT, 1986b).

As the results of the pilot tests for modules 1 to 7 were analyzed by CORD/ AIT, several trends consistently appeared. These correlated closely with the results from the pilot testing of the material that made up the Force module. Students and teachers appeared to be responding positively to the curriculum, but there were still problems with laboratory equipment acquisition and usage. It was also found that students who had no prior experiences with algebra struggled with the course content (AIT, 1987; Selland, 1986).

During the latter half of the first-year pilot test program fewer and fewer test school sites returned completed evaluation instruments on time. This was attributed to the inability of pilot test teachers to teach the PT modules according to the recommended schedule; many teachers needed more time than was thought necessary to cover the principles and concepts in the PT materials (AIT, 1987). McKinney and Kohan (1986) describe one consequence of this delay:

> Very few of the PT pilot sites completed all seven units scheduled for the first year. This meant that the second-year program, which should have been devoted to units 8 - 14, was devoted to units 6 and 7 in most situations. In order to maintain continuity, the same evaluation instruments used for units 1 - 7 during the first year of the PT pilot were used for units 6 and 7 that were taught during the second year of the PT pilot. (p. 46)

Summarizing the results from year one of the pilot test, AIT (1987) claimed that students liked the hands-on labs and videos the best. The print-based materials, including the math labs, were the least liked. Major teacher problems centered around the acquisition of laboratory equipment and having to convert between metric and English units of measure. Teachers also complained that student acceptance of the PT curriculum was not always favorable, and that there was too much reading forced on the students, some of whom reacted by not reading the materials at all. This prompted one teacher to force the students to read during class time; this slowed module completion times significantly (AIT, 1987).

Pilot Test: Year Two (1985-1986)

By the summer of 1985, 33 state and provincial vocational education agencies had joined the Principles of Technology consortium (AIT, 1985b). Of the 33 participants were 31 states and the provinces of Alberta and Ontario (see Appendix F, page 157, for a list of project participants in 1985). The project budget was increased to $2.75 million from the original $2.5 million. CORD appointed an eight-person content review team, comprised of members from education and industry, to assist in curriculum development and modification. Pilot-testing of modules 1 through 7 had been concluded, and preparations were being made for pilot testing of modules 8 through 14 (AIT, 1985b). Minor changes in the project schedule were also made.

CORD and AIT published a recommended module teaching sequence for the consortia members during this period (AIT, 1985b). During the student's first year the following modules would be completed: 1. Force, 2. Work, 3. Rate, 4. Resistance, 5. Energy, 6. Power, and 7. Force Transformers. In the second year the remaining seven modules would be completed: 8. Momentum, 9. Waves and Vibrations, 10. Energy Convertors, 11. Transducers, 12. Radiation, 13. Optical Systems, and 14. Time Constants. It was also recommended that the unit entitled "Momentum" precede all other second year modules during the instructional sequence, but that module delivery was flexible thereafter.

In the fall of 1985 AIT issued to project consortia members a publication titled An Implementation Handbook for Principles of Technology (AIT, 1985a). The purpose of the Handbook was to assist teachers and administrators in the implementation of PT within their schools, and offer suggestions on how to publicize the course through available media. The Handbook also described the need for and evolution of the Principles of Technology project, and explained why Principles of Technology should be taught to eleventh- and twelfth-grade students in vocational-technical centres or comprehensive high schools who expressed interest in technical careers (AIT, 1985a). In the Handbook, AIT supplemented earlier arguments found in the 1983 Prospectus for a course in fundamental principles and concepts of technology to be taught at the secondary school level.

The Handbook further reported that the number of state education agencies in the fall of 1985 that were involved in the project increased from 33 to 35 when California and Missouri became members of the consortium. Alberta and Ontario continued to be the only Canadian provinces to participate in the project. The budget for the project was increased to $3.0 million from $2.75 million (AIT, 1985b).

The latter half of the Handbook provided information for teachers, counsellors, and school administrators regarding strategies to implement Principles of Technology in a school. For teachers, the Handbook described the Principles of Technology curriculum and suggested how it should be taught. A more detailed breakdown of the week-by-week instructional strategy was also outlined. An implementation timeline was provided along with descriptions of means of disseminating information about the Principles of Technology project through print and electronic media. The Handbook provided counsellors with information that detailed PT student prerequisites, career, and further education opportunities. A section of this publication titled "Occupational Information" identified job opportunities that exist for graduates within many different technologies (such as environmental control, electro-mechanical instrumentation, quality control, industrial production, electronic, robotic, and other technologies).

In March 1986 AIT published To the Teacher (AIT, 1986a), a publication which provided teachers with a more thorough explanation of the PT instructional system. To the Teacher explained that teaching PT involved the use of the student texts, the video, and the teacher's guide (AIT, 1986a; AIT, 1985a). According to this publication, each of the fourteen student concepts modules was subdivided into (at most) four subunits, and included an introductory overview and a summary section. Each subunit was designed to explain the theory underlying the fundamental physics concept and how it applied to each of the four energy systems (mechanical, electrical, thermal, and fluidal). Not all modules were divided into four subunits: some concepts did not carry analogous relationships across more than one or two other energy systems.

Teachers that were involved in the first year pilot test of modules 1 to 7 attended a second meeting in Dallas, Texas during the summer of 1985 to discuss with representatives of CORD/ AIT the results of the first-year pilot test (AIT, 1987). These teachers suggested minor modifications to be made to the pilot test procedures which were adopted for the remaining seven modules to be pilot tested during the 1985 - 1986 school year. Evaluation materials for unit 8 (Momentum) were mailed to teachers in mid-August 1985 (AIT, 1987); materials for units 9 and 10 followed in mid-September and mid-October of that year. The exception to this was that group of schools which had not completed the pilot test of modules 6 and 7 during the 1984 - 1985 school year. These test sites were required to pilot test the two modules that were outstanding using year one pilot test procedures and instruments before continuing with the next phase of the pilot test (McKinney & Kohan, 1986).

Findings for the second year pilot tests were consistent with the results obtained from the pilot test conducted during the first year of implementation. Laboratory equipment acquisition and set-up was problematic, but significant learning achievements and positive student and teacher attitudes towards the PT curriculum were noted.

As in year one of the pilot test, many test sites found it difficult to adhere to the pilot test evaluation deadlines imposed by AIT (McKinney & Kohan, 1986). By the time set for the return of the unit 10 (Energy Convertors) evaluation instruments, for example, AIT had received data representing only

36 students (AIT, 1987). The agency believed it necessary to modify the pilot test procedure for units 11 through 14 to allow the project to continue as scheduled. "Since so few classes were on a schedule that met the project's developmental needs," stated AIT (1987), "the evaluation procedures for Units 11 - 14 have been significantly modified, relying primarily on detailed teacher reviews of the course components" (p. 688). The literature does not report the details of how this process was conducted, nor the results of the teacher reviews.

Principles of Technology Teachers

An observation made by AIT and CORD during the pilot test phase was that teachers with different types of expertise were teaching Principles of Technology. These teachers included academic science teachers, industrial arts teachers, math teachers, and vocational education teachers (AIT, 1987; Jordan, 1986; Selland, 1986; Sherer, 1986). These teachers were occasionally teaching in a team-teaching mode. During a case study of a pilot test school environment in 1986, it was observed that, while the teachers presented information using different methods, "pilot test results showed comparable pre/posttest gains in classes taught by science teachers and those taught by vocational [education] teachers" (AIT, 1986b, p. 53).

"Teachers from existing faculty who have an interest in vocational [education] students should teach Principles of Technology", concluded McKinney and Kohan (1986). "These teachers should be familiar with or willing and able to become familiar with the physics and mathematics in the course. Team teaching may be required if qualified teachers are not available" (p. 27).

As a result of the initial pilot test findings which indicated that teachers with physics backgrounds tended to have better success with the course, CORD/ AIT recommended that a vocational education teacher with industrial experience and a "strong background (two or three college courses) in physics" (AIT, 1985a, p. 7) teach this course.

Recent Developments in Principles of Technology

Principles of Technology: 1986-1987

By April 1986, an additional five states had joined the Principles of Technology consortium, increasing the total number of participating educational agencies to 40 (Sherer, 1986). During this school year, the second year of the pilot test was scheduled to be completed in June. Modules 1 through 7 were distributed to consortia member schools in September 1985 for general use during the 1985 - 1986 school year. The number of minutes of videotape produced for the Principles of Technology curriculum was increased to 700 minutes from 500 minutes (Jordan, 1986; AIT, 1983). In addition, the project budget was raised to $3.5 million (Baker, personal communication, 1986).

Some teachers who attended the Dallas meeting continued to report that PT laboratory equipment was both difficult to obtain and expensive (Sherer, 1986). Both Sherer (1986) and AIT (1985b) stated that a single two-student work station for a laboratory could range in cost from $6,000 to $8,000 (U.S.). Since the laboratory equipment was found to be so expensive, teachers began making their own equipment (Sherer, 1986).

By November 1986 there were five more states that became members of the PT consortium. This brought total membership to 45 (Baker, personal communication, 1986).

Principles of Technology: 1987-1988

During 1987 - 1988, many of the equipment problems that plagued the early school implementation of the Principles of Technology were in the process of being resolved, and schools and teachers were able to devote themselves more fully to teaching and publicizing the course.

In 1987 two states published materials to assist teachers with the implementation of Principles of Technology in their schools. In Louisiana, the State Department of Education issued the Principles of Technology Curriculum Guide; in Indiana, the Implementation Handbook for Principles of Technology was released. Louisiana adopted the first seven units of the course (Force, Work, Rate, Resistance, Energy, Power, and Force Transformers) in an attempt to provide technology education and technological literacy for their secondary school students (Louisiana State Department of Education, 1987). The department cautioned that "the sequential nature of the course . . . [must be] preserved if maximum benefit is to be realized" from the Principles of Technology curriculum (Louisiana State Department of Education, 1987, p. 13).

Indiana's Handbook describes the PT course as "an excellent starting place for involvement in a focus which will prepare students for a future which we cannot accurately predict", and that the blending of basic education concepts in the applied setting of vocational/ technical education "prepares individuals with a foundation of transferable skills for lifelong learning" (O'Malley & Person, 1987, p. 6). These authors continue by stating that:

> Principles of Technology provides students a good knowledge of the basic principles of physics upon which their jobs will depend. It also provides the necessary mathematics knowledge and skills to fully apply those principles. The strengths of the program include excellent text materials, videos, a variety of good laboratory learning experiences, and its applied focus. (O'Malley & Person, 1987, p. 13)

Principles of Technology: 1988-1989

By the end of the 1988 - 1989 school year it was reported that the Principles of Technology consortium consisted of 47 members, and that the course was being taught in 1,200 schools (Perry, 1989). Characterizing Principles of Technology as "one of the hottest vocational [education] courses" in secondary schools, Perry (1989) also stated that equipment costs for a Principles of Technology laboratory averaged $30,000 per school (p. 129).

In addition to the Principles of Technology being taught in American and Canadian schools, it was being taught in Mexico and Bophuthatswana (a state in southern Africa) (Nelson, 1988). Nelson (1988) also reported that pilot-testing of PT was being carried out in Turkey. In all three cases, "the AIT design and evaluation methods are being used to enable producers to create materials that meet the special needs of each country" (Nelson, 1988, p. 7).

Hammer and Thode (1989), two experienced PT teachers and teacher trainers, made the following observations about the Principles of Technology:

> The curriculum for P.T. is well developed with quality activities, support videos, and printed materials.
>
> Equipment is revised and new vendors appear in response to suggestions of the teachers.
>
> Many of the original problems associated with the new curriculum have been resolved.
>
> Quality teacher inservice is critical to the success of the program.
>
> Technology education teachers with some mathematics and science background are among those best able to teach this curriculum . . .
>
> The P.T. activities have relevance and application to other technology courses . . .
>
> The expensive investment in the equipment required to teach the entire program is difficult to justify in some instances.

> Many instructors have voiced concern about the absence of computer use in the P.T. program.
>
> The excellent systematic structural approach to teaching about technology could be developed further through application of science and mathematics concepts in problem solving activities. (pp. 27 - 28)

Hammer and Thode (1989) summarized Principles of Technology as a program which "provides students with a framework on which an understanding of technology can be built. This marks the first time for many students to have the opportunity to see practical application of science and mathematics concepts" (p. 27).

Thode (1989) took the position that the Principles of Technology program could be used to reinforce the academic disciplines of mathematics and science:

> [Principles of Technology] has proven to be an excellent vehicle for the integration of science and math into Technology Education. One of the advantages of this program lies in its variety of presentation techniques, including well-illustrated texts, practical lab experiments, and a series of videotape presentations that show applications of physics-related topics in industrial settings. (p. 10)

Principles of Technology in Alberta

The Alberta School System

From material previously presented in this chapter, it should be evident that Alberta has been a member of the Principles of Technology consortium since it was first formed in 1983. In Alberta, as in all Canadian provinces, the development, implementation, and maintenance of educational curricula is under the direction of either a Ministry of Education or a Department of Education. In Alberta, Alberta Education fulfills these responsibilities. A provincial program of studies (or curriculum guide) issued by Alberta Education ensures that students throughout the province are exposed to the same content for any specific course. Province-wide standardized tests from Alberta Education are administered to the majority of students for core courses, with the exception of Physical Education, at the completion of grade 12.

Programs of study leading to either a "General" or "Advanced" High School Diploma are offered to students in Alberta. These differ by the number of courses required in each of the following Core subject areas: English, Mathematics, Science, Social Studies, and Physical Education. In addition to the core courses are complementary course offerings, designed to round out the requirements for the high school diploma (Mathew, 1989). These include business education, fine and applied arts, second languages, home economics, and industrial education. Course credits are based on the Carnegie unit, where each credit is equivalent to 25 hours of instruction. Industrial education courses are organized into five credit modules.

Industrial education in Alberta is subdivided into two streams at the senior high school level. In the general, or Industrial Arts, stream, many different industrial/ technical topics are taught in the learning environment that is organized as a multiple activity laboratory. The courses taught in this laboratory are numerically designated as 10 (Grade 10), 20 (Grade 11), and 30 (Grade 12). Vocational preparation courses, which are occupation specific, form the second category of industrial education courses; these are numbered 12 (Grade 10), 22 (Grade 11), and 32 (Grade 12). In the career track students study a single technology, trade, or service area. There are 17 vocational education courses approved by Alberta Education; these include Autobody, Automotives, Beauty Culture, Building Construction, Drafting, Electricity/ Electronics, Food Preparation, Graphic Arts, Health Services, Horticulture, Machine Shop, Piping, Sheet Metal, Visual Communications, and Welding.

Alberta Education and Principles of Technology

When Alberta Education became involved as a member of the Principles of Technology consortium in 1983 it agreed to finance and develop the curriculum described in the Prospectus: Principles of Technology (Pallas, 1989; AIT, 1985a; AIT, 1983). Based on the formula described in the Prospectus (which used school enrollment figures for the 1980 - 1981 school year) Alberta paid approximately $64,320 American dollars (equal at that time to about $99,000 Canadian dollars) to become a member of the consortium (Pallas, personal communication, 1990; AIT, 1983). These funds, which originated with Alberta Education, were provided through ACCESS Alberta, a Crown corporation funded by the Government of Alberta. As a consortium member, Alberta Education was given unrestricted duplication rights for ten years for all of the print- and video-based materials that comprised the PT curriculum. ACCESS Alberta was assigned responsibility for the maintenance and duplication of the Principles of Technology video segments, while Alberta Education monitored the duplication, distribution, and use of the print materials.

Principles of Technology in Alberta was given the course title Industrial Physics 12-22-32 (Pallas, 1989). This designation was made: (a) for the sake of expediency; (b) because the course content closely matched the course title; and (c) because the course code number already existed (Pallas, 1989). Students who successfully complete each of the three courses are granted five science elective credits for a total of 15 credits (Pallas, personal communication, 1990).

The presentation strategy originally outlined by the developers of Principles of Technology was modified by individual schools or teachers in the province to better suit the requirements of participating schools. For example, instead of teaching the curriculum over a two-year period, as recommended, several schools decided to present these materials over a three-year period. Teachers also had some freedom in deciding which units would be completed by students in each school year. The following outlines the general sequence used by most Principles of Technology teachers in the province, although there were variations of this format: in Industrial Physics 12, offered to grade 10 students, the first five or six concepts modules were taught (Force, Work, Rate, Resistance, Energy, and Power). Successful completion of Industrial Physics 12 was a prerequisite to Industrial Physics 22. Designed for grade 11 students, Industrial Physics 22 has the following physics principles taught: Force Transformers, Momentum, Waves and Vibrations, Energy Convertors, and Transducers. Students admitted to Industrial Physics 32, a course for grade 12 students, were required to successfully complete the 22 level course as a prerequisite. The 32 level course was designed to teach the remaining concepts modules (Radiation, Optical Systems, and Time Constants), and undertake various research and development projects initiated by the students (at the teacher's option).

Pilot Testing Principles of Technology in Alberta

Alberta Education did not participate in any of the pilot studies that were conducted by AIT between 1984 - 1986 to test the Principles of Technology materials since the pilot test sites for the province had either not been selected or they were not ready to begin teaching PT (Pallas, personal communication, 1990). As an option, Alberta Education began its own three-year pilot test of the curriculum which began in September 1986 and ended in May 1989 (Pallas, 1989). The purpose of the pilot test was "not only to validate the [Principles of Technology] content and resources, but to test whether the structure of the program . . . would suit Alberta requirements or whether adaptations would be required" (Pallas, 1989, p. 5). Alberta Education applied for and received permission to fund the establishment of pilot test sites for the 1986 - 1987 school year. These funds were provided to individual schools to purchase the requisite laboratory equipment and ready laboratory facilities and teaching materials. The amount of money given to each school varied, according to a formula established by Alberta Education; the dollar amount averaged $40,100 (Pallas, personal communication, 1990).

To select pilot test sites for Principles of Technology, Alberta Education asked a number of school districts across the province if they would be interested in pilot testing the PT materials. Chief executive officers of school districts were asked to submit to the Department of Education teacher names along with their request to participate. Personnel from Alberta Education evaluated each response and from these responses selected five pilot sites distributed throughout the province to gain a representative sample. The five schools selected included: Ardrossan Junior-Senior High School, County of Strathcona No. 20; Ernest Manning High School, Calgary Board of Education; Victoria Composite High School, Edmonton Public School Board; Lethbridge Collegiate Institute, Lethbridge School Division No. 51; and Ponoka Composite High School, County of Ponoka No. 3 (see Figure 2 on page 69 for the location of these pilot test sites). Ponoka withdrew from the project in 1985 after school personnel decided they could not proceed with the pilot test. This left four schools in the province to pilot test Principles of Technology.

By September of 1986, the Calgary Board of Education was the only school district actually pilot testing Principles of Technology curriculum materials (Pallas, personal communication, 1986); the remaining school districts were either in the process of readying their laboratories or their teachers and could not become involved in the pilot test until somewhat later in the 1986 - 1987 school year. In Alberta, there were no formal in-service programs available to assist teachers to prepare to teach PT; decisions regarding how and when teachers were to prepare were left up to individual schools (Pallas, personal communication, 1990).

The pilot test of the PT materials ended in May of 1989 (Pallas, 1989). Students were found to have demonstrated consistent and measurable learning gains. In addition:

> Positive student attitudes have been indicated; they are "turned on" because they can see the relationship between the classroom and the real world. Students found the material relevant, reported that the material was important to them and they liked the method of presentation. Teachers and administrators have all responded positively to this program. (Pallas, 1989, p. 5)

It was learned that the Principles of Technology content was adaptable to Alberta high school scheduling requirements, and that the material related most closely to high school physics or other technical subject areas that taught physics principles (Pallas, 1989).

Most of the problems associated with the implementation of the Principles of Technology mirrored those experienced in the United States and centered around laboratory equipment. Delivery problems and equipment of poor quality plagued the course start-up (Pallas, 1989). Teachers were forced to spend additional time pre-testing each laboratory activity, not only to become familiar with the laboratory procedures for the activity, but to intercept equipment problems before these problems were identified by the students. In reference to this, one PT teacher commented:

> New companies have now entered the PT equipment supply market. These companies have capitalized on the mistakes of the earlier suppliers and now offer substantially improved pieces of equipment specifically constructed for PT. Much of this equipment has been reduced in size and is suitable for desk top operation.

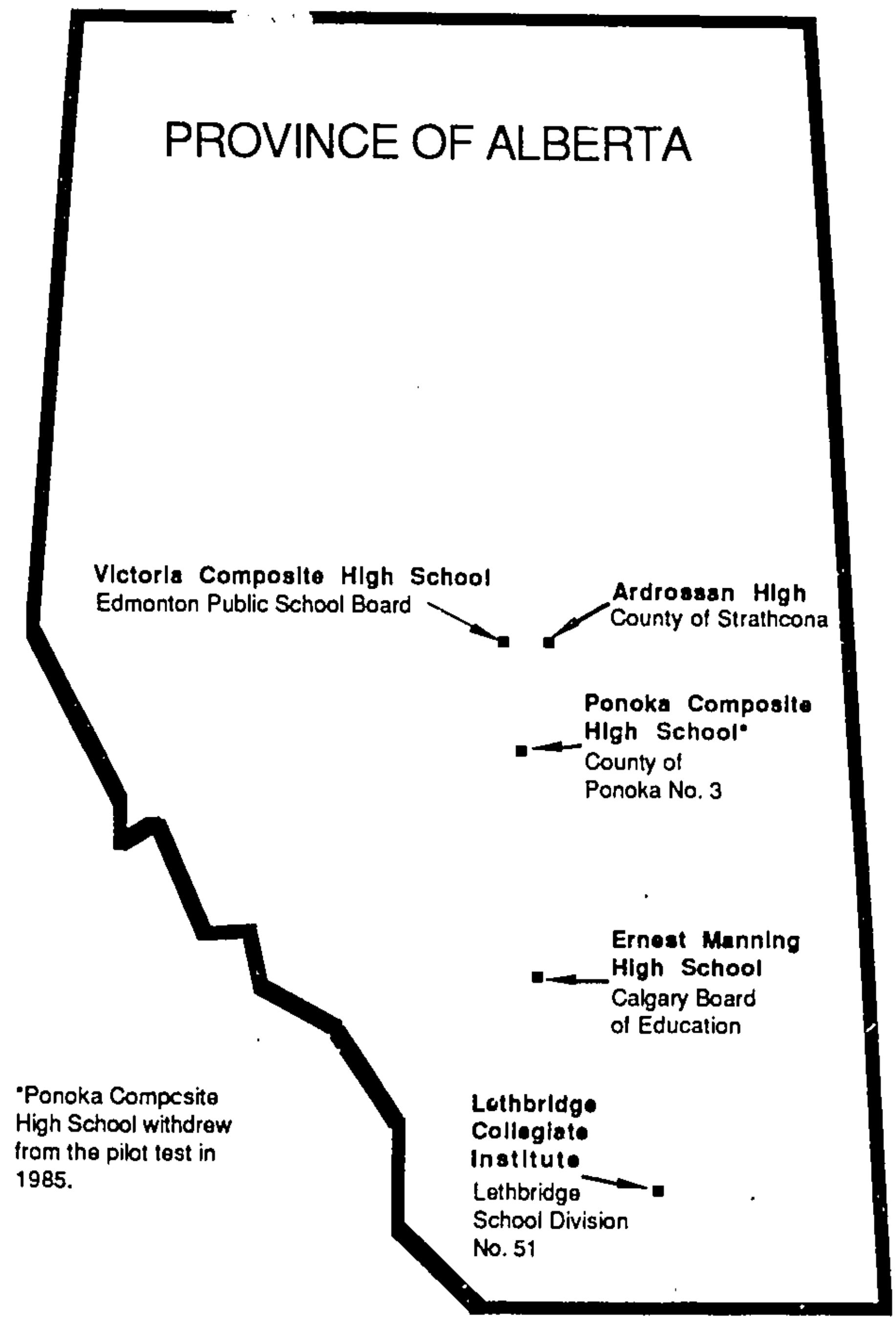

Figure 2
Principles of Technology Pilot Test Sites in Alberta

> Quality of materials used in the construction of the equipment has also improved. (Alberta Education, 1989, p. 6)

A second Principles of Technology teacher, commenting on the recommended laboratory equipment, said:

> Some of the equipment is a little weak and needs reinforcement. I found it easier to build some of my own [equipment]. . . I also had the good fortune to inherit the Electronics shop in our school and thus much of my equipment does not come from the [recommended] list. (Alberta Education, 1989, not paginated)

The four pilot test teachers in the province were asked a series of questions during the the final year of the pilot test by the Field Test Evaluation Committee from Alberta Education regarding the Principles of Technology course. This was to help determine the relevancy and viability of PT within the secondary education system of the province. Many observations, criticisms, and recommendations made by these teachers coincide with those made by teachers who participated in the evaluation of the Principles of Technology course materials in the United States. The questions posed by Alberta Education, and a selection of teacher responses, can be found in Appendix G, page 160.

Principles of Technology in Alberta: 1989-1990

At the time of this study (1990), Principles of Technology was being taught in four public schools and one separate school in the province. St. Joseph's Catholic High School of the Edmonton Catholic School District was planning for a January 1991 implementation date for Principles of Technology (Pallas, personal communication, 1990). Most schools involved in the provincial pilot test were maintaining the course designation Industrial Physics 12-22-32 for the Principles of Technology course.

School districts which did not participate in the provincial pilot test but who now want to teach Principles of Technology must pay for course start up costs from appropriate budget lines of the district; provincial monies are no longer available for this purpose (Pallas, personal communication, 1990). Alberta Education and ACCESS Alberta continue to make available to schools the print- and video-based components of the PT curriculum.

In 1989 the PT field test teachers proposed that Principles of Technology become part of the science curriculum in order for students to receive credit in science (Pallas, 1989). This proposal was unacceptable to secondary education science curriculum designers, as it was not one of the Secondary Education Review recommendations. The designers also had difficulty determining how or where Principles of Technology as a course would fit into the existing science curriculum. A second mitigating factor which influenced this decision was the science education survey conducted during the 1989 - 1990 school year. The results of that survey indicated that Alberta science teachers: (a) were not ready to teach Principles of Technology without extensive inservice; and (b) did not feel that substantive changes to the academic science curriculum were necessary (Pallas, personal communication, 1990).

The future of the Principles of Technology course in Alberta is difficult to determine. It is possible that it may become integrated as a course within the vocational education curriculum (Pallas, personal communication, 1990). Should that occur, funding for implementation in the schools would have to be addressed. An alternative would be for school districts to make Principles of Technology a locally-developed course. Following that approach, schools and teachers would be able to modify the course to suit their particular needs (Pallas, personal communication, 1990).

A final observation made by the writer, which is not supported by the research, is that Principles of Technology in Alberta has been successful to this point only because of the efforts of a few teachers and administrators. If these individuals were to leave their present responsibilities, it is unlikely that Principles of Technology as a course would survive.

DACUM (Developing a Curriculum)

A study by Duenk (1985) identified several different occupational analysis methods employed to identify worker competencies for specific occupations. The process of using a group of practitioners to identify and then document and verify worker competencies on a chart or competency profile is a common technique employed by curriculum development specialists. A major curriculum development process which is used world-wide and makes use of a group of specialists is the DACUM (for Developing a Curriculum) process.

DACUM is a job analysis procedure developed in Canada in the latter half of the 1960s for the purpose of developing relevant educational programs. The DACUM approach is often "used to analyze a job or occupational area, describe training goals, and recommend instructional approaches to achieve these goals" (Mitchell, 1983a, p. 10). The DACUM methodology is based on three tenets: 1) that practicing, competent workers are best able to identify actual job requirements; 2) that a job can be sufficiently described in terms of the job tasks (or competencies) that must be completed (or acquired); and 3) that each job task has direct implications for the cognitive, affective, and psychomotor abilities a worker must have in order to complete a job correctly (Norton, 1985).

In DACUM, a small group of competent practitioners who form the committee for the occupation being analyzed are led by a skilled coordinator through modified brainstorming sessions to construct a chart known as a competency profile (Mitchell, 1983b). The coordinator begins a session by leading the DACUM committee into an identification of the broad areas of worker responsibility, known as "general areas of competence" (Norton, 1985). As general areas of competence are identified they are written onto large cards and placed on a wall facing the participants. The specific employee competencies that comprise each general area of competence are then identified by the committee. These are referred to as "competency statements" and are written onto smaller cards which are posted next to the corresponding general area of competence. Competency statements on the DACUM chart consist of an action verb, followed by an object upon which the action is taken (Norton, 1985). These statements are arranged horizontally adjacent to the general area of competence to form rows; these are referred to as "bands". There is one band for every general area of competence and its supporting competency statements. It is common to find between 8 to 12 general areas of competence on a DACUM profile, with 6 to 30 competency statements for each general area of competence. Typically there are from 50 to 200 individual competency statements on a profile (Norton, 1985).

The basic elements of a DACUM chart are illustrated in figure 3.

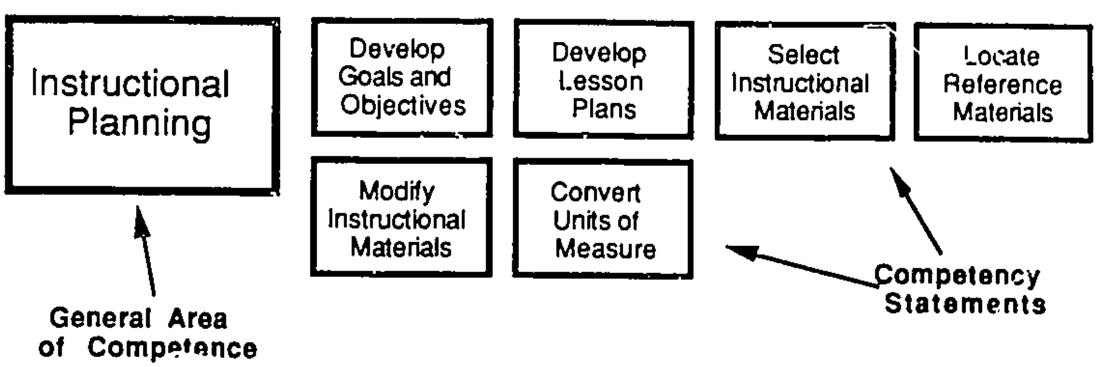

Figure 3
DACUM Chart Components

Once the initial DACUM chart is developed it is transferred by instructional designers onto a single sheet of paper. This allows an individual to review the complete job requirements in a single glance. The profile is then circulated among a larger group of practitioners for verification of the general areas of competence and the individual competencies (Mitchell, 1983c). If the profile is to be used for training program design or evaluation, instructional designers construct or evaluate training materials as needed, using the profile as a starting point.

Related Research

In chapter one it was noted that the researcher completed a literature search of a number of electronic databases in order to collect information for this study. Keywords used for these searches were taken from the Thesaurus of ERIC Descriptors, 11th Edition (Oryx Press, 1987), and included: Vocational Education; Technical Education; Secondary Education; Pretechnology Programs; Technological Literacy; Technological Advancement; Emerging Occupations; Futures (of Society); Science and Society. The name "Principles of Technology" was also used as a search term. The database searches yielded 398 hits, of which 76 were selected for review. From this review, two were considered by the researcher as bona fide educational research related to Principles of Technology. These studies are reviewed in the following paragraphs.

The Carter and Atkinson Study

Carter and Atkinson (1989), claiming that Principles of Technology had "made a significant impact on technology programs throughout the United States and Canada" (p. 1), completed a study of American and Canadian educators/ administrators in the spring of 1988 to determine (a) the amount of PT acceptance by educators in the consortium states and provinces where it has been implemented, and to (b) identify some of the means of credentialing and preparing PT teachers. The following key observations were made by these researchers from the data collected during the study, which involved responses from 227 PT teachers, teacher educators, and state/ provincial administrators.

> No single competency was found to be ideal to become a successful PT teacher; a combination of skills was required.
>
> Traditional academic teachers may need to work on laboratory process competencies, and technology teachers may need greater expertise in physics/ math, during PT teacher training workshops.
>
> PT teachers must teach skills in problem-solving, team-work, and cooperation during the labs.
>
> 78% of the respondents indicated that PT students should have one or more math classes completed before enrolling in the course; the figure was 56% for science classes, and 36% for technology classes.
>
> Workshops proved to be the most popular method of training PT instructors; workshop length ranged from 15 to 210 hours.
>
> 96% of the respondents believed that the average "C" student could participate successfully in a PT program without being discouraged.
>
> Respondents indicated that they were teaching from 49% to 99% of the original published PT materials; the average was 94%.
>
> 54% of those surveyed indicated that Principles of Technology was taught in a team teaching environment. Teachers came from physics, technology education, vocational education, and mathematics backgrounds. (Carter & Atkinson, 1989, not paginated)

The Dugger and Hall Study

Dugger and Hall completed a study in 1989 in Iowa which evaluated learning gains by PT students against students enrolled in traditional physics classes. The evaluation was proposed by the researchers to the Iowa State Department of Education and consisted of a three-year study of the success of the PT materials and methodology in teaching physics to the students of 15 state high schools (Dugger & Hall, 1989).

These researchers began their report by describing Principles of Technology as a course which "offers the middle quartiles in the junior and senior year [grade 11 and grade 12 respectively] an opportunity to gain knowledge and skills in basic physics concepts. This exposure is not currently being provided to this group of students since most physics students are in the top quartile" (Dugger & Hall, 1989, not paginated). The authors further described the PT course material as "a revolutionary system of content organization" (not paginated), consisting of units of basic physics concepts which are taught in relation to four fundamental energy systems.

The population for the Dugger and Hall study included 257 PT students, 275 physics pupils, and 135 control group students (Dugger & Hall, 1989; Perry, 1989). In a pre-test posttest control group design, students were tested on basic physics concepts at the beginning and end of their junior or senior year in high school (Perry, 1989). The results of the investigation showed that: (a) the physics students obtained a higher pretest score than the PT students. The researchers attributed this difference to their belief that "in most cases, the best students enroll in physics" classes (not paginated); (b) the control group showed no gains between pre- and posttest scores; (c) the Principles of Technology students outscored the physics students on the posttest by almost 15 percentage points. "This is even more surprising", state the investigators, "when one considers that PT students were 7 points below the physics students when the courses began" (not paginated). The pre- and posttest results are summarized below.

Group	Pretest Mean	Posttest Mean
PT	47.80	80.84
Physics	55.07	65.77
Control	37.78	36.45

(Dugger and Hall, 1989, not paginated)

Summary

This chapter began by examining the forces acting to redirect secondary school vocational education in the early 1980s. These were the back to basics movement, an emphasis on technological literacy and transferable skill development, and the continued inability of secondary school vocational education to become technologically up-to-date. Content in the chapter also described the roles the Agency for Instructional Technology and the Center for Occupational Research and Development had in developing the Principles of Technology curriculum to help secondary school vocational educators address these issues. The foundation for and components of Principles of Technology, which was derived from CORD's successful UTC Physics course, was reviewed in some detail. A description of the two-year pilot testing phase of the PT materials followed, with discussion of the salient features and results of the test. From research conducted by AIT and CORD it was found that there were four different types of teachers teaching the PT course (academic science and mathematics, vocational, and industrial arts teachers). The chapter also noted the growth in the number of consortium members in the years following the release of the Prospectus, from a low of 33 agencies in 1983 to a high of 47 in 1989. The proposed budget for the project increased as the number of member agencies increased, from $2.5 million at the outset to $3.5 million in 1986. A summary of comments by administrators and teachers of Principles of Technology on recent implementations of the course was also provided.

The latter part of this chapter described how Alberta Education became part of the Principles of Technology consortium, and how the province pilot tested, modified, and implemented the course in selected secondary schools throughout the province. In Alberta, the course designator for PT is Industrial Physics 12, 22, 32. Students who successfully complete each course level receives five course credits. Students who complete the 12, 22, 32 series of courses receive 15 credits.

A discussion of the DACUM approach to develop curriculum was presented. This described DACUM as a process which terminated in a product, which is a competency profile. Concluding the chapter was a review of the research related to Principles of Technology. This included the studies conducted by Carter and Atkinson (1989) and Dugger and Hall (1989).

The next chapter (Chapter III) presents an analysis of validator remarks and suggestions for change to develop the recommended profile of Principles of Technology teacher competencies.

CHAPTER III

Analysis and Presentation of Data

Introduction

The content of the previous chapter reviewed: (a) the forces acting to induce secondary school vocational education to change; (b) the origins and elements of the Principles of Technology, and how it was implemented in the United States and in Alberta; (c) the literature related to Principles of Technology; and (d) research related to the current study. The purpose of this chapter is to analyze and present the research data that were collected from the Principles of Technology teachers who served as members of the profile validation team.

The population for this study consisted of 20 urban and rural Principles of Technology teachers from randomly-selected states of the United States. Of this population, 14 teachers (70%) returned instruments that could be used in the study. The instruments used in this investigation consisted of a two-page questionnaire, designed to collect demographic data from the participating Principles of Technology teachers, and a competency profile, which graphically portrayed Principles of Technology teacher competencies. The profile was referred to as the "initial" profile during the pilot study only. Once the pilot study was completed and the profile was modified to reflect the necessary changes, it became known as the "revised" profile. The revised profile was used to collect data from Principles of Technology teachers in the United States. From the revised profile a "recommended" profile of Principles of Technology teacher competencies was developed by the researcher.

For ease of reporting the collected data, this chapter will be divided into three sections: Demographics, Analysis of the Revised Profile, and Construction of the Recommended Profile. The collected data will be presented in tables so that the reader may quickly review the information shown.

Demographics

The two-page questionnaire collected three types of demographic data from participating Principles of Technology teachers. These were teaching jurisdiction, teacher background, and professional preparation. The questionnaire consisted of seven questions that dealt with these variables: teaching jurisdiction, teaching experience, possession of a degree, industrial or business experience, mathematics and physics coursework completed at the undergraduate level, and how PT teaching competencies were acquired.

Question One:

1. How would you classify your school jurisdiction?

a. urban b. rural c. other ____________________

The purpose of this question was to determine the type of school jurisdiction that employed the teachers involved in the study. The data collected with this question are presented in table 1. These data show that 11/14 (78.6%) of the respondents considered themselves to be teaching in an urban environment, while 3/14 (21.4%) taught in a rural setting.

Question Two:

2. How many years of experience do you have teaching the Principles of Technology?

a. up to and including one b. two c. three

d. four e. five f. more than five years

Table 1

Employing Jurisdiction of Participants

(N=14)

Employing Jurisdiction	Participants	
	No.	%
Urban	11	78.6
Rural	3	21.4
Total	14	100.0

The purpose of this question was to determine the number of years of teaching experience each participant had teaching Principles of Technology. Collected data appear in table 2. Data in this table indicate that of the 14 urban or rural Principles of Technology teachers who participated in the study, 4 or 28.6% of that group had five years experience teaching PT. A further analysis of these data show that 3/14 (21.4%) had two years teaching experience; 3/14 (21.4%) had three years teaching experience; 2/14 (14.3%) had more than five years teaching experience; 1/14 (7.1%) had four years teaching experience; and 1/14 (7.1%) had up to and including one year teaching Principles of Technology. It can be seen from the above data that the majority of the respondents (42.9%) had five or more years teaching experience with this course. Since Principles of Technology was implemented five years ago, these data indicate that most of these teachers have taught the course since its inception in 1985.

Table 2

Principles of Technology Teaching Experience: Participants

(N=14)

Years of Experience	Participants					
	Rural		Urban		Total	
	No.	%	No.	%	No.	%
Up to one	0	0	1	7.1	1	7.1
Two	1	7.1	2	14.3	3	21.4
Three	1	7.1	2	14.3	3	21.4
Four	0	0	1	7.1	1	7.1
Five	0	0	4	28.6	4	28.6
More than five	1	7.1	1	7.1	2	14.3
Total	3	21.4	11	78.6	14	100.0

Question Three:

3. Check the highest degree you have earned:

a. 2 year postsecondary (technical or associate degree)

b. bachelors c. masters d. 6th year

e. doctorate f. other ____________________

Data collected from this part of the questionnaire were used to organize table 3. These data show that 1 rural and 3 urban teachers held a bachelors degree. This represented 28.6% of the research population. Of the remaining ten teachers: 6 (42.9%) indicated that they held a 6th year certificate; and 4 (28.6%) held a masters degree.

It is evident from these data that those involved in the research possessed a minimum of a baccalaureate degree. The majority of the respondents held a 6th year certificate.

Table 3

Highest Degree Earned by Participants

(N=14)

Highest Degree Earned	Participants					
	Rural		Urban		Total	
	No.	%	No.	%	No.	%
2-year post-secondary	0	0	0	0	0	0
Bachelors	1	7.1	3	21.4	4	28.6
Masters	0	0	4	28.6	4	28.6
6th year	2	14.3	4	28.6	6	42.9
Doctorate	0	0	0	0	0	0
Other	0	0	0	0	0	0
Total	3	21.4	11	78.6	14	100

Question Four:

This question was designed to secure data that would determine the trade, industrial, or business backgrounds of participants. For those who held journeyman certification, the question also determined the trade specialization of the individual.

Question four asked:

4. Check the type of industrial, trade, or business experience that you have had:

a. journeyman (specialization:________________________)

b. summer jobs only

c. no prior job experience

d. other ________________________ __________________

Data collected with this question were used to prepare table 4. Of the 13 respondents (one teacher did not answer this question), 3 (21.4%) held a journeyman certificate in these trades: construction, 2/14 (14.3%); and electrical, 1/14 (7.1%). Five of the teachers (35.7%) checked the "Other" item. Responses here covered a wide range of occupations, including: instructor with the United States Air Force; chemist; quality control technician; phlebotomist; aircraft maintenance technician; auto dealer; and physics teacher. A similar number of teachers (5/14, or 35.7%) indicated that they had either had summer jobs only or no industrial, trade, or business experience prior to becoming a Principles of Technology teacher. From these data the researcher concluded that: (a) most teachers had some type of related work experience, and (b) specific work experience, while probably of benefit to a teacher of Principles of Technology, does not appear to be a prerequisite for successful performance as a teacher of this course.

Question Five:

This question was related to the third question which dealt with the type of degree held by the participants. Question five was prepared to determine the number of mathematics courses participants had completed in their undergraduate degree programs. Collected data appear in table 5. Question five asked:

5. How many courses in mathematics did you have at the undergraduate level?

a. up to and including four b. five c. six

d. seven e. eight f. nine g. ten

h. other ______________________

Table 4

Type of Industrial, Trade, or Business Experience: Participants

(N=14)

Work Experience	Participants					
	Rural		Urban		Total	
	No.	%	No.	%	No.	%
Journeyman	0	0	3	21.4	3	21.4
Summer Jobs	0	0	3	21.4	3	21.4
No Prior Experience	1	7.1	1	7.1	2	14.3
Other	1	7.1	4	28.6	5	35.7
Total	2	14.3	11	78.6	13	92.9

Eight of the fourteen teachers (57.1%) participating in the study indicated they had completed "up to and including four" mathematics courses during their undergraduate years. All of these teachers were from urban teaching jurisdictions. Of the remaining teachers: 2/14 (14.3%) said they had had five mathematics courses; 2/14 (14.3%) said they had had six courses; and 2/14 (14.3%) said they had had eight courses in mathematics. It appears from these data that completion of a large number of mathematics courses in preparation for teaching Principles of Technology is not necessary. The fact that the rural teachers had completed, on average, more mathematics courses than their urban counterparts (7.3 courses vs. 4.4 courses) is not likely to be significant, given the small sample size in this study (this calculation assumes that the eight teachers who responded with the "up to and including four" option actually complete four mathematics courses. Using this assumption, the average number of completed mathematics courses for the 14 teachers was 5).

Question Six:

6. How many physics courses did you have at the undergraduate level?

a. up to and including four b. five c. six

d. seven e. eight f. nine g. ten

h. other ______________________________

This question helped determine the physics backgrounds of the individuals responsible for teaching Principles of Technology acquired as undergraduate students. Data collected with this question are presented in table 6. A majority of the respondents (8/14 teachers, or 57.1%) had completed up to and including four courses in physics. Two teachers (14.3%) indicated they had taken six physics courses, and one teacher (7.1% of the sample) had completed five courses. Three teachers (21.4%) responded with the "Other" option. Of these, two said that they were physics majors in university, and had completed more than ten courses in physics. The remaining teacher indicated that he/she had not completed any physics courses while an undergraduate student. These data suggest that: (a) most Principles of Technology teachers in the United States have completed one to four courses in physics while undergraduate students; and (b) school administrators had been generally following the recommendations made by the designers of the Principles of Technology course, who claimed that teachers would require at least two or three undergraduate level courses in physics for successful teaching of the course.

Question Seven:

7. How did you acquire the competencies to teach the instructional content of Principles of Technology? (Note: you may circle more than one response.)

a. undergraduate studies b. on the job

c. inservice d. Principles of Technology workshops

e. other ______________________________

The purpose of question seven was to identify where teachers of Principles of Technology involved in the research acquired their skills to teach the curriculum. Thirteen of the teachers (92.9%) indicated more than one of the options listed as the source of their teaching skill; the percentages shown, as a result, do not add up to 100%. Ten teachers (71.4%) said they had learned how to teach PT "on the job". Eight teachers (57.1%) indicated they had completed Principles of Technology teacher training workshops. Six teachers (42.9%) credited undergraduate studies as providing them with some of their teaching skills. Three teachers (21.4%) indicated that local inservice courses helped them attain Principles of Technology teaching skills. Using the "Other" option, four teachers (28.6%) responded that the following factors helped them learn how to teach PT: graduate studies, trial and error, prior teaching experience, and "a whole bunch of long nights studying". These data indicate that on job training played an important role in helping a large majority of these teachers learn how to teach Principles of Technology. This suggests that Principles of Technology teacher training workshops and undergraduate studies, the second and third most common responses, had not fully prepared them for their responsibilities as Principles of Technology teachers.

Table 5

Undergraduate Courses in Mathematics: Participants

(N=14)

Courses in Mathematics	Participants					
	Rural		Urban		Total	
	No.	%	No.	%	No.	%
Up to four	0	0	8	57.1	8	57.1
Five	0	0	2	14.3	2	14.3
Six	1	7.1	1	7.1	2	14.3
Seven	0	0	0	0	0	0
Eight	2	0	0	0	2	14.3
Nine	0	0	0	0	0	0
Ten	0	0	0	0	0	0
Other	0	0	0	0	0	0
Total	3	21.4	11	78.6	14	100

Table 6

Undergraduate Courses in Physics: Participants

(N=14)

Courses in Physics	Participants					
	Rural		Urban		Total	
	No.	%	No.	%	No.	%
Up to four	1	7.1	7	50	8	57.1
Five	0	0	1	7.1	1	7.1
Six	1	7.1	1	7.1	2	14.3
Seven	0	0	0	0	0	0
Eight	0	0	0	0	0	0
Nine	0	0	0	0	0	0
Ten	0	0	0	0	0	0
Other	1	7.1	2	14.3	3	21.4
Total	3	21.4	11	78.6	14	100

United States Principles of Technology Teachers

Developed from these data was a summary of the characteristics of the average Principles of Technology teacher who taught this course in the United States. The average Principles of Technology teacher surveyed: (a) taught in an urban setting; (b) had taught Principles of Technology since the implementation of the course in 1985; (c) possessed a minimum of a bachelor's degree; (d) had work experience in a trade, technical, business, medical/ chemical, or teaching environment prior to teaching Principles of Technology;

(e) completed from one to four mathematics and one to four physics courses while an undergraduate student; and (f) learned how to teach Principles of Technology from on job experience, Principles of Technology teacher training workshops, and through undergraduate studies.

Table 7

Sources of Competencies for Teaching Principles of Technology

(N=14)

Sources of Competencies	Participants					
	Rural		Urban		Total	
	No.	%	No.	%	No.	%
Undergrad. Studies	0	0	6	42.9	6	42.9
On the job	0	0	10	71.4	10	71.4
Inservice	1	7.1	2	14.3	3	21.4
PT Workshops	2	14.3	6	42.9	8	57.1
Other	2	14.3	2	14.3	4	28.6
Total	N/A	N/A	N/A	N/A	N/A	N/A

Analysis of the Revised Principles of Technology Teacher Competency Profile

The instrument used in this study to collect data on Principles of Technology teacher competencies was the revised Principles of Technology teacher competency profile that resulted from the pilot study. The revised competency profile had 15 bands which consisted of 15 general areas of competence encompassing a total of 162 specific competency statements. Principles of Technology teachers who were involved in the study were requested to review the general areas of competence and their related competency statements for validity, sequence, and wording, and to note suggested changes directly onto the profile. Respondents were also asked to add new general areas of competence or competencies they felt were missing and should be added to the chart.

Comments made on the profile were evaluated against the following criteria, arbitrarily established by the researcher, for inclusion on the recommended Principles of Technology teacher competency profile. Suggestions not meeting at least one of these criteria were not considered for the recommended profile and were thus eliminated from the study. The evaluation criteria for modifying, adding, or deleting either a general area of competence or a specific competency statement were:

(a) at least one-fifth (20%) of the respondents had to agree on the suggested change(s);

(b) any safety-related changes were considered important enough to warrant immediate adoption; and

(c) any obvious omissions from the Principles of Technology teaching methodology or instructional materials were similarly considered to be important enough to be adopted without challenge.

The analysis of the revised profile is presented on a band-by-band basis. There were 15 bands on the profile; each band was numbered consecutively, starting with 1.0 (Fundamental Principles of Technology) and ending with 15.0 (Applying Technology). Specific competency statements that formed the subdivisions of their respective bands were also numbered consecutively. To illustrate, the competencies for band 1.0 general area of competence were numbered 1.01, 1.02, 1.03, and so on.

BAND: 1.0

General Area of Competence: Fundamental Principles of Technology

Number of Competency Statements: 30

Number of Comments/ Suggested Changes: 4

The first three bands of the revised profile (1.0, Fundamental Principles of Technology; 2.0, Applied Principles of Technology; and 3.0, Advanced Principles of Technology), were derived from the learning objectives outlined in Principles of Technology modules 1 through 14. As such, the researcher did not anticipate that many changes to the competency statements would be requested by the study participants. In Band 1.0, only four changes were suggested.

1. One teacher thought that "Introduce Drafting and Design" should be included in this band.
2. A second respondent indicated that the band ought to reflect the laboratory learning experiences that followed the many topics presented.
3. It was suggested by a third teacher that: (a) the competency statement "Measure Power in Mechanical, Fluid, and Electrical Systems", should be incorporated between statements 1.27 (Identify Applications Where Power is Controlled or Measured) and 1.28 (Describe Concept of Force Transformers in Energy Systems); and (b) the competency statement "Measure IMA and AMA of Various Force Transformers" be added to this band.

After analysis of these suggestions, the researcher made the decision to adopt the latter two recommendations dealing with Force Transformers and Power, as these met criteria (c) above (i.e., any omissions from the Principles of Technology instructional materials would be adopted without dispute). A competency statement reading "Measure Power in Mechanical, Fluid, and Electrical Systems" was incorporated as statement number 1.28. This resulted in a renumbering of those competency statements from 1.28 to 1.30, to 1.29 to 1.31. Additionally, a competency statement reading "Measure IMA and AMA of Various Force Transformers" was added to the band as statement number 1.32.

BAND: 2.0

General Area of Competence: Applied Principles of Technology

Number of Competency Statements: 18.

Number of Comments/ Suggested Changes: 0

Respondents indicated satisfaction with this band, not suggesting any changes to it at all. One teacher did note that this band comprised the second year of Principles of Technology at his/her school.

Since there were no recommendations for modifying this band, the researcher made the decision to leave it as it appeared on the revised profile.

BAND: 3.0

General Area of Competence: Advanced Principles of Technology

Number of Competency Statements: 10

Number of Comments/ Suggested Changes: 3

Band 3.0 consisted of the final band of competency statements formulated from Principles of Technology module learning objectives. Once again, few changes were suggested.

1. One teacher believed that "Advanced Project Design", including the use of computer-aided-design, should be incorporated (this teacher neglected to provide a descriptive verb for this statement to help identify what was required of the Principles of Technology teacher in fulfilling this task).
2. A second respondent thought that band 3.0 should be incorporated within band 2.0 (Applied Principles of Technology), stating "I see no need to separate these".
3. "Measure Focal Lengths and Polarization" was recommended for inclusion after competency statements 3.04 (Identify Applications Where Radiation is Controlled or Measured) and 3.05 (Describe Concept of Time Constants).

After analysis of these suggestions, the researcher made the decision to adopt the latter recommendation for a new competency statement, numbered 3.05, reading "Measure Focal Lengths and Polarization", as it met criteria (c) listed above. This resulted in a renumbering of competency statements 3.05 to 3.10, to 3.06 to 3.11.

BAND: 4.0

General Area of Competence: Mathematics

Number of Competency Statements: 10

Number of Comments/ Suggested Changes: 9

This band was developed after an analysis of Principles of Technology mathematics laboratories and a mathematics competency listing for senior high school students. Several changes to this band were recommended. These suggestions included:

1. "Use Calculator" or "Use Scientific Calculator", from three validators.
2. "Use Engineering Notation" instead of "Use Scientific Notation" (competency statement 4.05).
3. "Use English/Metric Weights and Measures", instead of "Use Imperial/Metric Weights and Measures" (competency statement 4.02).
4. "Use Formula" instead of "Use Formulae" (competency statement 4.10).
5. "Use Unit Analysis" as a new competency statement.
6. "Solve Vector Analysis Problems Graphically", instead of "Solve Vector Analysis Problems" (competency statement 4.09).
7. "Solve Vector Analysis Problems Trigonometrically" as a new competency statement.

After analysis of the above recommendations, the researcher decided to adopt "Use Scientific Calculator", competency statement number 4.11, as it met criteria (a) above (i.e., at least one-fifth [20%] of the respondents agreed on the suggested change). It was also decided to clarify the wording of competency statement 4.02 (Use Imperial/Metric Weights and Measures). Some respondents seemed to believe that the Imperial and metric systems of measure were used in Canadian Principles of Technology materials. Competency statements which referred to the use of the Imperial system (such as 4.02 above, and 5.07, "Choose Imperial/SI Units of Measure") were incorrect in this regard, and should have read "English" instead of "Imperial" because all North American PT materials, as published, used the English (U.S.) and metric systems of measure. The researcher therefore decided to modify the wording of competency statement 4.02 to read "Use English/Metric Weights and Measures".

BAND: 5.0

General Area of Competence: Instructional Planning.

Number of Competency Statements: 7

Number of Comments/ Suggested Changes: 2

The next three bands of competency statements (5.0, Instructional Planning, 6.0, Instructional Execution: Classroom, and 7.0, Instructional Execution: Laboratory) were created by the researcher after a review of the recommended Principles of Technology teaching strategy and related vocational instructor competency profiles. Respondents indicated that band 5.0 was in need of two changes:

1. Several teachers expressed confusion over competency statement 5.07, "Choose Imperial/SI Units of Measure". One teacher commented that the statement "appears to mean: use only Imperial or SI, but not both." Two respondents suggested changing the verb portion of this statement to read "Use", not "Choose". Another teacher thought that the statement should read "U.S.", instead of Imperial, measure.
2. "Evaluate Availability of Necessary Funding to Obtain Supplies" was suggested as a new competency statement.

After analysis of these suggestions, the researcher concluded that the use of "Imperial" as a system of measure was incorrect. Also, the use of "SI" instead of "Metric" (as in 4.02, "Use Imperial/Metric Weights and Measures") was an inconsistency the researcher should not have allowed to occur on the revised profile. The researcher therefore made the decision to change the wording of competency statement 5.07 to "Use English/Metric Units of Measure".

BAND: 6.0

General Area of Competence: Instructional Execution: Classroom

Number of Competency Statements: 13

Number of Comments/ Suggested Changes: 1

Only one modification to this band, Instructional Execution: Classroom, was suggested. This teacher thought that a new competency statement, reading "Develop Higher Order Thinking Skills", belonged in this band. While no other validators made this suggestion, the researcher decided that this competency was one of the goals of the Principles of Technology teaching strategy, and should thus be included on the recommended profile. A new competency statement, numbered 6.14, ""Develop Higher Order Thinking Skills", was added.

BAND: 7.0

General Area of Competence: Instructional Execution: Laboratory

Number of Competency Statements: 11

Number of Comments/ Suggested Changes: 10

This band of competency statements, Instructional Execution: Laboratory, inspired respondents to suggest the greatest number of modifications for any band on the profile, to a total of ten. The broad range of suggestions included nine new competency statements and one request for rewording an existing statement. These recommendations were:

1. "Identify Communication Skills for Technology" as a new competency statement.
2. "Use Communication Skills" as a new competency statement.
3. "Plan for Make-Up Lab" as a new competency statement.
4. "Take Students to Shop Area for Labs" as a new competency statement.
5. "Teach Micrometer and Caliper Labs" as a new competency statement.
6. "Set-Up Special Labs for Voc-Ed Teachers" as a new competency statement.
7. "Conduct Lab Safety Training" as a new competency statement.
8. "Maintain Equipment in Working Order" as a new competency statement.
9. "Use Common Examples of Technology" as a new competency statement.
10. "Anticipate Student Difficulties through Instructor Pre-Lab" instead of "Anticipate Student Difficulties".

After an analysis of the above suggestions, the researcher elected to adopt the two safety-related recommendations to this band. These were "Conduct Lab Safety Training", to be placed after competency 7.02 (Identify Laboratory Safety Hazards), and "Maintain Equipment in Working Order", as a new competency statement. None of the other suggestions met the selection criteria.

BAND: 8.0

General Area of Competence: Evaluation

Number of Competency Statements: 4

Number of Comments/ Suggested Changes: 2

Band 8.0, Evaluation, was developed after a review of evaluation competencies for vocational teachers on related profiles. Only two changes were suggested for this band:

1. One teacher remarked that "The provincial education authority (or higher) should coordinate development of evaluation instruments. Each instructor need not be required to perform this task redundantly. They should develop only the unique evaluations required for their situation." This comment was in apparent response to competency statement 8.01, "Develop Evaluation Instruments".
2. A second teacher commented that it was important to "emphasize the necessity of students to do homework assignments". A competency statement to reflect this belief was not put forth by this validator.

After analysis, the researcher decided that no changes would be made to the competency statements in this band, since (a) both teachers had neglected making specific suggestions for changing the band; and (b) neither teacher's comments met any of the selection criteria.

BAND: 9.0

General Area of Competence: Course Management

Number of Competency Statements: 10

Number of Comments/ Suggested Changes: 1

This band of ten competency statements registered a solitary suggestion for improvement: that a new competency statement, "Develop Lab Equipment Storage System", be added. The researcher believed this recommendation to be at least partially safety-related, and therefore decided to incorporate the suggestion as statement 9.05, between statements 9.04 (Maintain Laboratory

Equipment Inventory) and the old 9.05 (Develop Equipment Check-Out System).

BAND: 10.0

General Area of Competence: Laboratory Maintenance and Upkeep

Number of Competency Statements: 10

Number of Comments/ Suggested Changes: 5

Respondents indicated that the band Laboratory Maintenance and Upkeep was in need of five changes. These were:

1. "Construct Examples Mach. Bldg." as a new competency statement. The researcher has not been able to understand exactly what was meant by this suggestion.
2. Delete competency statements 10.03 (Use Machine Tools), 10.05 (Perform Basic Plumbing Repairs), and 10.06 (Perform Basic Metalworking Operations).
3. "Develop Equipment Replacement Plan" as a new competency statement.

Since none of these suggestions met any of the selection criteria, the researcher decided not to adopt any of them. Therefore, no changes were made to this band.

BAND: 11.0

General Area of Competence: Professional Development

Number of Competency Statements: 7

Number of Comments/ Suggested Changes: 4

The following changes to this band were recommended by participants in the study:

1. "Develop Network of PT for Information and Knowledge" as a new competency statement. The researcher was unclear as to what exactly was meant by this comment, i.e., whether the teacher was referring to an electronic network, paper-based circulation, or some other form of communication.
2. Delete competency statements 11.04 (Supervise Student Teachers), and 11.05 (Plan Student Teaching Experiences). Apparently this respondent does not perform either of these functions as a Principles of Technology teacher.
3. Regarding competency statements 11.04 and 11.05, one teacher commented that he/she would have to be certified by the state before these tasks could be fulfilled.

After analysis by the researcher it was decided that none of the above suggestions met any of the selection criteria and thus could not be incorporated into the recommended profile of Principles of Technology teacher competencies.

BAND: 12.0

General Area of Competence: Special Competencies

Number of Competency Statements: 7

Number of Comments/ Suggested Changes: 0

As with band 2.0 (Applied Principles of Technology), respondents indicated satisfaction with this band, not suggesting any changes to it at all.

Since there were no recommendations for modifying this band, the researcher made the decision to leave it as it appeared on the revised profile.

BAND: 13.0

General Area of Competence: Computers and Computer Programs

Number of Competency Statements: 7

Number of Comments/ Suggested Changes: 2

This band was created by the researcher after discovering that many Principles of Technology teachers had incorporated the use of computers in their classes, even though this is not a recognized component of the Principles of Technology curriculum. Respondents made two comments about this band:

1. "Intro to CAD" was suggested as a new competency statement. A very similar competency statement was already on the revised profile in band 15.0 (Applying Technology), as statement 15.07, "Use Computer-Aided Design Technologies";
2. One teacher, in commenting on this band and band 15.0 (Applying Technology), said "These would be nice, but are they necessary?"

After analysis, the researcher elected not to make any changes to this band, since the suggestions made: (a) did not provide specific examples of what changes were thought necessary; and (b) did not meet any selection criteria for inclusion on the recommended profile.

BAND: 14.0

General Area of Competence: Educational Technology

Number of Competency Statements: 5

Number of Comments/ Suggested Changes: 0

As with band 2.0 (Applied Principles of Technology), respondents indicated satisfaction with this band, not suggesting any changes to it at all. Since there were no recommendations for modifying band 14.0, the researcher made the decision to leave it as it appeared on the revised profile.

BAND: 15.0

General Area of Competence: Applying Technology

Number of Competency Statements: 13

Number of Comments/ Suggested Changes: 2

This final band of competency statements was created to reflect the growing use of technology within Principles of Technology laboratories and classrooms. As with the band on computers (13.0, Computers and Computer Programs), these tasks do not comprise part of the "official" Principles of Technology curriculum, though they are mentioned as examples of relevant technologies that students may wish to explore. Two teachers commented that these tasks were either not being performed in their classes, or were not really necessary (see comment in band 13.0 analysis). One respondent said that "As Principles of Technology evolves we may put these skills to use." The researcher decided that no changes were needed to this band.

Construction of the Recommended Principles of Technology Teacher Competency Profile

The major purposes of this study were to validate a modified DACUM chart of Principles of Technology teacher competencies, and to construct a "recommended" profile representing the competencies required of a PT teacher.

These goals were accomplished through review and critique of a revised profile of Principles of Technology teacher competencies by practicing PT teachers in the United States. Evaluation criteria for modifying, adding, or deleting either a general area of competence or a specific competency statement were:

(a) at least one-fifth (20%) of the respondents had to agree on the suggested change(s);

(b) any safety-related changes were considered important enough to warrant immediate adoption; and

(c) any obvious omissions from the Principles of Technology teaching methodology or instructional materials were similarly considered to be important enough to be adopted without challenge.

Table 8 summarizes the number of comments or suggested changes made by validators, the number of changes adopted by the researcher, and for what reason (i.e., what criteria were met).

Types of Changes

From validator comments and suggestions on the revised Principles of Technology competency profile, it was evident that major changes to the profile (such as deletion of a band of competencies, or complete reorganization of an existing band) were not required. Teacher comments generally fell into one of six groups: (a) suggestions for new competency statements; (b) rewording of an existing statements; (c) unclear or vague suggestions; (d) deletion of existing competency statements; (e) general observations; and (f) major changes. These data are summarized in table 9.

Most teacher comments focused on the need for either new competency statements (48.9%) or the rewording of an existing statements (13.3%). Five validator suggestions (11.1%) did not clearly specify what changes were desired. Another five comments (11.1%) suggested deletion of existing competency statements. Four comments (8.9%) were observations that teachers wrote onto the revised profile, not necessarily indicating that changes were either needed or desired. Three suggestions were for relatively major changes to the profile (complete reorganization of Band 1.0, for example, or the merging of Bands 2.0 and 3.0).

Table 8

Summary of Comments and Adopted Changes to Revised PT Competency Profile

	Band	Competency Statements	Comments/ Suggestions	Adopted	Criteria
1.0	Fundamental Principles of Technology	30	4	2	(c)
2.0	Applied Principles of Technology	18	0	0	N/A
3.0	Advanced Principles of Technology	10	3	1	(c)
4.0	Mathematics	10	9	2	(a), (c)
5.0	Instructional Planning	7	2	1	(a)
6.0	Instructional Execution: Classroom	13	1	1	(c)
7.0	Instructional Execution: Laboratory	11	10	2	(b)
8.0	Evaluation	4	2	0	N/A
9.0	Course Management	10	1	1	(b)
10.0	Laboratory Maintenance and Upkeep	10	5	0	N/A

11.0	Professional Development	7	4	0	N/A
12.0	Special Competencies	7	0	0	N/A
13.0	Computers and Computer Programs	7	2	0	N/A
14.0	Educational Technology	5	0	0	N/A
15.0	Applying Technology	13	2	0	N/A
TOTALS		162	45	10	N/A

Of the 45 suggestions made by validators, the researcher incorporated changes only from comments that fell into either of the first two groups (new competency statements and rewording of existing competency statements); all of the remaining suggestions were either unclear as to what change was thought necessary, or did not meet any of the selection criteria for incorporation on the recommended profile of Principles of Technology teacher competencies. Of the 22 suggestions for new competency statements, 8 (17.8% of the total number of comments) met selection criteria and were adopted. Revisions to the wording of two competency statements (4.4%) were made from the six validator suggestions for such changes.

The Recommended Profile of Principles of Technology Teacher Competencies

From the preceding analysis, the researcher created a recommended profile of Principles of Technology teacher competencies. This profile incorporated all validator suggestions meeting selection criteria. In all, 10/45 (22.2%) of the suggestions for change met the criteria established for adoption, which resulted in changes to 7/15 (46.7%) of the bands on the revised teacher profile. Of the 10 changes were eight new competency statements, which increased the number of statements on the profile from 162 (revised profile) to 170 (recommended profile). Specific changes to each band are discussed in the following paragraphs.

Table 9

Validator Comments: Principles of Technology Revised Competency Profile

Type of Comment/Suggestion	No.	Percent	Adopted	Percent
New Competency Statement	22	48.9	8	17.8
Modify Competency Statement	6	13.3	2	4.4
Unclear/Vague Suggestions	5	11.1	0	0
Delete Competency Statement	5	11.1	0	0
Observations	4	8.9	0	0
Major Changes	3	6.7	0	0
TOTALS	45	100.0	10	22.2

Two new competency statements were added to Band 1.0 (Fundamental Principles of Technology). These were: 1.28, "Measure Power in Mechanical, Fluid, and Electrical Systems"; and 1.33, "Measure IMA and AMA of Various Force Transformers".

No changes were made to Band 2.0 (Applied Principles of Technology).

In Band 3.0 (Advanced Principles of Technology), one new competency statement was incorporated, reading "Measure Focal Lengths and Polarization", number 3.05.

Two changes were made to Band 4.0 (Mathematics). "Use Scientific Calculator", a new competency statement numbered 4.11, was adopted, and "Use Imperial/Metric Weights and Measures" (4.02) was modified to read "Use English/Metric Weights and Measures".

The Band titled Instructional Planning (5.0) required only one change. The wording of statement 5.07 (Choose Imperial/SI Units of Measure) was changed to read "Use English/Metric Units of Measure".

Instructional Execution: Classroom (Band 6.0) received one revision. A new competency statement, reading "Develop Higher Order Thinking Skills" (number 6.14) was added to the Band.

Two new competency statements were added to Band 7.0 (Instructional Execution: Laboratory). These were: (a) "Conduct Lab Safety Training", numbered 7.03; and (b) "Maintain Equipment in Working Order", as competency statement 7.13.

No changes were made to Band 8.0 (Evaluation).

Band 9.0 (Course Management) required one revision. In it, a new competency statement titled "Develop Lab Equipment Storage System" was added as competency statement number 9.05.

None of the remaining six bands on the revised Principles of Technology teacher competency profile (10.0, Laboratory Maintenance and Upkeep; 11.0, Professional Development; 12.0, Special Competencies; 13.0, Computers and Computer Programs; 14.0, Educational Technology; and 15.0, Applying Technology) were changed in any way.

A copy of the recommended Principles of Technology Teacher Competency Profile can be found in the pocket on the inside back cover of this report. Note that changes to each band are highlighted through shading of the new or revised competency statement(s).

CHAPTER IV

Summary, Conclusions, Recommendations, and Observations

Introduction

The third chapter of this report briefly described the instruments that were used to collect data for the study, and presented the information collected from the research population of rural and urban Principles of Technology teachers in selected states of the United States. These data were used to create a recommended Principles of Technology teacher competency profile.

This final chapter will consist of four related sections. The first section includes an overview of the problem and the other major components of the research design. Included in this section is a summary of the findings that were generated from the data collected. Section two consists of conclusions made from the findings of the study. The third section presents recommendations resulting from the findings and are made to the following groups: to Alberta Education personnel; to other researchers; and to academic staff of The University of Alberta, Department of Adult, Career, and Technology Education. Observations made by the researcher while conducting the study form the fourth and final section of this chapter.

Summary

This section summarizes the problem statement, the research population, the instrumentation, and the methodology.

The Problem

The major purpose of this study was to validate a modified DACUM profile of the competencies required of a secondary school Principles of Technology teacher. Two objectives were identified to give support to the major purpose of the study. These objectives were:

(a) To have selected, practicing Principles of Technology teachers in the United States/ Canada serve as members of a team to validate a Principles of Technology teacher competency profile; and

(b) To modify the competency profile according to the recommendations made by the members of the validation team to produce a recommended Principles of Technology teacher competency profile.

Data collection instruments designed and developed to fulfill both the major purpose of the research and the supporting objectives for this study included a questionnaire and a modified DACUM chart of Principles of Technology teacher competencies. Both instruments were pilot tested and refined prior to being used in the main study.

Fifteen general areas of competence and 162 competency statements were found on the revised profile. The researcher determined that, based on the validation comments, 7/15 (46.7%) of the general areas of competence found on the profile were in need of revision. Included in these modifications were eight new competency statements and changes to the wording of two statements to help clarify or correct their meanings. These changes were made to the revised profile, at which point it became known as the recommended Principles of Technology teacher competency profile.

The Population

The population for this study consisted of all practicing Principles of Technology teachers in the United States and Ontario. From this population a stratified random sample of 12 states was selected from which Principles of Technology teachers could be asked to serve as profile validators. To identify these teachers, a letter was drafted and sent to each of the 12 states' vocational education administrators requesting the permission of the administrator to allow two outstanding Principles of Technology teachers in their state to become involved in the research. The letter additionally requested that the administrators provide the names and addresses of these two Principles of Technology teachers so that these teachers could be contacted directly by the researcher. This process would have generated a sample of 24 Principles of Technology teachers (two teachers from each of twelve states). One of the 12 states decided not to participate in the study, and a second was withdrawn by the researcher. The ten remaining state administrators provided the researcher with the names and addresses of a minimum of two PT teachers from their state. These 20 teachers were located in various school districts within their respective states.

The 20 Principles of Technology teachers were contacted by the researcher and asked to participate in the study as profile validators. Of the 20 teachers, 10 (50%) responded by the deadline date set for return of the research instruments. Through a follow-up procedure an additional four participants returned completed research instruments, bringing the total to 14/20 (70%) of the research population. Of these, 11 (78.6%) taught in an urban environment and 3 (21.4%) taught in a rural jurisdiction.

Instrumentation

Two instruments were developed by the researcher to collect data for the study. These consisted of a two-page questionnaire, designed to collect demographic data from study participants, and a revised Principles of Technology teacher competency profile, which was a modified DACUM chart representing competencies required to teach Principles of Technology.

The questionnaire used by the researcher was developed after a review of several publications in the field of instrument design and development. The initial Principles of Technology teacher competency profile, used in the pilot study, was created after a content analysis of Principles of Technology textual and support materials, published materials relating to Principles of Technology, and three existing DACUM charts for vocational and industrial teachers/ administrators.

Both the questionnaire and the initial Principles of Technology teacher competency profile were tested through a pilot study before they were used in the main data collection phase of the research. The purposes of the pilot study were to determine: (a) if the instructions for completion of the instruments were explicit and easy to follow; (b) if the general areas of competence and competency statements were phrased and arranged correctly on the initial competency profile; and (c) the amount of time it took to complete the questionnaire and the validation of the profile.

From the results of the pilot study changes were made to both the questionnaire and the initial competency profile to improve the quality of the instruments for the main study. The initial Principles of Technology teacher competency profile consisted of 10 general areas of competence and 82 competency statements; the "revised" profile (so named after the pilot study) consisted of 15 general areas of competence and 162 competency statements.

Those teachers who participated in the pilot study were not involved in the main research. These teachers were selected because they were readily available to the researcher, and had extensive teaching experience with Principles of Technology in Alberta.

Participants in the main study were asked to complete the questionnaire and validate the revised profile by reviewing and evaluating each general area of competence and the corresponding competency statements, noting required changes on the profile itself. From the validated revised competency profiles the researcher developed the recommended Principles of Technology teacher competency profile, which included a total of 15 general areas of competence and 170 competency statements.

Methodology

To select articles and publications relevant to this study, seven electronic databases and several education indexes were searched. This search yielded 398 hits of which 76 publications were determined to be related to the present study. An analysis of these articles and documents provided the researcher with information on the need for, and origins and implementation of Principles of Technology in both the United States and Canada.

Two data collection instruments, in the form of a questionnaire and a Principles of Technology teacher competency profile, were developed and used for the study. A letter was prepared and mailed to 12 randomly selected state vocational education administrators requesting their cooperation in the study by identifying Principles of Technology teachers in their state who they would nominate as competency profile validators. Ten of the twelve selected states participated in the study. A research package, consisting of a covering letter, a questionnaire, directions for validators, a revised Principles of Technology teacher competency profile, and a self-addressed envelope were assembled and mailed to 20 research participants in ten states of the United States.

By the deadline date established, 50% (10/20) of the research participants had returned completed instruments. A follow-up procedure resulted in four additional research instruments being collected, bringing the total number of participants up to 70% (14/20). Instruments returned after three weeks past the deadline date were not used in the study. Data collected were analyzed and findings, conclusions, and recommendations were formulated.

Literature Review and Related Research

Chapter two of this report provides the reader with an overview of the Principles of Technology project, from its origins in the Unified Technical Concepts (UTC) Physics curriculum to its implementation in consortia member schools. The DACUM procedure for curriculum development is discussed, along with a review of related research in Principles of Technology.

The review of the development of the Principles of Technology course began with a description of the forces acting to change the focus of secondary school vocational education in the early 1980s. A strong movement away from the liberal and general secondary school programs of the seventies gathered momentum as dozens of studies and reports trumpeted the failures of the public school system in the United States. This led to a much stronger emphasis on the teaching and acquisition of the "academic basics" of English, mathematics, and science. Many states raised graduation requirements and began to take a critical look at their secondary school vocational education offerings for their level of academic "thoroughness". Technological literacy was quickly identified by both science and vocational/ technical educators as a new "basic" to be offered to all students to enable them to become better prepared for an increasingly complex world. This re-ignited the on-going debate over whether vocational education teachers should teach occupation-specific skills or transferable, generic work skills (such as decision-making, analysis, and problem-solving). Many educators and researchers, it was shown, were convinced that specific skill training was no longer relevant to the workers of today or tomorrow. Since most secondary school vocational education courses focused on the teaching of specific work skills, they came under great pressure to adapt their courses to the realities of the workplace. All of this attention on secondary school vocational education highlighted its inability to provide relevant learning experiences for students with up-to-date, technologically current tools and equipment.

The role of the Center for Occupational Research and Development (CORD) and the Agency for Instructional Technology (AIT) was described in detail. These agencies recognized the need for a redirection in secondary school vocational education in the early eighties and sought to create a course based on the underlying principles, and not specifics, of technology. They decided that the course would have to be academically challenging, provide some measure of technological literacy, teach fundamental principles of technology, and not require expensive laboratory equipment that would quickly become obsolete. The result was Principles of Technology, an adaptable, modularized, secondary school course of studies in technology. Derived from CORD's successful Unified Technical Concepts Physics, which was being used in many postsecondary technician training programs, Principles of Technology focused on the learning and application of essential physics and mathematics concepts required by technicians. What made UTC Physics and Principles of Technology different from other courses in physics was the emphasis on the unifying, analogous relationships extending across the four major energy systems. Using videotape, student and teacher modules, hands-on laboratories, math labs, lectures, and class discussions, Principles of Technology generated wide acceptance as a legitimate secondary school vocational education course that was relevant to the needs of the decade--and beyond. It was eventually adopted by the 47 state and provincial educational agencies that agreed to fund development of the project, and is being implemented in Mexico, Turkey, and South Africa.

A brief clarification of the term 'curriculum' as defined by authorities in this field was presented. CORD and AIT used the term curriculum to describe the UTC and Principles of Technology courses, even though this was shown to be at variance with accepted definitions of curriculum.

The discussion of the implementation of Principles of Technology in secondary school systems described the successes and failures of this phase of the PT project. Equipment acquisition and set-up difficulties plagued the early school implementations, but this was countered by the broad acceptance of and enthusiasm for the course. Most importantly, significant learning gains were achieved in physics, a subject area that many had considered "hard" to learn.

The description of Alberta's involvement in the Principles of Technology project centred on the implementation and pilot testing of the course in the province from September 1986 to May 1989. Start-up problems mirrored those experienced in the United States implementation of the course. At the time of this report (1990) Principles of Technology is being taught in four public schools and one separate school in the province, with a sixth (also from a separate school board) implementation slated for January 1991.

The latter part of chapter two examined the DACUM curriculum development process and identified research related to the study. DACUM was described as both a process and a product. The process consisted of brainstorming by a team of competent practitioners from a specific occupation in the identification of the general areas of responsibility and specific competencies required by a worker in that job. A competency profile, consisting of a graphic portrayal of the general areas of worker competence and the specific competencies identified from the group session(s), was the product. The research related to this study was confined to two studies conducted in the United States in 1989. These studies concluded that there was wide acceptance of Principles of Technology throughout the U.S. and Canada, and that significant, measurable learning gains in physics could be observed.

The Findings of the Study

The following research findings resulted from an analysis of the data collected during the study.

Of the 14 teachers returning completed research instruments, 11/14 (78.6%) considered themselves to be teaching in an urban environment, and 3/14 (21.4%) teaching in a rural setting. Six of the teachers (42.9%) had five or more years' teaching experience with Principles of Technology; 3/14 (21.4%) had two years teaching experience; 3/14 (21.4%) had three years teaching experience; 1/14 (7.1%) had four years teaching experience; and 1/14 (7.1%) had up to and including one year teaching Principles of Technology. Supporting data for these findings can be found in table 2, page 82.

The majority of the respondents in this study (6 teachers, or 42.9% of the research population) held a 6th year certificate, beyond their baccalaureate degrees. Of the remaining 8 teachers, 4 (28.6%) held a baccalaureate degree, and 4 (28.6%) held a master's degree. Table 3 on page 83 shows this information.

Respondents had a wide variety of trade, industrial, or business backgrounds. Of the Principles of Technology teachers surveyed, 3/14 (21.4%) were certified journeymen. Five participants (35.7%) had work experiences that ranged from teaching, laboratory technology, technical maintenance, and quality control technician, to automobile sales. Five respondents (35.7%) indicated that they had had only summer jobs, or no trade, industrial, or business experience prior to teaching Principles of Technology. These data are summarized in table 4 on page 85.

Eight of the fourteen teachers (57.1%) participating in the study indicated they had completed "up to and including four" mathematics courses during their undergraduate years. Of the remaining teachers: 2/14 (14.3%) said they had had five mathematics courses; 2/14 (14.3%) said they had had six courses; and 2/14 (14.3%) said they had had eight courses in mathematics. Table 5, page 88 includes this data.

A majority of the respondents (8/14 teachers, or 57.1%) had completed up to and including four courses in physics. Two teachers (14.3%) indicated they had taken six physics courses, and one teacher (7.1% of the sample) had completed five courses. Three teachers (21.4%) responded with the "Other" option. Of these, two said that they were physics majors in university, and had completed more than ten courses in physics. The remaining teacher indicated that he/she had not completed any physics courses while an undergraduate student. These data are presented in table 6, page 89.

Teachers involved in this study claimed that they had acquired their skills in teaching Principles of Technology from a variety of sources. Ten teachers (71.4%) said they had learned how to teach Principles of Technology "on the job". Eight teachers (57.1%) indicated they had completed Principles of Technology teacher training workshops. Six teachers (42.9%) credited undergraduate studies as providing them with some of their teaching skills. Three teachers (21.4%) indicated that local inservice courses helped them attain Principles of Technology teaching skills. Four teachers (28.6%) responded that a variety of factors helped them learn how to teach PT (including graduate studies, trial and error, and prior teaching experience).

The research population, as a group, made a total of 45 comments on the revised Principles of Technology teacher competency profiles they had been asked to validate, for an average of 3.2 comments/profile (45/14). The researcher believed that, of these suggestions, 10 (22.2%) met one or more of the following criteria for inclusion on the recommended Principles of Technology teacher competency profile:

(a) at least one-fifth (20%) of the respondents had to agree on the suggested change(s);

(b) any safety-related changes were considered important enough to warrant immediate adoption; and

(c) any obvious omissions from the Principles of Technology teaching methodology or instructional materials were similarly considered to be important enough to be adopted without challenge.

These 10 revisions consisted of 8 new competency statements and changes to the wording of two competency statements, affecting 7/15 (46.7%) of the bands on the profile. These changes are summarized in the following paragraphs.

Two new competency statements were added to Band 1.0 (Fundamental Principles of Technology). These were: 1.28, "Measure Power in Mechanical, Fluid, and Electrical Systems"; and 1.32, "Measure IMA and AMA of Various Force Transformers".

In Band 3.0 (Advanced Principles of Technology), one new competency statement was incorporated, reading "Measure Focal Lengths and Polarization", number 3.05.

Two changes were made to Band 4.0 (Mathematics). "Use Imperial/ Metric Weights and Measures" (4.02) was modified to read "Use English/Metric Weights and Measures", and "Use Scientific Calculator", a new competency statement numbered 4.11, was adopted.

The Band titled Instructional Planning (5.0) required only one change. The wording of statement 5.07 (Choose Imperial/SI Units of Measure) was changed to read "Use English/Metric Units of Measure".

Instructional Execution: Classroom (Band 6.0) received one revision. A new competency statement, reading "Develop Higher Order Thinking Skills" (number 6.14) was added to the Band.

Two new competency statements were added to Band 7.0 (Instructional Execution: Laboratory). These were: (a) "Conduct Lab Safety Training", numbered 7.03; and (b) "Maintain Equipment in Working Order", as competency statement 7.13.

Band 9.0 (Course Management) required one revision. In it, a new competency statement titled "Develop Lab Equipment Storage System" was added as competency statement number 9.05.

None of the remaining eight bands on the revised Principles of Technology teacher competency profile (2.0, Applied Principles of Technology; 8.0, Evaluation; 10.0, Laboratory Maintenance and Upkeep; 11.0, Professional Development; 12.0, Special Competencies; 13.0, Computers and Computer Programs; 14.0, Educational Technology; and 15.0, Applying Technology) were changed in any way.

Conclusions

The following conclusions are reported and are based on the findings from the research.

The focus of this study was to validate a revised Principles of Technology teacher competency profile and so create a recommended PT teacher competency profile. Teachers who participated in the study as validators made a total of 45 comments on the revised profiles, of which 10 resulted in actual changes to the revised profile. Eight new competency statements were added to the profile, and the wording of two competency statements was improved to help clarify the intended meanings.

No major changes to the revised Principles of Technology teacher competency profile were made. The findings of the study suggest that the profile was a relatively complete representation of the competencies required of a teacher of PT even before the validation phase began. The researcher came to this conclusion based on: (a) the few changes suggested to the revised profiles by the validators (only, on average, 3.2 remarks per profile. Two validators did not recommend any changes to the profile at all, stating that it was "thoroughly done" or looked "great"); and (b) the number of positive evaluations written onto the profiles by validators as they reviewed the general areas of competence and competency statements. These included remarks such as:

1. "The PT Profile is extremely complete and identifies the major competencies that should be addressed."
2. "I think overall it [the competency profile] looks very good indeed."
3. "Everything looks great to me."
4. "You have been most thorough in [developing the profile]. I am pleased to be a part of your research."
5. "This is a **super** profile of teacher competencies in PT" (emphasis in original).

A second conclusion which can be made is that not all teachers follow the Principles of Technology curriculum as described by CORD/AIT. Evidence for this can be found in the remarks made on bands of competency statements which deviated from the approved Principles of Technology curriculum (mostly bands 13.0, Computers and Computer Programs, and 15.0, Applying Technology). Both of these bands were incorporated from the results of the pilot study, but many of the competencies described by these bands are not found in the PT materials themselves. The pilot study Principles of Technology teachers (in addition to the many other United States PT teachers who served as validators) appeared to have more flexibility in their approach to the course, using it as a "springboard" to explore and apply technology through the use of computers and robots (for example). There were a few comments, however, that competency statements deviating from the Principles of Technology curriculum were unnecessary. It would seem that these teachers had elected to (or were forced to) teach PT "as is", without significantly modifying its approach. The researcher does not believe this affected the accuracy of the competency profile in any way.

A final conclusion which the researcher made was that the recommended Principles of Technology teacher competency profile may be useful as a curriculum or in-service planning document for vocational education teachers as well as teacher educators. In no way should the profile be interpreted or construed as a job description by those responsible for employing Principles of Technology teachers.

Recommendations

Alberta Education

It is recommended that the Department of Education make available to the superintendents of schools who may wish to implement Principles of Technology in their schools the recommended profile of Principles of Technology teacher competencies. These administrators could make use of the profile for selecting teachers to teach this course, and structuring/ selecting in-service training opportunities for current PT teachers.

It is further recommended that Alberta Education continue to explore the relationship between Principles of Technology and technology education.

Finally, it is recommended that the profile of Principles of Technology teacher competencies be used as a planning/ evaluation tool for future developmental efforts in technology education in Alberta.

Other Researchers

The following recommendations are made to any researcher who may wish to conduct a similar study.

It is recommended that performance objectives for each competency statement on the Principles of Technology teacher competency profile be prepared. This would help instructional designers to refine the chart, and would help provide a solid foundation for the development of teacher training activities.

In designing an instrument for use in a cross-cultural investigation, other researchers are cautioned to become familiar with and use terminology that is acceptable to participants in the study.

It is recommended that this study be replicated using a larger sample of Principles of Technology teachers to determine if the competencies identified are valid within a larger sample. This may help to confirm the validity of the competencies on the recommended profile.

It is further recommended that if the study is replicated a brief explanation of the organization of an instrument like the competency profile accompany the instructions to the validators. The researcher assumed for this study that the structure and layout of the bands and competency statements was reasonably self-evident to the Principles of Technology teachers who validated the chart, but this was not always the case.

Department of Adult, Career, and Technology Education

It is recommended to personnel of the Department of Adult, Career, and Technology Education that the recommended Principles of Technology teacher competency profile be used as a curriculum planning document for a course that would prepare pre-service teachers of technology education. As such the document may help department personnel determine content for an Alberta technology teacher training program. The chart may also help department personnel prepare for and provide in-service training opportunities for technology teachers in the province.

Observations

The following observations were made by the researcher while conducting the research.

There was evidence that some teachers were unclear of the "depth" of the competency statements on the revised profile. Some validators suggested breaking some competency statements down into more competencies, or rewording others to expand or clarify their meaning. This probably helped these teachers to identify the context within which the different competencies were to be used. Very few of these suggestions met selection criteria, however, and were not incorporated into the recommended profile.

Few consistent suggestions were noted from validator comments. As a result, not many comments met criteria (a) for profile selection (i.e., that at least one-fifth [20%] of the respondents had to agree on the suggested change(s)). It can be observed from table 8, page 105 that only 2/15 bands on the profile were modified as a result of recurring suggestions. The non-modified DACUM process would almost certainly have been of help in this regard, as it would have presented an opportunity for group discussion and consensus-building among (in this case) Principles of Technology teachers.

Several comments on the profiles that did not meet selection criteria appeared to be excellent suggestions for improving the chart. Once again, using the standard DACUM process would have enabled teachers to discuss the merits of each of these suggestions, and then decide whether or not to incorporate them on the chart. Indeed, the competency profile seemed to spark an interesting range of thoughts and ideas from validators. A large majority of the suggestions for improving the profile (48.9%) were for new competency statements.

The use of "Imperial" as a system of measure on the profile was certainly a source of confusion for several teachers. The print-based Principles of Technology materials refer to "English" and "Metric" systems of measure, and the researcher should have used these terms in the relevant competency statements. The researcher also erred in the inconsistent use of "Metric" on the revised profile — competency statement 4.02 read "Use Imperial/Metric Weights and Measures", but statement 5.07 read "Choose Imperial/SI Units of Measure". Use of the term "SI" should probably have been avoided.

Individual state/ county regulations seem to have influenced some validator comments, especially with respect to band 11.0, Professional Development. Some teachers commented that they could not train student teachers without prior certification or approval.

A few validators appear to have not reviewed the profile carefully before making comments about its organization and wording. Periodically teachers recommended adopting "new" competency statements that were already on the profile, placed in a different band. These same teachers gave no indication that they saw an identical competency statement on the profile, or that these same statements were perhaps out of place. Since no consistent suggestions emerged regarding a reorganization of the competency statements in the bands, the researcher assumed that the identical competency statements were simply overlooked by the validators.

While the organization of the bands and competency statements on the profile seems to have pleased most of the teachers in the study, there was one teacher who commented that the first three bands (dealing with the content of the course) ought to reflect the actual teaching sequence. Organizing the profile in such a manner would have created a most unwieldy document, with much repetition. The researcher believes that a brief description of the layout and organization of the profile would have been helpful for teachers, and should have accompanied the research instruments during the study.

Clearly, not all Principles of Technology teachers are required to perform the competencies described by the competency profile. This applied mostly to the bands which strayed furthest from the approved Principles of Technology curriculum (13.0, Computers and Computer Programs, and band 15.0, Applying Technology); a few teachers commented that they did not perform many of these competencies. This suggests that there are varying degrees to which teachers adhere to the prescribed PT curriculum.

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APPENDIX A

Included in this appendix is a list of vocational education teacher training modules developed by the National Center for Research In Vocational Education, Columbus, Ohio. This list was consulted when the researcher was developing the initial Principles of Technology teacher competency profile.

NATIONAL CENTER FOR RESEARCH IN VOCATIONAL EDUCATION

PERFORMANCE-BASED VOCATIONAL EDUCATION TEACHER TRAINING MODULES

Category A: Program Planning, Development, and Evaluation

A-1 Prepare for a Community Survey
A-2 Conduct a Community Survey
A-3 Report the Findings of a Community Survey
A-4 Organize an Occupational Advisory Committee
A-5 Maintain an Occupational Advisory Committee
A-6 Develop Program Goals and Objectives
A-7 Conduct an Occupational Analysis
A-8 Develop a Course of Study
A-9 Develop Long-Range Program Plans
A-10 Conduct a Student Follow-Up Study
A-11 Evaluate Your Vocational Program

Category B: Instructional Planning

B-1 Determine Needs and Interests of Students
B-2 Develop Student Performance Objectives
B-3 Develop a Unit of Instruction
B-4 Develop a Lesson Plan
B-5 Select Student Instructional Materials
B-6 Prepare Teacher-Made Instructional Materials

Category C: Instructional Execution

C-1 Direct Field Trips
C-2 Conduct Group Discussions, Panel Discussions, and Symposiums
C-3 Employ Brainstorming, Buzz Group, and Question Box Techniques
C-4 Direct Students in Instructing Other Students
C-5 Employ Simulation Techniques
C-6 Guide Student Study
C-7 Direct Student Laboratory Experience
C-8 Direct Students in Applying Problem-Solving Techniques
C-9 Employ the Project Method
C-10 Introduce a Lesson
C-11 Summarize a Lesson
C-12 Employ Oral Questioning Techniques
C-13 Employ Reinforcement Techniques
C-14 Provide Instruction for Slower and More Capable Learners
C-15 Present an Illustrated Talk
C-16 Demonstrate a Manipulative Skill
C-17 Demonstrate a Concept or Principle
C-18 Individualize Instruction
C-19 Employ the Team Teaching Approach
C-20 Use Subject Matter Experts to Present Information
C-21 Prepare Bulletin Boards and Exhibits
C-22 Present Information with Models, Real Objects, and Flannel Boards
C-23 Present Information with Overhead and Opaque Materials

C-24 Present Information with Filmstrips and Slides
C-25 Present Information with Films
C-26 Present Information with Audio Recordings
C-27 Present Information with Televised and Videotaped Materials
C-28 Employ Programmed Instruction
C-29 Present Information with the Chalkboard and Flipchart

Category D: Instructional Evaluation

D-1 Establish Student Performance Criteria
D-2 Assess Student Performance: Knowledge
D-3 Assess Student Performance: Attitudes
D-4 Assess Student Performance: Skills
D-5 Determine Student Grades
D-6 Evaluate Your Instructional Effectiveness

Category E: Instructional Management

E-1 Project Instructional Resource Needs
E-2 Manage Your Budgeting and Reporting Responsibilities
E-3 Arrange for Improvement of Your Vocational Facilities
E-4 Maintain a Filing System
E-5 Provide for Student Safety
E-6 Provide for the First Aid Needs of Students
E-7 Assist Students in Developing Self-Discipline
E-8 Organize the Vocational Laboratory
E-9 Manage the Vocational Laboratory

Category F: Guidance

F-1 Gather Student Data Using Formal Data-Collection Techniques
F-2 Gather Student Data Through Personal Contacts
F-3 Use Conferences to Help Meet Student Needs
F-4 Provide Information on Educational and Career Opportunities
F-5 Assist Students in Applying for Employment or Further Education

Category G: School-Community Relations

G-1 Develop a School-Community Relations Plan for Your Vocational Program
G-2 Give Presentations to Promote Your Vocational Program
G-3 Develop Brochures to Promote Your Vocational Program
G-4 Prepare Displays to Promote Your Vocational Program
G-5 Prepare News Releases and Articles Concerning Your Vocational Program
G-6 Arrange for Radio and Television Presentations Concerning Your Vocational Program
G-7 Conduct an Open House
G-8 Work With Members of the Community
G-9 Work With State and Local Educators
G-10 Obtain Feedback About Your Vocational Program

Category H: Student Vocational Organization

H-1 Develop a Personal Philosophy Concerning Student Vocational Organizations
H-2 Establish a Student Vocational Organization
H-3 Prepare Student Vocational Organization Members for Leadership Roles
H-4 Assist Student Vocational Organization Members in Developing and Financing a Yearly Program of Activities
H-5 Supervise Activities of the Student Vocational Organization
H-6 Guide Participation in Student Vocational Organization Contests

Category I: Professional Role and Development

I-1 Keep Up-to-Date Professionally
I-2 Serve Your Teaching Profession
I-3 Develop an Active Personal Philosophy of Education
I-4 Serve the School and Community
I-5 Obtain a Suitable Teaching Position
I-6 Provide Laboratory Experiences for Prospective Teachers
I-7 Plan the Student Teaching Experience
I-8 Supervise Student Teachers

Category J: Coordination of Cooperative Education

J-1 Establish Guidelines for Your Cooperative Vocational Program
J-2 Manage the Attendance, Transfers, and Terminations of Co-op Students
J-3 Enroll Students in Your Co-op Program
J-4 Secure Training Stations for Your Co-op Program
J-5 Place Co-op Students on the Job
J-6 Develop the Training Ability of On-the-Job Instructors
J-7 Coordinate On-the-Job Instruction
J-8 Evaluate Co-op Students' On-the-Job Performance
J-9 Prepare for Students' Related Instruction
J-10 Supervise an Employer-Employee Appreciation Event (National Center for Research in Vocational Education, 1982).

APPENDIX B

Included in this appendix is a copy of the letter sent to state vocational education coordinators requesting their permission for two of their Principles of Technology teachers to participate in the study, and further asking them to provide the names and addresses of these teachers.

University of Alberta
Edmonton
Canada T6G 2G5

Adult, Career and Technology Education
Faculty of Education
633 Education South. Telephone (403) 492-3678
Fax (403) 492-0236

I am presently an instructor at the Northern Alberta Institute of Technology, as well as a part-time student enrolled in the Faculty of Graduate Studies and Research at the University of Alberta, where I am completing the requirements for a masters degree in vocational education. The thesis topic I have selected to research is "Principles of Technology Teacher Competencies".

The research design for this study involves surveying Principles of Technology (PT) teachers who will be asked to validate PT teacher competencies from a competency profile I have developed. The profile graphically depicts those competencies that I identified as being required by teachers to teach Principles of Technology.

The purpose of this letter is to request your cooperation in identifying and granting permission to TWO outstanding Principles of Technology teachers in your state to participate in the study. Specifically, I would need, in addition to your permission, the names and addresses of these teachers so that I could contact them by mail.

The validation of the profile by these teachers does not probe into any personal or school-related problems, and all responses will be kept strictly confidential.

Enclosed is a response card for you to check and return in the self-addressed, stamped envelope. It would be appreciated if you would return the card by ________ so that the research may proceed according to the time frame I have established for its completion. Please feel free to fax your response(s) to me at (403) 492-0236.

I believe the results of this study will be of benefit not only to those associated with technology/industrial education in Canada and the United States, but also to those responsible for the teacher education programs at universities across North America.

Your assistance in this phase of the research is very much appreciated.

Sincerely,

Peter Hansen

Peter Hansen
Graduate Student

encl.

PRINCIPLES OF TECHNOLOGY
TEACHER COMPETENCY PROFILE VALIDATION

After reading the preceding letter, the researcher:

___ is granted permission to survey two state Principles of Technology teachers

___ is not granted permission to survey two state Principles of Technology teachers.

Also, please indicate below whether you would like a summary of the results of the completed study.

___ I would like a summary of the study results

___ I would not like a summary of the study results.

PRINCIPLES OF TECHNOLOGY TEACHERS:

APPENDIX C

This appendix lists the 12 states, along with their student enrollment data for the 1980 to 1981 school year (in brackets) and the Principles of Technology project contact person's name and address, that were contacted as a result of the random selection process described in Chapter I.

Large School Enrollments (more than 1,000,001 students):

California (4,118,022)
-contact: Bill Callahan
California Dept. of Education
Division of Vocational Education
721 Capitol Mall, Fourth Floor
Sacramento, California 95814
(916) 445-3314

New Jersey (1,246,008)
-contact: Joseph Ryczkowski
New Jersey State Dept. of Education
Division of Vocational Education CN-500
225 West State Street
Trenton, New Jersey 08625
(609) 292-7490

North Carolina (1,129,376)
-contact: Phillip Rollain
Project Coordinator of Principles of Technology
North Carolina DPI
Education Building
Raleigh, North Carolina 27611
(919) 733-7421

Pennsylvania (1,909,292)
-contact: Vernon Register
Curriculum Coordinator
Dept. of Education
333 Market Street
Harrisburg, Pennsylvania 17126-0333
(717) 783-8506

Medium School Enrollments (400,001 to 1,000,000 students):

Colorado (546,033)
-contact: John Brosseau
Cherry Creek High School
9300 East Union Street
Englewood, Colorado 80111
(303) 773-8920

Kentucky (669,798)
-contact: Robert Petry
Dept. of Education
Division of Vocational Education
2025 Capitol Plaza Tower
Frankfort, Kentucky 40601

(502) 564-2890

Mississippi (477,059)
-contact: Travis Cliett
Assistant Director
Dept. of Education
Box 771
Jackson, Mississippi 39205
(601) 359-3074

Missouri (844,648)
-contact: Frank Drake
Assistant Commissioner/Director of Vocational Ed.
Missouri Dept. of Elementary and Secondary Ed.
Box 480
Jefferson City, Missouri 65102
(314) 751-2660

Oregon (464,599)
-contact: John Harvey
Division of Vocational Education
Oregon Dept. of Education
700 Pringle Parkway, S.E.
Salem, Oregon 97310
(503) 378-8421

South Carolina (619,223)
-contact: Lloyd Steele
Trade and Industrial Consultant
Dept. of Education
Rutledge Building, 9th Floor
Columbia, South Carolina 29201
(919) 758-2482

Small School Enrollments: (up to 400,000 students)

Alaska (86,514)
-contact: Kelly Tonsmeire
Curriculum Coordinator
Alaska Dept. of Education
Pouch F
Juneau, Alaska 99811
(907) 465-2841

Nebraska (280,430)
-contact: Marge Harouff
Director, Vocational Education
Dept. of Education
301 Centennial Mall South

Lincoln, Nebraska 68509
(402) 471-2432

APPENDIX D

This appendix contains copies of correspondence mailed to Principles of Technology teachers in the United States in May 1990, including: (a) the covering letter; (b) directions on how to validate the competency profile; and (c) the two-page questionnaire. A copy of the revised profile, which accompanied this material, can be found in a pocket on the inside back cover of this report.

University of Alberta
Edmonton
Canada T6G 2G5

Adult, Career and Technology Education
Faculty of Education

633 Education South, Telephone (403) 492-3678
Fax (403) 492-0236

In addition to teaching at the Northern Alberta Institute of Technology, I am also enrolled as a part-time graduate student in the Faculty of Graduate Studies and Research at the University of Alberta, where I am completing the requirements for a Master of Education degree in voca-tional education. The topic of my research is "Principles of Technology Teacher Competencies".

The research design for the study involves selected Principles of Technology (PT) teachers who will validate the PT teacher competencies found on the enclosed profile. Because you are presently teaching PT, and have been identified as an outstanding teacher of this subject by your state vocational education coordinator, you were selected to be part of the team to validate the enclosed profile.

The reason for this letter is to ask that you cooperate in the study by serving as a validator. Results from the pilot study indicate that you will need approximately 50 minutes to validate the profile. After you have validated the profile, please return it in the self-addressed envelope by __________. All information you provide will be treated as confidential and will be made available only to the researcher. No names will be associated with the survey and all instruments will be destroyed at the conclusion of the study. You may withdraw from the study at any time without prejudice.

As a validation team member you are asked to carefully read each statement on the profile for accuracy, complete-ness, and sequence. There is space on the profile for other competencies you believe should be added. As a validator you should delete those competency statements you consider to be redundant or unnecessary.

Please note that an International Reply Coupon has been enclosed to pay for return postage. The coupon can be redeemed at any U.S. Post Office, or can be used for reim-bursement on your school postage meter, for up to $0.78 return postage.

Your assistance in this phase of the research is very much appreciated.

Sincerely,

Peter Hansen

Peter Hansen
Graduate Student

encl.

Please indicate below whether you would like a copy of the final (recommended) profile:

___ I would like a copy of the final profile.

___ I would not like a copy of the final profile.

DIRECTIONS TO VALIDATORS

Note: Please ensure all changes to the profile are legible.

1. **REVIEW** the profile of Principles of Technology teacher competencies. This will help you to acquaint yourself with the organization and presentation of the competencies. Note that the box for each competency is numbered, and begins with an action verb (or verbs) to identify what teachers actually do on the job.

2. **EVALUATE** each competency statement carefully:
   - -is the wording in the statement accurate?
   - -is the statement complete?

3. **CHECK** each band of competencies thoroughly:
   - -are all of the competencies for this band represented?
   - -are the competencies logically arranged?
   - -are there bands of competencies you feel should be included?

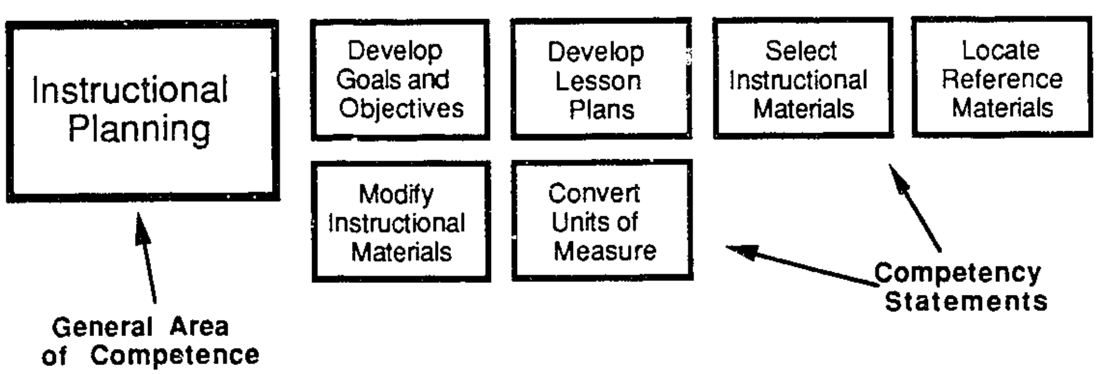
4. **MODIFY** the competency statements or general areas of competence by writing comments or changes on the profile. Delete unnecessary/ redundant competency statements or general areas of competence.

5. **FILL** empty competency boxes and bands with competencies you believe were omitted. (NOTE: empty competency boxes are provided for your convenience only; they are not meant to suggest that there are deliberate omissions from the profile.)

6. **RETURN** the validated profile on or before the deadline date in the enclosed stamped envelope.

Thank you once again for your input.

COMPONENTS OF A DACUM CHART



PRINCIPLES OF TECHNOLOGY

TEACHER QUESTIONNAIRE

DIRECTIONS

Please circle your response to each of the following statements. Return the completed questionnaire with the validated Principles of Technology teacher profile. **(Note: it is not necessary for you to sign this questionnaire or to otherwise identify yourself.)**

1. How would you classify your school jurisdiction?

   a. urban
   b. rural
   c. other ______________________

2. How many years of experience do you have teaching the Principles of Technology?

   a. up to and including one
   b. two
   c. three
   d. four
   e. five
   f. more than five years

3. Check the highest degree you have earned:

   a. 2 year postsecondary (technical or associate degree)
   b. bachelors
   c. masters
   d. 6th year
   e. doctorate
   f. other ______________________

4. Check the type of industrial, trade, or business experience that you have had:

   a. journeyman (specialization: ________ ____________________)
   b. summer jobs only
   c. no prior job experience
   d. other ______________________

5. How many courses in mathematics did you have at the undergraduate level?

a. up to and including four
b. five
c. six
d. seven
e. eight
f. nine
g. ten
h. other ______________________

6. How many physics courses did you have at the undergraduate level?

a. up to and including four
b. five
c. six
d. seven
e. eight
f. nine
g. ten
h. other ______________________

7. How did you acquire the competencies to teach the instructional content of Principles of Technology? (Note: you may circle more than one response.)

a. undergraduate studies
b. on the job
c. inservice
d. Principles of Technology workshops
e. other ______________________

APPENDIX E

Included in this appendix is a copy of the follow-up letter sent to Principles of Technology teachers in the United States who had not responded to the initial request for validation of the competency profile.

University of Alberta
Edmonton

Canada T6G 2G5

Adult, Career and Technology Education
Faculty of Education

633 Education South, Telephone (403) 492-3678
Fax (403) 492-0236

Early last June I sent you a profile of competencies required of teachers of the Principles of Technology along with a brief questionnaire. You were requested to complete the questionnaire and modify the profile after a review of each competency statement and row heading on the profile. To date I have received encouraging replies from other PT teachers, but I have not received completed materials from you.

Unfortunately I was caught by the shorter school year in the United States, and the questionnaire and profile probably did not arrive at your school until very near the close of 1989-1990 school year. As a result, you may not have been able to review and complete the materials. There is also the possibility that you never received the original questionnaire and profile, or that they were misplaced. Please find enclosed another questionnaire and profile for you to complete. It would be appreciated if you could return the validated profile in the stamped, self-addressed envelope by _________________.

I realize that your free time is limited, but I do hope that you can see the value of the information I am trying to collect and analyze for the improvement of those who teach or who are selected to teach PT. Since the sample of Principles of Technology teachers selected to participate is extremely small, your opinions are necessary and considered worthwhile. Without your contribution, the results of this study will lack significance.

Please note that an International Reply Coupon has been enclosed to pay for return postage. The coupon can be redeemed at any U.S. Post Office, or can be used for reimbursement on your school postage meter, for up to $0.78 return postage.

Should you have already validated the profile and returned it, please disregard this letter.

Thank you for your time and cooperation.

Sincerely,

Peter Hansen

Peter Hansen

encl.

Please indicate below whether you would like a copy of the final (recommended) profile:

___ I would like a copy of the final profile.

___ I would not like a copy of the final profile.

APPENDIX F

This appendix identifies the educational agencies who participated in the funding for and development of the Principles of Technology curriculum in 1985.

PARTICIPATING AGENCIES

1. Alaska Department of Education
2. Alberta Education
3. Arizona Department of Education
4. Arkansas State Department of Education, Vocational and Technical Education Division
5. Florida Department of Education, Division of Vocational Education and Office of Instructional Television and Radio
6. Georgia Department of Education, Office of Vocational Education
7. Idaho Division of Vocational Education
8. Illinois State Board of Education, Department of Adult, Vocational, and Technical Education
9. Indiana State Board of Vocational and Technical Education
10. Iowa Department of Public Instruction, Career Education Division
11. Kansas State Department of Education, Community College and Vocational Education Division
12. Kentucky Department of Education, Division of Vocational Education
13. Louisiana State Department of Education, Office of Vocational Education
14. Maine State Department of Educational And Cultural Services, Bureau of Vocational Education/ Division of Program Services
15. Maryland State Department of Education, Division of Vocational/ Technical Education
16. Massachusetts Department of Education, Division of Occupational Education
17. Minnesota Special Intermediate School District 916
18. Mississippi State Department of Education, Vocation-Technical Division
19. Nebraska Department of Education, Division of Vocational Education
20. North Carolina State Department of Public Instruction, Division of Vocational Education
21. North Dakota State Board for Vocational Education

22. Ohio Department of Education, Division of Vocational and Career Education
23. Oklahoma State Department of Vocational and Technical Education
24. TVOntario
25. Oregon Department of Education, Division of Vocational Education
26. Pennsylvania Department of Education
27. Rhode Island State Department of Education, Division of Vocational Education
28. South Carolina Department of Education, Office of Vocational Education
29. Utah State Office of Education
30. Vermont State Department of Education, Division of Adult and Vocational-Technical Education
31. Virginia Department of Education, Vocational and Adult Education
32. West Virginia State Department of Education, Bureau of Vocational, Technical, and Adult Education
33. Wisconsin Department of Public Instruction, Bureau for Vocational Education (AIT, 1985).

APPENDIX G

This appendix consists of comments from Alberta Principles of Technology teachers in response to a questionnaire designed by Alberta Education to evaluate the implementation and use of the PT curriculum in Alberta secondary schools.

1. What is the rationale for offering a program such as Principles of Technology in our schools?

Currently there is not another course in Alberta that deals with . . . Science, Technology, and Math. Principles of Technology is proving to be as good as or better than traditional physics courses.

[Traditional science programs] tend to have a large drop out of students who feel the existing science content is of no real importance to their future. Principles of Technology offers students an applied science course that directly relates to a developing technical society, one which many of them soon will join in the role of technician or consumer.

At the present time there is no program or selection of courses that . . . provides the awareness of the career possibilities for the students who would find [technologist and technician careers] to be excellent career choices.

2. What type of students (individuals and groups) would benefit the most from this type of program?

I have observed during the last year and one half that there are great numbers of very bright children who do very well in math and physics but have very little practical understanding of the concepts they are dealing with. For these students I feel there is a great deal of benefit in developing, for example, Ohm's Law by observing the results in an applied setting to supplement the theoretical knowledge they are able to regurgitate with ease.

. . . students that opted into Principles of Technology were mainly advance diploma route students. Since this course was designed for low end students and it attracts the high end students, **this course is beneficial to <u>all</u> students** (emphasis in original).

. . . the matriculation students found little difficulty with the course content and subject matter. Their motivation to enrol in the course appears not just to obtain 5 credits but to experience a "hands-on" application of the science they had previously covered. To them it was an opportunity for equipment manipulation and some experimentation that they had not accessed in their normal science programs.

The present [PT] course seems to benefit male physical science/ math students in Grades 11 and 12. . . Grade 10 Math 15/ Science 11 [students] are quickly intimidated by the amount of student course material and math demands.

There are a great number of students who enter into a full university entrance program in high school with every intention of continuing on to careers in engineering and other related fields at the university level. Unfortunately many of these students even though they have the appropriate courses do not have the academic average that would allow them to enter university. They clearly have an interest in the technical area and need an awareness of the other related fields that are available that do not require as much secondary training.

. . . students [who] were already working toward a [career] goal either at NAIT or vocational training and who saw the opportunity to gain science credit in subject matter they felt suited their goals. As such the motivation to succeed was an integral part of their studies, because PT covers a wide curriculum content these students could also "look into" material that as yet they would not require for their particular vocational selection.

. . . [students] with no firm career choice yet made, but with some motivation towards technical studies, . . . were perhaps the most enthused and often innovative of the [class]. With less concern in poor marks or with failure they chose PT basically because of the course content. It appeared more interesting or "neat" than the other science courses. They often entered with a more open mind and their expectation levels were not too high.

3. <u>What type of professional preparation would a person need to teach Principles of Technology?</u>

A teacher must have a hands on aptitude in science and technology. A teacher must also be able to work in a multiple activity environment and have a professional commitment to the course.

Professional preparation for instruction of this course would be a teaching certificate based on either a science degree or vocational industrial arts degree.

Personnel who choose to instruct this course must be confident in the math, science and most of all a fluid lab oriented format of instruction. Constant equipment processing, repair and adaptation demand skills that the individual should be competent with.

Primarily I feel the person needs to believe in the importance of what is uniquely offered by this program. A fairly strong background in mathematics and physics would certainly be an asset. If you also happen to be very strong in electronics it certainly would not hurt.

An IA teacher with a physics background is required. My student teacher with this background worked out well.

4. What type of inservice needs to be provided to update current potential teachers for Principles of Technology?

I would recommend the short course type training currently being offered by the universities to update and prepare the teachers of the new math curriculum.

. . . upgrading in the form of professional inservice structured through the department of education and/ or by NAIT re: a pre-technology program should be available if required.

Inservicing of PT could be done in the two major cities during the summer, one week per year. . . A workshop type course involving theory, lab setup and the making of some equipment would be the type of inservice needed.

5. Is the equipment that is specified in the Principles of Technology equipment list appropriate?

Three years ago when we first started PT the quality of some of the equipment was poor, and today these companies no longer exist. . . It would be advisable that a study be made of current suppliers and equipment available to get a more adequate answer to this question.

The equipment list contains items that are inappropriate and some that are non-effective for the course content. As the course progresses modifications to the original equipment are completed to upgrade what was received.

I found it easier to build some of my own [equipment]. For example, to show the mechanical advantage of pulleys I used a washing machine motor mounted against a pulley that works far better and has significantly less friction problems than the supplied materials.

6. What facilities are most appropriate to teach Principles of Technology?

The room should be a lab oriented multi station room where the students are able to spend most of their time working in pairs or singly on hands on labs. Water and electricity are essential ingredients but gas would be nice [also].

An IA lab/ classroom set up NOT shared by other departments. Even the physics lab is satisfactory for Momentum and Optics (emphasis in original).

[We have] utilised a physics lab for the implementation of this course. It is equipped with permanent lab benches and has electrical power, water and gas. Large amounts of open shelving and glass door cupboards are available. . . It has however been a cramped instruction facility.

The most appropriate facilities for PT implementation would be a room equipped with access to AC/DC power, water and compressed air. Lab tables, not benches, to allow groupings and a separate but adjoining storage room. Gas outlets are not a requirement.

7. What is the minimum cost figure that can be used to set up a three level (grades 10, 11, 12) Principles of Technology lab (equipment only)?

I would recommend a study of current vendors and equipment in order to get a relevant figure as to the cost of equipment.

My estimate for [the] present course supplementing present science equipment in established high schools would be $500 per unit. BUT if more high tech [equipment] is used - Macintoshes, CAD, CAM, Robotics, at $5,000 each - this could run to $50,000 (emphasis in original).

[Lab equipment] costs for units 1 - 14 [totalled] $26,972. . . Additional equipment costs for equipment purchased to supplement the existing course [totalled] $4,875.

8. What is your recommended "breakdown" of the 14 existing units of study over a three year period? Is a 15th unit required? What should its content be? What should the credit allocation be?

. . . it is easy to split the course [into]: 1st year - Units 1 - 5; 2nd year - Units 6 - 10; 3rd year - Units 11 - 14.

There are, I believe, three natural units that come out of the program that are each 5 credit units. [These are]: 10 level - Units 1 to 5; 20 level - Units 6, 7, 8, 10, 11; 30 level - Units 9, 12, 13, 14 and a "student's interest" designed unit.

[We] implemented the following unit sequence and experience shows that is is the most logical sequence to follow in curriculum content and difficulty. Level 12: Units 1 to 5; Level 22: Units 6 to 10; Level 32: Units 11 to 14, [plus] Unit 15, Research and Development. . . At present Unit 15 consists of student-initiated projects loosely based on previous course content.

The 15th unit could be one that is locally developed and could focus in on careers.

It's conceivable to give students a credit per unit, so that if a student has met all the requirements he would receive one credit (emphasis in original).

Five credits per level of instruction is preferred.

9. Should Principles of Technology be offered for only two years (e.g. grades 11 and 12)?

Even though PT has been designed as a two year course, it is my feeling that there is too much content for two years. The course must take three years.

I see no reason that the course should not be offered at all three grades.

10. Based on your experience in your school, and taking into consideration all matters such as scheduling, credit allocation, and the new High School Diploma Requirements, how do you see Principles of Technology being offered in Alberta high schools?

PT should be considered as science credit and offered at high schools across the province. If PT cannot find a niche under the science umbrella, Industrial Education would be the other natural area for this course, because of PT's hands on component.

I have no reservations for categorically stating that the PT program as is, or with minor modifications, is essential to be included in the course of studies in Alberta.

The new diploma requirements place many restrictions on the student's timetable and give them very little flexibility. If this course is to be one of their options then I feel it will have to serve another role. . . I do not feel that any course that can not be some how used to help complete the new diploma requirements will last very long in the current school situation.

I would strongly advise against the bastardisation of the PT course to include such as the technology content in the new STS science curriculum. Such instruction about technology should be approached from a different education methodology.

11. What implications do you feel the revised high school science program and the future practical arts program have for the Principles of Technology?

The question "Where does PT fit?" cannot truly be answered as PT is a new concept. It is new in curriculum design and development. It is new in the way that it is a North American developed course. PT is not sci: :e or math or practical arts. It is a mix of all of these.

Both the ne practical arts and the science programs will have an impact on P and vice versa. A dialogue is needed to determine these effects in light of proposed curriculum changes and department of education direction.

12. Can the concept of "High Technology" be addressed within the context of Principles of Technology, or are these two distinct concepts that are unique and need to be treated as different subjects?

We have introduced several units in PT - CAD (Computer Assisted Drafting), CAM (Computer Assisted Manufacturing), telecommunications, and robotics. . .

Students in a PT environment become interested in how things work and why they work. When cold fusion made the news . . . we had an opportunity to do some research.

. . . it is difficult to assess the relationship between PT and high technology until a clear understanding of what is meant by the term "high technology" [is made]. PT was designed and fulfills the requirement to introduce to the student more fully the basics of today's technology. To ask that PT move beyond this mandate would be to change the nature of the course. Even so the basics that are taught are taught with an eye to the future and developments presently taking place including those that are called high technology.

I feel that students should be exposed to high technology within the [PT] course. Students need to see where some of the concepts we deal with lead to in future studies. This course is an ideal means of exposing the students to a great number of high tech ideas they were not aware of. (Alberta Education, 1989)

CURRICULUM VITAE

Peter Boyd Hansen

Education/Training

1976	Graduated from College of Trades and Technology, St. John's, Nfld, with certificate in Machine Shop Technology.
1980	Acquired Interprovincial (Red Seal) Millwright certificate after completion of 4-year apprenticeship.
1985	Graduated from Memorial University of Nfld. with B. Ed. in Vocational Education.
1986-1990	Completed requirements for M. Ed. at University of Alberta.

Work Experience

1976-1980	Millwright/Mechanical Fitter for HMC Dockyard, Halifax, N.S. Performed mechanical maintenance on naval vessels.
1980-1984	Millwright for Cardinal River Coals, Hinton, Alberta. Performed mechanical maintenance on coal processing equipment.
1986-1987	Sessional Lecturer, University of Alberta, Edmonton. Instructed undergraduate courses in Metalworking Technologies (part-time only).
1987-1989	Consultant, The Training Group, Edmonton. Assisted in development and deployment of competency-based operations and maintenance training programs for TransAlta Utilities, Obed Mountain Coals, Shell Canada, Esso Canada, Exxon Corp. (USA).
1989-1990	Instructor, Northern Alberta Institute of Technology, Edmonton. Taught apprentices in Millwright program; assisted in development and delivery of service courses for internal and external clients.
1990 to present	Consultant, The Training Group, Edmonton. Assisted in development and deployment of competency-based operations and maintenance training programs for Phillips Petroleum Company (USA) and Exxon Corp. (USA).

Travel Experience

1972	Denmark, Sweden
1985	India
1988	Italy
1989	India, Singapore

PRINCIPLES OF T

TEACHER COMPET

1.0 Fundamental Principles of Technology	1.01 Describe Concept of Force in Energy Systems	1.02 Describe Similarities in Force, Pressure, Voltage, and Temp. Differences	1.03 Predict System Effects as Forces are Balanced/ Unbalanced	1.04 Measure Force in Mechanical, Fluid, Electrical, and Thermal Systems	1.05 Identify Devices Which Control, Measure, or Apply Force	1.06 Identify Occupations That Deal With Force	1.07 Describe Concept of Work in Energy Systems	7.
	1.08 Describe Relationship Between Work and Force	1.09 Identify Effects of Work in Mechanical, Fluid, and Electrical Systems	1.10 Measure Work in Mechanical, Fluid, and Electrical Systems	1.11 Describe Concept of Rate in Energy Systems	1.12 Measure Rate in Mechanical, Fluid, Electrical, and Thermal Systems	1.13 Identify Applications Where Rate is Controlled or Measured	1.14 Describe Concept of Resistance in Energy Systems	
	1.15 Explain How Resistance Equals Force Divided by Rate	1.16 Identify Effects of Resistance in Energy Systems	1.17 Identify Applications Where Resistance is Controlled or Measured	1.18 Measure Resistance in Mechanical, Fluid, Electrical, and Thermal Systems	1.19 Describe Nature of Energy in Energy Systems	1.20 Describe Potential and Kinetic Energy	1.21 Describe Relationship Between Potential, Kinetic, and Heat Energy	8.
	1.22 Describe Relationship Between Work and Energy	1.23 Measure Energy in Mechanical, Fluid, Electrical, and Thermal Systems	1.24 Identify Applications Where Energy is Controlled or Measured	1.25 Describe Concept of Power in Energy Systems	1.26 Explain How Power Equals Work Divided by Time/ Force Times Rate	1.27 Identify Applications Where Power is Controlled or Measured	1.28 Describe Concept of Force Transformers in Energy Systems	9.
	1.29 Explain How Force Transformers Form a Unifying Principle in Energy Systems	1.30 Identify Examples of Force Transformers in Energy Systems	1.31	1.32	1.33	1.34	1.35	
2.0 Applied Principles of Technology	2.01 Describe Linear Momentum in Energy Systems	2.02 Describe Angular Momentum in Energy Systems	2.03 Describe Relationship of Impulse to Change	2.04 Explain How Momentum Affects Mechanical and Fluid Systems	2.05 Describe Wave Motion and How It Transmits Energy	2.06 Explain How Waves Are Described	2.07 Distinguish Between Longitudinal and Transverse Waves	10
	2.08 Identify Applications Where Waves and Vibrations are Found	2.09 Describe Purpose of Energy Convertors in Energy Systems	2.10 Identify Devices That Convert Energy From One Form to Another	2.11 Explain Efficiency in Energy Convertors	2.12 Describe How Transducers Sense Information from Energy Systems	2.13 Distinguish Between Energy Convertors and Transducers	2.14 Identify Types of Transducers Used in Energy Systems	
	2.15 Describe Concept of Radiation	2.16 Describe Electromagnetic Radiation	2.17 Describe Nuclear Radiation	2.18 Identify Applications Where Radiation is Controlled or Measured	2.19	2.20	2.21	11
3.0 Advanced Principles of Technology	3.01 Explain Why Light is Represented by Rays or Waves	3.02 Identify Characteristics of Laser Light	3.03 Identify Optical Systems that Process Light	3.04 Identify Applications Where Radiation is Controlled or Measured	3.05 Describe Concept of Time Constants	3.06 Distinguish Between Uniform and Nonuniform Change	3.07 ID Systems Where Time Constants are Used to Describe System Behaviour	12
	3.08 Identify Types of Time Constants	3.09 Identify Examples of Time Constants in Energy Systems	3.10 Identify Applications Where Time Constants are Controlled or Measured	3.11	3.12	3.13	3.14	13
4.0 Mathematics	4.01 Perform Basic Mathematical Operations	4.02 Use Imperial/ Metric Weights and Measures	4.03 Calculate Ratios/ Proportions	4.04 Use Mathematical Tables	4.05 Use Scientific Notation	4.06 Construct/ Interpret Graphs and Charts	4.07 Identify Basic Geometric Figures	14
	4.08 Calculate Area and Volume	4.09 Solve Vector Analysis Problems	4.10 Use Formulae	4.11	4.12	4.13	4.14	15
5.0	5.01	5.02	5.03	5.04	5.05	5.06	5.07	

TECHNOLOGY REVISED

TENCY PROFILE

May 14, 1990

7.0 Instructional Execution: *Laboratory*	7.01 Organize/ Prepare Laboratory	7.02 Identify Laboratory Safety Hazards	7.03 Anticipate Student Difficulties	7.04 Demonstrate Equipment Setup and Operation	7.05 Supervise Student Laboratory Activities	7.06 Reinforce Technological Principles Concepts During Laboratory Activities	7.07 Direct Students in Applying Problem-Solving Techniques
	7.08 Promote Teamwork	7.09 Follow Laboratory Safety Rules	7.10 Return Laboratory Equipment to Storage	7.11 Perform Laboratory Housekeeping	7.12	7.13	7.14
8.0 Evaluation	8.01 Develop Evaluation Instruments	8.02 Assess Student Performance	8.03 Determine Student Grades	8.04 Maintain Student Records	8.05	8.06	8.07
9.0 Course Management	9.01 Determine Status of Resources	9.02 Try-Out New Laboratory Equipment	9.03 Purchase Laboratory Equipment	9.04 Maintain Laboratory Equipment Inventory	9.05 Develop Equipment Check-Out System	9.06 Identify Laboratory Equipment Suppliers	9.07 Develop/Follow a Budget
	9.08 Maintain Filing System	9.09 Provide for Student Safety	9.10 Attend to Minor Student Injuries	9.11	9.12	9.13	9.14
10.0 Laboratory Maintenance and Upkeep	10.01 Use Hand Tools	10.02 Use Power Tools	10.03 Use Machine Tools	10.04 Perform Basic Electrical Repairs	10.05 Perform Basic Plumbing Repairs	10.06 Perform Basic Metalworking Operations	10.07 Perform Basic Woodworking Operations
	10.08 Construct New Lab Equipment	10.09 Modify Existing Lab Equipment	10.10 Establish Local Contacts for Equipment Repair	10.11	10.12	10.13	10.14
11.0 Professional Development	11.01 Keep Professionally Up-to-Date	11.02 Maintain Media Watch of Technological Developments	11.03 Attend In-Service Professional Development Opportunities	11.04 Supervise Student Teachers	11.05 Plan Student Teaching Experiences	11.06 Promote Principles of Technology Philosophy of Learning	11.07 Promote Principles of Technology in School/Community
12.0 Special Competencies	12.01 Organize and Conduct Field Trips	12.02 Assist Exceptional Needs Students	12.03 Employ Team Teaching	12.04 Discipline Students	12.05 Adapt Instructional Methods to Meet Student Needs	12.06 Adapt Instructional Methods to Meet Institutional Needs	12.07 Design/Modify Laboratory Layout
13.0 Computers and Computer Programs	13.01 Identify Computing Needs	13.02 Evaluate Computer Hardware/Software Options	13.03 Obtain Hardware/Software	13.04 Install Computers and Peripherals	13.05 Use Computers and Peripherals	13.06 Use Computer Programs	13.07 Maintain Computers and Peripherals
14.0 Educational Technology	14.01 Use Video Cassette Recorders and Camcorders	14.02 Use Videodisk Equipment	14.03 Use CD-ROMs	14.04 Use Computer-Aided Instruction	14.05 Use Computer Networking Systems	14.06	14.07
15.0 Applying Technology	15.01 Identify/Evaluate Student Research and Development Projects	15.02 Develop/Evaluate Student Challenges	15.03 Incorporate New Technologies into Curriculum	15.04 Use Networking/ Database Technologies	15.05 Use Laser/ Electro-Optics Technologies	15.06 Use Robotics Technologies	15.07 Use Computer Aided Design Technologies
	15.08	15.09	15.10	15.11	15.12	15.13	15.14

PRINCIPLES OF TE

TEACHER COMPETEN

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1.0 Physics Principles	1.01 Interpret/Explain Principles of Force	1.02 Interpret/Explain Principles of Work	1.03 Interpret/Explain Principles of Rate	1.04 Interpret/Explain Principles of Resistance	1.05 Interpret/Explain Principles of Energy	1.06 Interpret/Explain Principles of Power
	1.07 Interpret/Explain Principles of Force Transformers	1.08 Interpret/Explain Principles of Momentum	1.09 Interpret/Explain Principles of Waves and Vibrations	1.10 Interpret/Explain Principles of Energy Convertors	1.11 Interpret/Explain Principles of Transducers	1.12 Interpret/Explain Principles of Radiation
	1.13 Interpret/Explain Principles of Light/ Optical Systems	1.14 Interpret/Explain Principles of Time Constants	1.15	1.16	1.17	1.18
2.0 Instructional Planning	2.01 Develop Goals and Objectives	2.02 Develop Lesson Plans	2.03 Select/Prepare Instructional Materials	2.04 Locate/Use Reference Materials	2.05 Modify Instructional Materials	2.06 Convert Imperial/SI Units of Measure
3.0 Instructional Execution: *Classroom*	3.01 Present Information with Audiovisual Equipment	3.02 Lead Class Discussions	3.03 Demonstrate Concepts/ Principles	3.04 Present Information with Chalkboard/ Flipchart	3.05 Present Information with Models/ Real Objects	3.06 Employ Oral Questioning Techniques
	3.07 Employ Reinforcement Techniques	3.08 Summarize Lessons	3.09 Assign Homework	3.10 Conduct Math Skills Labs	3.11 Monitor/ Supervise Student Progress	3.12 Assist Students with Practical Exercises
4.0 Instructional Execution: *Laboratory*	4.01 Organize/ Prepare Laboratory	4.02 Identify Laboratory Safety Hazards	4.03 Anticipate Student Difficulties	4.04 Demonstrate Physical Tasks	4.05 Supervise Student Laboratory Activities	4.06 Reinforce Physics Principles/Concepts During Laboratory
	4.07 Direct Students in Applying Problem-Solving Techniques	4.08 Promote Teamwork	4.09 Follow Laboratory Safety Rules	4.10 Return Laboratory Equipment to Storage	4.11 Perform Laboratory Housekeeping	4.12
5.0 Evaluation	5.01 Develop Evaluation Instruments	5.02 Identify Student Research and Development Projects	5.03 Evaluate Student Research and Development Projects	5.04 Assess Student Performance	5.05 Determine Student Grades	5.06 Maintain Student Records

Note: 1. Large boxes on the Profile denote broad categories of teacher responsibilities.
2. Small boxes on the Profile contain competency statements. Taken together, they should represent all of the knowledge, skills and abilities required for this occupation.

TECHNOLOGY *INITIAL*

ENCY PROFILE

April 6, 1990

6.0 Course Management	6.01 Purchase Laboratory Equipment	6.02 Maintain Laboratory Equipment	6.03 Maintain Laboratory Equipment Inventory	6.04 Identify Laboratory Equipment Suppliers	6.05 Try-Out New Laboratory Equipment	6.06 Determine Resource Needs
	6.07 Develop/Follow a Budget	6.08 Maintain Filing System	6.09 Provide for Student Safety	6.10 Attend to Minor Student Injuries	6.11	6.12
7.0 Guidance	7.01 Develop Student Awareness of Career Opportunities	7.02 Interpret/Explain Principles of Time Constants	7.03 Help Students with Personal Problems	7.04	7.05	7.06
8.0 Professional Development	8.01 Keep Up-to-Date Professionally	8.02 Attend In-Service Professional Development Opportunities	8.03 Supervise Student Teachers	8.04 Plan Student Teaching Experiences	8.05 Develop/Promote Principles of Technology Philosophy of Learning	8.06
9.0 Special Competencies	9.01 Construct New Lab Equipment	9.02 Modify Existing Lab Equipment	9.03 Organize and Conduct Field Trips	9.04 Assist Exceptional Needs Students	9.05 Employ Team Teaching	9.06 Discipline Students
	9.07 Adapt Instructional Methods to Meet Institutional Needs	9.08 Design/Modify Laboratory Layout	9.09	9.10	9.11	9.12
10.0 Computers and Computer Programs	10.01 Identify Computing Needs	10.02 Evaluate Computer Hardware/Software Options	10.03 Purchase/Obtain Hardware/Software	10.04 Install Computers and Peripherals	10.05 Use Computers and Peripherals	10.06 Design/Develop/Debug Computer Programs
	10.07 Maintain Computers and Peripherals	10.08	10.09	10.10	10.11	10.12

PRINCI

1.0 Fundamental Principles of Technology

- 1.01 Describe Concept of Force in Energy Systems
- 1.02 Describe Similarities in Force, Pressure, Voltage, and Temp. Differences
- 1.03 Predict System Effects as Forces are Balanced/ Unbalanced
- 1.04 Measure Force in Mechanical, Fluid, Electrical, and Thermal Systems
- 1.0 Identify Devic Which Contr Measure, o Apply Forc
- 1.08 Describe Relationship Between Work and Force
- 1.09 Identify Effects of Work in Mechanical, Fluid, and Electrical Systems
- 1.10 Measure Work in Mechanical, Fluid, and Electrical Systems
- 1.11 Describe Concept of Rate in Energy Systems
- 1. Measure Rat Mechanical, Fl Electrical, a Thermal Syst
- 1.15 Explain How Resistance Equals Force Divided by Rate
- 1.16 Identify Effects of Resistance In Energy Systems
- 1.17 Identify Applications Where Resistance is Controlled or Measured
- 1.18 Measure Resistance in Mechanical, Fluid, Electrical, and Thermal Systems
- 1. Describe Na of Energy i Energy Syst
- 1.22 Describe Relationship Between Work and Energy
- 1.23 Measure Energy in Mechanical, Fluid, Electrical, and Thermal Systems
- 1.24 Identify Applications Where Energy is Controlled or Measured
- 1.25 Describe Concept of Power in Energy Systems
- 1 Explain How F Equals Wc Divided by T Force Times
- 1.29 Describe Concept of Force Transformers in Energy Systems
- 1.30 Explain How Force Transformers Form a Unifying Principle in Energy Systems
- 1.31 Identify Examples of Force Transformers in Energy Systems
- 1.32 Measure IMA and AMA of Various Force Transformers

2.0 Applied Principles of Technology

- 2.01 Describe Linear Momentum in Energy Systems
- 2.02 Describe Angular Momentum in Energy Systems
- 2.03 Describe Relationship of Impulse to Change
- 2.04 Explain How Momentum Affects Mechanical and Fluid Systems
- Describe V Motion and It Transmits
- 2.08 Identify Applications Where Waves and Vibrations are Found
- 2.09 Describe Purpose of Energy Convertors in Energy Systems
- 2.10 Identify Devices That Convert Energy From One Form to Another
- 2.11 Explain Efficiency in Energy Convertors
- Describe Transducers Information Energy Sys
- 2.15 Describe Concept
- 2.16 Describe
- 2.17 Describe Nuclear
- 2.18 Identify Applications

CIPLES OF TECHNO

TEACHER COMPETENCY PROFILE©

1.05	1.06	1.07
dentify Devices Which Control, Measure, or Apply Force	Identify Occupations That Deal With Force	Describe Concept of Work in Energy Systems

1.12	1.13	1.14
Measure Rate in Mechanical, Fluid, Electrical, and Thermal Systems	Identify Applications Where Rate is Controlled or Measured	Describe Concept of Resistance in Energy Systems

1.19	1.20	1.21
Describe Nature of Energy in Energy Systems	Describe Potential and Kinetic Energy	Describe Relationship Between Potential, Kinetic, and Heat Energy

1.26	1.27	1.28
Explain How Power Equals Work Divided by Time/ Force Times Rate	Identify Applications Where Power is Controlled or Measured	Measure Power in Mechanical, Fluid, and Electrical Systems

2.05	2.06	2.07
Describe Wave Motion and How It Transmits Energy	Explain How Waves Are Described	Distinguish Between Longitudinal and Transverse Waves

2.12	2.13	2.14
Describe How Transducers Sense Information from Energy Systems	Distinguish Between Energy Convertors and Transducers	Identify Types of Transducers Used in Energy Systems

7.0 Instructional Execution: *Laboratory*

8.0 Evaluation

9.0 Course Management

10.0 Laboratory Maintenance and Upkeep

11.0 Professional Development

TECHNOLOGY RECC

ETENCY PROFILE©

7.0	Instructional Execution: *Laboratory*	7.01 Organize/ Prepare Laboratory	7.02 Identify Laboratory Safety Hazards	7.03 Conduct Lab Safety Training	7.04 Anticipate Student Difficulties
		7.08 Direct Students In Applying Problem-Solving Techniques	7.09 Promote Teamwork	7.10 Follow Laboratory Safety Rules	7.11 Return Laboratory Equipment to Storage
8.0	Evaluation	8.01 Develop Evaluation Instruments	8.02 Assess Student Performance	8.03 Determine Student Grades	8.04 Maintain Student Records
9.0	Course Management	9.01 Determine Status of Resources	9.02 Try-Out New Laboratory Equipment	9.03 Purchase Laboratory Equipment	9.04 Maintain Laboratory Equipment Inventory
		9.08 Develop/Follow a Budget	9.09 Maintain Filing System	9.10 Provide for Student Safety	9.11 Attend to Minor Student Injuries
10.0	Laboratory Maintenance and Upkeep	10.01 Use Hand Tools	10.02 Use Power Tools	10.03 Use Machine Tools	10.04 Perform Basic Electrical Repairs
		10.08 Construct New Lab Equipment	10.09 Modify Existing Lab Equipment	10.10 Establish Local Contacts for Equipment Repair	
11.0	Professional	11.01 Kee[illegible]	11.02 Maintain Media [illegible]	11.03 Attend In-Service Professional	11.04 Supervise Student Teachers

RECOMMENDED

November 1, 1990

7.04 Anticipate Student Difficulties	7.05 Demonstrate Equipment Setup and Operation	7.06 Supervise Student Laboratory Activities	7.07 Reinforce Techno-logical Principles/ Concepts During Laboratory Activities
7.11 Return Laboratory Equipment to Storage	7.12 Perform Laboratory Housekeeping	7.13 Maintain Equipment in Working Order	
8.04 Maintain Student Records			
9.04 Maintain Laboratory Equipment Inventory	9.05 Develop Lab Equipment Storage System	9.06 Develop Equipment Check-Out System	9.07 Identify Laboratory Equipment Suppliers
9.11 Attend to Minor Student Injuries			
10.04 Perform Basic Electrical Repairs	10.05 Perform Basic Plumbing Repairs	10.06 Perform Basic Metalworking Operations	10.07 Perform Basic Woodworking Operations
11.04 Supervise Student Teachers	11.05 Plan Student Teaching	11.06 Promote Principles of Technology	11.07 Promote Principles of Technology in

	... Relationship Between Work and Force	... Work in Mechanical, Fluid, and Electrical Systems	... Mechanical, Fluid and Electrical Systems	... of Rate in Energy Systems	... Mechanical, Fluid, Electrical, and Thermal Systems	... Where Rate is Controlled or Measured	... of Resistance in Energy Systems	
	1.15 Explain How Resistance Equals Force Divided by Rate	1.16 Identify Effects of Resistance in Energy Systems	1.17 Identify Applications Where Resistance is Controlled or Measured	1.18 Measure Resistance in Mechanical, Fluid, Electrical, and Thermal Systems	1.19 Describe Nature of Energy in Energy Systems	1.20 Describe Potential and Kinetic Energy	1.21 Describe Relationship Between Potential, Kinetic, and Heat Energy	8.
	1.22 Describe Relationship Between Work and Energy	1.23 Measure Energy in Mechanical, Fluid, Electrical, and Thermal Systems	1.24 Identify Applications Where Energy is Controlled or Measured	1.25 Describe Concept of Power in Energy Systems	1.26 Explain How Power Equals Work Divided by Time/ Force Times Rate	1.27 Identify Applications Where Power is Controlled or Measured	1.28 Describe Concept of Force Transformers in Energy Systems	9.
	1.29 Explain How Force Transformers Form a Unifying Principle in Energy Systems	1.30 Identify Examples of Force Transformers in Energy Systems	1.31	1.32	1.33	1.34	1.35	
2.0 Applied Principles of Technology	2.01 Describe Linear Momentum in Energy Systems	2.02 Describe Angular Momentum in Energy Systems	2.03 Describe Relationship of Impulse to Change	2.04 Explain How Momentum Affects Mechanical and Fluid Systems	2.05 Describe Wave Motion and How It Transmits Energy	2.06 Explain How Waves Are Described	2.07 Distinguish Between Longitudinal and Transverse Waves	10.
	2.08 Identify Applications Where Waves and Vibrations are Found	2.09 Describe Purpose of Energy Convertors in Energy Systems	2.10 Identify Devices That Convert Energy From One Form to Another	2.11 Explain Efficiency in Energy Convertors	2.12 Describe How Transducers Sense Information from Energy Systems	2.13 Distinguish Between Energy Convertors and Transducers	2.14 Identify Types of Transducers Used in Energy Systems	
	2.15 Describe Concept of Radiation	2.16 Describe Electromagnetic Radiation	2.17 Describe Nuclear Radiation	2.18 Identify Applications Where Radiation is Controlled or Measured	2.19	2.20	2.21	11.
3.0 Advanced Principles of Technology	3.01 Explain Why Light is Represented by Rays or Waves	3.02 Identify Characteristics of Laser Light	3.03 Identify Optical Systems that Process Light	3.04 Identify Applications Where Radiation is Controlled or Measured	3.05 Describe Concept of Time Constants	3.06 Distinguish Between Uniform and Nonuniform Change	3.07 ID Systems Where Time Constants are Used to Describe System Behaviour	12.
	3.08 Identify Types of Time Constants	3.09 Identify Examples of Time Constants in Energy Systems	3.10 Identify Applications Where Time Constants are Controlled or Measured	3.11	3.12	3.13	3.14	13
4.0 Mathematics	4.01 Perform Basic Mathematical Operations	4.02 Use Imperial/ Metric Weights and Measures	4.03 Calculate Ratios/ Proportions	4.04 Use Mathematical Tables	4.05 Use Scientific Notation	4.06 Construct/ Interpret Graphs and Charts	4.07 Identify Basic Geometric Figures	14
	4.08 Calculate Area and Volume	4.09 Solve Vector Analysis Problems	4.10 Use Formulae	4.11	4.12	4.13	4.14	15
5.0 Instructional Planning	5.01 Assess Background of Prospective Students	5.02 Develop Goals and Objectives	5.03 Develop Lesson Plans	5.04 Select/Prepare Instructional Materials	5.05 Locate/Use Reference Materials	5.06 Modify Instructional Materials	5.07 Choose Imperial/SI Units of Measure	
6.0 Instructional Execution: *Classroom*	6.01 Present Information with Audiovisual Equipment	6.02 Lead Class Discussions	6.03 Demonstrate Concepts/ Principles	6.04 Present Information with Chalkboard/ Flipchart	6.05 Present Information with Models/ Real Objects	6.06 Employ Oral Questioning Techniques	6.07 Employ Reinforcement Techniques	
	6.08 Develop Student Awareness of Career Opportunities	6.09 Summarize Lessons	6.10 Assign Homework	6.11 Conduct Math Skills Labs	6.12 Monitor/Supervise Student Progress	6.13 Assist Students with Practical Exercises	6.14	

		Teamwork	Safety Rules	Equipment to Storage	Housekeeping			
8.0	Evaluation	8.01 Develop Evaluation Instruments	8.02 Assess Student Performance	8.03 Determine Student Grades	8.04 Maintain Student Records	8.05	8.06	8.07
9.0	Course Management	9.01 Determine Status of Resources	9.02 Try-Out New Laboratory Equipment	9.03 Purchase Laboratory Equipment	9.04 Maintain Laboratory Equipment Inventory	9.05 Develop Equipment Check-Out System	9.06 Identify Laboratory Equipment Suppliers	9.07 Develop & Follow a Budget
		9.08 Maintain Filing System	9.09 Provide for Student Safety	9.10 Attend to Minor Student Injuries	9.11	9.12	9.13	9.14
10.0	Laboratory Maintenance and Upkeep	10.01 Use Hand Tools	10.02 Use Power Tools	10.03 Use Machine Tools	10.04 Perform Basic Electrical Repairs	10.05 Perform Basic Plumbing Repairs	10.06 Perform Basic Metalworking Operations	10.07 Perform Basic Woodworking Operations
		10.08 Construct New Lab Equipment	10.09 Modify Existing Lab Equipment	10.10 Establish Local Contacts for Equipment Repair	10.11	10.12	10.13	10.14
11.0	Professional Development	11.01 Keep Professionally Up-to-Date	11.02 Maintain Media Watch of Technological Developments	11.03 Attend In-Service Professional Development Opportunities	11.04 Supervise Student Teachers	11.05 Plan Student Teaching Experiences	11.06 Promote Principles of Technology Philosophy of Learning	11.07 Promote Principles of Technology in School/Community
12.0	Special Competencies	12.01 Organize and Conduct Field Trips	12.02 Assist Exceptional Needs Students	12.03 Employ Team Teaching	12.04 Discipline Students	12.05 Adapt Instructional Methods to Meet Student Needs	12.06 Adapt Instructional Methods to Meet Institutional Needs	12.07 Design/Modify Laboratory Layout
13.0	Computers and Computer Programs	13.01 Identify Computing Needs	13.02 Evaluate Computer Hardware/Software Options	13.03 Obtain Hardware/Software	13.04 Install Computers and Peripherals	13.05 Use Computers and Peripherals	13.06 Use Computer Programs	13.07 Maintain Computers and Peripherals
14.0	Educational Technology	14.01 Use Video Cassette Recorders and Camcorders	14.02 Use Videodisk Equipment	14.03 Use CD-ROMs	14.04 Use Computer-Aided Instruction	14.05 Use Computer Networking Systems	14.06	14.07
15.0	Applying Technology	15.01 Identify/Evaluate Student Research and Development Projects	15.02 Develop/Evaluate Student Challenges	15.03 Incorporate New Technologies into Curriculum	15.04 Use Networking/Database Technologies	15.05 Use Laser/Electro-Optics Technologies	15.06 Use Robotics Technologies	15.07 Use Computer Aided Design Technologies
		15.08 Use Computer-Aided Manufacture Technologies	15.09 Use Composite Materials	15.10 Use Communications Technologies	15.11 Use Computer-Numerical-Control Technologies	15.12 Use Microelectronic Technologies	15.13 Use Synthetic Fuel Technologies	15.14

2.0 Applied Principles of Technology

- 2.01 Describe Linear Momentum in Energy Systems
- 2.02 Describe Angular Momentum in Energy Systems
- 2.03 Describe Relationship of Impulse to Change
- . 4 Explain How Momentum Affects Mechanical and Fluid Systems
- Describe W Motion and It Transmits E
- 2.08 Identify Applications Where Waves and Vibrations are Found
- 2.09 Describe Purpose of Energy Convertors in Energy Systems
- 2.10 Identify Devices That Convert Energy From One Form to Another
- 2.11 Explain Efficiency in Energy Convertors
- Describe I Transducers Information Energy Sys
- 2.15 Describe Concept of Radiation
- 2.16 Describe Electromagnetic Radiation
- 2.17 Describe Nuclear Radiation
- 2.18 Identify Applications Where Radiation is Controlled or Measured

3.0 Advanced Principles of Technology

- 3.01 Explain Why Light is Represented by Rays or Waves
- 3.02 Identify Characteristics of Laser Light
- 3.03 Identify Optical Systems that Process Light
- 3.04 Identify Applications Where Radiation is Controlled or Measured
- Measure Lengths Polariza
- 3.08 ID Systems Where Time Constants are Used to Describe System Behaviour
- 3.09 Identify Types of Time Constants
- 3.10 Identify Examples of Time Constants in Energy Systems
- 3.11 Identify Applications Where Time Constants are Controlled or Measured

4.0 Mathematics

- 4.01 Perform Basic Mathematical Operations
- 4.02 Use English/ Metric Weights and Measures
- 4.03 Calculate Ratios/ Proportions
- 4.04 Use Mathematical Tables
- Use Sci Nota
- 4.08 Calculate Area and Volume
- 4.09 Solve Vector Analysis Problems
- 4.10 Use Formulae
- 4.11 Use Scientific Calculator

5.0 Instructional Planning

- 5.01 Assess Background of Prospective Students
- 5.02 Develop Goals and Objectives
- 5.03 Develop Lesson Plans
- 5.04 Select/Prepare Instructional Materials
- Loca Refe Mat

6.0 Instructional Execution: *Classroom*

- 6.01 Present Information with Audiovisual Equipment
- 6.02 Lead Class Discussions
- 6.03 Demonstrate Concepts/ Principles
- 6.04 Present Information with Chalkboard/ Flipchart
- Present with Real
- 6.08 Develop Student Awareness of Career Opportunities
- 6.09 Summarize Lessons
- 6.10 Assign Homework
- 6.11 Conduct Math Skills Labs
- Monitor Studen

- 2.05 escribe Wave otion and How ansmits Energy
- 2.06 Explain How Waves Are Described
- 2.07 Distinguish Between Longitudinal and Transverse Waves

- 2.12 Describe How nsducers Sense formation from nergy Systems
- 2.13 Distinguish Between Energy Convertors and Transducers
- 2.14 Identify Types of Transducers Used in Energy Systems

- 3.05 Measure Focal Lengths and Polarization
- 3.06 Describe Concept of Time Constants
- 3.07 Distinguish Between Uniform and Nonuniform Change

- 4.05 Use Scientific Notation
- 4.06 Construct/ Interpret Graphs and Charts
- 4.07 Identify Basic Geometric Figures

- 5.05 Locate/Use Reference Materials
- 5.06 Modify Instructional Materials
- 5.07 Use English/ Metric Units of Measure

- 6.05 Present Information with Models/ Real Objects
- 6.06 Employ Oral Questioning Techniques
- 6.07 Employ Reinforcement Techniques

- 6.12 Monitor/Supervise Student Progress
- 6.13 Assist Students with Practical Exercises
- 6.14 Develop Higher Order Thinking Skills

10.0 Laboratory Maintenance and Upkeep

11.0 Professional Development

12.0 Special Competencies

13.0 Computers and Computer Programs

14.0 Educational Technology

15.0 Applying Technology

10.0 Laboratory Maintenance and Upkeep

- Use Hand Tools
- Use Power Tools
- 10.03 Use Machine Tools
- 10.04 Perform Basic Electrical Repairs
- Perform Plumbing
- 10.08 Construct New Lab Equipment
- 10.09 Modify Existing Lab Equipment
- 10.10 Establish Local Contacts for Equipment Repair

11.0 Professional Development

- 11.01 Keep Professionally Up-to-Date
- 11.02 Maintain Media Watch of Technological Developments
- 11.03 Attend In-Service Professional Development Opportunities
- 11.04 Supervise Student Teachers
- Plan S Teac Experi

12.0 Special Competencies

- 12.01 Organize and Conduct Field Trips
- 12.02 Assist Exceptional Needs Students
- 12.03 Employ Team Teaching
- 12.04 Discipline Students
- Adapt Ins Methods Studen

13.0 Computers and Computer Programs

- 13.01 Identify Computing Needs
- 13.02 Evaluate Computer Hardware/Software Options
- 13.03 Obtain Hardware/Software
- 13.04 Install Computers and Peripherals
- Use Co and Pe

14.0 Educational Technology

- 14.01 Use Video Cassette Recorders and Camcorders
- 14.02 Use Videodisk Equipment
- 14.03 Use CD-ROMs
- 14.04 Use Computer-Aided Instruction
- Use C Net Sy

15.0 Applying Technology

- 15.01 Identify/Evaluate Student Research and Development Projects
- 15.02 Develop/Evaluate Student Challenges
- 15.03 Incorporate New Technologies into Curriculum
- 15.04 Use Networking/Database Technologies
- Use Elec Tech
- 15.08 Use Computer-Aided Manufacture Technologies
- 15.09 Use Composite Materials
- 15.10 Use Communications Technologies
- 15.11 Use Computer-Numerical-Control Technologies
- Micr Tec

Perform Basic Plumbing Repairs

Perform Basic Metalworking Operations

Perform Basic Woodworking Operations

11.05 Plan Student Teaching Experiences

11.06 Promote Principles of Technology Philosophy of Learning

11.07 Promote Principles of Technology in School/Community

12.05 Adapt Instructional Methods to Meet Student Needs

12.06 Adapt Instructional Methods to Meet Institutional Needs

12.07 Design/Modify Laboratory Layout

13.05 Use Computers and Peripherals

13.06 Use Computer Programs

13.07 Maintain Computers and Peripherals

14.05 Use Computer Networking Systems

15.05 Use Laser/ Electro-Optics Technologies

15.06 Use Robotics Technologies

15.07 Use Computer-Aided Design Technologies

15.12 Use Microelectronic Technologies

15.13 Use Synthetic Fuel Technologies