DOCUMENT RESUME

ED 351 502 | CE 062 270

TITLE	Identification of Mathematics Competencies Taught in Industrial Arts/Technology Education Programs in Louisiana High Schools. Vocational Education Research.
INSTITUTION	Northwestern State Univ., Natchitoches, La.
SPONS AGENCY	Louisiana State Dept. of Education, Baton Rouge. Div. of Vocational Education.
PUB DATE	15 Aug 89
NOTE	68p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Course Selection (Students); Educational Change; Graduation Requirements; High Schools; Industrial Arts; *Integrated Curriculum; *Mathematics Curriculum; *Mathematics Instruction; Required Courses; State Curriculum Guides; *Technology Education
IDENTIFIERS	*Louisiana

ABSTRACT

A study that identified mathematics processes and concepts taught in industrial arts-technology education courses in Louisiana high schools and the time spent teaching used the following methods: literature review; phone interviews with persons recognized nationally for their efforts at infusing math, science, and technology into the high school curriculum; examination of state-adopted curriculum guides for 16 courses; examination of 8 state-adopted curriculum guides for mathematics courses; and a questionnaire mailed to 248 Louisiana high school industrial arts-technology education instructors. According to instructors, 753 math objectives were taught in 16 courses and mathematics is an integral part of most of the courses. The following recommendations were made: (1) Louisiana teachers should continue to incorporate additional math-related objectives and instructional materials into their courses; (2) math-related course content should be made readily identifiable in curriculum guides; (3) educational administrators should recognize that math concepts and skills are being taught and reinforced in industrial arts-technology education courses and they should not eliminate vocational education courses to make room for required math programs. (The document contains a list of math competencies taught, report of hours spent on each competency in each of the courses, and eight references.) (CML)

Vocational Education Research

Identification of Mathematics Competencies Taught in Industrial Arts/Technology Education Programs in Louisiana High Schools

NORTHWESTERN STATE UNIVERSITY

1989

LOUISIANA DEPARTMENT OF EDUCATION

WILMER S. CODY, Ed.D.
State Superintendent

EQUAL OPPORTUNITY STATEMENT

IN COMPLIANCE WITH TITLE VI OF THE CIVIL RIGHTS ACT OF 1964, TITLE IX OF THE EDUCATION AMENDMENTS OF 1972, AND SECTION 504 OF THE REHABILITATION ACT OF 1973, THIS EDUCATIONAL AGENCY UPHOLDS THE FOLLOWING POLICY:

THIS IA AN EQUAL OPPORTUNITY INSTITUTION AND IS DEDICATED TO A POLICY OF NON-DISCRIMINATION IN F' PLOYMENT OR TRAINING. QUALIFIED STUDENTS, APPLICANTS OR EMPLOYEES WILL NOT BE EXCLUDED FROM ANY COURSE OR ACTIVITY BECAUSE OF AGE, RACE, CREED, COLOR, SEX, RELIGION, NATIONAL ORIGIN OR QUALIFIED HANDICAP. ALL STUDENTS HAVE EQUAL RIGHTS TO COUNSELING AND TRAINING.

This public document was published at a total cost of $350.00; 200 copies of this public document were published in this 1st printing at a cost of $350.00. The total cost of all printings of this document, including reprints is $350.00. This document was published by Louisiana Department of Education, Office of Vocational Education, Post Office Box 94064, Baton Rouge, Louisiana 70804-9064 for the dissemination of vocational education research materials for new and changing occupational fields under authority of Public Law 98-524. This material was printed in accordance with the standards for printing by state agencies established pursuant to R.S. 43:31.

IDENTIFICATION OF MATHEMATICS COMPETENCIES TAUGHT IN INDUSTRIAL ARTS/TECHNOLOGY EDUCATION PROGRAMS IN LOUISIANA HIGH SCHOOLS

Research Project Director:
Dr. William H. Dennis
Department of Industrial Technology
Northwestern State University
Natchitoches, LA 71497

August 15, 1989

Funded By:
State of Louisiana
Department of Education
Office of Vocational Education

FOREWORD

In their concern for improving secondary education, many educational leaders throughout the United States are advocating that our schools improve student competencies in mathematics. We also share their belief that we must do something to increase student math proficiency.

As many concerned professionals have advocated, we too believe that mathematics can be taught and made applicable in instructional programs outside the mathematics classrooms.

As we continue to review efforts to update and improve education in Louisiana, we must base our decisions upon professional knowledge, experience and accurat research. This publication is the report of a study undertaken to identify the mathematics competencies taught in the Industrial Arts/Technology Education (IA/TE) curriculum areas in Louisiana high schools.

It is anticipated that the results of this study may help the various levels of educational decision-makers by informing them of the amount of math being taught in various IA/TE courses. This information will enable curriculum decisions to be made more intelligently.

Wilmer S. Cody
Louisiana State Superintendent of Education

ACKNOWLEDGEMENTS

In an attempt to recognize all who were helpful in making the completion of this investigation become a reality, there is risk that there could be the omission of many who deserve acknowledgement. However, despite this risk, we are compelled to recognize the following for their special contributions to this research effort:

Dr. William H. Dennis, Professor of Industrial Technology at Northwestern State University of Louisiana, and project director and principal investigator of this research project.

Dr. Florent Hardy, Jr., Director of the Coordinating Unit of the Louisiana Office of Vocational Education in the Department of Education, and project report editor.

Mr. Richard Lucas, Senior Research Assistant for the study; also, Thomas Bradley, student research project assistant.

The faculty of the Department of Industrial Technology at Northwestern State University, who gave assistance to this research effort.

The following are the research advisory committee members:

Lucetta Anthony, Mathematics Department Head, Natchitoches Central High School;

Jerry O'Shee, Industrial Arts/Technology Education Program Manager, State Office of Vocational Education, Louisiana;

David Poston, Director, Louisiana Vocational Curriculum Development and Research Center;

Martha Talbert, Mathematics Department Head, Louisiana School for Math, Science and the Arts.

Last, but certainly not considered least, appreciation is extended to the numerous teachers who completed and returned data collection instruments to be used in this study.

Don R. Wood

Don R. Wood
Assistant Superintendent
Office of Vocational Education

TABLE OF CONTENTS

INTRODUCTION TO THE STUDY

Since the 1950's there has been an added emphasis in our educational systems for equality of education. In some educational settings this has meant that all students must have equal access to all courses offered within the school. To others, equality of education has led to diversity in the curriculum, intended to make the acquisition of knowledge more interesting and appealing to everyone. Often, however, the quality of education has been reduced by excessive diversity, resulting in the proliferation of insignificant elective courses.

Educational leaders throughout the United States who are concerned about the lack of quality in education are justified in their concerns. High schools are often not satisfying the academic needs of today's students. Students are leaving high school without the required knowledge of mathematics and science. Many (approximately 25 percent) are not even finishing high school. Other countries, Japan and the U.S.S.R. for example, are placing increased emphasis on the teaching of mathematics in their high schools. They are graduating 93 and 98 percent, respectively, of their students while in the United States we graduate only 73 percent.

The average I.Q. in Japan is 111 compared to the average in the U.S. of 100. The point of concern is that our average is decreasing while Japan's I.Q. is increasing.

Government and industry in the United States realize that in order to compete in a world economy we must make changes in our education systems. As a result, school systems have begun to alter their curriculums to ensure student exposure to more mathematics and science.

Many states have mandated revisions in the high school curriculums to increase the number of math credits required for graduation. These revisions have generally meant that high school students had to enroll in additional mathematics courses. At the same time the number of required math courses has increased, the number of elective courses a student could enroll in has, of necessity, decreased.

In most cases, vocational education courses are considered to be elective courses. Consequently, enrollment in vocational education has decreased as the number of required high school courses has increased. Until recently, little consideration has been given to the potential of teaching mathematics competencies in other than traditional math courses. However, some states are examining vocational education courses, such as industrial arts/technology education (IA/TE), as a means of teaching mathematics to high school students.

Therefore, this study was commissioned by the Louisiana Department of Education to identify the mathematics competencies taught in industrial arts/technology education programs in Louisiana high schools. It was anticipated that, as a result of this study, educational decision-makers would gain new information as to the extent to which mathematics is being taught in our IA/TE courses. Also, new insights could be gained as to how to increase the teaching of additional mathematics concepts and skills in these courses.

STATEMENT OF THE PROBLEM

The purpose of this project was to identify the mathematics processes and concepts which are taught in industrial arts/technology education programs in Louisiana. In addition, the amount of time being spent by IA/TE instructors in teaching those math competencies in industrial arts/technology education classes was sought.

This project included an examination of the industrial arts/technology education curriculum guides to determine the mathematics-related objectives in each guide, as well as a survey of IA/TE instructors to determine what math is actually being taught in the IA/TE courses in our Louisiana high schools.

OBJECTIVES OF THIS RESEARCH STUDY

To achieve the purposes of this study, the following objectives were used as guidelines:

1. To determine what mathematics competencies are expected to be taught in each industrial arts/technology education course, as indicated by the objectives given in the curriculum guides;
2. To determine those mathematics processes and concepts which are being taught in Louisiana high school industrial arts/technology education courses;
3. To determine the amount of time IA/TE teachers devote to teaching mathematics competencies in their courses.

RELATED LITERATURE

A review of literature related to this research effort indicated that students should learn more mathematics in high school, that mathematics is best taught and retained by teaching it through practical application, that industrial arts/technology education offers benefits beyond those of other courses, and that mathematics is being emphasized in many IA/TE programs throughout the U.S.

More math skills needed.

Brown (1984) makes the following statement in his book, Crisis in Secondary Education:

> In the 1980's schools have two important missions: (1) to widen the range of high-quality mathematics, science, and technology educational offerings so that more students will have the option of choosing technically oriented careers and professions, and (2) to raise the general mathematics, science, and technology literacy of all citizens to prepare them to live, work, and participate fully in the society of the future.

Data from a number of sources confirm the extent of the decline of student mathematical achievement:

1. Mathematics scores of seventeen-year-olds are down, as measured by the national assessment of mathematics for the years 1973, 1978, and 1982.
2. Mathematical Scholastic Aptitude Test (SAT) scores declined for eighteen years in a row from 1962 to 1980.
3. Remedial mathematics enrollments at four-year institutions of higher education increased 72 percent between 1975 and 1980. Total student enrollment only increased by 7 percent.
4. Twenty-five percent of the mathematics courses are remedial in the nation's four-year colleges and universities. Forty-two percent of community college enrollees are taking remedial work in mathematics.

The declining mathematics capabilities of today's students is in direct contrast to requirements for more mathematics capability in industry. If our nation is to continue to maintain its lead in high-technology, the mathematics capability of today's students must improve and continue to keep pace with technological advances.

Math is best taught by teaching it through practical application.

Some questions asked by the National Assessment of Educational Progress (1984) are: "To what extent do students have opportunities to engage in real problem solving? Are students regularly challenged to apply mathematics to problem situations, or are they generally asked to memorize and repeat?"

In a study by the National Assessment of Educational Programs (1984), the following information was obtained from student responses:

> It is interesting to note that, despite the fact that almost half of the students view mathematics as mostly memorizing, three-fourths of them agree that mathematics helps a person to think logically and more than three-fifths of them agree that justifying the statements one makes is an extremely important part of mathematics.

The National Council of Teachers of Mathematics (NCTM) has published The Agenda In Action in which it proposes a problem-solving approach to teaching mathematics (National Council of Teachers of Mathematics 1989). To that end the NCTM has recommended the following:

1. Problem solving must be the focus of school mathematics in the 1980s.
2. The concept of basic skills in mathematics must encompass more than computational facility.
3. Mathematics programs must take full advantage of the power of calculators and computers at all grade levels.
4. Stringent standards of both effectiveness and efficiency must be applied to the teaching of mathematics.

The above recommendations would result in the following:

1. Spending less class time on rote drills and more time on problem solving.
2. Emphasize the application of mathematics to everyday/real-world problems.
3. Use of computers and calculators in the problem solving process.
4. Encourage group learning arrangements and open-ended questioning by teachers.

The problem solving approach to teaching/learning mathematics makes mathematics more interesting to a broader body of students. Problem solving further encourages students to become more creative in their thinking.

<u>Math concepts and skills are ideally taught in Industrial Arts/Technology Education.</u>

Selby, a professor of science Education in the Department of Mathematics, Science and Statistics Education at New York University, New York stated:

> Because technologies can be seen, touched, and perceived with all the senses and because

> technologies are indigenous to all cultures, understanding why and how things are made and how they work is accessible and can be made interesting and relevant to all students and teachers.
>
> This accessibility and relevance is exactly what has been missing in math and science curricula.... (Selby 1988)

This author goes on to explain how studies in the technologies can bridge many gaps in the learning process, including those in mathematics and science.

Haynie reports his findings on the approaches used to teach mathematical concepts in Industrial Arts/Technology Education. The approaches discussed are, the "traditional approach" and the "concepts to math" model (Haynie 1989).

He stated that the "traditional approach" is most often employed to teach mathematical concepts in technology education and has been termed the "engineering school model" (Haynie, 1985). In this method, the technical concepts and relationships under study are presented and explained by means of mathematical formulas and problems. These methods are used in engineering schools and university physics classes. It is, however, possible that these methods are inappropriate for secondary school students who do not have strong backgrounds in mathematics. Haynie continues by stating that the "concepts to math" model has been shown to be effective in classes of varying ability levels for the past 18 years. He states:

> It includes four essential phases. Each of these phases should be initiated on a different day and in the sequence shown. During each phase, concepts and information must be presented clearly and with some repetition to ensure that students understand and feel comfortable with them. After each phase, some time should be allowed for the new information to become part of the students' repertoire. Follow-up activities to the lessons such as meaningfully related lab experiments or construction activities should separate each phase whenever possible. Topics should be divided into small, bite-sized chunks instead of the traditional 10 or 12 chapters per year. The sequence for teaching an important concept is:
>
> 1. First the concepts should be taught without any reference to math or quantification.
> 2. Next the methods of quantifying should be covered and the relationship reviewed. Allow repetition to help students possess the new terms and concepts as part of their language.
> 3. Then, the basic formula should be presented via very simple problems with values which students may easily calculate "in their heads." The mechanics of the formula and how to work it are stressed as well as emphasizing how the formula represents the previously learned relationship.
> 4. Only in the last phase of the sequence should more difficult problems with realistic values be presented. At this time, students should be taught how to properly use logic and estimation along with calculators.

Each phase of the sequence progresses from simple to complex and builds upon previously learned information. Concepts must be taught prior to mathematical operations and there must be application activities and time for reflection between each phase.

Other special abilities of Industrial Arts/Technology Education.

Industrial Arts/Technology Education is capable of some accomplishments with which the core curriculum has difficulty. Industrial Arts/Technology Education has proven to be effective in the control of drop-outs, a major problem in today's schools. Industrial Arts/Technology Education can enrich education for the high achievers as well as the slow achievers by offering them practical areas of study not normally taught elsewhere. Some of these areas are suggested by Brown in his "contemporary technology curricula." (Brown 10)

Subjects included would be hybrid microelectronics, robotics, instrumentation technology, computergraphics, microcomputer maintenance & repair, microcomputer programming, bioengineering technology, telecommunications technology, solar energy technology, automated office technology, nuclear technology, metal working technology, genetic engineering technology, microprecision machine tool technology, and chemical technology.

Model Programs Emphasizing Math Education in Industrial Arts/Technology Education Programs.

Several programs have been developed, primarily within the past five years, which emphasize the teaching of mathematics and science in industrial arts/technology education. These include: "Technology Education - Mathematics and Science Interface Curriculum Project," developed by the Maryland State Department of Education; Texas' "Interfacing Math, Science and Technology" program, and others. These programs, and others presently being developed, are becoming models for the teaching of mathematics in a meaningful educational setting.

RESEARCH PROCEDURE

Throughout this investigation the research staff endeavored to follow research procedures which were acceptable for this type of study. And, on occasion, it was necessary to alter the research study to incorporate the recommendations of the research advisory committee and to reflect new directions, as the study indicated.

Upon beginning this research study, a four-member advisory committee was selected, their charge being to give expert opinion on methods and procedures of the study and to function as resource persons in their fields of expertise. The advisory committee consisted of the mathematics department head of a local public high school, the head of the mathematics department of the Louisiana School for Math, Science and the Arts, the director of the Louisiana Vocational Curriculum Development and Research Center, and the Industrial Arts/Technology Education Program Manager in the Louisiana Office of Vocational Education.

As the investigation began, a review of related literature was conducted. Also, telephone interviews were conducted with persons recognized nationally for their efforts with the infusion of math, science, and technology into the high school curriculum. These reviews and interviews helped to give direction to this study.

Next, the research staff secured and meticulously examined fifteen Louisiana state adopted industrial arts/technology education curriculum guides. Before the study was long underway, the Construction Curriculum Guide became available and was included in this effort, bringing the total number of IA/TE curriculum guides used to sixteen. Using these guides, all instructional objectives that require math competency were identified. The IA/TE curriculum guides surveyed for this study were: General Industrial Arts, Basic Electricity/Electronics, Advanced Electronics, Advanced Electronics/Microprocessors and Robotics, Basic Metals, Advanced Metals, Power Mechanics, Power and Energy, Basic Woodworking, Advanced Woodworking, Principles of Technology, Basic Technical Drafting, Advanced

Technical Drafting, Architectural Drafting, Construction, and Beginning Graphic Arts.

In addition, eight Louisiana state adopted mathematics curriculum guides were examined in an effort to more thoroughly understand the nature of the mathematics skills and concepts presently being taught in Louisiana high schools. These guides included the following: Mathematics I, Introduction to Algebra, Algebra I, Algebra II, Geometry, Business Mathematics, Consumer Mathematics, and Advanced Mathematics.

After identifying the math-related objectives in the IA/TE curriculum guides, the research staff prepared a questionnaire-type data collection instrument. (Sample presented in Appendix A.) This ten page response form was designed to have Louisiana high school instructors of industrial arts/technology education identify which math-related objectives they teach and in which courses they teach them. Then they were to indicate the amount of time they devote to teaching each math-related objective. Additionally, instructors were requested to supply information about mathematics processes and concepts they teach which were not specifically evident in the curriculum guides.

Once the math-related objectives were selected and prepared for the data collection instrument, the two mathematicians who were members of the advisory committee surveyed them to offer their expert opinions as to the appropriate selection of each objective initially considered by the research to be math-related. None was judged to be inappropriate to include in the questionnaire.

The data collection instrument was sent to 248 high school instructors of industrial arts/technology education throughout the state of Louisiana. A letter of explanation and a postage-paid return envelope were included in the mailing. (See letter in Appendix C.) Approximately one month later a second mailing of the questionnaire was made to solicit a response from those instructors who had not already done so. (See Appendix D.)

The study was concluded with tabulation and analysis of the data, after which results and conclusions were drawn and appropriate recommendations were made.

RESULTS

As the research staff completed its intensive survey of the industrial arts/technology education curriculum guides, the math-related objectives contained in each guide were listed. Adding the math-related objectives for all 16 courses included in the study, the total was 187. Fifty-five of the objectives were found to be repeats of others. Therefore, 132 different objectives were identified in the IA/TE curriculum guides that teach mathematics skills or concepts. These 132 objectives were used as the main response items in the data collection instrument.

Of the 16 industrial arts/technology education curriculum guides used in this investigation, all 16 were found to contain math-related objectives. The curriculum guide of Basic Electricity/Electronics topped the list with the largest number of math-related objectives, that being 41, while the Principles of Technology curriculum guide was close behind with 38 math-related objectives. A complete listing of the IA/TE curriculum guides included in this study, along with the number of math-related objectives observed in each curriculum guide, is given in Table 1.

Data obtained through the questionnaire-type survey instrument revealed, however, that the number of math-related objectives actually being taught by industrial arts/technology education teachers is vastly different from the listed objectives found in the curriculum guides. For example, where 14 math-related objectives were observed in the General Industrial Arts curriculum guide, instructors reported teaching 101 math-related objectives in this

Table 1

Summary of selected data regarding the math-related objectives observed in each Industrial Arts/Technology Education curriculum guide, the number of math-related objectives actually taught in each course, and the total number of hours of math-related instruction given in each of these courses.

Industrial Arts/ Technology Education Curriculum Guide	Number of Math-Related Objectives Observed in Each Curriculum Guide	Number of Math-Related Objectives Reportedly Taught	Sum of Avg. Hours Devoted to Math Instr. in Each IA/TE Course if all Objectives are Taught
GIA - General Industrial Arts	14	101	110.28
BEE - Basic Electricity/ Electronics	41	77	138.05
AE - Advanced Electronics	16	43	67.00
AE/MR - Advanced Electronics/ Microprocessors and Robotics	6	0	0
BM - Basic Metals	5	42	35.30
AM - Advanced Metals	4	31	40.00
PM - Power Mechanics	11	53	45.39
PE - Power and Energy	16	0	0
BW - Basic Woodworking	8	59	61.93
AW - Advanced Woodworking	4	58	62.77
POT - Principles of Technology	38	65	34.86
BTD - Basic Technical Drafting	6	71	70.22
ATD - Advanced Technical Drafting	2	76	68.65
AD - Architectural Drafting	1	62	55.63
CON - Construction	14	15	12.25
BGA - Beginning Graphic Arts	1	0	0
	187[1]	753[2]	

[1]Sum of objectives observed in all IA/TE curriculum guides used in this study.
[2]Sum of math-related objectives reported to have been taught in all IA/TE courses.

course. And, in the Architectural Drafting curriculum, where only one math-related objective was found, instructors reported teaching 62 math-related objectives.

On the other hand, three of the courses had fewer math-related objectives reportedly taught than were observed in the curriculum guides. These courses are Beginning Graphic Arts, Advanced Electronics/Microprocessors and Robotics, and Power and Energy. (The research staff is fully aware that mathematics is indeed taught and used in these courses. However, the instructors of these courses failed to return a response questionnaire to the research staff.) Whereas the sum of the math-related objectives observed in all industrial arts/technology education curriculum guides used in this study is 187, there was a sum of 753 objectives reported to have been taught in all of these courses. A complete listing of the number of math-related objectives reportedly taught in each course included in this study is recorded alongside other data in Table 1.

This study also determined the amount of time industrial arts/technology education instructors devote to teaching mathematics concepts and skills in their courses. On the response questionnaire, teachers were instructed as follows: "Estimate the amount of time you spend teaching each different course during the school year, estimated to the nearest 1/4 hour. (Time each student is exposed to the instruction.) If you teach the competency in more than one course, list each course and its corresponding time."

An extensive volume of data was collected from the responses to this aspect of the questionnaire, since every instructor responded with estimated times devoted to teaching each math-related objective in each industrial arts/technology education course they instructed. Estimated times for teaching various objectives ranged from zero to forty hours. All responses greater than ten hours were not recorded and, thus, were not used to figure averages. (Three questionnaires were omitted entirely because it appeared to the research staff that the amounts of time devoted to teaching the math-related objectives were unrealistically high.) The total number of hours given to math-related instruction in each of the IA/TE courses used in the study is presented in Table 1. For a detailed listing of the average number of hours reportedly devoted to teaching each math-related objective, consult Table 2, in Appendix E.

It should be noted that comments were written on the data collection forms by numerous instructors that the hours they listed for "time you spend per year teaching the math competency to each class," were the number of hours devoted to actual math instruction, and that additional time is given to the application of mathematics skills. Other instructors, on 15 occasions, responded with the word "continually", rather than with a definitive measure of time, when reacting to this response category. A more exacting response in hours would, no doubt, have increased the average hours devoted to teaching math-related objectives. But, of course, this verbal response was omitted and was not used in calculating this response category.

A survey of Table 2 (Appendix E) also reveals that only three of the math-related objectives found in the industrial arts/technology education curriculum guides were not marked as being taught by any of the instructors responding to the survey form. Yet instructors responding to the survey listed 11 math-related objectives which they teach, but were not addressed in the curriculum guides. Appendix B presents a listing of these additional 11 objectives.

CONCLUSIONS

The purpose of this study was to identify the math-related objectives contained in 16 secondary industrial arts/technology education (IA/TE) curriculum guides, to determine the math concepts and processes which are being taught in these courses, and to determine the amount of time IA/TE instructors devote to math-related instruction.

Based upon the review of literature undertaken during the initial stages of this study, it can be concluded that the nationwide concern for the need to improve the mathematics competencies of our youth is imperative. Further review also revealed that IA/TE at the national level has responded well to the need to improve math competency, through the revision of existing curriculums and by adding new courses, such as Principles of Technology.

New directions in teaching mathematics and science in industrial arts/technology education programs have even mandated a recent change in the subject title from Industrial Arts to Technology Education, or as in Louisiana, Industrial Arts/Technology Education. (It was beyond the scope of this study to compare the amount of math-related instruction being taught in IA/TE in 1988-1989 with that being taught in past years. However, the researchers have observed an increase in recent years that is in keeping with the national trend.)

Results of this study show that all 16 industrial arts/technology education curriculum guides surveyed for this study contain math-related objectives, with some of the guides containing far more than others. It can be concluded that most IA/TE courses are courses in which mathematics is an integral part of the course. In many of the courses, success in math performance is necessary for success in the course. For example, students completing the course in Basic Electricity/Electronics would have just over 138 hours of math-related instruction if instructors spent the average reported time teaching every objective responded to by the instructors teaching the course. Even in the Construction course, where the least amount of time teaching math skills and concepts was reported, the sum of the average hours of math-related instruction was 12.5 hours for the course. It is concluded that student success in courses such as General Industrial Arts, Basic Electricity/Electronics, Advanced Technical Drawing and many others is highly dependent upon the learning and application of math concepts and skills taught in the course. Conversely, student success in courses such as Construction is less dependent upon the students' ability to learn and apply mathematics that is taught and required in the course. (Refer to Table 1, Page 16, for a summary.)

The data obtained in this study lead us to conclude that there is much more mathematics taught in most industrial arts/technology education courses than is evident in the curriculum guides for each course. The sum of math-related objectives taught, as reported by the responding instructors is actually more than four times the sum of the objectives observed in the curriculum guides. (Again, reference is made to Table 1.) And, it was pointed out to the research staff by many of the responding instructors that mathematics concepts and skills are reinforced in the labs/shops through practical application.

It is further concluded, from the data, that some of the industrial arts/technology education courses, such as Advanced Metals and Construction, should be revised to intentionally include more math-related instructional objectives.

RECOMMENDATIONS

Based upon the findings and conclusions of this study, the following recommendations are set forth:

1. That the trend toward teaching an increasing amount of mathematics and science in industrial arts/technology education courses be continued in our Louisiana schools. This can be accomplished by several methods: (a) Industrial arts/technology education teachers should revise their lesson plans and teaching strategies to intentionally incorporate additional math-related objectives and related instructional support materials.

2. That all math-related content be readily identifiable in each of the industrial arts/technology education curriculum guides. This can be accomplished by: (a) adding mathematics competency summary listings, (b) including a separate column identifying the math to be taught related to each relevant instructional objective, and (c) by providing periodic exams of mathematics skills, as they relate to the course content.

3. That educational administrators recognize that mathematics concepts and skills are being taught and reinforced in industrial arts/technology education and other phases of vocational education. And, it is recommended that educational decision-makers bear this in mind when considering curriculum changes. They should not eliminate vocational education courses in order to require additional mathematics, but should recognize vocational education for its unique ability to reinforce this area of study, as well as to provide exploratory work experiences and job preparation.

REFERENCES

Brown, B. F. 1984. Crisis in Secondary Education. Englewood Cliffs, NJ: Prentice - Hall.

Haynie, W. J. 1985. The Basics: Is Your Laboratory a Battleground in the Fight Against Ignorance? The Technology Teacher. 44(8):6-9.

Haynie, W. J. 1989. Mathematics in Technology Education: The Concepts to Math Approach. The Technology Teacher. 48(6):11-14.

Maley, D. 1987. Integrating Math and Science Into Technology Education. The Technology Teacher. 46(8):9-12.

National Assessment of Educational Progress. 1984. The Third National Mathematics Assessment: Results, Trends and Issues. Denver, CO.

National Council of Teachers of Mathematics. The Agenda in Action. As presented in: New Focus on Math Urged. The Dallas Morning News. Wed. 22 March, 1989.

Selby, C. C. 1988. Integrated Mathematics, Science and Technology Education. The Technology Teacher. 47(5): 3-5.

Task Force on Science and Math Education. October 1982. Report of the Conference Board Committee on Mathematics and Science. New York.

APPENDICES

APPENDIX A

IDENTIFICATION OF MATHEMATICS COMPETENCIES TAUGHT IN INDUSTRIAL ARTS/TECHNOLOGY EDUCATION PROGRAMS IN LOUISIANA HIGH SCHOOLS

Below are listings of mathematics competencies which were identified in industrial arts/technology curriculum guides for courses taught in our Louisiana secondary schools.

Check here, if you wish to receive a report of the results of this study. ___

SECTION I INSTRUCTIONS.

(1) For each math competency that you teach, please list, in abbreviated form, the name of the course(s) in which you teach that competency.

(2) Estimate the amount of time you spend teaching each of the math competencies in each different course during the school year, estimated to the nearest 1/4 hour. (Time each student is exposed to the instruction.) If you teach the competency in more than one course list each course and its corresponding time.

(3) Make notes, if desired, because in SECTION II you will be asked to list additional math competencies which you teach.

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
EXAMPLE 1 Calculate the total floor area of a building in square feet.	General IA	½ hr.
EXAMPLE 2 Determine the radius of a rod that has a diameter of 2.375".	Begin. Metals Adv. Metals	½ hr. 1/4 hr.
EXAMPLE 3 Calculate the RPM to set a lathe spindle using the formula: RPM = CS x 12 / [3.1416 x Dia.]	Adv. Metalworking	3/4 hr
Add and subtract whole numbers.		
Multiply and divide whole numbers.		
Reduce given fractions to their lowest common denominator.		
Add and subtract fractions and combinations of whole numbers and fractions.		
Multiply and divide given common fractions.		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
Convert common fractions to decimals and decimals to fractions.		
Multiply and divide decimals.		
Add and subtract decimals.		
Round off numbers to any specific place value through one million.		
Solve addition problems requiring combinations of two or more linear measurements.		
Be able to select the proper scale on a multiple scale rule.		
Make correct measurements with a rule having metric divisions.		
Make measurements with a rule having English divisions (ft./inch.).		
Make accurate English and metric measurements using fractional divisions.		
Make accurate English and metric measurements using linear scales.		
Make accurate English and metric measurements using compressed scales.		
Using a rule, measure an object drawn to scale. Then convert the measurements to the actual size of the object.		
Be able to estimate length measurements from a scale legend.		
Convert English units of feet to inches, square feet to square inches, pounds to ounces, etc.		
Convert metric units of kg to gm, mm to m, etc.		
Read dimensions to given tolerances.		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
Calculate the square roots of whole numbers to the thousandths place.		
Calculate perimeter.		
Calculate the areas of given squares. ($A = L^2$)		
Calculate the areas of rectangles in square inches, square feet, square yards, etc.		
Calculate the volume of a box, a room, a volume of soil, etc. ($V = L \times W \times H$)		
Calculate the volume of a cylinder in cubic inches, cubic feet, cubic yards, etc. ($V = \pi R^2 \times H$)		
Calculate the area of various circles. ($A = \pi R^2 = [\pi D^2 / 4] = 0.7854 \times D^2$)		
Calculate the volume of spheres. ($V = [4\pi R^3 / 3]$)		
Compute the volume of pyramids.		
Compute the volume of cones.		
Compute the volume of prisms, such as in units of cubic yards.		
Compute the areas of common polygons.		
Calculate the area of various triangles. ($A = [1 / 2]D \times A$)		
Compute the area of various areas that are combinations of triangles, rectangles and circles or arcs.		
Calculate arc length, given the radius.		
Calculate circumferences. ($C = \pi D$)		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
Express angular measurement as degrees, minutes and seconds.		
Use a protractor to read/draw angles of correct degrees.		
Convert degrees to radians and radians to degrees.		
Lay out geometric shapes involving lines, arcs, circles and angles.		
Divide lines, arcs and angles into equal segments using proper instruments.		
Construct squares, hexagons, octagons and pentagons.		
Erect perpendiculars, using proper instruments.		
Construct tangent arcs and circles.		
Check the squareness of a rectangle using the 6, 8, 10 mathematical method.		
Square up the layout of a rectangle using the diagonal measuring method.		
Make a drawing of an oblique plane and describe principles of geometric location.		
Correctly round off given 5-place decimal amounts to 2 or 3 places, as assigned.		
Compute the cost of constructing a circular sidewalk at an estimated cost of $1.20 per square foot. (Or similar problem.)		
Solve problems for unknown voltage, current and resistance using Ohm's law. ($E = I \times R$, $R = E / I$ $R_A = [R_2 \times R_3] / [R_2 + R_3]$		
Measure and calculate quantities in series-parallel circuits.		
Calculate voltage drops, branch currents and power use in series-parallel circuits.		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
Convert AC measurements from one quantity to another.		
Work problems involving voltage division.		
Compute problems using Watt's law. (W = I x E)		
Calculate power in terms of Joule's law. (P = I x W)		
Calculate the equivalent resistance of series circuits.		
Work problems involving bridge to determine resistance, voltages, and currents.		
Calculate capacitive reactance for various circuits.		
Analyze numerically and vectorialy circuits involving resistance and inductive reactance.		
Calculate inductive reactance for a circuit.		
Work problems to determine capacitance.		
Solve problems of reactance, impedance and parameters of resonant circuits.		
Determine peak to peak and root mean square voltages. ($V_{p-p} = V/_{cm} \times cm$)		
Work formulas for wattage. (W = I x [V or E])		
Work problems involving voltage drops and Kirchoff's law.		
Compute current, using the power formula.		
Calculate resonance in a RCL circuit.		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
Mathematically analyze the AC of RCL circuits.		
Calculate resonant frequency of an LC circuit.		
Solve problems involving turns ratio of transformers.		
Calculate time constants of capacitors.		
Determine the total capacitance and working voltage of series and parallel circuits.		
Work simple story problems that require several calculations to get final answer, such as: calculate current from voltage and resistance. $(I = V / R)$		
Use Delta-Tee formulas to solve resistance problems.		
Perform arithmetical functions on a scientific calculator.		
Solve basic algebraic equations for a given property.		
Be able to rearrange simple equations to isolate a variable, such as: $F = P \times A$ (solve for P) and $KE = 1/2\ MV^2$ (solve for V)		
Be able to make direct substitutions of units of measure for terms in algebraic equations, such as: $F = P \times A$.		
Calculate trigonometric equations.		
Be able to solve right angle trigonometry for sine A, cosine A, and tangent A.		
Be able to use $A^2 + B^2 = C^2$ in right angle trigonometry.		
Calculate logarithms and reciprocals.		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
Be able to change word equations to symbol notation, such as: pressure = Force / Area --> p = F / A.		
Be able to read and solve basic story problems.		
Given necessary data, draw a graph.		
Given a graph, interpret the data.		
Graph linear variations.		
Graph non-linear variations.		
Graph capacitor voltage.		
Graph alternating current waveforms and discuss phase relationships.		
Graph capacitive reactance versus frequency.		
Graph the frequency response curves of RLC circuits.		
Graph the waveforms of voltage doublers.		
Calculate horsepower. (H = [Work x 33,000] / Time (in minutes)) or (H = Watts / 746)		
Work formula for brake horsepower. $Horsepower_B$ = [Force(02.) x RPM] / 100,000		
Work formula for area of bore. Area of Bore = D^2 x .7854		
Calculate displacement. (Disp = πR^2 x stroke length or Disp = D^2 x .7854 x stroke)		
Calculate torque. (Torque = F x Radius)		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spenc per year teach ing the math competency to each class
Calculate power. (Power = force x distance x time)		
Calculate work. (Work = Force x Distance, or FXD / Input Work = FXD / Output Work)		
Calculate work energy. (Work = Energy = Power x Time)		
Work formula for force. (F = M x A)		
Correctly figure units of pressure.		
Solve mathematical problems such as that involving change in pressure and volume. ($P_1V_1 = P_2V_2$)		
Solve mathematical problems such as that involving changes in pressure and temperature. ($P_1 / T_1 = P_2V_2 / T_2$, or $V_1 / T_1 = V_2 / T_2$)		
Work problems of significant figures (roughly). $P = F / A = 10.2N / 2.32518M^2 = 4.38675154N/M^2 = 4.39N/M^2$		
Compute compression ratios, gear ratios and other ratio problems.		
Define/discuss the meaning of ratio, such as: A / B or A : B		
Define equality of two ratios (proportion): A / B = C / D or A : B :: C : D		
Compute kinetic energy. ($KE = [Mass \times Vol]^2 / 2$)		
Correctly figure units of speed.		
Work formulas related to solar energy.		

BEST COPY AVAILABLE

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teaching the math competency to each class
Work formula for efficiency. (Efficiency = Output Work / Input Work)		
Work formula for average wind speed. $WS\ (avg) = \frac{\text{total observed windspeed}}{\text{number of observations}}$		
Compute power using trigonometric functions.		
Compute board feet. BF = [no. pieces x T x W x L] / 144		
Calculate main and flash exposures of film.		
Express numbers in scientific notation.		
Add, subtract, multiply and divide numbers expressed in scientific notation.		
Calculate the square root of numbers in scientific notation.		
Convert between the following number bases: decimal, binary, octal and hexidecimal.		
Change numbers expressed as scientific notation into decimal numbers.		
Express numbers by use of unit prefixes and be able to convert from one prefix to another.		
Convert decimal numbering to binary numbering.		
Have an understanding of dimensional analysis. (Dist = Speed x Time + (1/2 [Acc x Time])		
Calculate total cost by multiplying number of units by the unit cost. (total cost = # units x unit cost)		
Figure profit and loss projections for a mass production product.		

Specific Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach each objective	Time you spend per year teach ing the math competency to each class
Make a cost analysis and determine the market selling cost for a product.		
Calculate return on investment (ROI).		
Calculate the interest on $120,000 for 24 months at 12.5% per annum, or work other similar problems.		

SECTION II INSTRUCTIONS.

(1) Please list additional industrial arts/technology education objectives that you teac where mathematics is required.

(2) List, in abbreviated form, the name of the course(s) in which you teach each of the objectives.

(3) Estimate the amount of time you spend teaching each of these additional math-relate competencies, estimated to the nearest 1/4 hour. (If you teach the competency in m than one course, list a time for each course.)

Additional Industrial Arts/Technology Education Objectives Identified as Requiring Mathematics Competency	Name of IA/TE course(s) in which you teach this objective	Time you spend per year teach-ing the math competency to each class

Please use additional sheet, if needed.

On the lines below, please list all of the industrial arts/technology education courses th you regularly teach.

APPENDIX B

Additional Math-Related Objectives Taught in Industrial Arts/Technology Education Courses, as Reported by Instructors Returning Survey Forms

1. Transfer scale measurements and angles on a drawing to actual measurements and angles on stock materials.
2. Calculate the true length and size of skewed lines and planes.
3. Using a transit, calculate and denote land elevations.
4. Place three different views of an object on drafting paper, as assigned, leaving equal spacing between them.
5. Correctly work slope and pitch formulas.

   example: RISE / RUN = PITCH
6. Solve systems of equations having two or three variables.
7. Read linear meter scales and determine correct values.
8. Read logarithmic scales and determine correct values.
9. Read Boolean algebra notation related to electronic circuits.
10. Compute worker hours and pay for a job.
11. Make a total cost estimate for a residential construction job.

STATE OF LOUISIANA
DEPARTMENT OF EDUCATION
P. O. BOX 94064
BATON ROUGE, LOUISIANA 70804-9064

March 10, 1989

TO: Selected Industrial Arts/Technology Education Teachers

FROM: Jerry O'Shee, Industrial Arts/Technology Education Program Manager

SUBJECT: Survey to Determine the Mathematics Taught in Industrial Arts/Technology Education in Louisiana

You have been selected to return valuable information to us because of your involvement in teaching industrial arts/technology education at the high school level in Louisiana. We believe that you and other Industrial Arts/Technology Education (IA/TE) teachers should be recognized for your contributions to other academic goals within the educational setting.

The Office of Vocational Education in the Louisiana State Department of Education has funded a project through Northwestern State University intended to identify the objectives in Industrial Arts/Technology Education in which mathematics is required or highly desirable. Your response is needed to identify the math competencies which you teach in your courses and to list additional IA/TE objectives which you teach where mathematics is required. In addition, you are asked to estimate the amount of time you spend teaching the mathematics-related objectives.

After giving approximately thirty minutes of your time to complete the questionnaire, please return your completed survey form in the enclosed postage-paid envelope within the next two weeks.

Be assured that your responses will be kept anonymous and all data will be reported in tabular or summary form. As a result of your response, and that of other selected IA/TE teachers, we hope to provide educational administrators with new insights that will improve Industrial Arts/Technology Education.

Thank you for your assistance.

JO:WHD/rl

Attachment

APPENDIX D

STATE OF LOUISIANA
DEPARTMENT OF EDUCATION
P. O. BOX 94064
BATON ROUGE, LOUISIANA 70804-9064

April 10, 1989

TO: Selected Industrial Arts/Technology Education Teachers

FROM: Jerry O'Shee, Industrial Arts/Technology Education Program Manager

SUBJECT: Survey to determine the mathematics taught in Industrial Arts/Technology Education in Louisiana

On March 6, 1989, I sent you a letter accompanied by a questionnaire. This was sent to you at your school address. If you have returned the completed questionnaire to me I am most appreciative of your professional involvement in this important study, and you may dispose of the form enclosed with this mailing.

The Office of Vocational Education in the Louisiana State Department of Education has funded a project through Northwestern State University intended to identify the objectives in Industrial Arts/Technology Education in which mathematics is required or highly desirable. Your response is needed to identify the math competencies which you teach in your courses and to list additional IA/TE objectives which you teach where mathematics is required. In addition, you are asked to estimate the amount of time you spend teaching the mathematics-related objectives.

The short amount of time you take in completing the form will help your profession and may directly affect you by helping maintain enrollment in Industrial Arts/Technology Eduction!

If you have not yet returned the questionnaire, please fill it out and return it at your very earliest convenience. We have enclosed another copy of the questionnaire and a postage-paid envelope with this letter. It is of utmost importance that we receive your completed questionnaire within a few days so that the research report may be prepared immediately.

Thank you for your assistance.

J:WHD/ko

Attachment

APPENDIX E

Table 2

Detailed listing of the average number of hours devoted to teaching each math-related objective, as estimated by the Industrial Arts/Technology Education instructors.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	Beginning Graphic Arts BGA	Construction CON	Architectural Drafting AD	Advanced Technical Drawing ATD	Basic Technical Drawing BTD	Principles of Technology POT	Advanced Woodworking AW	Basic Woodworking BW	Power and Energy PE	Power Mechanics PM	Advanced Metals AM	Basic Metals BM	Advanced Electronics/ Microprocessors and Robotics AE/MR	Advanced Electronics AE	Basic Electricity/ Electronics BEE	General Industrial Arts GIA
1. Add and subtract whole numbers.	.92			.56	.66	.76		.62	1.00		.56	2.00	1.12			.38	1.16
2. Multiply and divide whole numbers.	1.36			1.08	1.18	1.88		1.35	1.00		.56	2.00	1.37			.38	1.33
3. Reduce given fractions to their lowest common denominator.	1.69			1.33	2.15	1.86		1.70	1.55		1.50	.50	.62			.25	1.81
4. Add and subtract fractions and combinations of whole numbers and fractions.	1.44			1.07	2.15	1.47	.75	1.58	1.25			.50	1.29		.50	.38	1.70
5. Multiply and divide given common fractions.	1.52			1.32	1.15	1.50	.50	2.00	1.32		.25	.50	1.62		.50	.38	2.07
6. Convert common fractions to decimals and decimals to fractions.	1.20		.50	1.91	1.00	1.10	.75	1.50	.78		.62	.50	1.75			.75	1.73
7. Multiply and divide decimals.	.77			.41	.75	.78	.50	1.00	.97		.58	1.00	.58			.56	.81
8. Add and subtract decimals.	.71			.40	.50	.65	.25	.50	1.58		.81	.75	.56			.56	.60

[1] Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/MR	AE	BEE	GIA
9. Round off numbers to any specific place value through one million.	.68			.50	.45	.72	.38	1.08	.96		.58		.50			.41	.66
10. Solve addition problems requiring combinations of two or more linear measurements.	1.18		1.00	1.12	.80	1.03		1.02	1.25		.25	2.00	2.00				1.34
11. Be able to select the proper scale on a multiple scale rule.	1.35			1.36	.70	1.27		1.40	1.58			4.00	2.25			.50	1.46
12. Make correct measurements with a rule having metric divisions.	.82			.62	.45	.87	.75	.66	.62			1.00	1.00			.25	1.03
13. Make measurements with a rule having English divisions (ft./inch.).	2.07		1.00	1.92	1.46	2.04	.25	3.16	2.09			3.00	1.53			.25	2.17
14. Make accurate English and metric measurements using fractional divisions.	1.65		1.00	2.25	1.00	1.28		3.33	2.25		.25	1.50	1.33				1.58
15. Make accurate English and metric measurements using linear scales.	1.35			1.25	1.43	1.09	1.38	.91	.93			1.25	1.00				2.01
16. Make accurate English and metric measurements using compressed scales.	1.20			.83	.85	1.32	.50										1.80
17. Using a rule, measure an object drawn to scale. Then convert the measurements to the actual size of the object.	1.54			1.62	2.10	1.63		1.35	1.57			4.00	1.00				1.10
18. Be able to estimate length measurements from a scale legend.	.79			.87	1.07	.77	.50	.41	.58			2.00	.50				.64
19. Convert English units of feet to inches, square feet to square inches, pounds to ounces, etc.	.91			.93	.50	1.47	.50	.60	1.06		.25	1.00	.66				.77
20. Convert metric units of kg to gm, mm to m, etc.	.47			.38	.66	.30	.50	.50	.50				.25			1.00	.50
21. Read dimensions to given tolerances.	.79			1.16	1.18	.69	.25	.38	.56		.81	1.00	.75		1.00	1.00	.80

[1] Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/MR	AE	BEE	GIA
22. Calculate the square roots of whole numbers to the thousandths place.	.50				.25	.50		.50	.75								
23. Calculate perimeter.	.54		.50	.79	.46	.46		.70	.59				.25				.33
24. Calculate the areas of given squares. $(A = L^2)$	.67		.50	.90	.35	.45		.37	1.37			2.00	.38				.50
25. Calculate the areas of rectangles in square inches, square feet, square yards, etc.	.71		.25	1.03	.37	.58		.41	.50		.25	3.00	1.16				.50
26. Calculate the volume of a box, a room, a volume of soil, etc. $(V = L \times W \times H)$	.50			.56	.38	.63	.50	.37	.35			.50	.37				.50
27. Calculate the volume of a cylinder in cubic inches, cubic feet, cubic yards, etc. $(V = \pi R^2 \times H)$	.53			.58	.37	.50	.50		1.00		.25	.50	.38				.83
28. Calculate the area of various circles. $(A = \pi R^2 = [\pi D^2 / 4] = 0.7854 \times D^2)$	.49			.41	.33	.55	.62				.25	.50	.38				.75
29. Calculate the volume of spheres. $(V = [4\pi R^3 / 3])$	.58			.50	.25						1.00						
30. Compute the volume of pyramids.	.44			.25	.50	.50											
31. Compute the volume of cones.	.50			.50	.50	.50											
32. Compute the volume of prisms, such as in units of cubic yards.	.58			1.00	.50	.50		.50				.50					
33. Compute the areas of common polygons.	.48			.41	.62	.43											.25
34. Calculate the area of various triangles. $(A = [1 / 2]D \times A)$	.50			.25	.58	.67		.50					.25				.41
35. Compute the area of various areas that are combinations of triangles, rectangles and circles or arcs.	.58			.66	.58	.70	.50					.50	.50				.25

[1]Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/ MR	AE	BEE	GIA
36. Calculate arc length, given the radius.	.54			.38	.41	.67	.50	.75	.41								.25
37. Calculate circumferences. (C = πD)	.51			.38	.66	.63	.38	.38	.29		.50	.50	1.00				.43
38. Express angular measurement as degrees, minutes and seconds.	.50			.50	.43	.54	.50	.58	.62			.25	.38			.50	.41
39. Use a protractor to read/draw angles of correct degrees.	.82			.50	.50	1.11	.25	.42	.70				.75				.86
40. Convert degrees to radians and radians to degrees.	3.73			.25	.38	.41	.75		.25								.50
41. Lay out geometric shapes involving lines, arcs, circles and angles.	2.88			3.29	3.08	3.85		1.18	1.48				.62				2.80
42. Divide lines, arcs and angles into equal segments using proper instruments.	1.54			1.89	1.78	1.56		.90	1.33								1.51
43. Construct squares, hexagons, octagons and pentagons.	1.55			2.08	1.83	2.51		.35	1.03				.62				2.33
44. Erect perpendiculars, using proper instruments.	.93			1.25	.90	.89		.83	1.04		.25						1.00
45. Construct tangent arcs and circles.	1.36			1.75	1.78	1.52		.38	.87		.50						.94
46. Check the squareness of a rectangle using the 6, 8, 10 mathematical method.	.47		.50	.33	.31	.45		.71	.48								.65
47. Square up the layout of a rectangle using the diagonal measuring method.	.52		.50	.67	.68	.55		.42	.36				.25				.60
48. Make a drawing of an oblique plane and describe principles of geometric location.	1.24			1.25	1.13	1.16											1.83
49. Correctly round off given 5-place decimal amounts to 2 or 3 places, as assigned.	.59			.33	.63	.73	.25	.50	.50				.50			.25	.70

[1]Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/ MR	AE	BEE	GIA
50. Compute the cost of constructing a circular sidewalk at an estimated cost of $1.20 per square foot. (Or similar problem.)	.89		1.00	.96	.58	.75		.50	1.20			.50	.50				1.19
51. Solve problems for unknown voltage, current and resistance using Ohm's law. ($E = I \times R$, $R = E / I$, $R_A = [R_2 \times R_3] / [R_2 + R_3]$	2.77			.75	2.00		1.00				.88	1.00			3.00	6.00	2.11
52. Measure and calculate quantities in series-parallel circuits.	2.96			.50	2.00						1.00	.50			2.50	5.14	2.32
53. Calculate voltage drops, branch currents and power use in series-parallel circuits.	2.26			.75	2.00		.63				.75	.25			1.50	4.29	2.08
54. Convert AC measurements from one quantity to another.	1.77						1.00									1.80	2.00
55. Work problems involving voltage division.	2.25						1.00				.83				6.00	3.00	1.70
56. Compute problems using Watt's law. ($W = I \times E$)	1.83						.38				.83				1.00	3.50	1.44
57. Calculate power in terms of Joule's law. ($P = I \times W$)	1.67						.38								1.00	1.33	1.25
58. Calculate the equivalent resistance of series circuits.	2.60						.25				1.00				1.50	4.54	1.80
59. Work problems involving bridge to determine resistance, voltages, and currents.	1.78														1.00	2.25	1.25
60. Calculate capacitive reactance for various circuits.	1.88						.50				1.00				2.00	3.33	.50
61. Analyze numerically and vectorialy circuits involving resistance and inductive reactance.	1.58														1.50	3.00	.25

[1]Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/MR	AE	BEE	GIA
62. Calculate inductive reactance for a circuit.	1.19														2.00	2.33	.50
63. Work problems to determine capacitance.	2.37														2.50	3.00	.25
64. Solve problems of reactance, impedance and parameters of resonant circuits.	2.70														2.00	3.67	.50
65. Determine peak to peak and root mean square voltages. ($V_{p-p} = V/_{cm} \times cm$)	1.41															2.00	.25
66. Work formulas for wattage. (W = I x [V or E])	1.69						.50								1.00	2.50	1.21
67. Work problems involving voltage drops and Kirchoff's law.	2.40														1.00	3.17	1.50
68. Compute current, using the power formula.	1.31						.25								1.00	2.04	.88
69. Calculate resonance in a RCL circuit.	2.50														2.00	2.67	
70. Mathematically analyze the AC of RCL circuits.	2.66														2.00	3.00	
71. Calculate resonant frequency of an LC circuit.	2.66														2.00	3.00	
72. Solve problems involving turns ratio of transformers.	1.37						.25				1.00				2.00	2.33	.38
73. Calculate time constants of capacitors.	1.37														1.50	1.33	
74. Determine the total capacitance and working voltage of series and parallel circuits.	2.00						1.00								2.00	2.67	1.00
75. Work simple story problems that require several calculations to get final answer, such as: calculate current from voltage and resistance. (I = V / R)	1.75			.50			.38								1.00	2.86	1.00

[1]Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/MR	AE	BEE	GIA
76. Use Delta-Tee formulas to solve resistance problems.	2.00															2.00	
77. Perform arithmetical functions on a scientific calculator.	1.85			1.13	1.75	1.67		2.00	4.00		1.00					2.33	1.67
78. Solve basic algebraic equations for a given property.	1.43				.58	1.50	.25	.75	.88		.50				1.00	2.50	2.25
79. Be able to rearrange simple equations to isolate a variable, such as: F = P x A (solve for P) and KE = 1/2 MV^2 (solve for V)	1.09			.25	.25	.25	1.00	.88	.75							2.00	1.42
80. Be able to make direct substitutions of units of measure for terms in algebraic equations, such as: F = P x A.	1.49			.25	1.08	2.00	1.00	1.38	2.75		1.50		.50			2.38	1.00
81. Calculate trigonometric equations.	2.00					3.00									1.00	2.00	
82. Be able to solve right angle trigonometry for sine A, cosine A, and tangent A.	1.33					2.00									1.00	1.00	
83. Be able to use $A^2 + B^2 = C^2$ in right angle trigonometry.	1.09			.25	.50	.56		1.50	1.00							4.00	1.25
84. Calculate logarithms and reciprocals.	1.00															1.00	
85. Be able to change word equations to symbol notation, such as: pressure = Force / Area --> p = F / A.	1.10				.75	.50	.38	1.50	.50		2.00					2.00	.88
86. Be able to read and solve basic story problems.	.91				.92	.58	.50	1.50	1.00		3.00		.50			.50	1.00
87. Given necessary data, draw a graph.	1.02				1.14	.67	.75		2.00		3.00				1.00	1.38	.65
88. Given a graph, interpret the data.	.77				.94	.65	.38		1.00		1.00				1.00	1.38	.42
89. Graph linear variations.	.64				.88	.67	.38		.50						1.00	.75	.25

[1] Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/MR	AE	BEE	GIA
90. Graph non-linear variations.	.50				.63	.25	.38								1.00		.25
91. Graph capacitor voltage.	.93														1.00	1.25	.25
92. Graph alternating current waveforms and discuss phase relationships.	1.34														2.00	1.50	1.06
93. Graph capacitive reactance versus frequency.	1.16														2.00	.75	
94. Graph the frequency response curves of RLC circuits.	1.16														2.00	.75	
95. Graph the waveforms of voltage doublers.	.62															1.00	.25
96. Calculate horsepower. (H = [Work x 33,000] / Time (in minutes)) or (H = Watts / 746)	1.18						.63				1.08					1.33	1.81
97. Work formula for brake horsepower. $Horsepower_B$ = [Force(02.) x RPM] / 100,000	1.57						.63				1.30						2.75
98. Work formula for area of bore. Area of Bore = D^2 x .7854	1.05						.25				.80						2.17
99. Calculate displacement. (Disp = πR^2 x stroke length or Disp = D^2 x .7854 x stroke)	1.33						.63				.86						3.25
100. Calculate torque. (Torque = F x Radius)	1.20						.63				.93						[illegible].75
101. Calculate power. (Power = force x distance x time)	.66				.50		.38				.86					.50	.56
102. Calculate work. (Work = Force x Distance, or FXD / Input Work = FXD / Output Work)	.85				.25		.38				1.00					2.00	.75
103. Calculate work energy. (Work = Energy = Power x Time)	.81				.25		.38				.75					1.00	.50

[1] Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/ MR	AE	BEE	GIA
104. Work formula for force. (F = M x A)	.88				.25		.38				1.33						.75
105. Correctly figure units of pressure.	.45						.38				.50						.50
106. Solve mathematical problems such as that involving change in pressure and volume. ($P_1V_1 = P_2V_2$)	.54						.38				.38					1.00	.75
107. Solve mathematical problems such as that involving changes in pressure and temperature. ($P_1 / T_1 = P_2V_2 / T_2$, or $V_1 / T_1 = V_2 / T_2$)	.62						.50				.25					1.00	.75
108. Work problems of significant figures (roughly). $P = F / A = 10.2N / 2.32518M^2 = 4.38675154N/M^2 = 4.39N/M^2$	1.12						.25									2.00	
109. Compute compression ratios, gear ratios and other ratio problems.	1.02				.67	1.00	.25				1.75					2.00	.33
110. Define/discuss the meaning of ratio, such as: A / B or A : B	.90				2.00	.38		.50			.71					.75	.67
111. Define equality of two ratios (proportion): A / B = C / D or A : B :: C : D	.57				.50	.63		.50			.58					1.00	.50
112. Compute kinetic energy. (KE = [Mass x Vol]^2 / 2)	1.00										1.00						
113. Correctly figure units of speed.	.58						.75				.50						
114. Work formulas related to solar energy.																	
115. Work formula for efficiency. (Efficiency = Output Work / Input Work)	.75						.63				.50	1.00				2.00	.50

[1]Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/ MR	AE	BEE	GIA
116. Work formula for average wind speed. $WS\ (avg) = \frac{\text{total observed windspeed}}{\text{number of observations}}$																	
117. Compute power using trigonometric functions.	2.00															2.00	
118. Compute board feet. BF = [no. pieces x T x W x L] / 144	2.36			1.00	1.00	.38		3.06	2.50				1.00				2.05
119. Calculate main and flash exposures of film.																	
120. Express numbers in scientific notation.	.88				.50	.50	.50									1.20	.50
121. Add, subtract, multiply and divide numbers expressed in scientific notation.	.90						.63	.75	.75						1.00	1.17	
122. Calculate the square root of numbers in scientific notation.	.71						.50	.75	.75						1.00	.75	
123. Convert between the following number bases: decimal, binary, octal and hexidecimal.	2.00														2.00		
124. Change numbers expressed as scientific notation into decimal numbers.	1.39						.25								2.00	1.58	
125. Express numbers by use of unit prefixes and be able to convert from one prefix to another.	1.41						.50	1.00							1 00	3.00	
126. Convert decimal numbering to binary numbering.	.87							2.00							1.00	.75	
127. Have an understanding of dimensional analysis. (Dist = Speed x Time + (1/2 [Acc x Time])	2.00							2.00									

[1]Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

Math-Related Objectives Observed in the IA/TE Curriculum Guides	AVE[1]	BGA	CON	AD	ATD	BTD	POT	AW	BW	PE	PM	AM	BM	AE/MR	AE	BEE	GIA
128. Calculate total cost by multiplying number of units by the unit cost. (total cost = # units x unit cost)	1.15		2.00	.63	2.00	1.25		1.82	1.10				1.08				.98
129. Figure profit and loss projections for a mass production product.	1.21		.50					1.69	.95				.50				1.50
130. Make a cost analysis and determine the market selling cost for a product.	1.07		1.00	1.08	1.00	1.00		1.36	1.21				.75				1.17
131. Calculate return on investment (ROI).	.88		1.00	1.00		1.00		.75	.63				1.00				.63
132. Calculate the interest on $120,000 for 24 months at 12.5% per annum, or work other similar problems.	.93		1.00	1.00	1.00	1.00		.75	1.00		1.00						

[1]Ave. (Average) - The average number of hours spent teaching the math-related objectives to each student, as estimated by the instructors teaching the objective.

67

68