A STUDY OF THE BASIC MATHEMATICAL SKILLS NEEDED TO TEACH INDUSTRIAL ARTS IN THE PUBLIC SCHOOLS

Thesis for the Degree of Ed. D.
MICHIGAN STATE UNIVERSITY

James E. Bowman

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This is to certify that the

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by
James E. Bowman
December 1958

A STUDY OF THE BASIC MATHEMATICAL SKILLS NEEDED TO TEACH INDUSTRIAL ARTS IN THE PUBLIC SCHOOLS

The problem set for this study was to determine the mathematical skills needed to be a successful industrial arts teacher in the public schools. The skills were conceived to be needed in two situations: Those necessary to fulfill the requirements for college graduation with a major in industrial arts education and those needed and used while teaching.

The mathematics necessary to become an industrial arts teacher was determined through surveys of: (1) The mathematics admission requirements of higher institutions with industrial arts teacher-preparation programs; (2) The mathematics courses required of industrial arts students; (3) The mathematical skills used in drawing, electricity, metalwork, and woodwork; (4) The mathematics courses considered desirable for industrial arts majors.

The need for and usage of mathematics in industrial arts teaching was analyzed by surveys of: (1) The opinions of authors of industrial arts textbooks; (2) The actual mathematical usage of selected outstanding industrial arts teachers. The usage of mathematics was sub-divided into (a) that within the ability of the student, requiring little attention from the teacher; (b) that necessitating teaching the mathematics before completion of the industrial arts assignments; (c) that encountered in the non-pupil-contract activities connected with industrial arts teaching.

The responses to the surveys came from 162 colleges representing forty-three states; from 100 professors of drafting, sixty-three professors of electricity, 105 professors of metalwork, and 101 professors of woodwork; from forty-nine authors; and from 189 public school industrial arts teachers representing 40 states.

The mathematical requirements for admission to and completion of the industrial arts program varied tremendously. Over one-third of the colleges responding mentioned no mathematics for admission. About one-fifth of the colleges required both elementary algebra and plane geometry. The remaining colleges required various combinations of general mathematics with or without other secondary mathematics courses. The size of the industrial arts departments of the colleges made little difference in the admission requirements. The colleges of the northeastern part of the United States seldom mentioned mathematics in their requirements. The colleges of the southern states required algebra and geometry more often than those of the other areas.

The in-college requirements also varied. No mathematics was required in 28 per cent of the colleges. Twenty-eight per cent required both college algebra and trigonometry. General mathematics was the only mathematics requirement in fifteen colleges; shop mathematics in nine colleges; and four colleges accepted any course in college mathematics.

The total mathematical background required for graduation involved as many as forty-one combinations of grouped academic and non-academic mathematics courses. Nineteen colleges required no secondary or college mathematics for graduation. Fifteen colleges required two units of academic mathematics for admission and two courses in academic mathematics while in college. Seven colleges required a total of six combined high school and college mathematics courses.

College industrial arts professors recommended courses in the following frequency order: (1) elementary algebra, (2) plane geometry, (3) trigonometry, (4) college algebra, (5) solid geometry, (6) intermediate algebra, and (7) analytic geometry. The first five courses were listed by more than 48 per cent of the professors. Their class usage ranked the courses in this order: (1) plane geometry, (2) solid geometry, (3) elementary algebra, (4) trigonometry, (5) intermediate algebra, (6) analytic geometry, and (7) college algebra. The first five courses were used in classes by more than one-half of the respondents. The drafting and woodworking professors used more of the line and figure mathematics courses than the other two groups. Those in electricity used the greatest per cent of the algebraic courses. The professors of metalwork recommended both line and figure and algebraic courses.

Of the outstanding public school industrial arts teachers, over one-half had taken elementary algebra, plane geometry, intermediate algebra, solid geometry, college algebra and trigonometry. Over 40 per cent had taken shop mathematics. Drafting teachers showed the least intermediate algebra (44 per cent), college algebra (65 per cent), and trigonometry (60 per cent). Teachers of electricity ranked comparatively low in solid geometry (48 per cent) but were highest in college algebra (85 per cent) and trigonometry (82 per cent).

Some teachers wished they had taken more mathematics courses in their preparation while others thought they should have taken less. Still others expressed satisfaction with the number of courses they had taken. The group that checked "more" averaged nearly five courses of secondary and/or college mathematics. Those that checked "less", none of whom were teachers of electricity, averaged 6.6 courses in mathematics. Those that expressed satisfaction had completed, on the average, slightly more than six courses in mathematics.

Approximately one-half of the teachers indicated they had taught some of the skills from the following courses, arranged in the frequency of occurrence: arithmetic, plane geometry, solid geometry, and elementary algebra.

The authors of industrial arts textbooks recommended mathematics courses, in the following order, for the teachers who used their book: (1) plane geometry—80 per cent, (2) solid geometry—65 per cent, (3) elementary algebra—54 per cent, (4) trigonometry—44 per cent, (5) intermediate algebra—44 per cent, (6) analytic geometry—8 per cent, and (7) college algebra—5 per cent.

On the basis of the evidence in this study, the college industrial arts teacher-preparation student should be required to complete courses in elementary algebra, plane geometry, intermediate algebra, solid geometry, and trigonometry.

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The publishing companies, who supplied the current addresses of the textbook authors; and the authors, with their insight of industrial arts course content, were very helpful. Many thanks for your efforts.

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James E. Bowman

candidate for the degree of

Doctor of Education

Final examination: October 22, 1958

Thesis: A Study of the Basic Mathematical Skills Needed to Teach Industrial Arts in the Public Schools

Outline of Study

Major Field: Foundations of Education

Minor Fields: Guidance (Education)
Engineering

Biographical Items

Born, September 19, 1907

High school, Frankfort, Michigan, 1925

Undergraduate, Life Certificate, Central Michigan College, 1927; Bachelor of Science, Central Michigan College, 1937

Graduate, Master of Arts, University of Michigan, 1944
Doctoral, Michigan State University, 1950-1958

Experience:	Onekama, Michigan, Principal	1927-1928
	Maple City, Michigan, Superintendent	1928-1930
	Metal trades, industry	1930-1935
	Coleman, Michigan, Principal	1937-1942
	Coleman, Michigan, Superintendent	1942-1944
	Gaylord, Michigan	1944-1945
	Lakeview, Michigan, Principal	1945-1946
	Central Michigan College, Industrial Arts Department, from	1946

Membership: Michigan Education Association
National Education Association
Saginaw Valley Industrial Arts Association
Michigan Industrial Education Society
American Industrial Arts Association
American Council on Industrial Arts Teacher Education
Iota Lambda Sigma
Phi Delta Kappa

CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

Introduction

After the termination of World War II, many ex-servicemen found themselves financially able to attend college. This influx of students presented many problems, both to the colleges and to the students. Some of these men, for various reasons, had elected programs in high school other than the college preparatory and were thus confronted with admission deficiencies. Many of these students enrolled in the industrial arts education program, and some encountered difficulty meeting the mathematical prerequisites for admission. A few students transferred to colleges with less demanding requirements in mathematics.

The author became interested in the mathematical requirements for industrial arts education in these colleges and attempted to survey their catalogs for this information. This was not enlightening. However, one fact became obvious: there was little agreement among colleges as to the mathematics required to become an industrial arts teacher. The admission requirements, as stated in the catalogs, ranged from none mentioned to two units of high school mathematics, and the in-college requirements also varied from no mention of mathematics to the specific sequence of college algebra, trigonometry, and analytic geometry. Some colleges deviated from the conventional courses and provided trade or shop mathematics. This course was required of industrial arts majors either in combination with some of the conventional mathematics courses or as a single requirement.

The author welcomed the opportunity to make a more thorough study of the mathematical requirements of industrial arts teacher-education programs. This study attempted to determine the mathematics courses that should be part of the program of industrial arts teacher preparation.

The Problem

Statement of the problem. The problem was to determine the mathematical skills needed to be a successful industrial arts teacher in the public schools. The skills were concieved to be needed in two situations: those necessary to fulfill the college requirements for graduation with a major in industrial arts education and those needed while teaching.

Importance of the Problem

Financial. The greatly increased cost of a college education, both to the student and the supporting organization, demands that every effort be made to ascertain the optimum content of each curriculum. As this cost continues to increase, studies of curricula become more important.

Student restrictions. Industrial arts embraces many areas of technical and industrial information. The acquisition of manipulative and mechanical skills requires extensive laboratory participation. Thus the student may have few opportunities to elect courses which he may consider desirable. This may also leave minimum possibilities for general education enrichment. Therefore, every effort should be made to determine the desirability of proposed additions to curriculum requirements.

Participation restrictions. Any mathematical requirement has a limiting effect as to who may participate in, and complete, the industrial arts education program. These specified requirements deny admission to those who, for many reasons, have not studied mathematics. They also deny admission, regardless of other competencies the student may possess.

Some mathematical ability is necessary to pursue industrial arts in college. However, there is a point beyond which a student's time in college might be more profitably spent in pursuit of other knowledge. This optimum level of mathematical achievement for industrial arts teachers is not known. In accordance with the American philosophy of educational opportunity, an attempt should be made to determine the proper level for rejection.

Need for the Study

Counseling. Counseling, in both the elementary and secondary school, should provide information concerning the educational requirements of the professions the student may anticipate. The requirements for industrial arts teacher education are not readily available. This information is needed for more effective counseling in the elementary grades.

Mathematics courses are pyramidal or sequential. Students may be deterred from conventional high school mathematics because of lack of mastery of arithmetic. College mathematics may prove difficult because of omissions in high school mathematics. Recognition of this continual re-use of mathematical skills may provide impetus for the mastery of each assignment.

Mathematical needs of teachers may vary. The techniques of teaching industrial arts are different from those of other classes. Mathematics may be encountered more often in industrial arts than in the usual classroom. The assignments in industrial arts are more individualized, and the student may encounter mathematics in more diverse situations. The industrial arts teacher may have need for additional mathematical ability. Any error in computation may involve the cost of material and often many hours of student effort.

Questionable basis for requirements. The mathematical requirements for admission and the specific course requirements are often established by administrators who may be unfamiliar with the in-class usage of mathematics and the needs of those teaching industrial arts.

The preliminary survey revealed the almost total lack of uniformity in the mathematical requirements among industrial arts colleges.

Definitions of Terms

Skills. Mathematical skill is considered as the ability to use efficiently the mathematical computation necessary to validate the student's answer. It further involves the ability to select correct and appropriate mathematical procedures to meet specific situations. The term also implies teaching skill when it may be necessary to teach those mathematical skills essential to the work of the class.

Industrial arts. Most current authors consider industrial arts to be a part of general education, embracing the use of tools, machines, and materials and imparting to the student the importance of the industrial society of which he is a member. Industrial arts concerns: the technical skills, the productive organization, and the distribution of, products essential to our standard of living. Industrial arts is a way of learning. The student establishes a situation in which he may be creative, solve problems, think critically, and organize procedures to meet his objectives. The student may achieve without lexical restrictions. Industrial arts should be desirable for girls as well as boys. It should not be contingent upon economic background or future professional aspirations. Industrial arts should not be confused with vocational education.

Public schools. The reference to public schools was made not to eliminate private or parochial schools, but to avoid the inclusion of trade and vocational schools or those training programs maintained by industry. Grade levels were purposely omitted as many states do not distinguish between preparation for the various levels.

Plan of the Study

Mathematics to become a teacher. The study was organized into two parts. The first section was concerned with the mathematics necessary to become a teacher of industrial arts. This area included (1) the mathematical admission requirements of the universities or colleges preparing industrial arts teachers, (2) the specific mathematics courses required of the college industrial arts student, and (3) the opinions of selected industrial arts professors concerning the mathematical ability needed to complete successfully the college industrial arts classes.

Mathematical usage of the teachers. The second section of the study was devoted to the mathematical skills used by industrial arts teachers in the public schools. In addition to which skills were used, the study identified how, and in what subject-matter area, they were used. This section further included a survey of the opinions of the authors of industrial arts textbooks concerning the mathematics involved in the use of their book as a text or reference.

Scope of the Study

Admission requirements and specific mathematics courses. The data concerning admission requirements and the mathematics courses required for the industrial arts education program were supplied by the heads of the industrial arts departments in those colleges or universities listed in the 1952 yearbook[1] and the 1956 directory.[2] These data came from forty-five of the states and 127 colleges or universities.

College class needs. Data concerning the industrial arts class usage of mathematics were supplied by selected professors in the industrial arts areas in the above colleges or universities. Professors from 100 colleges supplied data concerning mathematical usage in college drafting; professors from sixty-three institutions furnished data for electricity; 106 for metal; and 104 for wood.

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[1] Walter R. Williams, Jr., and Harvey K. Meyer, Inventory-Analysis of Industrial Arts Teacher Education Facilities, Personnel and Programs, Yearbook of the American Council on Industrial Arts Teacher Education (Oxford, Ohio: Miami University, 1952).

[2] G. S. Wall, Industrial Teacher Education Directory (Menomonie, Wisconsin: Stout State College, 1956).

Teaching needs. Selected outstanding industrial arts teachers from the public schools of forty states supplied the data concerning the mathematical usage.

Opinions of authors. Opinions were solicited from authors and co-authors of high school textbooks listed in the *Bibliography of Industrial Arts Textbooks*[3] and publishers' catalogs, and of additional books recommended by the publishers.

Limitations of the Study

Type of study. Because of the geographic area covered by the study, the collection of data was limited to the use of a questionnaire. This type of survey presents limitations of (1) communication or understanding; (2) the number of questions that could be used to secure the data; and (3) for various reasons, the percentage and reliability of the responses. Public concepts of the exalted importance of mathematics at the time of the study could limit the validity of the responses.

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[3]George Ferns and Earl A. Ferns, *Bibliography of Industrial Arts Textbooks* (Lansing, Michigan: Office of Vocational Education, Department of Public Instruction, 1953).

Mathematical background of the respondents. The opinions of each college professor concerning the mathematical needs for college industrial arts classes might be biased by his own mathematical background. If he were proficient in mathematics, his opinion would probably indicate that the extensive use of mathematics was desirable. If the mathematical background of the professor were limited, he probably would not require as much mathematical calculation.

Influence of teacher-preparation classes. The mathematical usage of the public school industrial arts teacher may be influenced by the usage of mathematics in his teacher-preparation industrial arts classes. If these classes involved the extensive use of mathematics, his teaching may reflect similar emphasis on mathematics.

Teacher uses only those skills he has mastered. The high school teacher probably uses little mathematics if he feels incompetent in that area. The course-content of industrial arts is seldom rigidly structured, and the teacher often stresses areas which he likes and in which he feels confident. Therefore, the teacher who has taken few mathematics courses will probably use comparatively little mathematics in his teaching.

Limitation of time. Contacts with the high school teachers were contingent upon the college department chairman's selection of outstanding industrial arts teachers and upon his providing their mailing addresses. Delays in the selection resulted in the teacher's survey being made late in the school year. The date of the survey prevented proper follow-up procedures. The data also prevented subsequent mailing when questionnaires were returned "unknown." The lateness of the survey, likewise, prevented remailing when the returned questionnaires indicated (1) lack of experience, (2) incomplete information, and (3) spurious usage. Attempts to recontact the high school teachers during the summer vacation were deemed impractical.

Assumptions

Several assumptions are inherent in the study of basic mathematical skills needed to teach industrial arts in the public schools.

Selection of teachers. The chairmen of the industrial arts departments of the colleges and universities were assumed to be the best qualified to select the outstanding industrial arts teachers in the public schools in their state.

Opinions of in-class mathematical usage. The professors teaching the college industrial arts classes were assumed to be the most authoritative source of information concerning the mathematical usage in the classes.

Mathematical skills are needed. The study assumed that some mathematical ability on the part of the student was necessary to enter college, to do the class work in industrial arts, to complete the specified mathematics courses, and to teach industrial arts successfully in the public schools.

College applicants have some mathematical skill. The elementary schools provide preparation in arithmetic. Most secondary schools require at least one year of mathematics for graduation, and many require two years of conventional mathematics for recommendation to college. Colleges presuppose some mathematical skill on the part of the applicant even though they fail to state mathematical prerequisites.

Skills are acquired in formal classes. In most instances mathematical concepts and skills are acquired in formal mathematics classes. There are exceptions to this statement, but the majority of teachers acquire the mathematical skills they possess by participation in mathematics classes. This is especially true in the more advanced areas of mathematics. Mathematical skills are pyramidal and the mastery of some skill may involve coverage of the work of several mathematics classes. Mathematical skills are assumed to be acquired by participation in classes of mathematics.

Usage depends upon the students. The intellectual ability of the students, the work habits, and the professional or vocational aspirations of the student may affect the mathematical usage in the industrial arts classes.

Usage influenced by the textbook and references. The mathematical content of the reading the student is expected to peruse may affect the over-all usage of mathematical skills in the class. The assumption was made that if little mathematics is encountered, little mathematics will be used.

Usage varies with objectives. The objectives of industrial arts vary among school systems. The objectives of industrial arts are often influenced by the philosophy of the teacher. If the sole objective of the course is the acquisition of skill, the mathematical usage may be entirely different from that of a class in which the objectives correspond more closely with the objectives of general education.

Need for teacher skill. There are many variables which may affect the mathematical usage in a class. The study assumes that industrial arts teacher preparation should prepare the teacher to meet the mathematical needs if and when they arise. Teacher preparation should develop the ability to recognize applications of mathematics.

Skills may be estimated by courses taken. The kind and number of mathematics courses taken could indicate the maximum mathematical skills the teacher could be expected to use. The kind and number of mathematical courses taken by the teacher may not be a true indication of his mathematical skills. He may have failed to master some concepts and skills in the class. However, the study assumes the more mathematics he may have successfully completed, the more mathematical skills he will be likely to possess.

Difficulty of courses. The study assumes algebra to be more abstract and more difficult for the majority of high school students than general mathematics. Thus, when a college will accept students with one unit of general mathematics, the college would also accept students with credit in algebra.

Plan of the Thesis

Chapter II. Reference to selected literature will be made to establish the status of mathematics at the time when most of the respondents did their teacher preparation. The few studies similar to the present one will be discussed.

Chapter III. This chapter will be devoted to the purpose of the questionnaire and the procedure used in its construction.

Chapter IV. This chapter will contain the data concerning the admission requirements for students on the industrial arts education programs.

Chapter V. The chairmen of the industrial arts departments in the colleges offering industrial arts teacher preparation supplied data concerning the mathematics courses their students were required to take in college. These data will be summarized in this chapter.

Chapter VI. Industrial arts education professors recommended certain courses to form the mathematical background of industrial arts teachers. The professors also completed the check list to indicate the mathematics courses that could provide the skills used in their industrial arts classes. Both the data of recommendations and of class usage will be compared and discussed in this chapter.

Chapter VII. This chapter will concern the mathematics used by selected outstanding teachers of industrial arts in the public schools of the United States. The data concerning the mathematical content of the industrial arts textbooks will be a part of this chapter.

Chapter VIII. The final chapter will summarize the study. Conclusions concerning the mathematical needs of industrial arts teachers will be drawn. Any recommendations for future studies, as a result of the present one, will be made in the final chapter.

CHAPTER II

REVIEW OF THE LITERATURE

The respondents to all phases of this study are individuals who had received their undergraduate education prior to 1953. This fact is important, for mathematics was relatively unpopular and many students met only the minimum requirements. The requirements were generally low. The realization of the unpopularity of mathematics helps one to understand the plight of the veteran as he attempted to enter college and to appreciate the mathematical background of the many respondents of this study.

Status of Mathematics

Mathematics had been declining in popularity in the high schools for many years. Many educational writers advocated substituting general mathematics for algebra and plane geometry. Studies were made indicating that general mathematics more adequately met the needs of the students in high school than the study of academic mathematics. Many questions were raised concerning the need for algebra and plane geometry even for those students planning to attend college.

Other studies were made attempting to predict college success from patterns of subjects taken in high school. Many of these studies specifically analyzed the relationship of high school mathematics to success in various areas in college. In many instances the conclusions questioned the advisability of any high school students taking mathematics in high school.

In some instances the literature questioned the quality of the textbooks and the ability of the mathematics teacher. It seemed common practice for the teacher, specializing in other areas, to be assigned a mathematics class to complete the teacher's schedule. Kline[1] was quite critical of both quality and ability and suggested that much improvement was necessary to restore mathematics to the status it deserved.

Faced with the multitude of antimathematics literature, counselors often suggested their students take the nonacademic additions to the curriculum.

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[1] M. Kline, "Mathematics Texts and Teachers: a Tirade," Mathematics Teacher, 49:162-72, March, 1956.

Studies Questioning the Content of Arithmetic

There were several early studies questioning the content of arithmetic courses. These probably helped contribute to the decline in popularity of all forms of mathematics. Wilson[2] found that parents used only the four fundamental operations of arithmetic and simple fractions in the solution of mathematical problems confronting adults. Mitchell[3] found that only very simple arithmetic was involved in adult reading in four selected areas. Wise[4] also found adults used little but the fundamental operations and fractions in the solution of over seven thousand mathematical problems which they encountered.

A study that caused considerable discussion when it appeared in 1929 was that of Bowden,[5] who surveyed the adult usage of

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[2]G. M. Wilson, "A Survey of the Social and Business Use of Arithmetic," Sixteenth Yearbook of the National Society for the Study of Education, Part I (Bloomington, Illinois: Public School Publishing Company, 1917), pp. 20-22.

[3]H. E. Mitchell, "Some Social Demands on the Course of Study in Arithmetic," Seventeenth Yearbook of the National Society for the Study of Education, Part I (Bloomington, Illinois: Public School Publishing Company, 1918), pp. 7-17.

[4]Carl T. Wise, "A Survey of Arithmetic Problems Arising in Various Occupations," Elementary School Journal, 20:118-36, October, 1919.

[5]A. O. Bowden, "Consumers Uses of Arithmetic," Contributions to Education No. 340 (New York: Columbia University, 1929).

arithmetic by the check list technique. He prepared a list of 145 typical textbook problems and requested adults to check if the problem was encountered. Only forty-four of the problems were thus checked. He concluded that 85 per cent of the arithmetic taught might well be eliminated from the curriculum.

Studies Advocating General Mathematics

Criticism of the requirements for algebra and plane geometry appeared soon after the studies concerning the content of the arithmetic courses.

Sueltz[6] contended that (1) students have not mastered arithmetic prior to their admission to secondary school; (2) the one year of algebra permitted only algebraic manipulation without proper understanding; and (3) the informal or experimental geometry in the junior high school permitted comparable application of geometric principles. He further suggested more functional mathematics in the high school.

Hunt[7] maintained that high school mathematics should have more functional value. He suggested more arithmetical understanding

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[6]Ben Albert Sueltz, "Mathematical Understandings and Judgment Retained by College Freshmen," Mathematics Teacher, 44:13-19, January, 1951.

[7]Herold C. Hunt, "Mathematics, its Role Today," Mathematics Teacher, 43:313-17, November, 1950.

and reasoning ability would result from an additional year of arithmetic in the ninth grade. Beckman[8] found little difference in the retention of general mathematics and first year algebra. In both cases there was only about half-mastery of the essentials considered necessary for functional competence.

Mary Carter[9] questioned the transfer of abstract reasoning ability, a major premise of those advocating conventional mathematics for high school. She further urged that high schools provide mathematics which will be more useful to the vast majority of their students.

Breslich,[10] a proponent of more secondary mathematics, contended that general mathematics would be desirable for all the ninth grade. The mathematics and science students would start algebra the following year. Waggoner,[11] while urging a strong mathematics

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[8] Milton W. Beckman, "How Mathematical Literate is the Typical Ninth Grader after Having Completed Either General Mathematics or Algebra," School Science and Mathematics, 52:449-55, June, 1952.

[9] Mary Carter, "The Modern Secondary School Looks at College Admission," College and University, 26:349-61, April, 1951.

[10] Ernest R. Breslich, "Importance of Mathematics in General Education," Mathematics Teacher, 44:1-6, January, 1951.

[11] Wilbur J. Waggoner, "The Relationship of High School Mathematics to Success in College," Unpublished Doctor's Project (Laramie, Wyoming: University of Wyoming, 1955).

program in the secondary school for mathematics and science students, suggested that general mathematics is more functional for the majority of the students. If the college student then finds he needs formal mathematics, it would be more advantageous to take the introductory courses in college. Waggoner proposed the colleges provide these introductory courses in formal mathematics.

Richtmeyer,[12] in a study of the mathematical usage of teachers and administrators, found a need for additional arithmetic. He developed a college course in general mathematics for the prospective teacher of subjects other than mathematics or science.

Studies Questioning College Admission Requirements

Douglass[13] made one of the earlier studies relative to the pattern of high school subjects and success in college. His study has been widely quoted. While the study covered all subject matter areas, he found the over-all college grades are lower for those having had four years of high school mathematics than for those

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[12] C. C. Richtmeyer, "Functional Mathematics Needs of Teachers," Unpublished Doctor's Field Study (Greeley: Colorado State College of Education, 1937).

[13] Harl R. Douglass, "The Relation of Pattern of High School Courses to Scholastic Success in College," The North Central Association Quarterly, 6:283-97, December, 1931.

having less. Nelson,[14] in a study following that of Douglass, found the coefficient of correlation between freshmen grades at the Iowa State Teachers College and the number of units of mathematics in high school to be r = .11 ± .05. He also found that those students presenting more than two and one-half units in mathematics earned an average grade of 89.1 and had twenty-seven withdrawals. Those students presenting less than two and one-half units in mathematics earned an average grade of 91.3 and had only sixteen withdrawals. Froelich,[15] at the University of Wisconsin, found no significant difference in the types of courses taken in high school and the scholastic success in the university. Vaughn,[16] in a summary of studies made prior to 1947, showed there was little relationship between the secondary educational pattern of subjects and success in college.

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[14] M. J. Nelson, "A Study of the Value of Entrance Requirements at Iowa," School and Society, 37:262-64, February, 1933.

[15] G. L. Froelich, "Academic Prediction of the University of Wisconsin," Journal of the American Association of Collegiate Registrars, 17:65-76, October, 1941.

[16] William Hutchinson Vaughn, "Are Academic Subjects in High School the Most Desirable Preparation for College Entrance?" Peabody Journal of Education, 25:94-99, September, 1947.

Edwards[17] presented a rather complete summary of the mathematical requirements for admission to college on the various curricula. He omitted mentioning mathematical requirements for industrial arts education, however. He recommended that the undecided high school student take three semesters of algebra and two semesters of plane geometry. The student would thus have the college entrance requirements, in mathematics, for the majority of college programs.

Krubeck,[18] in a study specifically directed at high-school mathematics and the college of engineering, found practically zero correlation between the number of mathematics courses taken in high school and success in the college of engineering.

Studies Depicting Mathematics Status

Authors recognized the low status of mathematics in the secondary curricula. Peak[19] commented on the low mathematical ability

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[17] P. D. Edwards and others, "Mathematical Preparation for College," Mathematics Teacher, 45:321-30, May, 1952.

[18] Floyd E. Kruebeck, "Relation of Units Taken and Marks Earned in High School Subjects and Achievement in the Engineering College," Unpublished Doctor's Dissertation (Columbia: University of Missouri, 1954).

[19] Philip Peak, "Today's High School to College Situation in Mathematics," School Science and Mathematics, 54:471-72, June, 1954.

of those who have courses in high school mathematics. He pointed out that even though students may have credit in mathematics, they lack mastery or competence. He suggested that colleges use placement tests as a more reliable admission technique. Cairns[20] also deplored the deficiencies in mathematics, especially in college freshmen. He suggested, as a partial remedy, that states establish high school standards and adopt the practice of state-wide examinations. He lauded the Regents Examinations of the state of New York. Bush[21] noted the unpopularity of science and mathematics in public education. He suggested more application possibilities to make them more functional and in this way to revive their prestige. He also stressed the need for more mathematics and science in mid-century education within the high schools.

Rasmussen[22] studied the mathematical content of college courses at the University of Kansas and found the mathematics used

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[20] S. S. Cairns, "Elementary and Secondary School Training in Mathematics," Mathematics Teacher, 47:299-302, May, 1954.

[21] Robert N. Bush, "The Waning of Science and Mathematics in Secondary Education," California Journal of Secondary Education, 28:242-43, May, 1953.

[22] Otho M. Rasmussen, "Mathematics Used in Courses of Various Departments in a University," Mathematics Teacher, 48: 237-42, April, 1955.

in the undergraduate classes to be quite elementary. He also learned that a large majority of the students lacked sufficient arithmetical ability to gain maximum value from the courses. His data were obtained by questionnaire and interview techniques, and he cautioned that the responses may have been influenced by preconceived notions with respect to the importance of mathematics.

Russkopf[23] has suggested that three things contribute to the low status of mathematics in the high schools of the United States: (1) the Thorndyke school of psychology, which refused to accept the transfer of the ability to think in the abstract, (2) the philosophy of John Dewey, and (3) the earning power of the working man due to the technological advances in American industry. The last of these, he maintained, has removed much of the incentive for academic effort.

Hirschi expressed the prevalent concern for formal mathematics in secondary education. He commented as follows: ". . . Only the pressure from the universities and colleges seems now to be holding them [algebra and plane geometry] in the high school curriculum."[24]

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[23] Myron F. Russkopf, "Trends in Content of High School Mathematics in the United States," Teachers College Research, 56: 135-38, December, 1954.

[24] L. Edwin Hirschi, "Whither High School Algebra and Geometry?" California Journal of Secondary Education, 28:262-64, May, 1953.

Optimistic Studies in Mathematics

The postwar surge of interest in science and engineering may have had a beneficial effect on the status of mathematics in secondary education. College entrance requirements seem to have had considerable influence on student elections of courses in the public schools. Wiseman[25] of South Dakota State College of Agriculture and Mechanic Arts has made studies of the credits offered in mathematics by those applying for admission in the years 1922-1923, 1932-1933, 1942-1943, and 1952-1953. In the last report, he pointed out that students are presenting more mathematics, as part of the high school units, than in previous studies. The average rose from 1.75 to 1.95 units of mathematics over the ten-year period. He found that only 2 per cent of the students presented units in general mathematics while 95 per cent of the students offered algebra and 75 per cent of the students offered first-year geometry. Many more students are offering advanced algebra, but the number of units of solid geometry is declining. He qualified his findings by the statement that possibly the increase is due to better counseling in the high schools.

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[25] Clinton R. Wiseman, "Continued Study of College-Entrance Credits, of Graduates of South Dakota High Schools," School Review, 62:296-98, May, 1954.

Harrington[26] wrote of the strong science and mathematics program in the Albuquerque, New Mexico, educational program. He predicted: "One out of every three graduates will go to the universities with majors in both science and mathematics." However, he cautioned against the policy of requiring conventional mathematics and science of all students.

Studies More Closely Related

The above studies and literature were cited to develop a concept of the status of mathematics during the time the majority of the respondents received their undergraduate education. The influence of the college admission requirements may account for the fact that they took as much mathematics as they did.

Apparently industrial arts education has been neglected. No reference to the admission requirements for industrial arts teacher preparation was made in any of the studies cited. There seem to have been no studies of the in-college requirements in mathematics nor any of the in-college usage of mathematics. Even in the study

[26] E. R. Harrington, "Science and Mathematics in the Albuquerque High Schools," American School Board Journal, 132:31-33, June, 1956.

by Rasmussen[27] no attempt was made to show the use of mathematics in the field of industrial arts.

The study by Richtmeyer[28] concerned the mathematical usage of teachers in general. Many of his data came from rural teachers. No attempt was made to compare teaching area requirements. Little inference could be drawn concerning the mathematical needs of industrial arts teachers.

Several studies have been made concerning the mathematics curriculum, but they, for the most part, were concerned with mathematics research, mathematics education, and the program for science and engineering students.

The only study similar to the present one was the recent study of the mathematical needs of agriculture students by Layton.[29] The present study closely follows the plan he used. His questionnaire of seventy-three mathematical items has similar divisions. One part deal with general questions; a second section concerned the mathematical college entrance requirements for agricultural

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[27] Rasmussen, op. cit., p. 25.

[28] Richtmeyer, op. cit., p. 22.

[29] W. I. Layton, "College Mathematical Training for Students Specializing in Agriculture," Mathematics Teacher, 50:55-57, January, 1957.

students, while a third division was devoted to the specific college mathematics requirements for agriculture majors and minors. The fourth section of the study contained the recommendations of the agricultural departments concerning desirable specific mathematical requirements. He maintained separate areas in the study for those students on agricultural education and for those on the Smith-Hughes vocational program.

His data came from forty states. He found the admission requirements in mathematics varied from zero to three units of high school mathematics. Thirty-five colleges specified high school algebra, twenty-six required plane geometry, and only one specified general mathematics as a prerequisite.

The specified college mathematics likewise varied. Of those responding, twenty colleges required college algebra for their agricultural students, ten required a course in agricultural mathematics, while eleven indicated no mathematics was required of the agricultural students while in college.

He selected forty-six of the seventy-three items which the agricultural departments considered desirable for their majors. ". . . These forty-six topics, in the main, could be classified as arithmetic and algebra and their specific application to agricultural problems."[30]

The recommendations of the agricultural departments were quite different from the requirements established by the colleges. The departments agreed that agricultural mathematics would be more desirable than college algebra and/or trigonometry.

Summary

Mathematics, as a school subject, has been declining in popularity for a number of years. Students often took only the minimum classes required for their program. Deficiencies were prevalent among those applying for admission to college.

Little research has been done to ascertain the mathematical needs or usage in many of the nonacademic areas. No studies have been made regarding the mathematical needs of industrial arts students or teachers. Only one study similar to the present one has been made. That was in agricultural education.

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[30] Ibid., p. 29.

CHAPTER III

THE QUESTIONNAIRE

This study attempted to determine the mathematics courses that should be part of the program of industrial arts teacher preparation. To accomplish this, the study tried to ascertain the mathematical usage and needs of selected industrial arts teachers. These needs and usages might occur in (1) the admission requirements of the college, in (2) the specified mathematics courses required as part of their program, or in (3) the subject-matter content of the industrial arts classes which were part of their program.

The mathematical needs or usage may also occur in the teaching of industrial arts as (1) verifying the mathematical computations of the students, as (2) the necessity to teach certain mathematical skills in connection with the industrial arts classwork, or in (3) nonpupil-contact situations. Thus mathematics may be encountered in the technical and professional literature; it may be encounted in the development of teaching devices and instructional materials; and in the requisitioning and disbursement of materials and supplies. As part of the teaching usage of mathematics the study sought the opinions of the authors of industrial arts textbooks concerning the mathematical skills the teacher should possess to obtain maximum value from the use of their books as texts or references.

The study further attempted to determine the relative mathematical usage in different subject-matter areas of industrial arts. The areas selected were those of drafting, electricity, metal, and wood.

Need for a Questionnaire

To get these opinions, it was necessary to use a questionnaire which was sent to college professors and the authors of industrial arts textbooks. The use of a questionnaire was required to determine the mathematical skills that experienced industrial arts teachers had used in their teaching.

Need for a Check List

The present eminence of mathematics could conceivably bias any data concerning mathematical needs or usage. An effort was made to minimize this aggrandizement by the inclusion of a check list of possible industrial arts usage of mathematical skills. Thus some information was solicited by direct request and certain elements of the same information were included in the check list.

Construction of the Check List

The construction of the check list involved the following considerations:

1. The purpose of the check list was to verify and substantiate the mathematical needs and usage stated in the responses to the direct inquiries.

2. The range, in terms of mathematical courses, of the check list should be based upon the college entrance and specific mathematics course requirements. These requirements reflect the opinions of the administrators of the colleges concerning desirable mathematical courses, and skills, for college industrial arts students.

3. The possible coverage of the individual mathematics courses is necessarily limited. To cover the entire area of the several courses completely would result in a check list entirely too extensive. Approximately fifty items in the check list were considered the maximum that would bring responses.

4. The items used in the check list should be: (a) representative of major concepts or abilities developed in the mathematics courses; (b) applicable to industrial arts usage whenver possible;

(c) identifiable with specific mathematics courses so that, if the item were checked as used, the course most likely to develop that skill could be identified.

The Selection of Items

The following procedure was employed in the selection of the items of the check list:

1. The catalogs from several colleges were examined to determine the entrance requirements and the specific mathematics courses required for industrial arts students. These requirements varied from that of no mention of mathematics to that of requiring algebra and plane geometry as part of the high school credits. The in-college requirements for mathematics also ranged from none mentioned to specified college algebra, trigonometry, and analytic geometry. When no mention of mathematics was made, the study assumes that the colleges presupposed some arithmetical ability of the applicant. On the basis of the survey, the check list should contain items from the mathematics courses that would be taken in sequential order through analytic geometry. This would include arithmetic, first-year algebra, plane geometry, third-semester or intermediate algebra, solid geometry, college algebra, trigonometry, and analytic geometry.

2. Assistance in the selection of the items was requested from members of the department of mathematics in a teacher-preparation college. Their suggestions were so helpful, additional requests for advice were made in other parts of the study.[1]

3. Standardized arithmetic tests were examined for items in that area. The items that were selected were then rephrased, and examples of application, in the industrial arts area, were provided.[2]

4. Items representing the other mathematics courses were obtained from textbooks used in those courses. Selection was based upon the number of pages devoted to the development of the concept or skill. This procedure helped establish the concept or skill as being an important part of the course.[3]

5. Technical and shop mathematics books were examined for examples of the use of the mathematical skills selected by the above procedure.[4] Examples of all the items were not found, which may indicate two possible conclusions. Either there were no applications or the mathematical skill was too difficult for the assumed reader to comprehend.

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[1] Mathematics Advisory Committee, see Appendix A, p. 160.

[2] Standardized arithmetic tests, see Bibliography A, p. 149.

[3] Mathematics textbooks, see Bibliography A, p. 149.

[4] Technical and shop mathematics books, see Bibliography B, p. 152.

6. A pilot study, involving ten experienced industrial arts teachers, was made. This was done to check on ambiguity, clearness of the terminology, and appropriateness of the examples. Comments and suggestions were solicited and received. The pilot study resulted in the elimination of four items and the rewording of two others.

7. The mathematics faculties of three colleges[5] were asked to judge the course-representation and/or the identification-with-course phase of each item. The purpose of securing this professional opinion was to be able to identify the mathematics course most likely to develop that skill.

The item concerning the ability to extract square root (item no. 15) had been included in the skills acquired in first-year algebra. The college mathematics faculties, especially the supervising teachers, credited that ability to eighth-grade arithmetic. Incomplete returns were received on two items; namely, proving or deriving a formula in plane geometry (item no. 9 with only nineteen associations) and the item involving the focus-directrix properties of conic sections in analytic geometry (item no. 14 with only twenty responses). The lowest agreement of course identification was that of the graphic

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[5]For identification of colleges and data concerning mathematical faculty, see Appendix A, pp. 163-64.

solution of systems of nonlinear equations (item no. 43) in which two-thirds of the respondents concurred that the item represented third-semester algebra. Additional data concerning this part of the study are shown in Table I. The item concerning the use of the slide rule (item no. 4) was included upon the advice of the advisory committee.[6] Instructions for the use of the slide rule were not found in the mathematics course textbooks but were found in most of the books for technical or shop mathematics courses.

The Questionnaire

The above check list comprises pages 2, 3, and 4 of the questionnaires sent to authors and college professors, and with modified checking provisions, to the public-school teachers.

Page 1 of the questionnaire sent to authors, in addition to the explanation of the study, contained the request for the grade level for which the book was written and for the author's opinion of the formal mathematics courses desirable for the student to have completed prior to the use of the book as a text.[7]

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[6] Mathematics Advisory Committee, see Appendix A, p. 159.

[7] Author's questionnaire, see Appendix D, p. 189.

TABLE I

NUMBER AND PERCENTAGE OF PROFESSORS WHO IDENTIFIED ITEMS IN MATHEMATICS COURSES

Item No.	No. of Pro-fessors	Pct. of Total	Item No.	No. of Pro-fessors	Pct. of Total
Arithmetic (9 items)			Elementary Algebra (8 items)		
1	21	100	11	20	95.3
7	17	80.8	18	19	90.5
12	21	100	20	20	95.3
15	15	71.5	26	17	80.8
17	21	100	38	21	100
24	21	100	42	21	100
27	21	100	45	18	85.7
40	21	100	48	21	100
47	21	100			
Plane Geometry (6 items)			Intermediate Algebra (5 items)		
10	20	95.3	2	17	80.8
19	21	100	8	15	71.5
23	19	90.5	13	15	71.5
25	18	85.7	35	18	85.7
29	19	90.5	43	14	66.6
31	20	95.3			

TABLE I (Continued)

Item No.	No. of Pro-fessors	Pct. of Total	Item No.	No. of Pro-fessors	Pct. of Total
Solid Geometry (5 items)			College Algebra (4 items)		
9	16/19	84.2	5	18	85.7
16	18	85.7	22	16	76.3
21	18	80.8	28	18	85.7
33	20	95.3	44	17	80.8
36	19	90.5			
Trigonometry (6 items)			Analytic Geometry (4 items)		
6	21	100	3	17	80.8
32	20	95.3	14	20/20	100
34	21	100	30	18	85.7
37	19	90.5	39	20	95.3
41	19	90.5			
46	20	95.3			

The first page of the questionnaire sent to the college professors also contained an explanation of the study, a request for identification data, and for opinions concerning the mathematics courses desirable for industrial arts students to have taken prior to graduation.[8]

The first page of the questionnaire sent to the industrial arts teachers contained an explanation of the study, the request for identification data, and a listing to determine the mathematics courses the teacher had taken. A reply to the question, "Do you feel you should have taken more, or less, mathematics in college?" was requested.

The check list comprising pages 2, 3, and 4 of the teacher's questionnaire contained scoring provisions to determine the area in which the mathematics was encountered. The scoring further indicated how the mathematics was encountered.[9]

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[8] College professor's questionnaire, see Appendix B, p. 165.

[9] Teacher's questionnaire, see Appendix C, p. 180.

CHAPTER IV

MATHEMATICAL ADMISSION REQUIREMENTS

Variation in Requirements

The variation, previously mentioned, in mathematical admission requirements among the industrial arts teacher-preparation programs is substantiated by Table II. A prospective college student contemplating industrial arts education has ample opportunity to select a college or university that will accept his mathematical background for admission.

In approximately one-third (36.0 per cent) of the colleges or universities responding there were no mathematical requirements, specifically stated, for admission to the industrial arts program. However, many replies, answering "none" to the request, "Please indicate the number of units of high school mathematics required for admission, or that must be taken as deficiencies, before graduation as a major in your department," contained subscripts denoting the student was expected to be able to do the mathematics involved in the classwork. Additional notes implied students would be

TABLE II

DISTRIBUTION OF ADMISSION REQUIREMENTS AND NUMBER IN INDUSTRIAL ARTS FACULTY

No. in Faculty	Admission Requirements[a]									
	A	B	C	D	E	F	G	H	I	J
1	2	1		1						1
2	2	1	1		2	2	3			
3	9	2		2		2	3		1	1
4	5	3		2	2	2	7		1	
5	2	1		1	1		3		3	1
6	6	3		1		1	1		2	1
7	2	1				1	3	1		
8	3				1		1			
9	3	1								
10	1						1			
11	1									1
12	1						1			
13	2						1			
14					1				1	
15	1						1			
16	1						2			1
18	1						1			
20										1
25	2									
33	1									
Total	45	13	1	7	7	9	27	1	8	7
Pct.	36.0	10.4	0.8	5.6	5.6	7.2	21.6	0.8	6.4	5.6

[a] Admission requirements: A = none required; B = general mathematics only; C = general mathematics plus other; D = general mathematics plus algebra; E = general mathematics plus algebra plus geometry; F = algebra only; G = algebra plus geometry; H = algebra plus other; I = any one; J = any two.

counseled to take either remedial or additional mathematical courses in college if their backgrounds in mathematics were limited.

General education mathematics was mentioned several times, and presumably it was required of all students in those colleges. This could compensate for the omission of specific mathematical requirements. Several subscripts requested copies of the results of the study inasmuch as their colleges were studying possible changes in requirements for admission, especially in the area of mathematics.

The second most common mathematical requirement, occurring in twenty-seven of the responses (21.6 per cent) was the combination of algebra and geometry. These two courses have been the traditional requirement for the college-preparatory program in the high school. They are the academic mathematics courses and, along with arithmetic, the introductory courses in the mathematical sequence.

The third most common mathematical requirement was general mathematics. It was the sole requirement in thirteen (10.4 per cent) of the replies. This indicates the acceptance of a relatively new course in mathematics. The recognition of general mathematics by the colleges and the elimination of all mathematics in the requirements (36.0 per cent) permit students to be admitted to nearly one-half of the college industrial arts education programs without having taken either algebra or geometry. One unit of general mathematics would also suffice in eight more colleges which accept one unit in any high school mathematics. Thus students without algebra or geometry could enter 52.8 per cent of the industrial arts education departments cooperating in the study.

The least common of the nine combinations of mathematical classes that were reported as requirements was those of general mathematics or algebra, plus one additional unit of secondary mathematics. However, the degree of rarity was not significant. The five combinations reported least often comprise only 18.4 per cent of the total responses.

The arrangement of Table II does not indicate a pattern or tendency of the requirements. Neither does it portray the occurrence of the different mathematics courses within the requirements. Another table (Table III) was prepared to combine the occurrence of each course and also to summarize the number of courses required for admission.

Occurrence of Secondary Mathematics Courses

In Table III general mathematics is specified alone and in combination with other courses. General mathematics was specified

TABLE III

NUMBER AND PERCENTAGE OF COLLEGES AND THE MATHEMATICAL COURSES REQUIRED FOR ADMISSION

Mathematical Requirements	No. of Colleges	Pct. of Colleges
None	45	36.0
General mathematics	36	28.8
Algebra	51	40.8
Geometry	34	27.2
No courses	45	36.0
One course	25	20.0
Two courses	46	36.8
Three courses	7	5.6
Four courses	2	1.6
Total	125	100.0

with another high school course in mathematics, with algebra, and with algebra and geometry. The total number of colleges specifying general mathematics, alone and in combination, was thirty-six (28.8 per cent of the colleges or universities responding). In a like manner, Table III shows algebra, either alone or in combination with other courses, to be specified by fifty-one or 40.8 per cent of the respondents. Geometry is specified by thirty-four (27.2 per cent) of the colleges. The total of the number of colleges does not represent the correct number of respondents, for many of them require two or more courses. The percentages shown were computed on the basis of the 125 colleges responding.

The high school units of mathematics may represent greater occurrence of algebra and geometry because of the two combinations specifying either general mathematics _and_ an additional course. The additional course might be algebra or geometry in one instance or general mathematics or geometry in the other combination.

Number of Mathematics Courses Specified

The largest percentage of colleges (36.0) do not require secondary mathematics for admission to the industrial arts education program. Almost as many colleges (34.4 per cent) require two courses of secondary mathematics. One-fifth of the colleges responding require only one course of high school mathematics, while 36.8 per cent require any two courses. A small number of colleges (seven) require three or four courses of mathematics for admission to the industrial arts teacher-preparation program. Only two of this group specified the third semester of algebra. Solid geometry was not specifically required although it was mentioned as a possibility for the third or fourth unit. Trigonometry was not specified or mentioned as a high school mathematics course.

Comparison of Department Size and Requirements

The colleges with fewer faculty members in the industrial arts department seemed to specify general mathematics more often, as shown in Table II, than did those with larger departments. Table IV was prepared to examine differences in the mathematical requirements among the large- and small-sized departments. The mean of the faculty members of the industrial arts departments was found to be 6.70.

A comparison was then made of the mathematical requirements of colleges whose industrial arts departments had six or fewer members with those colleges whose industrial arts departments had seven or more members. There were more small-department colleges specifying general mathematics but a comparison of the

TABLE IV

MATHEMATICS COURSES REQUIRED BY COLLEGES WITH LARGE AND SMALL DEPARTMENTS

Courses Required	Departments of Six or Fewer Members		Departments of Seven or More Members	
	No.	Pct.	No.	Pct.
None	23	27.4	22	53.7
General mathematics	24	28.6	12	29.3
Elementary algebra	39	46.5	12	29.3
Plane geometry	23	27.4	11	26.9
No courses	23	27.4	22	53.7
One course	23	27.4	2	4.9
Two courses	31	37.0	15	36.6
Three courses	5	5.9	2	4.9
Four courses	2	2.4		
Total	84	100.1	41	100.1

percentage of small-department colleges specifying general mathematics with the percentage of the large-department college with the same requirement indicates no significant difference. No mathematics was required by a larger percentage of the large-department colleges. Algebra was required by more of the small-department colleges. In the number-of-mathematical-courses area of Table V the small-department colleges require one course of high school mathematics more often (27.4 per cent) than the 4.7 per cent of the large-department colleges. Only the small-department colleges require four years of high school mathematics.

Comparison of Geographic Area and Requirements

The size of the industrial arts departments of the colleges or universities did indicate differences in the mathematical requirements. Would the geographic location of the college show differences in the mathematical requirements? The areas represented by the several accrediting associations were used as a basis for geographic comparison. There were sixty-five responses from colleges or universities within the states served by the North Central Association of Colleges and Secondary Schools, thirty-two in the Southern Association area, eleven in the combined areas of the Middle States and the New England States Association, and seventeen colleges in the

TABLE V

AREA SUMMARY OF MATHEMATICAL ADMISSION REQUIREMENTS

Mathematical Requirements	Area							
	North Central Assn.		Southern Assn.		Middle and New England		North-western	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
None	27	41.5	6	18.8	7	63.6	5	29.4
General mathematics only . . .	8	12.3	6	18.8	3	27.3	1	5.9
General mathematics + one . .	2	3.1	3	9.4	1	9.1	3	17.4
General mathematics + algebra	6	9.2	1	3.1			1	5.9
General mathematics + algebra + geometry.	3	4.6	1	3.1			1	5.9
Algebra only . .	7	10.8						
Algebra + geometry	11	16.9	13	40.6			5	29.4
Miscellaneous . .	1	1.5	2	6.2			1	5.9
Total	65	99.9	32	100.0	11	100.0	17	99.8

area of the Northwestern Association of Secondary and Higher Schools. No attempt was made to determine the accreditation of the respondents nor was any attempt made to determine association policy or its effect upon the mathematical requirements of the colleges in the areas served by the associations.

The replies from the area of the Middle and New England States associations show nearly two-thirds (63.6 per cent) of the colleges responding require no mathematics for admission to the industrial arts education program. The second largest ratio (41.5 per cent) requiring no mathematics for admission was from the North Central Association area. The smallest percentage (18.7) of colleges requiring no mathematics was from the Southern Association area.

The colleges of the Southern Association area did require the largest percentage (40.6) of the algebra and geometry combination for admission. The area ranking second in this requirement was that of the Northwestern Association.

The area of the North Central Association was the only one to specify one unit of algebra only for admission.

The miscellaneous grouping contained two colleges requiring three units of high school mathematics and two colleges requiring four units of mathematics for admission. The two colleges requiring three units of mathematics were in the Southern Association area, while the colleges requiring four units were divided in the areas of the North Central and the Northwestern associations.

Students Affected by Requirements

The study did not determine the number of students involved in the mathematical admission requirements of the colleges. However, the number of faculty members in the industrial arts departments indicate, to some extent, the student enrollment in the departments. There were a total of 808 faculty members in the departments responding; 316 in the smaller departments and 492 in the larger departments. The percentages shown in Table VI are computed on these totals. The largest percentage of indicated college students (42.5) could be admitted with no mathematical requirements specified by the colleges. An even larger percentage (50.8) could be admitted if they enrolled in the colleges or universities with the larger departments.

The second highest percentage of the indicated college students (22.1) would have to present credits in both algebra and geometry. If these students enrolled in colleges with larger industrial arts departments, they would have to present credits in both algebra and geometry in approximately one-fourth (24.8 per cent) of the colleges.

TABLE VI

STUDENTS ENCOUNTERING REQUIREMENTS BASED UPON THE NUMBER OF FACULTY MEMBERS IN THE DEPARTMENT

Mathematics Required	Total Faculty Membership		Six or Fewer in Department		Seven or More in Department	
	No.	Pct.	No.	Pct.	No.	Pct.
None	346	42.5	96	30.4	250	50.8
General mathematics only	95	11.6	72	22.8	23	4.7
General mathematics + one	68	8.3	21	6.7	47	9.6
General mathematics + algebra	36	4.4	29	9.2	7	1.4
General mathematics + algebra + geometry	33	4.0	11	3.5	22	4.5
Algebra only	30	3.7	23	7.3	7	1.4
Algebra + geometry	180	22.1	58	18.4	122	24.8
Miscellaneous	20	2.5	6	1.9	14	2.8
Total	808	99.1	316	100.2	492	100.0

Summary

The mathematical admission requirements do vary. Apparently the state, the size, or the geographic area do not produce uniformity in requirements.

Slightly more than one-third of the colleges responding do not require high school mathematics as part of their entrance stipulations. The combination of algebra and geometry is required by more than one-fifth of the responding colleges that specify mathematics as entrance requirements.

A larger over-all percentage of the colleges that replied require two courses in secondary mathematics for admission to the industrial arts education program. However, practically the same percentage of colleges stated that no mathematics course was required. Algebra is mentioned most often, while geometry and general mathematics are nearly tied for second place.

The larger percentage of colleges responding from the northeastern part of the United States did not require high school mathematics. The smallest percentage requiring no mathematics was from the southern states.

The converse of the above was indicated. A larger percentage of the colleges replying from the southern states required algebra and geometry. None of the colleges responding from the northeastern part of the United States required algebra and/or geometry.

Slightly over one-half of the industrial arts education requirements do not mention algebra or geometry.

Prevalent concepts of the relative difficulty of the secondary mathematics courses would place the entrance requirements of the Southern Association area colleges as the most difficult and those of the northeastern colleges the easier.

Of the 125 colleges surveyed, 84 had industrial arts departments with six or fewer faculty members. However, on the basis of a relatively constant ratio between students and faculty members, there are more students enrolled in industrial arts departments having seven or more faculty members. Over half of the students in the large-department colleges could be admitted without high school mathematics. Nearly one-fourth of the students in the smaller departments could be admitted with one unit of general mathematics. In either department well over half of the students could be admitted without algebra and/or geometry. Applicants who have credit in algebra and geometry would be admissible, to the extent that mathematics is concerned, in 92.6 per cent of the colleges involved in the study.

The extreme variation in mathematical admission requirements promotes the conclusion: There is no apparent rationality to the requirements. They may be the result of committee compulsion-to-report, of administrative ideology, or of tradition. They reflect the lack of, and the need for, scientific study.

CHAPTER V

MATHEMATICS COURSES REQUIRED IN COLLEGE

The arrangement of these data is similar to that in Chapter IV to permit easier comparisons between the mathematical admission requirements and those required while in college.

Variations in College Requirements

The mathematical offerings of the colleges are more extensive than those found in most secondary schools. This may account for the even wider variation in the in-college requiremen s for industrial arts majors.

There are so many different requirements that it is necessary to combine some courses for tabulation purposes. One of these combinations was that of general education mathematics and general mathematics. Of the colleges responding, five stated they required general education mathematics and ten indicated they required general mathematics. These two courses were combined under the heading "general mathematics" in Table VII.

TABLE VII

DISTRIBUTION OF COLLEGE MATHEMATICS COURSES AND NUMBER IN INDUSTRIAL ARTS FACULTY

No. in Faculty	None Re-quired	Gen. Math. Only	College Alge-bra Only	Alge-bra + Trig.	Shop Math. Only	Any College Math.	Mis-cella-neous
1	2	1	1				1
2	2	1	1	3		1	3
3	7	3	1	7			2
4	7	2	3	7	1		2
5	2			3	2	2	3
6	2	4	3	3	3		
7	2	1		2	1		2
8	1			3			1
9	2	2					
10	1	1					
11	1			1			
12					2		
13	1		1				1
14				1			1
15	1			1			
16	2			2			
18				1		1	
20	1						
25	1			1			
33							1
Total	35	15	10	35	9	4	17
Pct.	28.0	12.0	8.0	28.0	7.2	3.2	13.6

The "miscellaneous" column contains the replies from seventeen colleges having a total of ten different requirements. In no instance did more than three colleges require the same mathematics courses in this division. Most of the ten different requirements were specified by only one college. The small-department colleges seem to predominate in the miscellaneous requirements; fourteen of these requirements came from colleges with seven or fewer faculty members in the industrial arts departments.

Size of Department and Requirements

The in-college mathematical requirements were arranged according to the number of faculty in the industrial arts departments to permit examination of any relationship between the size of the department and the mathematics required in the college. There is no apparent relationship between the size of the industrial arts department and the mathematical requirements for their students.

The two most popular requirements were (1) no mathematics required, and (2) college algebra and trigonometry. In each case thirty-five or 28 per cent of the colleges require either no mathematics courses or the combination of college algebra and trigonometry. General mathematics only (12.0 per cent) was the third most prevalent requirement. Also in the one course of mathematics section, college algebra (8.0 per cent) slightly outranked shop mathematics (7.2 per cent). Only four colleges (3.2 per cent of the total) specified any mathematics course would suffice. Conclusions concerning this requirement are impossible unless one knows the offerings of the mathematics department in the colleges specifying this requisite. Two colleges required the three courses: college algebra, trigonometry, and analytic geometry. These are placed in the "miscellaneous" column.

The arrangement of Table VII does not portray a pattern or tendency in the in-college mathematical requirements. Another table (Table VIII, arranged similar to Table III) was prepared to show the occurrence of each course in the requirements and also to summarize the number of college mathematics courses required.

Occurrence of College Mathematics Courses

College algebra was mentioned, either alone or in several combinations, in 43.5 per cent of the responses. Trigonometry, mostly in combination with college algebra, was the second most common requirement. It was specified in 34.4 per cent of the replies. General mathematics (16.8 per cent) was the third most common course requirement. Shop mathematics was fourth in rank with 12 per cent. Over one-fourth of the colleges (28.0 per cent)

TABLE VIII

NUMBER AND PERCENTAGE OF COLLEGES AND THE MATHEMATICS COURSES REQUIRED IN COLLEGE

Mathematical Requirements	No. of Colleges	Pct. of Colleges
None	35	28.0
General mathematics	21	16.8
Shop mathematics	15	12.0
College algebra	54	43.5
Trigonometry	43	34.4
Analytic geometry	2	1.6
Miscellaneous	9	7.2
No course	35	28.0
One course	39	31.2
Two courses	45	36.0
Three courses	3	2.4
Four courses	3	2.4
Total	125	100.0

do not require the industrial arts students to complete any mathematics courses. Industrial arts students could avoid contact with the academic mathematics courses in over one-half (56.5 per cent) of the colleges cooperating in the study. The miscellaneous grouping consisted of surveying and/or another course in mathematics.

Number of Mathematics Courses Required

The most common mathematical requirement (36.0 per cent) was two courses in college mathematics. In most instances this was college algebra and trigonometry. A slightly smaller percentage (31.2) of the responding colleges require only one course of college mathematics. This group includes those colleges that specify general mathematics only, shop mathematics only, algebra only, trigonometry only, and those indicating one course in any college mathematics. Only a small percentage of colleges require three or four courses of college mathematics.

Department Size and Requirements

Table IX is essentially a breakdown of Table VIII to examine the requirements of the large- and small-department colleges. There was less variation in the in-college requirements of the large- and

TABLE IX

COLLEGE MATHEMATICS COURSES REQUIRED BY COLLEGES WITH LARGE AND SMALL INDUSTRIAL ARTS DEPARTMENTS

Courses Required	Departments of Six or Fewer Members		Departments of Seven or More Members	
	No.	Pct.	No.	Pct.
None	22	26.2	13	31.8
General mathematics	14	16.7	7	17.1
Shop mathematics	9	11.4	6	14.6
College algebra	33	39.4	21	51.3
Trigonometry	27	32.2	16	39.0
Analytic geometry			2	4.0
Miscellaneous	6	7.1	3	7.3
No course	22	26.2	13	31.8
One course	27	32.1	12	29.2
Two courses	31	36.9	14	34.2
Three courses	2	2.4	1	2.4
Four courses	2	2.4	1	2.4
Total	84	100.0	41	100.0

small-industrial-arts-department colleges than there was in the admission requirements of the same colleges.

There is less difference in the percentage requiring no mathematics courses (31.8 and 26.2 per cent as compared to 53.7 and 27.4 per cent in Table IV). There is a small difference in the percentage of large departments and small departments requiring college algebra. Otherwise, the large and small groups are quite similar in their requirements. The same consistency exists between the large- and small-department colleges in the number of college mathematics courses required. There are fewer than six percentage points difference between the large- and small-department colleges in any of the number-of-course combinations. The size of the industrial arts departments does not seem to affect the in-college mathematical requirements in the study.

Geographic Area and Mathematics in College

In Table V there were differences in the admission requirements of the colleges representing different geographic areas.

The colleges of the North Central Association are apparently the more lenient in college mathematics requirements, while those of the Southern Association are the more demanding or more academic in their requirements. Over one-third (35.3 per cent) of the colleges of the Northwestern Association area require no mathematics and a like number require both college algebra and trigonometry. This extremity in requisites is evident in the over-all college requirements. It may be that some colleges adhere to the traditional requirements while others, for want of a satisfactory alternative, have abandoned all mathematical requirements.

The data in Table X are from the same colleges and are grouped in the same geographic areas as the admission requirements shown in Table V. This permits easier comparisons of the admission and the in-college requirements. The percentages of no mathematics for admission and none while in college are relatively consistent for all areas except for the northeastern colleges. No secondary mathematics was necessary for admission to 63.5 per cent of the colleges from that area while all of them require some mathematics of the industrial arts education student. General mathematics is not quite as popular for in-college as for admission requirements in the areas of the North Central, the Middle States, and the New England associations. It remains about the same in the Southern Association area, and is more popular in the colleges of the area of the Northwestern Association. The requirement of algebra only is more prevalent as an in-college requirement than as a requirement for admission. The academic pairings of elementary algebra

TABLE X

AREA SUMMARY OF THE MATHEMATICS COURSES REQUIRED IN COLLEGE

Mathematical Requirements	Area: North Central Assn. No.	Pct.	Southern Assn. No.	Pct.	Middle and New England No.	Pct.	North-western No.	Pct.
None	26	40.0	3	9.4			6	35.3
General mathematics only . . .	3	4.6	6	18.8	2	18.2	4	23.5
College algebra only	5	7.7	3	9.4	2	18.2		
Algebra + trigonometry . .	16	24.6	11	34.2	2	18.2	6	35.3
Shop mathematics only . . .	7	10.7	1	3.1	1	9.1		
Any college mathematics . . .			1	3.1	2	18.2	1	5.9
Miscellaneous . .	8	12.8	7	21.9	2	18.2		
Total	65	99.9	32	99.9	11	100.1	17	100.0

and plane geometry and of college algebra and trigonometry are the most common requisites, especially in the Southern and Northwestern association areas.

Students Encountering the In-College Requirements

In Table XI an effort was again made to indicate the probable number of students that might be affected by the in-college mathematical requirements based upon the number of faculty members in the industrial arts departments of the colleges. The colleges cooperating in the study have 808 faculty members in the industrial arts departments; 316 are in departments with six or fewer members, and 492 are in departments of seven or more faculty members. If the professor-student ratios are relatively constant in the large and small departments, the percentages of faculty in each division would indicate the relative number of students that might encounter the different mathematical requirements.

About one-third of the students in the larger-department colleges would not be required to take mathematics while in college. About one-fourth, likewise, would be exempt in the smaller-department colleges.

Approximately the same percentage of students would have to complete both college algebra and trigonometry. In this case

TABLE XI

STUDENTS ENCOUNTERING IN-COLLEGE REQUIREMENTS AND THE NUMBER OF FACULTY MEMBERS IN THE DEPARTMENT

Mathematics Required	Total Faculty Membership		Six or Fewer in Department		Seven or More in Department	
	No.	Pct.	No.	Pct.	No.	Pct.
None	239	29.4	77	24.4	162	33.0
General mathematics only	74	9.2	48	15.2	26	5.3
Algebra only	49	6.1	36	11.4	13	2.6
Algebra + trigonometry	232	28.4	89	28.2	143	29.0
Shop mathematics .	63	7.9	32	10.2	31	6.3
Any college mathematics	30	3.9	12	3.8	18	3.6
Miscellaneous	121	14.9	22	7.0	99	20.3
Total	808	99.8	316	100.2	492	100.0

it would make no difference if they were in the large- or small-department colleges.

There is less variation in the number of students affected by the in-college requirements in the large and small departments as indicated in Table XI than in the entrance requisites shown in Table VI.

The number of colleges shown in a table of the in-college requirements and the same number of colleges shown in a table of admission requirements might not be the same colleges. To illustrate: In Table VIII, thirty-five colleges do not require mathematics of the college student. In Table III, forty-five of the colleges do not require secondary mathematics of the applicant. These numbers may not, and probably do not, represent the same colleges.

Mathematics Background of Industrial Arts Graduates

There were so many possible combinations of mathematics courses that could make up the entrance requirements and the in-college requirements that some form of synthesis was necessary. By grouping the secondary and college mathematics courses into academic and nonacademic divisions it was possible to show, in Table XII, the combinations of secondary and college mathematics

TABLE XII

COMBINATIONS OF MATHEMATICS COURSES FULFILLING REQUIREMENTS FOR INDUSTRIAL ARTS EDUCATION

Sec. Req. (a)		College Requirements (A-N)[b]										
A	N	0-0	1-0	0-1	1-1	2-0	0-2	3-0	2-1	1-2	2-2	To-tal
0	0	19	2	9	1	9	4	1				45
1	0	3	2	1			1					7
0	1	4	3	4	1	2	3		1			18
1	1			2		5					1	8
2	0	4	1	3	3	15	1		1		1	29
0	2	4		1		1	3					9
3	0					1						1
2	1					2		3				5
0	3							1				1
2	2	1				1						2
Total		35	8	20	5	36	12	5	2		2	125

[a] Secondary requirements: A = academic mathematics courses required for admission; N = nonacademic mathematics courses required for admission.

[b] College requirements: digit preceding hyphen indicates academic mathematics courses required for admission; digit following hyphen indicates nonacademic mathematics courses required for admission.

courses that would fulfill both admission and in-college requirements of the colleges participating in the study.

Number of Combinations

Even with the above grouping there are forty-one different combinations of secondary and college mathematics courses that could fulfill the requirements for admission to, and graduation from, the industrial arts education programs. There are practically one-third as many required combinations of mathematics courses as there are industrial arts teacher-preparation colleges or universities. This variation of requirements indicates there is little agreement as to what should constitute the mathematical background of the industrial arts teacher.

Academic or Nonacademic Agreement

The college mathematical requirements for admission and for graduation of industrial arts education students are consistent in some instances. Nineteen colleges will admit and graduate industrial arts teachers who are not required to have any mathematical training after leaving the eighth grade. This condition may be alleviated by the requirements of the secondary school for graduation, by the efforts of the counselors in high school and college, and by the efforts of the professors in the industrial arts classes in college.

Other policies, consistent with the academic-nonacademic grouping, are those of requiring two years of academic mathematics in high school and two courses of academic mathematics in college. This was found to be the policy in fifteen of the colleges. In most instances the admission requirements were algebra and plane geometry and the in-college requirements were college algebra and trigonometry. Two colleges admit students with one academic unit of mathematics and require one course of academic mathematics while in college; four colleges have the same requirements in the nonacademic area. Three colleges admit students with two units of nonacademic mathematics and require two courses of nonacademic mathematics of the industrial arts education student.

Inconsistency in Requirements

Many colleges are inconsistent in their admission and in-college mathematical requirements. A good example of this lack of consistency is found in the first column of Table XII in which sixteen colleges require secondary mathematics for admission but do not require any course in college mathematics for the industrial arts education student. Three colleges require algebra and plane geometry for admission but require only one nonacademic mathematics course in college.

In a like manner twenty-six colleges do not require any mathematics for admission but do require varying numbers of courses while in college. Nine colleges which do not specify mathematics for entrance credit require the industrial arts major to take both college algebra and trigonometry. One college with no admission requirements in mathematics asks the student to take college algebra, trigonometry, and analytic geometry. In two colleges, students are admitted with one unit of nonacademic mathematics but must take the two academic courses while in college. Five colleges permit students to enroll with algebra and one other secondary mathematics course but they must take the two academic courses while in college.

Irrationality of the Requirements

There are forty-one synthesized combinations of mathematical requirements which serve as the minimum requirements for the completion of the industrial arts education program. Only two combinations are required by more than ten colleges. The remainder of the combinations are distributed over ninety-one cooperating colleges or universities. There are seventeen combinations of entrance and attending requirements that are unique to a single college.

Comments Concerning the Requirements

Several chairmen of the industrial arts departments were sufficiently perturbed by the mathematical requirements of their colleges to offer comments concerning their requirements. Only two such chairmen implied satisfaction with the requirements:

> I believe this [college algebra and trigonometry] is entirely sufficient.
>
> Considering the trend to General Shop, a good working knowledge of math. is all that one needs for instructional purposes.

These comments were made deploring the high school mathematics course required for admission:

> A high school diploma (makes no difference how they get it???).
>
> Policy of the school, not my own idea.
>
> None actually to admit, I do not endorse this policy.
>
> I think it [mathematics] should be a must.

The following comments came from the colleges which do not require mathematics courses of the industrial arts education students:

> Changing to algebra and trig. this fall.
>
> Recommend math. minor for students whose specialization is in mechanics or electricity.
>
> The Curriculum Committee is now working on a plan for certain mathematics requirements.

None actually required as such in I. A., I do not endorse this policy.

Should have math. through trig.--.

We expect to require three semester hours of basic math. next year.

These comments are from chairmen in colleges which have nonacademic mathematical requirements for the industrial arts education students (the nonacademic courses are other than college algebra, trigonometry, or analytic geometry):

We are now in process of revising curriculum and more math. and physics will be required for teaching graduates.

We are studying the need for requiring more mathematics.

Inadequate! We plan to add a technical math. sequence which will cover basic algebra, trig., and geometry.

Not, in my opinion, a satisfactory solution.

The same thought is implied by other chairmen in colleges requiring college algebra and trigonometry as part of the industrial arts education curriculum (the majority of these comments came from the area of the Southern Association):

I do not believe this is enough math.

More emphasis should be placed on functional math.

New program starting in fall (Analytical Geometry will be added to the requirements).

> Would like to add Analytic Geometry (2 sem. hrs.) and Calculus (2 sem. hrs.) to our curriculum but we can only do it by deleting something else which appears essential.

> Should have a course in Analytic Geometry (3 sem. hrs.).

> We are now in the process of changing our curriculum to include 15 quarter credits, at least, of mathematics.

The remainder of the comments received from the chairmen of the industrial arts departments are from colleges with heterogeneous mathematical requirements:

> Like for them to have physics.

> Require 16 sem. hours of science or math: 8 must be in physics.

This comment came from a college requiring only one unit of general mathematics for admission but requiring college algebra of the industrial arts education student:

> One of our problems is to get applicants with an adequate math. background when they graduate from high school.

The above comments indicate the chairmen of the industrial arts departments consider mathematics to be an important part of industrial arts education. The fact that twenty-five (20 per cent) of the replies contained comments denotes profound interest in the mathematical requirements, or lack thereof, for industrial arts education students. Only two chairmen seemed satisfied with the requirements of their college while twenty-one implied more mathematics should be required for the industrial arts education program.

Summary

The in-college mathematical requirements for industrial arts education majors are even more diversified than the entrance requirements. The larger mathematical offerings of the colleges may contribute to this extended variation.

There is likewise no pattern of mathematical requirements for the industrial arts education student. An applicant could easily locate a college that would permit him to exercise his likes or dislikes for mathematics.

There is comparatively little relationship between the size of the industrial arts department or the geographic location of the college and the in-college mathematical requirements for industrial arts education students. The only differences that appear significant are that: the larger-department colleges tend to require college algebra; the northeastern colleges in the study all require some college mathematics; and the southern colleges require the most, and especially the academic, courses in mathematics while the student is in college.

Both the secondary and the college mathematics courses contribute to the mathematical skills of the industrial arts teacher. There is even less congruity to the requirements when both are considered together. Even when the mathematics courses are grouped into those that are academic or those that are nonacademic, the two college requirements produce a total of forty-one combinations of mathematics that would permit a student to enter and graduate from the industrial arts teacher-preparation programs.

Many colleges still adhere to the traditional academic mathematics requirements for admission and for graduation as an industrial arts major.

Many colleges apparently had considered the traditional mathematics admission program to be unsatisfactory and had revised their entrance policies to conform to the lowered status of mathematics. Other colleges, apparently for lack of scientific data concerning the mathematical needs of industrial arts teachers, abandoned all mathematical requirements. The number of changes that are presently being made in the mathematical requirements, as indicated in the comments, imply these revisions are considered unsatisfactory.

The heterogeneity of the requirements and the revisions of policy indicate a need for a scientific study of the needs and usage of the industrial arts teacher.

CHAPTER VI

MATHEMATICS RECOMMENDED AND USED BY INDUSTRIAL ARTS PROFESSORS

The fact that the majority of colleges require some mathematical background of all entering students and many colleges have specific requirements for industrial arts education applicants implies acceptance of the idea that mathematics is needed for college classwork. The practice of requiring supplementary courses in mathematics while in attendance, usually early in the program, substantiates this thought.

However, the diversity of the requirements signifies complete lack of agreement on what should be the mathematical background of the industrial arts education graduate.

In the controversy of what the situation is and what it should be, these data more nearly describe what should become the mathematical skills and abilities of the industrial arts teachers. This chapter contains the opinions of the experts of what should be the mathematical background.

Securing the Data

The four areas--drafting, electricity, metalwork, and woodwork--are considered the more common and the more basic of the subject-matter areas of industrial arts. The opinions of college professors in these areas are used in the data. Each area is considered separately to determine variations in the mathematical requirements within the areas.

Authorities in industrial arts. There is no up-to-date listing of mailing addresses of college professors and their subject-matter areas. Even if there had been such a list, some selection of representatives would have been advisable. The cooperation and assistance of the chairmen of the industrial arts departments were used in the selection and location of the college professors.

The chairmen of the industrial arts education departments were requested to select the best qualified men of their faculty in each of the four areas. The chairmen were further requested to solicit the cooperation of those selected. This method of selection and contact proved very satisfactory.[1] In many instances the

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[1]For personal data of respondents, see Table XVIII, Appendix B, p. 178.

professors responded even when the chairmen did not. However, direct follow-up procedures were not possible. Recontact was attempted through the chairmen of the departments.[2]

Because of the rapid growth of the industrial arts departments with the additions to the staff, even the most recent directories[3] are out of date in the staff-listing and area-offering of the colleges or universities. For this reason questionnaires for four professors were sent to the chairmen of each department of industrial arts education in those colleges or universities with teacher-preparation in this field. Some questionnaires were returned incompleted with notations to the effect there were fewer than four members in the department or that the college did not offer work in that area. This was particularly true in electricity. There were probably similar situations in which the questionnaires were not returned.

The questionnaire. The opinions of the college professors thus selected were solicited by direct question. They were asked to indicate the mathematics courses they considered desirable for

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[2] See follow-up, Appendix B, p. 165.

[3] *Supra*, p. 8.

the industrial arts education student to take either in secondary school or in college.

Mathematics Courses Considered Desirable

The opinions of the college professors are summarized in Table XIII. The percentages shown in this table are based upon the number of professors who expressed their opinions concerning the mathematics courses they considered desirable. Replies were received from 106 professors in the metal area but one failed to express his beliefs. The percentages shown were computed on the 105 replies. In a like manner three professors in the area of wood (104 replied) failed to complete this part of the questionnaire. The woodwork percentages were computed on the 101 opinions that were expressed.

There was unanimous agreement on the desirability of arithmetic for industrial arts education students.

Only eleven of the professors (368) who responded to this section of the study did not feel that the first course in algebra was desirable. Four of the eleven were professors in the area of wood.

Plane geometry appears to be least important in the area of electricity. Only fifty-one (82.3 per cent) of the professors in that

TABLE XIII

MATHEMATICS COURSES PROFESSORS LISTED AS DESIRABLE FOR INDUSTRIAL ARTS TEACHERS

Mathematics Courses	Drafting		Electricity		Metalwork		Woodwork		Pct. Total
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	
Arithmetic . . .	100	100	63	100	105	100	101	100	100
Elementary algebra	98	98.0	61	95.5	102	97.3	97	96.0	97.1
Plane geometry	97	97.0	51	82.3	94	89.5	95	94.1	91.4
Intermediate algebra	44	44.0	23	37.2	35	33.3	35	34.6	37.2
Solid geometry	53	53.0	26	42.0	55	52.4	46	45.6	48.8
College algebra	60	60.0	34	55.0	62	58.1	49	48.5	55.6
Trigonometry	69	69.0	44	71.0	74	70.5	62	61.4	67.5
Analytic geometry	20	20.0	9	14.5	19	18.2	15	14.8	17.1
Calculus	5	5.0	3	4.8	5	4.8	7	6.9	5.4
Shop mathematics . .	2	2.0	3	4.8	9	8.6	4	4.0	4.9

area considered plane geometry to be desirable. Professors of drafting consider it desirable in 97 per cent of the replies.

Third-semester or intermediate algebra was the first of the sequence to receive the approval of less than one-half of the respondents. Only 37.3 per cent of the professors gave it their approval. There was relatively close agreement, varying only from 33 to 44 per cent.

Solid geometry was considered desirable by about one-half (180 of the 368, or 48.9 per cent) of the respondents. Slightly over one-half of the professors in drafting and metalwork gave it approval while those of electricity and woodwork gave less than 50 per cent approval. In all areas it was approved by more professors than was third-semester or intermediate algebra.

College algebra was considered much more desirable than third-semester algebra. Well over one-half of the professors (205 or 55.7 per cent) considered college algebra desirable for industrial arts education students.

Two factors may contribute to this popularity of college algebra. The word "college" probably denoted greater academic status to the professors. A second and probably more important factor may have been the misconception of the content of the two courses. An examination of the entrance and the in-college mathematical requirements of algebraic courses illustrates this lack of distinction between the two courses. Many colleges teach algebra, often actually intermediate algebra, which may be confused with an entirely different course, college algebra. To add to the confusion, the "college algebra" that many of the professors took as undergraduates is more similar to the intermediate algebra in the present mathematics curriculum. The authors and publishers of new algebraic textbooks make a clear distinction between the courses in the titles of their books. The Mathematics Advisory Committee[4] considered third-semester or intermediate algebra--with good grades--to be adequate preparation for trigonometry.

Trigonometry ranked fourth in the desirability of mathematics courses for industrial arts teachers. It followed plane geometry in the percentage of approval and was checked as desirable by over two-thirds (67.7 per cent) of the respondents. There was relatively close agreement among professors of the different areas. The professors of electricity gave it the highest percentage, the woodwork professors the lowest, but there was a range of only ten percentage points.

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[4] Mathematics Advisory Committee, see Appendix A, p. 159.

Analytic geometry received less than one-fifth (17.2 per cent) of the desirable rating from all the respondents. It was considered least desirable by the professors of electricity and woodwork.

Calculus was considered desirable by only a small percentage (5.4 per cent) of the respondents.

Shop mathematics received the lowest acceptance (4.9 per cent of the total responses) of any of the mathematics courses listed in the questionnaire. Its highest rating was in metalwork; its lowest, in the areas of drafting and woodwork, and the same as calculus in industrial arts electricity.

Mathematical Usage

The instrument used for the collection of the opinions of college professors concerning the mathematics courses contained direct questions of the desirability of several specific mathematics courses.

However, in the interval between the conception of the study and the mailing of the questionnaires, mathematics increased in popularity. This change in status may be the result of the impetus of science due to the international competition in space travel. This comparatively sudden surge in mathematical popularity tends to cause exaggeration of the mathematical needs. To counterbalance this tendency a check list of mathematical usage was prepared and included in the questionnaire. The check list contained examples of mathematical concepts and skills, applicable to industrial arts classes whenever possible, from the eight mathematics courses in the academic sequence from arithmetic through analytic geometry. It also contained a statement relative to the desirability of using a slide rule in industrial arts classes. The inclusion of the check list was based upon the premise that, if a skill in mathematics were stated to be needed, it would be shown as being used; and conversely, a mathematical skill said to be used would need to be learned or acquired.

The items from the eight mathematics courses were dispersed throughout the check list. This helped to make the source of the skill, and the mathematics course in which the skill could be acquired, less apparent. The purpose of the check list was thus camouflaged. This disarrangement and the apparent lack of relationship to the questionnaire may have been responsible for the omission of some data in the returns of the professors.

The questionnaire requested the number of units of secondary mathematics and the semester or term (quarter) hours of college credit in the courses they considered desirable for the mathematical background of industrial arts education graduates. So many professors failed to give either the number of hours or to specify if the hours were semester or term, the hour provision in the data was abandoned. The data are based upon the mathematical courses instead of the number of hours in the course.

Mathematical usage in college classwork. The question, ''Will you also check the examples . . . , if that type of problem presents itself in your college class work?'' brought the responses shown in Table XIV. The above examples were from mathematics courses that were required, either for admission or in-college, of industrial arts education students. The examples comprise pages 2, 3, and 4 of the questionnaire.

There were also omissions in this part of the study. Four drafting professors and one woodwork professor failed to do the check list. The percentages were computed on the responses of 96 for drafting, 63 for electricity, 106 for metalwork, and 103 for woodwork. The mathematical areas were again presented in their sequential order.

There was no apparent reason why one professor of electricity failed to show usage of arithmetic. Except for this omission, arithmetic was unanimously used in the four areas of industrial arts.

The first course of algebra was used considerably less than arithmetic. More than one-fifth of the professors in the areas of

TABLE XIV

MATHEMATICS SHOWN USED IN COLLEGE INDUSTRIAL ARTS CLASSES

Mathematics Courses	Drafting		Electricity		Metalwork		Woodwork		Pct. Total
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	
Arithmetic . . .	96	100	62	97.5	106	100	103	100	99.8
Elementary algebra	75	78.2	58	92.1	89	84.0	73	70.9	81.3
Plane geometry	95	99.1	53	84.1	104	98.2	100	97.1	97.0
Intermediate algebra	41	42.7	53	84.1	63	59.5	31	30.3	51.8
Solid geometry	90	93.8	41	65.2	94	88.7	88	85.5	86.4
College algebra	18	28.7	25	39.7	19	17.9	12	11.6	20.4
Trigonometry	77	80.3	51	81.0	89	84.0	69	67.0	78.8
Analytic geometry	46	48.0	18	28.6	22	20.8	13	12.6	27.3
Slide rule	37	38.6	36	57.2	40	37.7	26	25.2	38.4

drafting and woodwork did not show usage of algebra. It was rated highest in electricity. However, it was used in over 80 per cent of the college industrial arts classes.

Plane geometry was used more than algebra in all areas except that of electricity. It was used by all but one drafting professor, two professors of metalwork, three of woodwork, and nine professors of electricity. It was used in 95.8 per cent of the classes, approximately 15 per cent more than algebra.

Third-semester or intermediate algebra usage took a serious drop in rating. Its total was only 51.2 per cent. In only two areas of industrial arts was it used by more than one-half of the classes. More than eight-tenths of the classes in electricity used this course while only about three-tenths of the classes in woodwork used intermediate algebra.

Solid geometry, considering all the courses, ranked third in usage in college industrial arts classes. It was used in 85.2 per cent of the classes. It was used most in drafting, least in electricity, and approximately the same in metalwork and woodwork.

The usage of college algebra was low. Only 20.7 per cent of the classes used any of the four examples in the check list. It was used in about two-fifths of the classes in electricity but in only about one-tenth of the classes in woodwork.

Trigonometry ranks fifth in usage in the college industrial arts classes. It was well ahead of the two advanced courses in algebra and only slightly below the elementary course in algebra. Arithmetic, the two courses in geometry, and elementary algebra are the only mathematics courses used more in college industrial arts classes.

Analytic geometry closely approaches college algebra for the low rating of the mathematics courses considered in the study. It was used in 26.9 per cent of the classes, only 6 per cent more than college algebra.

Approximately two-fifths of the college professors stated the ability to use the slide rule was desirable. It was most desirable in the classes in electricity and least desirable in the classes in the wood area.

Comparison of Needs and Usage

The need for and the usage of arithmetic (Tables XIII and XIV) were acknowledged by all but one professor.

A few professors considered calculus and shop mathematics desirable for industrial arts teachers (Table XIII). These two mathematics courses were not represented in the check list. Calculus was omitted from the check list, for the preliminary survey did not reveal its requirement by the student while in college. Shop mathematics was omitted because it is not as standardized or structured as the rest of the mathematics courses. However, there were seven mathematics courses--elementary algebra, plane geometry, third-semester or intermediate algebra, solid geometry, college algebra, trigonometry, and analytic geometry--that were common to both the stated needs and the check list. Opinions were expressed concerning the desirability of those courses for industrial arts teachers. The class usage of mathematics in industrial arts by professors of drafting, electricity, metalwork, and woodwork was indicated.

Table XV was arranged to permit comparisons between the percentage of professors who stated the course was desirable and the percentage of professors who stated that the examples taken from the course were used in their classwork.

Drafting needs and usage. The data of Table XV are presented in percentage form in as much as there were one hundred professors who responded to the questions relating to the desirability or needs (Table XIII) of the mathematical courses, while only ninety-six responded to the items pertaining to the usage of the mathematical skills in their classes (Table XIV).

TABLE XV

COMPARISON OF STATED NEEDS AND USAGE OF MATHEMATICS IN COLLEGE INDUSTRIAL ARTS

Mathematics Courses	Needs		Usage	
	Pct.	Rank	Pct.	Rank
Drafting				
Elementary algebra	98.0	1	78.2	4
Plane geometry	97.0	2	99.1	1
Intermediate algebra	44.0	6	42.7	6
Solid geometry	53.0	5	93.8	2
College algebra	60.0	4	28.7	7
Trigonometry	69.0	3	80.3	3
Analytic geometry	20.0	7	48.0	5
Electricity				
Elementary algebra	98.5	1	92.1	1
Plane geometry	82.3	2	84.1	2.5
Intermediate algebra	37.2	6	84.1	2.5
Solid geometry	42.0	5	65.2	5
College algebra	55.0	4	39.7	6
Trigonometry	71.0	3	81.0	4
Analytic geometry	14.5	7	28.6	7

TABLE XV (Continued)

Mathematics Courses	Needs		Usage	
	Pct.	Rank	Pct.	Rank
Metalwork				
Elementary algebra	97.3	1	84.0	3.5
Plane geometry	89.5	2	98.2	1
Intermediate algebra	33.3	6	59.5	5
Solid geometry	52.4	5	88.7	2
College algebra	58.1	4	17.9	7
Trigonometry	70.5	3	84.0	3.5
Analytic geometry	18.2	7	20.8	6
Woodwork				
Elementary algebra	96.0	1	70.9	3
Plane geometry	94.1	2	97.1	1
Intermediate algebra	34.6	6	30.3	5
Solid geometry	45.6	5	85.5	2
College algebra	48.5	4	11.6	7
Trigonometry	61.4	3	67.0	4
Analytic geometry	14.8	7	12.6	6
Total				
Elementary algebra	97.1	1	81.3	3
Plane geometry	91.4	2	97.0	1
Intermediate algebra	37.2	6	51.8	5
Solid geometry	48.8	5	86.4	2
College algebra	55.6	4	20.4	7
Trigonometry	67.5	3	78.8	4
Analytic geometry	17.1	7	27.3	6

The percentages of drafting professors who stated the mathematical course was desirable for industrial arts teachers and the percentages of those who indicated the skills of the course were used in their classes were quite consistent for some of the mathematics courses. The percentages shown for plane geometry, third-semester or intermediate algebra, and trigonometry are quite similar.

Ninety-eight per cent of the drafting professors advocated elementary algebra, while only 78 per cent are actually using it in their classes.

The reverse was true for analytic geometry. Twenty per cent stated its desirability, but 48 per cent were actually using it.

The largest discrepancies in percentages occurred in solid geometry and in college algebra. Solid geometry was used, compared to the expressed need, by nearly twice as many drafting professors. The variation in college algebra was in the reverse order. Less than one-half of the percentage of drafting professors who expressed a need for the course actually used the examples of skills representing the course.

Needs and usage of mathematics in electricity. The same number of professors of electricity expressed their opinions concerning the desirability of the mathematical courses and the usage of the mathematical skills represented in the check list.

This group of professors was quite consistent in their opinions of needs and indicated usage of elementary algebra, plane geometry, and reasonably consistent in trigonometry.

The variation in the percentages shown for needs and usage is about fourteen points for college algebra and analytic geometry. College algebra was used less than had been anticipated. Analytic geometry was used about twice as much as the percentage of needs had indicated. Solid geometry was used more than implied by the percentage of needs in the classes in electricity. Third-semester algebra had much greater usage than the needs had indicated.

<u>Needs and usage of mathematics in metalwork</u>. In the area of metal, 105 professors expressed their opinions of the desirability of the several mathematics courses. There were 106 who responded to the check list on mathematical usage in their classes.

The only mathematics course in which there was close agreement between needs and usage was analytic geometry. However, this course was used less in metalwork than in the two preceding areas of industrial arts. About 13 per cent fewer professors of metalwork showed elementary algebra to be used than indicated it to be needed.

Plane geometry was used in metalwork more than the professors of that area had anticipated. There were about twenty-six percentage points difference between the opinions of needs and the indicated usage of third-semester algebra in the college classes in metalwork. Solid geometry was also used more than had been anticipated. College algebra was considered desirable by a relatively larger percentage of metalworking professors, but was used by a smaller percentage than were any of the other mathematics courses. Trigonometry was again used by more professors than the percentage of needs implied.

<u>Woodworking needs and usage</u>. A different number of professors in the area of wood responded to the questionnaire and to the check list. There were 101 who gave their opinions of the mathematical courses desirable for the industrial arts curriculum and 103 indicated the mathematical usage within their college classes.

The percentages, needed and used, of these professors were quite consistent for plane geometry, third-semester algebra, trigonometry, and analytic geometry. These professors showed relatively better consistency between needs and usage in more mathematics courses than did the other groups.

Many more professors of woodwork used solid geometry than indicated it was desirable for industrial arts students. College algebra was desirable in the opinions of nearly half of these professors, while fewer than one-eighth of them used it in their classes.

Needs and usage of mathematics courses. Elementary algebra was considered desirable for industrial arts education students by over 95 per cent of the professors in each of the four areas. The check list indicated it was used in the classes by a smaller percentage of professors. Elementary algebra, arranged in order of percentage of professor use, ranks highest in the area of electricity, next in metalwork, third in drafting, and lowest in woodwork.

Plane geometry closely follows elementary algebra in both desirability and usage. The largest percentage of drafting professors rated it desirable, the second percentage was in wood, the third was in the area of metal, and the lowest percentage of professors to rank it desirable were those of electricity. In the order of percentage of professor use, plane geometry ranks highest in drafting, next in metalwork, nearly the same in woodwork, and considerably lower in the area of electricity. In each area of industrial arts it was used by a larger percentage of professors than the percentage who had indicated it as desirable.

Third-semester algebra was considered desirable for industrial arts education students by fewer than one-half of the professors in each of the areas. There was little difference in area desirability. Comparison of the need and use percentages reveals little differences in the areas of drafting and woodwork. However, there were 26 per cent difference between need and usage in the area of metalwork. There was an even larger difference between need and use (47 per cent) in the area of electricity. In both cases the usage received the larger percentage.

In each of the four areas of industrial arts solid geometry was considered to be more desirable than was third-semester algebra. It ranked fifth in the order of desirability (48.8 per cent of the total responses in Table XIII) but advanced to second place in industrial arts class usage (86.4 per cent of the total responses in Table XIV). When ranked according to the percentage of area usage, it was used by the largest percentage of professors in drafting. The second largest was in metalwork, the next largest was in the area of wood, with the lowest percentage of usage by the professors of electricity. Solid geometry showed an increase in percentage of use over the percentage of need by 40 per cent in the areas of drafting and woodwork, 36 per cent increase in metalwork, and a 23 per cent increase in electricity.

Solid geometry showed considerable difference between the usage of mathematics and the need for mathematics. College algebra also showed a wide variation, but in the reverse order. It ranked fourth in desirability but dropped to the seventh, or lowest, ranking in usage. It was indicated to be the most desirable in the area of drafting and the least desirable in woodwork. College algebra was used by a larger percentage of the professors of electricity and by the lowest percentage of professors of woodwork. The greatest drop in percentage, between those who considered it desirable and those who indicated it was used in their classes, was in the area of metalwork, followed by woodwork, then drafting. The least difference was in electricity.

Trigonometry was considered to be more desirable and had greater class usage than did college algebra. The percentage of professors indicating usage in their classes was higher in each area than the percentage of professors who stated it was desirable for industrial arts education programs. However, the differences between the two percentages were relatively small and comparatively consistent. The smallest difference was ten percentage points while the largest was only fifteen percentage points.

Analytic geometry also showed an increase in the percentage of professors who used it in three of the areas, over the percentage of professors who indicated the course was desirable.

The data concerning the percentage of the total responses, and how they ranked, for both the stated needs and the usage in class, are condensed in Figure 1. In general, the percentages were fairly consistent. The largest variation in the two percentages occurs in solid geometry and college algebra. The percentage of professors indicating a use for solid geometry was higher than the percentage stating the course was desirable. The opposite was true for college algebra. The percentage showing use for college algebra was less than the percentage which recommended the course. However, the usage of intermediate algebra was higher than the recommendations and also higher than the usage of college algebra.

The percentages indicated for plane geometry, solid geometry, and trigonometry were higher than the corresponding grade level courses in algebra.

Summary

The opinions of the industrial arts professors concerning the mathematical skills for their students were not in agreement with the

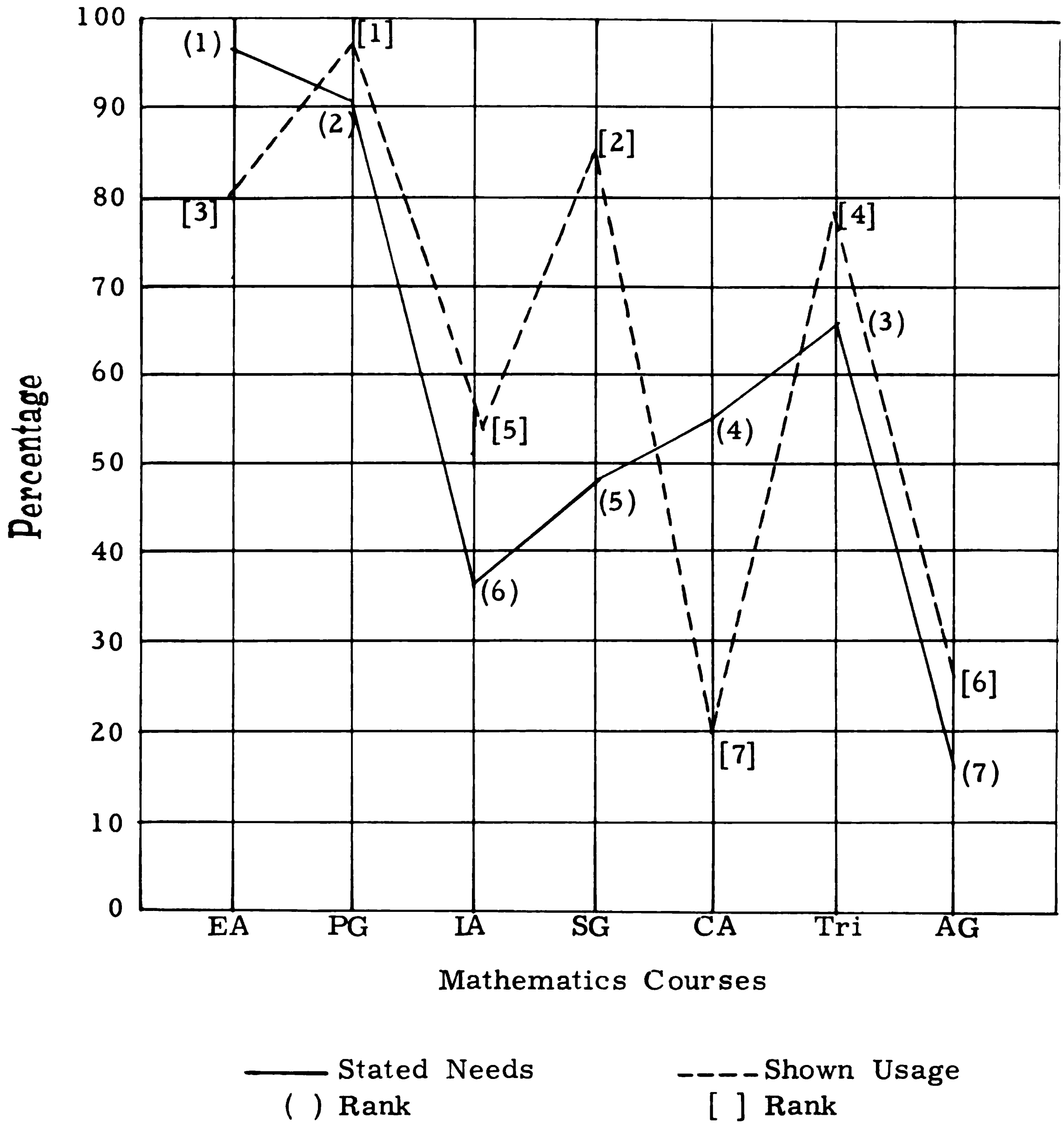

Figure 1. Percentage of total stated needs and usage of mathematics in college industrial arts. (Key: EA = Elementary Algebra, PG = Plane Geometry, IA = Intermediate Algebra, SG = Solid Geometry, CA = College Algebra, Tri = Trigonometry, AG = Analytic Geometry.)

admission policies of the colleges or with the in-college mathematical requirements.

The recommendations of the industrial arts professors and the usage in a large percentage of their classes substantiates the admission policy of those colleges which require elementary algebra and plane geometry of their applicants. Students without these courses would be handicapped in a large majority of the college industrial arts classes.

The fact that elementary algebra was highly desirable in the opinions of the professors but that its usage in their classes was somewhat lower should not be regarded as inconsistent. Elementary algebra is one of the basic mathematics courses, and while its skills and concepts are not necessarily applicable to many situations in industrial arts classes, those skills and concepts are necessary to progress to those mathematics courses which were considered to be used to a greater extent.

College algebra was ranked relatively high in needs but low in class usage, while third-semester or intermediate algebra was ranked low in needs and high in usage. These reversals in ranking support the contention that the respondents may have been confused about the content of the algebraic courses.

The low percentage of desirability indicated for solid geometry, and its near absence from the admission requirements for industrial arts education, may indicate a general reluctance to recommend or require the formal course in solid geometry. Conventional solid geometry courses are abstract and often difficult to comprehend. The fact that it ranks second in usage (only plane geometry ranks ahead of it) has implications for the mathematical curriculum of the secondary schools.

Trigonometry ranks about the same in the recommendations of the college professors and in the usage in the college industrial arts classes. There is relatively high consistency between the desirability and usage in all the areas of industrial arts.

The examples of the mathematical skills in the check list contained an item from analytic geometry relative to the focus-directrix properties of a hyperbola, or ellipse. The focus of an ellipse is a common concept in industrial arts, particularly in drafting and in woodwork. The similarity of the two terminologies may have influenced the high percentage of usage of analytic geometry.

The area of electricity seems to indicate more usage and also a high percentage of recommendations for the algebraic courses. Drafting seems to make greater use of the geometric skills. The area of metalwork seems to use the combined skills of algebra and geometry to a greater degree than does woodwork. All four areas of industrial arts recommend trigonometry for industrial arts education students and show uniformly high usage in their classes.

The mathematical recommendations of the industrial arts professors and the indicated percentages of mathematical usage in the industrial arts education classes suggest the ideal minimum combination of secondary and college mathematics to be: elementary and intermediate algebra, plane and solid geometry, and one course in trigonometry. These courses could be taken in secondary school, in college, or in any convenient division in the educational pattern.

CHAPTER VII

MATHEMATICS IN PUBLIC SCHOOL INDUSTRIAL ARTS

Some of the previous chapters summarized the mathematics involved in the college admission requirements. A summary of the in-college requirements in mathematics was also made. Another chapter presented the opinions of professors regarding the desirable mathematics courses for industrial arts education students. A summary of the mathematical usage in the college industrial arts classes of the teacher-preparation program was presented.

This chapter is devoted to (1) the actual usage of mathematics by selected, outstanding, experienced industrial arts teachers of the public schools and (2) the opinions of the authors of industrial arts textbooks used in the public schools.

Pertinent Assumptions

The mathematical background of the teacher may influence the extent of the mathematical usage in the public school industrial arts classes. For that reason a summary of the mathematics courses taken by these experienced teachers was made.

The mathematics encountered in the textbooks and references used in the industrial arts classes may have some effect on the total mathematical usage in the classroom. For that reason the opinions of the authors of industrial arts textbooks were solicited concerning the mathematical ability of the students who use their books. Their opinions were also obtained regarding the desirable mathematical background of the teachers who used their book as a text or reference.

Selection of the Teachers

The chairmen of the industrial arts departments in the teacher-preparation colleges were requested to nominate outstanding industrial arts teachers of the public schools of their state who had taught for five years or more. Space for ten nominations was provided. The chairmen were also asked to supply the mailing addresses of the nominees. The responses provided the names and addresses of 892 outstanding industrial arts teachers. This procedure provided names from forty-two states. The number of outstanding teachers thus nominated ranged from one per state to as high as sixty-four.

A maximum of ten teachers per state was used in the study. A questionnaire was mailed to any teacher whose name appeared on two or more nomination lists. Otherwise names were chosen, from the top of each nomination list, according to the ratio of names on the list to the total number of names from that state. Thus questionnaires were sent to ten teachers in thirty-four states, nine in one state, eight in another, and six in a third state, five teachers in three states, three teachers in one state, and to only one teacher in one state. Questionnaires were mailed to 382 outstanding industrial arts teachers thus selected. The teachers thus contacted represented forty states.

Limiting Factors

In addition to the inherent limitations of a questionnaire survey, additional limiting factors were encountered. One problem was the inaccuracy of the mailing addresses. Ten letters were returned with the postal notation: "Addressee Unknown."

Sixteen responses were received from teachers with less than five years' teaching experience. These responses, in view of the limited experience of the teachers, were not used in the data.

An additional limitation was time. The date of the mailing of the questionnaires to the public school industrial arts teachers was delayed as late as possible to permit the inclusion of the maximum number of nomination lists from each state. This late date resulted in inadequate time to follow up the request before the start of the summer vacation. Three of those letters which were undeliverable were addressed to teachers in nearby states. Questionnaires were then mailed to the person whose name followed on the nomination lists. In the other seven instances the closing of the school year would probably have prevented responses.

The present eminence of mathematics may have been responsible for the tendency to inflate the position of mathematics in the industrial arts program. Thirteen of the replies indicated every example of mathematical skill as being either encountered or taught in the high school industrial arts classes. These replies were considered invalid because of such spurious responses.

Personal Data of Public-School Teachers

The experience and educational backgrounds of the 148 respondents used in the study are summarized in the appendix.[1] There is some overlapping of the data. Sixty-seven one-area replies were received in response to the item: "Now teaching mainly in area of: Wood___, Metal___, Electricity___, Drafting___." Forty-five teachers indicated they were teaching mainly in two areas, twenty-four checked

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[1]See Table XIX, Appendix C, p. 185.

three areas, and eleven teachers checked all four spaces. The data from all but sixty-seven responses were represented in two or more areas; i.e., if the teacher checked both drafting and wood, his responses were tabulated in both areas.

Mathematical Background of Public-School Teachers

The data for Figure 2 were taken from Table XX in the appendix.[2] The uniformity of the mathematical background of the teachers from the different areas may be due to the fact that the majority of the teachers were involved in more than one area. Any variation in the mathematical background among the different areas might have been magnified with additional single-area data.

Nearly 95 per cent of the teachers from the four areas of industrial arts completed the conventional academic mathematical requirements for college admission. However, many of the respondents were in secondary school or in college prior to World War II and the admission requirements were probably more structured at that time.

Except for a few woodworking and electricity teachers, over one-half of the total had taken both intermediate algebra and solid geometry.

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[2]See Table XX, Appendix C, p. 186.

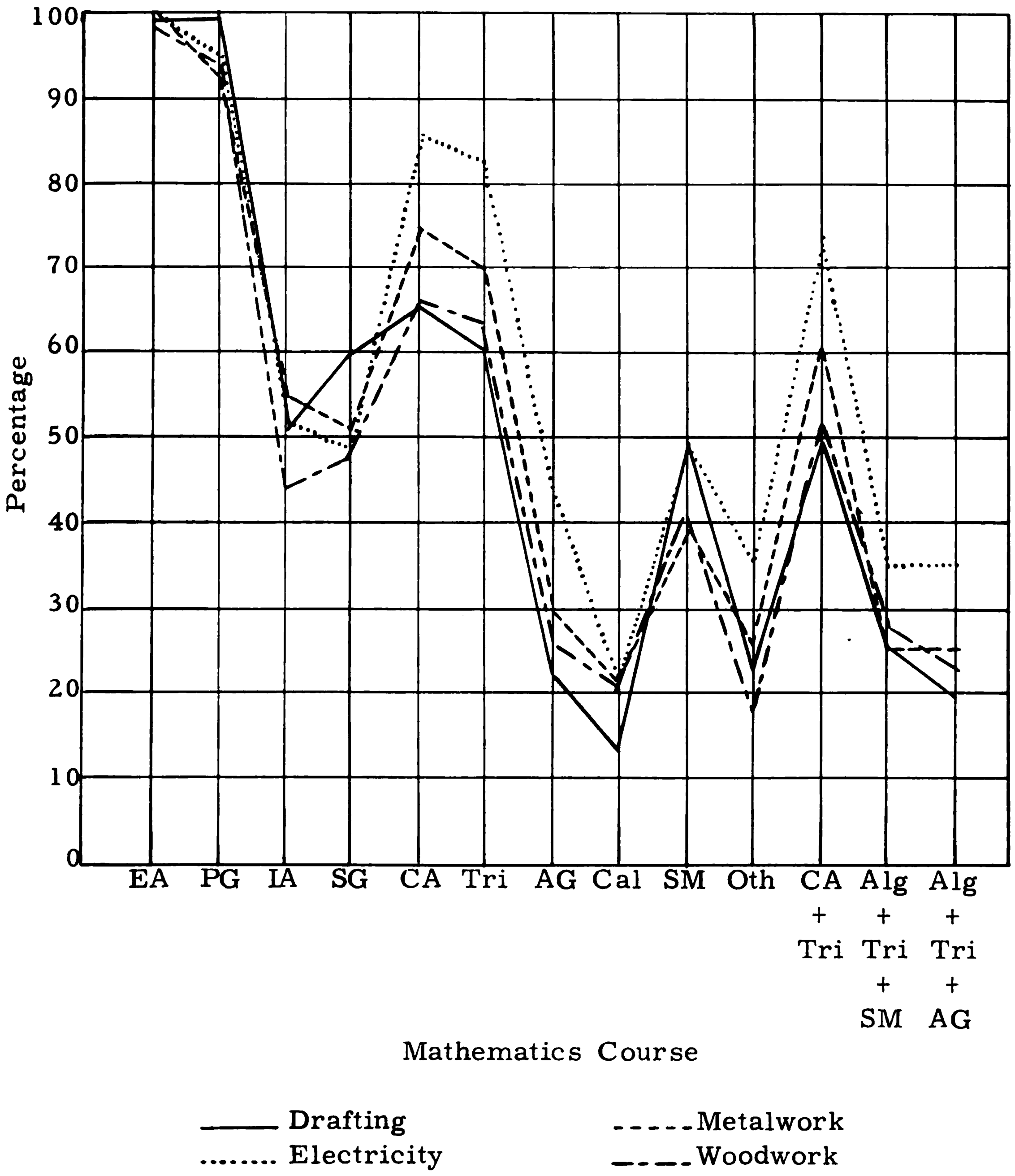

Figure 2. Percentage of teachers and their mathematical backgrounds. (Key: EA = Elementary Algebra, PG = Plane Geometry, IA = Intermediage Algebra, SG = Solid Geometry, CA = College Algebra, Tri = Trigonometry, AG = Analytic Geometry, Cal = Calculus, SM = Shop Mathematics, Alg = Algebra.)

Two-thirds or more of the teachers had taken college algebra and over 60 per cent of the total group had taken a course in trigonometry. The in-college combination of college algebra and trigonometry was popular in the era prior to World War II. This combination is still the most popular among colleges which require mathematics for industrial arts education students.[3]

About one-fourth of the industrial arts teachers had taken analytic geometry and about one-fifth of the total had taken courses in calculus. These last two courses are more advanced than most of the in-college requirements and beyond the recommendations of the college professors.[4]

Shop mathematics was more common to the teachers' mathematical background than to the professors' recommendations.

The percentage of industrial arts teachers who had taken mathematics courses other than those listed was about the same as those who had taken calculus. Courses in statistics, accounting, and surveying were the more common of the mathematics courses written-in as "other."

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[3] Cf. <u>supra</u>, Table XII, p. 71.

[4] Cf. <u>supra</u>, Table XIII, p. 84.

The most popular combination of advanced mathematics was that of college algebra and trigonometry. About one-fourth of the teachers had taken that combination. The second most popular combination was college algebra, trigonometry, and shop mathematics. The least popular of the combinations tabulated was that of college algebra, trigonometry, and analytic geometry.

Comparisons of Teaching-Area Backgrounds

Despite the overlapping of data for the different areas, there were slight differences in the mathematical backgrounds of the teachers in the different areas.

About 5 per cent fewer woodworking teachers had taken intermediate algebra. Drafting teachers also ranked slightly below the other two areas in the percentage having taken intermediate algebra. It is doubtful that differences shown for this course are statistically significant.

There are slight differences, probably not significant, for solid geometry. The largest percentage of teachers having solid geometry within their mathematical background was in drafting. This was followed by metalwork teachers, then teachers of electricity. Woodworking teachers ranked lowest. However, the spread in percentage points over the four areas was only about six points.

In general, the largest percentage of electricity teachers appeared in most of the mathematics courses, the percentage of metalwork teachers was second, the percentage of woodworking teachers was third. The drafting teachers had the lowest percentage.

The percentages of teachers having taken the combinations of courses were in about the same order.

How the Teachers Regard Their Mathematical Backgrounds

One item of the questionnaire sent to the public school industrial arts teachers asked: "Do you feel you should have taken more college mathematics in place of some of the other courses? More___, Less___." In addition to the responses checked "More" or "Less," many teachers left the spaces blank but added notes to the effect they felt their mathematical background was satisfactory, was sufficient, or that they thought it was about right. These subscripts were tabulated as adequate. Table XVI summarizes the number of secondary and college mathematics courses taken by those teachers who indicated they thought they should have taken more, by those that checked less, and by those who expressed satisfaction with their mathematical backgrounds.

TABLE XVI

TEACHERS' OPINIONS CONCERNING THEIR MATHEMATICAL BACKGROUND

No. of Courses	Opinions			Opinions		
	More	Less	Adequate	More	Less	Adequate
	Drafting			Electricity		
0	1					
1						
2	2					
3	10		2	2		
4	9		2	4		
5	11	1	4	2		1
6	5	1	2	2		1
7	5	2	7	1		2
8	2		4	2		1
9		1	3	1		2
10			1			1
Total	45	5	25	14		9
Avg.	4.58	6.80	6.56	5.43		6.89
	Metalwork			Woodwork		
0				1		
1				2		
2	4	1		6		
3	9		1	17		1
4	8	1				
5	5	2	6	10	2	4
6	5	1	2	6	1	2
7	5	1	5	2	2	7
8	3		3	4	2	5
9		3	5	2	2	4
10	1		1			
Total	40	9	27	61	9	30
Avg.	4.77	6.22	6.48	4.24	7.11	6.0

A large majority of the teachers who had indicated their teaching assignment involved the areas shown replied they felt they should have taken more college mathematics. A relatively small number of teachers thought they should have taken less mathematics while in college. No teacher, in the areas of drafting and woodwork, who checked "Less" had taken fewer than five courses in mathematics in college and/or in high school. None of the teachers of electricity indicated they thought they should have taken less mathematics.

The average number of courses taken by those teachers expressing their opinions concerning the adequacy of their mathematical backgrounds are presented in Figure 3. Teachers with an average of four or fewer mathematics courses indicated they felt they should have taken more college mathematics. Those teachers who had checked "Less" had taken approximately seven mathematics courses in high school and/or college. The teachers who considered their mathematical backgrounds adequate had taken six or more courses in mathematics in secondary school and/or college.

The average number of mathematics courses considered "less than desirable," "more than desirable," or as "adequate" are consistent with logic with one exception. The average of the teachers of metalwork who wished they had taken less mathematics was less

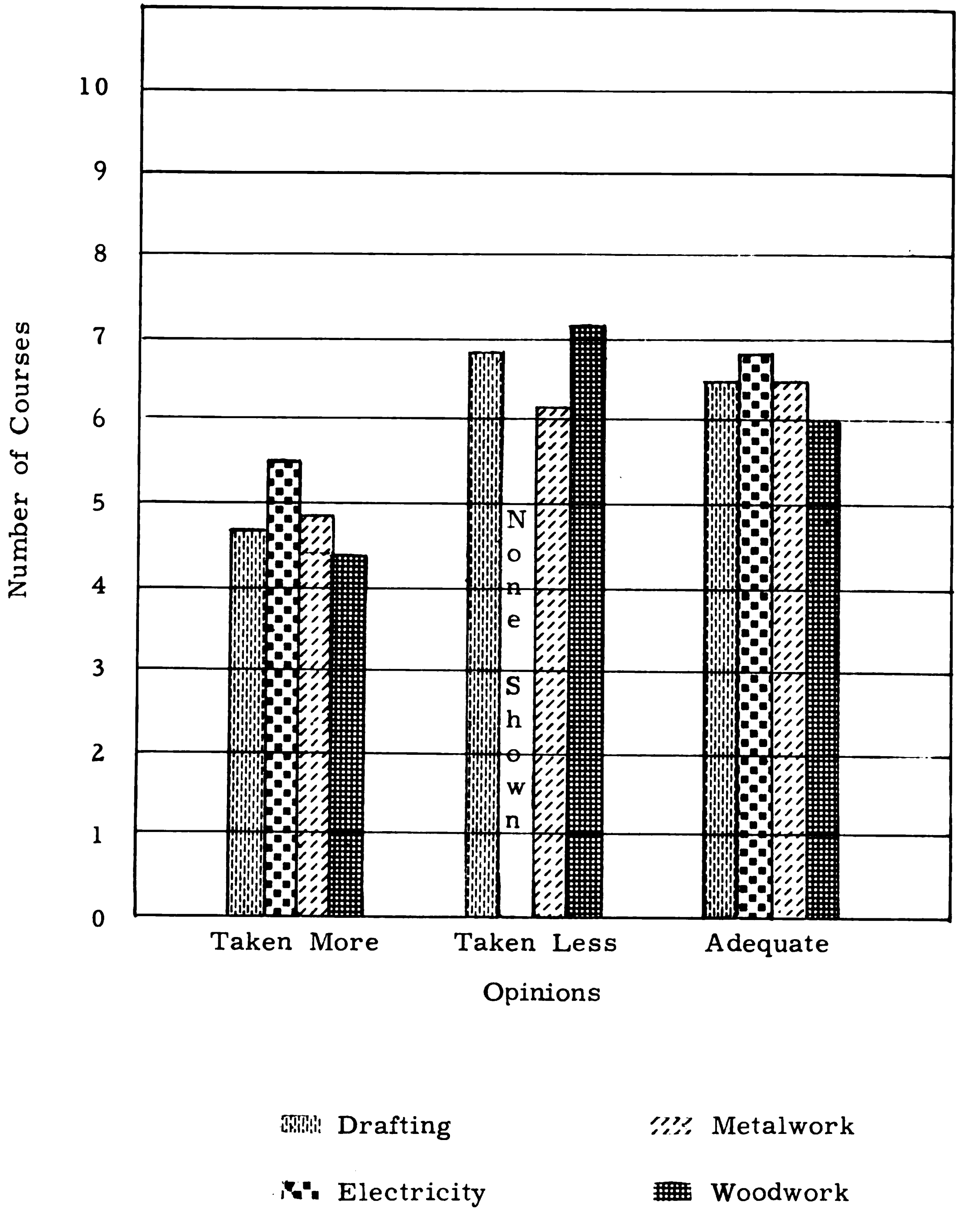

Figure 3. Average number of mathematics courses taken by the teachers and their opinions concerning the adequacy of the mathematical background.

than the average of the metalworking teachers who considered their backgrounds adequate. The data were 6.22 courses for those who indicated "less" and 6.48 for those who indicated satisfaction with their mathematical backgrounds. This difference is of doubtful significance and may be accounted for by the one teacher (Table XVI) who had taken only two mathematics courses but still thought he should have taken less.

An adequate mathematical background appears to be about six and three-quarters courses in mathematics for teachers of electricity, about six and one-half courses for teachers of drafting and metalwork, and six courses in mathematics for teachers of woodwork. These averages exceed the recommendations of the professors of industrial arts and the mathematical usage in college industrial arts classes.[5]

How the Mathematical Skills Were Encountered

The data portrayed in Figure 4 represent the per cent of the total respondents who indicated the example of mathematics had appeared in the following ways: (1) it did not require special attention on the part of the teacher, (2) it did require teaching the skill to the

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[5] Cf. supra, Chapter VI.

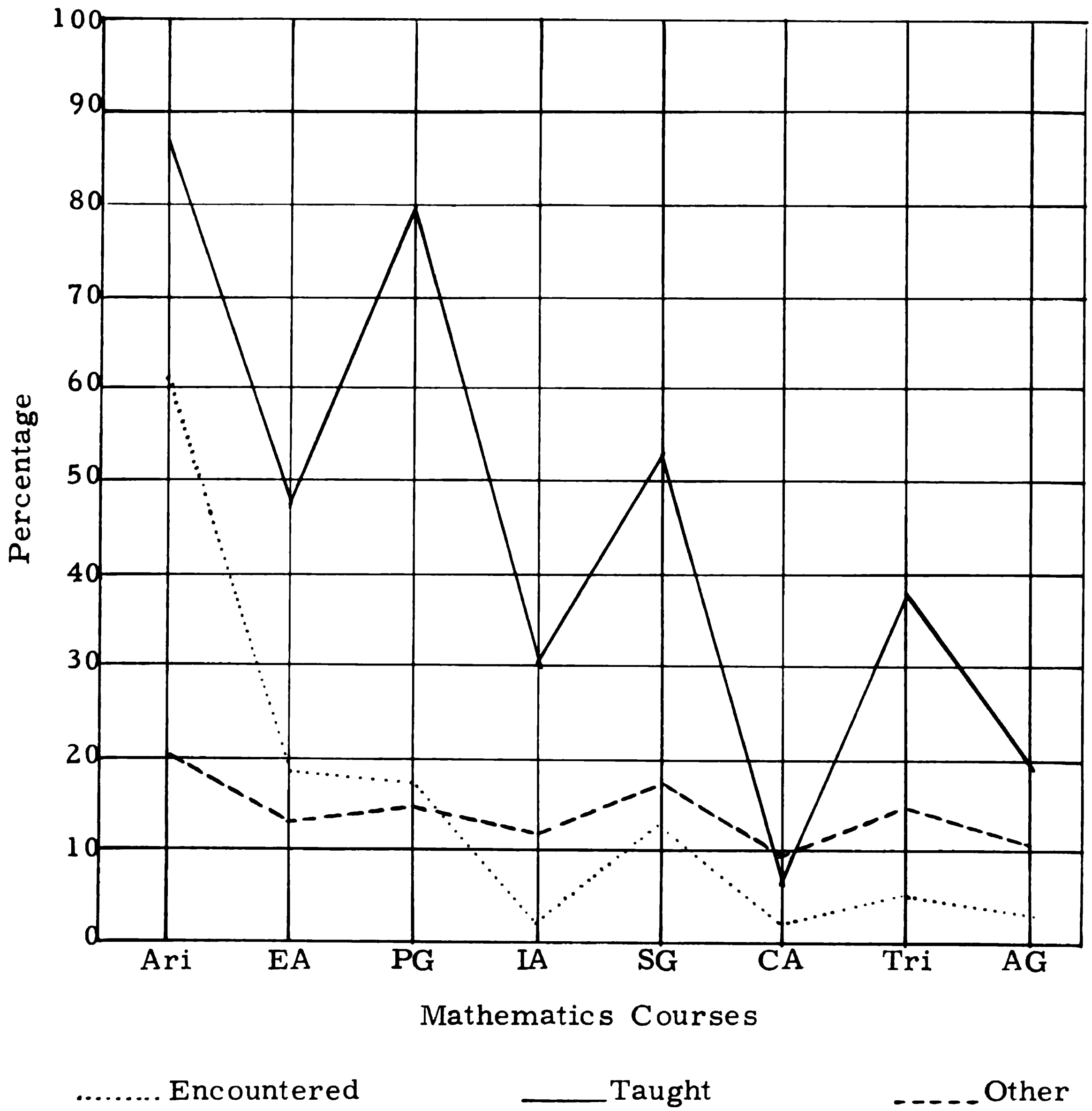

Figure 4. Percentage of teachers and ways in which the examples of mathematics courses were encountered. (Key: Ari = Arithmetic, EA = Elementary Algebra, PG = Plane Geometry, IA = Intermediate Algebra, SG = Solid Geometry, CA = College Algebra, Tri = Trigonometry, AG = Analytic Geometry.

students before continuing the industrial arts activity, or (3) it appeared in the nonpupil-contact teaching activities.

It is evident the teachers remembered the occasions in which they were called upon to teach the mathematical skill to a larger degree than when the mathematics had been encountered in the other ways.

The three mathematics courses, plane geometry, solid geometry, and trigonometry--pertaining to lines and figures--were encountered by a larger percentage of teachers than were the algebraic courses. The examples from college algebra occurred in the smallest percentage of responses. Analytic geometry also occurred in a relatively small percentage of the responses.

The data for Figure 5 were condensed from Table XX.[6] They represent the total of the three ways in which the mathematics was encountered and are expressed as contacts per teacher.

The predominance of line and figure mathematics over the algebraic courses is again evident. The mathematical skills and concepts from plane geometry, solid geometry, trigonometry, and to some extent from analytic geometry, were encountered more than were the skills and concepts from the corresponding algebraic

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[6]See Table XX, Appendix C, p. 186.

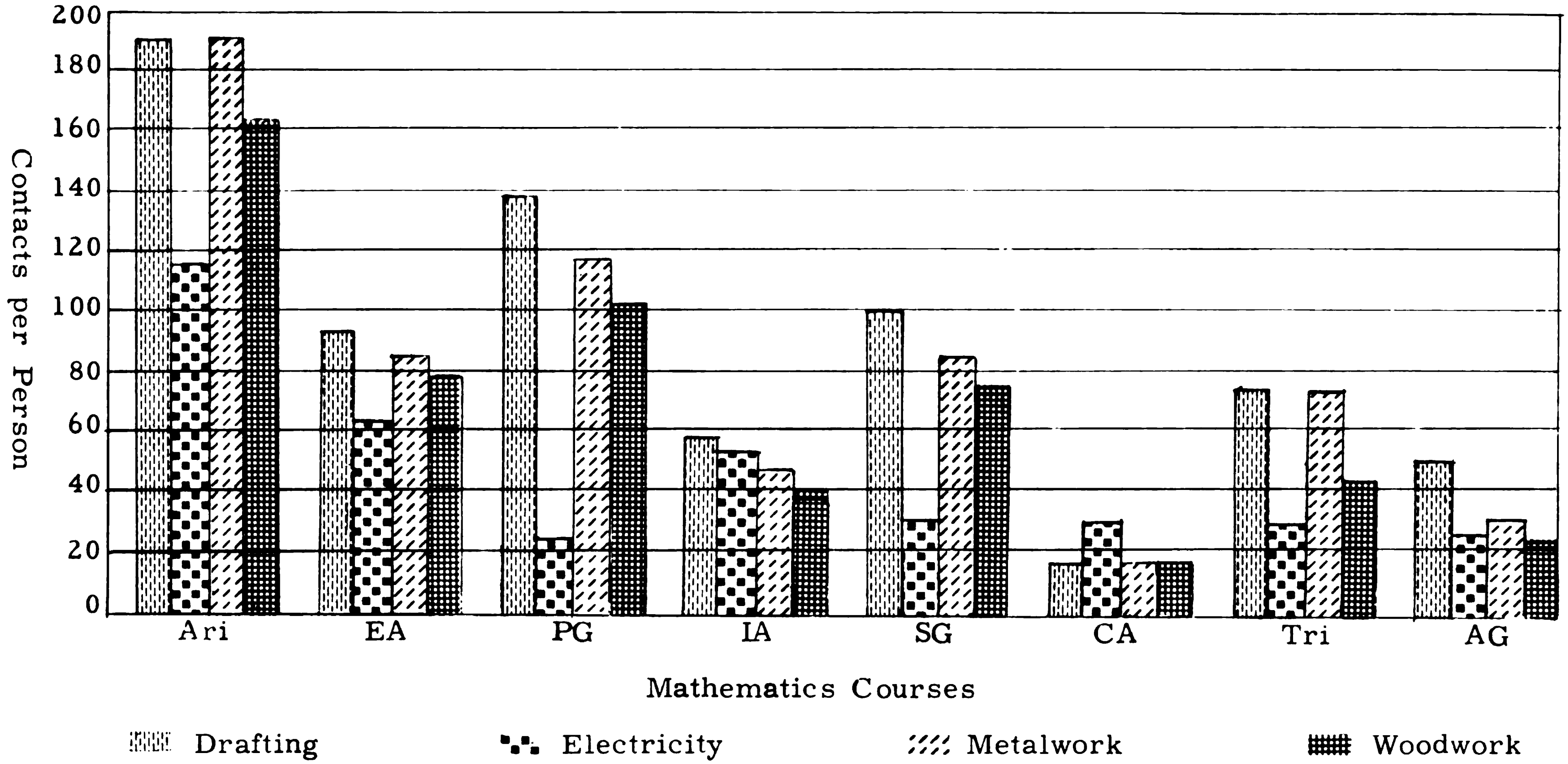

Figure 5. Average contact with mathematics courses by industrial arts teachers. (Key: Ari = Arithmetic, EA = Elementary Algebra, PG = Plane Geometry, IA = Intermediate Algebra, SG = Solid Geometry, CA = College Algebra, Tri = Trigonometry, AG = Analytic Geometry.)

courses. Teachers of drafting ranked higher in the geometric courses while teachers of electricity ranked comparatively high in the algebraic courses.

The Opinions of the Authors

The authors of industrial arts textbooks were asked to indicate: "What formal mathematics courses do you assume the student to have had prior to the use of your book as a text?" The responses are represented as percentages of the replies to this request. The authors were reluctant to commit themselves on this question. Fifteen of them did not express themselves on this item. The following indefinite replies were received: "Usual," "Normal for grade level," "Secondary," and "H. S. Math." These were not tabulated. Thus there are only thirty authors represented in the percentages for student mathematical background. Twenty-nine of the authors stated that arithmetic was assumed for the students, fourteen said algebra was assumed, eleven said geometry, and three said trigonometry was desirable.

The authors were also asked to respond to the question: "Will you . . . give me your opinion concerning the abilities you consider essential for the teacher to possess in order to obtain the maximum benefits from the use of your book as a reference or text?" The authors were very cooperative in responding to this question. The check list was used to solicit these data, which are represented in Figure 6. There were forty-nine authors that replied to this part of the study; all of them said the teacher should have had arithmetic. Twenty-six (53.1 per cent) checked items to indicate elementary algebra was desirable. Thirty-nine authors (79.7 per cent) indicated plane geometry was desirable. Only twenty-one (42.9 per cent) checked items representing intermediate algebra and thirty-two (65.4 per cent) checked items representing solid geometry. College algebra was indicated as desirable by only two authors. Trigonometry was checked by twenty-two, or 44.9 per cent of the authors, and analytic geometry was considered desirable by four, or 8.1 per cent.

The industrial arts preference for the line and figure mathematical courses was again evident.

The authors' recommendations for industrial arts teachers were similar to the recommendations of the professors of industrial arts education classes.[7]

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[7] Cf. <u>supra</u>, Chapter VI.

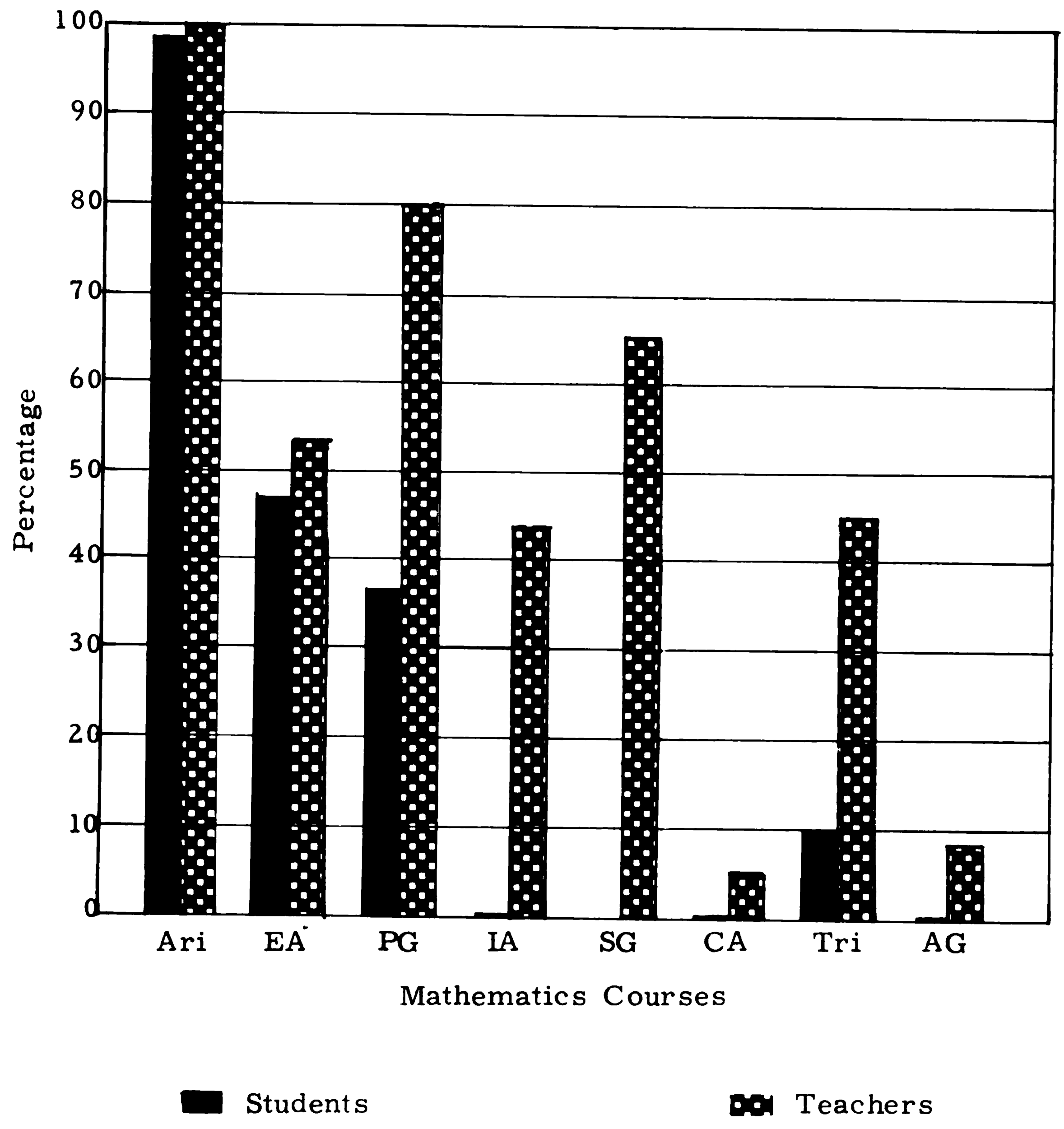

Figure 6. Authors' opinions concerning mathematical backgrounds of students and teachers. (Key: Ari = Arithmetic, EA = Elementary Algebra, PG = Plane Geometry, IA = Intermediate Algebra, SG = Solid Geometry, CA = College Algebra, Tri = Trigonometry, AG = Analytic Geometry.)

Summary

The nomination and selection of outstanding public school industrial arts teachers were satisfactory except for three factors: (1) the delay resulting from the late return of some of the nominating lists, (2) the inaccuracies in the mailing addresses, (3) the failure of the nominators to observe the teaching experience stipulations.

Some teachers were inclined to overemphasize the mathematical usage in their teaching.

Over one-half of the public-school industrial arts teachers had completed courses in elementary algebra, plane geometry, intermediate algebra, solid geometry, college algebra, and trigonometry. Approximately one-fourth of the teachers had taken analytic geometry and about 20 per cent had taken courses in calculus. About 40 per cent of the teachers had taken shop mathematics.

A large majority of the outstanding industrial arts teachers felt they should have taken more courses in mathematics while in college and only a small group thought they should have taken less mathematics. Many wrote in they thought their mathematical background was adequate or satisfactory. The group which felt they should have taken more mathematics had completed an average of nearly five courses in mathematics beyond arithmetic. None of the teachers of electricity felt they should have taken less mathematics. The teachers in the other three areas who checked "Less" had completed an average of nearly seven courses in mathematics in high school and college. There seemed to be only one teacher with an aversion for mathematics. The average of the group that felt that their background was adequate was over six courses in mathematics.

The teachers recalled the instances in which they taught the mathematical skill to a greater extent than when they encountered the mathematics without special attention or when it appeared in the nonpupil-contact activities. Over 50 per cent of the teachers had taught some of the examples from arithmetic, plane geometry, and solid geometry. This percentage was followed by that for elementary algebra (48 per cent), trigonometry, with 38 per cent, and the sixth rank was held by intermediate algebra with 31 per cent of the teachers indicating they had taught some of the examples contained in the check list. The predominance of the occurrence of the line and figure examples appears in the teaching requirements for industrial arts teachers.

The mathematical contact per teacher with the examples of the mathematics courses would place the courses in the following order: (1) arithmetic, (2) plane geometry, (3) solid geometry, (4) elementary algebra, (5) trigonometry, (6) intermediate algebra, (7) analytic geometry, and (8) college algebra.

Teachers of drafting generally ranked highest in mathematical contact per teacher in most of the mathematics courses. The second rank was for metalworking teachers, third was for the teachers of woodwork, and the lowest contact per teacher was for the teachers of electricity. The exception to the above ranking was the teachers of electricity, who ranked higher in the contact with intermediate and college algebra.

The mathematical courses dealing with lines and figures again were more prominent in the contact per teacher than were the algebraic courses.

The reluctance on the part of the authors to commit themselves concerning desirable mathematical background for the students using their book as a text or reference made the data limited. The books were written prior to the surge in mathematical popularity. They may have been purposely written with a minimum of mathematics. Less than 40 per cent of the authors who responded to this item indicated the students would need algebra and geometry to obtain maximum value from their book as a text or reference. They were not specific in designating which algebra or geometry course the student would need. Only three (10 per cent) stated that trigonometry would be beneficial.

The authors were more cooperative in indicating the mathematical background desirable for the teacher who used their books. The ranking of the courses desirable for the mathematical background of the teacher would place them in the following order: (1) arithmetic, (2) plane geometry, (3) solid geometry, (4) elementary algebra, (5) trigonometry, (6) intermediate algebra, (7) analytic geometry, and (8) college algebra.

The relative importance of the mathematics courses involving lines and figures is evident in the recommendations of the authors.

CHAPTER VIII

SUMMARY, CONCLUSIONS, IMPLICATIONS FOR FURTHER RESEARCH, AND RECOMMENDATIONS

Summary

Need for studies in industrial arts education. There is a need for more studies concerning the status of mathematics in industrial arts education. Mathematics is required for admission to most colleges or universities offering industrial arts teacher preparation. Most colleges require the student to take mathematics courses while in college. It is used in the college industrial arts classes and used by the teachers in the public schools. Despite the requirements and the mathematical usage there have been no studies relative to the mathematical content of industrial arts education or of needs of the industrial arts teacher.

Additional evidence of the need for scientific study may be found in the variation in the mathematical admission requirements and in the type and content of the mathematics courses the student must take in college. The admission requirements varied from zero to four courses in mathematics. The in-college mathematical requirements also varied from zero to four courses. Thus a student might graduate from college, as an industrial arts teacher, without taking any courses in mathematics after leaving the eighth grade. The other extreme would be that a student could be required to take four courses in mathematics while in high school, and be required to take four additional courses in mathematics on the industrial arts teacher-preparation program.

The type or content of the mathematics courses that are required also varied. Some colleges will accept one unit in general mathematics while other colleges require units in intermediate algebra and solid geometry. The in-college requirements have a similar range in mathematical content. Some require only general education mathematics while other colleges require college algebra, trigonometry, and analytic geometry.

Counselors have a need for scientific data on which to make their recommendations. Students are often unaware of the mathematics courses that must be taken before starting those that are listed as required. There have been no studies to help the counselors in this area.

The heterogeneity of the requirements indicates the mathematical needs of the industrial arts education graduate are not known. The following questions arise: What should be the minimum mathematical background of the industrial arts teacher? Do all areas of specialization in industrial arts require the same amount or content of mathematics? Where does the law of diminishing returns, in the mathematics sequence, begin to operate for the industrial arts teacher-preparation students?

Resumé. The problem was to determine the mathematical skills needed to be a successful industrial arts teacher in the public schools.

The questionnaire survey technique was used to determine:

1. The college admission requirements in mathematics for the industrial arts teacher-preparation program.
2. The mathematics courses which the students must take as part of the teacher-preparation programs. Data were received from 127 colleges or universities representing forty-five states concerning the admission and in-college mathematics requirements.
3. The mathematics used in the college industrial arts classes in the areas of drafting, electricity, metalwork, and woodwork.
4. The recommendations of college professors in the areas of drafting, electricity, metalwork, and woodwork concerning

the mathematical background of their students. Data concerning class usage and their recommendations were received from 100 professors of drafting, 63 professors of electricity, 106 of metalwork, and 104 professors of woodwork.

5. The recommendations of the authors of industrial arts textbooks concerning the mathematical abilities the teacher should have to use their books as texts or references efficiently.

6. The use of mathematics in the teaching activities of selected outstanding industrial arts teachers with five or more years of experience. Data concerning the use of mathematics, the mathematical background of the teacher, and their opinions of the adequateness of their background were received from 189 teachers representing forty states.

Mathematical admission requirements for industrial arts teacher-education students. There was no uniformity in admission requirements. More colleges did not specify mathematics in their admission requirements than did specify any of the combinations used in the study. In the admission policies that did require mathematics, the combination of elementary algebra and plane geometry was the most prevalent. Among the different mathematical subjects, elementary algebra was mentioned most often in the admission requirements. General mathematics ranked second in occurrence, while plane geometry was third.

Geographically, the results of the study indicated mathematics was seldom required by the colleges of the northeastern part of the United States but was required by most of the colleges in the southern areas. Likewise, the colleges of the north tended to accept general mathematics while the southern colleges adhered to the traditional requirement of elementary algebra and plane geometry.

Colleges with larger industrial arts departments were more inclined to accept students without high school mathematics than were the small-department colleges.

In-college mathematics for the industrial arts teacher-preparation student. The mathematical requirements for the student while in college were more heterogeneous than for admission. The diversity in requirements for mathematics in college was fairly independent of the size of the industrial arts department or the geographic area of the college or university.

The larger-department colleges were inclined to accept students without secondary mathematics but many of these colleges required the completion of college algebra prior to graduation. Most of the colleges of the northeastern area did not require mathematics for admission but all of these colleges required some form of mathematics in college. The colleges of the Southern Association area ranked first in the number of mathematics courses required while in college and tended to specify the academic courses more often than the colleges of the other areas.

The total mathematical background required of industrial arts education graduates practically defies classification. Even when grouped into academic and nonacademic mathematics there are forty-one different combinations that could fulfill the admission and in-college requirements of the colleges preparing industrial arts teachers.

Recommendations of the college professors. The professors of industrial arts technical courses do not agree with the admission policies of many of the colleges. Over 90 per cent of the 369 respondents recommended elementary algebra and plane geometry for their students. Of the total, 180 (48.8 per cent) recommended solid geometry. They ranked the courses in the following order: (1) elementary algebra, (2) plane geometry, (3) trigonometry, (4) college algebra, (5) solid geometry, (6) intermediate algebra, and (7) analytic geometry.

The responses to the items of the check list indicated the usage in the professors' classes was in the following order: (1) plane geometry, (2) solid geometry, (3) elementary algebra, (4) trigonometry, (5) intermediate algebra, (6) analytic geometry, and (7) college algebra.

The greatest discrepancy in the two rankings occurs in college algebra. It ranked fourth in the recommendations but dropped to seventh in usage in the college industrial arts classes.

The recommendations and indicated usage of mathematics exceeded any of the combinations of secondary and college mathematics that were required by the cooperating colleges.

One-half or more of the professors of the industrial arts technical courses recommended and indicated class usage of the following mathematics courses: elementary and intermediate algebra, plane and solid geometry, and trigonometry.

Mathematics courses taken by public-school teachers. The average mathematical background of the outstanding industrial arts teachers meets or exceeds the number of mathematics courses suggested by the industrial arts professors. A relatively large percentage of the teachers had taken a course in shop mathematics.

A large percentage of the teachers indicated they felt they should have taken more mathematics in college. A smaller group thought their mathematical background was adequate. This group had taken approximately six courses in mathematics while in high school or college. A much smaller group--of whom none taught electricity--indicated they should have taken less mathematics while in college. This group averaged about seven courses in mathematics per teacher.

<u>Mathematical usage in industrial arts</u>. The responses to the items of the check list indicated more occasions when the example was taught to the students than when it was encountered without special attention, or when it had occurred in the nonpupil-contact responsibilities of industrial arts teaching. The pattern of contacts with the mathematics courses was similar to that of the recommendations and usage in the college industrial arts classes.

The authors of industrial arts textbooks were averse to stating the mathematics needed by the students who used their books. Those who did respond indicated comparatively little mathematics would suffice.

The opposite attitude manifested itself concerning the authors' recommendations for the teacher's mathematical background. Their responses to the items on the check list indicated concentration, insight, and consistency. The authors' recommendations were similar to those of the professors.

Throughout the in-college requirements, the professors' recommendations, and the authors' recommendations, there seemed to be confusion concerning the content of the two algebraic courses; i.e., intermediate algebra and college algebra. The check list responses indicated more use or occurrence of the items from intermediate algebra than from college algebra, while college algebra had ranked higher than intermediate algebra in the recommendations.

In all facets of the study there was more emphasis on the mathematics courses involving lines and figures than on the corresponding algebraic courses.

Conclusions

1. A high school graduate, desirous of becoming an industrial arts teacher, has ample opportunity to select a college on the basis of his predilection or aversion for mathematics.

2. There is little rationality to mathematical admission policies or to the amount or content of the mathematics required of industrial arts teacher-education students.

3. Those persons in the colleges, responsible for the admission policies, either do not seek, or do not heed, the advice of the industrial arts departments.

4. The trend in college admission policies seems to be toward generalities and to be less specific in stating requirements.

5. The colleges seem to be providing courses in mathematics which were formerly expected of the high school graduate. For example, a college does not require any mathematics for admission but requires the college student to complete college algebra and trigonometry before graduation. The pyramidal nature of mathematics necessitates the college's offering the more elementary courses before the student takes the more advanced courses.

6. The size of the industrial arts department, the geographic area of the college, or the accreditation policies of the associations do not materially affect the admission requirements in mathematics for industrial arts teacher-education students.

7. The work of the counselor has become more important in high school. He may provide information concerning the mathematical requirements of the different colleges. He may also call

attention to the implied requirements which are not specifically stated in the admission requirements. There are mathematical skills which, while not specified, are implied and necessary for success in industrial arts teacher education.

8. Colleges with larger industrial arts departments are less rigid in their admission requirements in mathematics.

9. The need for more functional mathematics was expressed many times in the responses. The industrial arts teacher can assist the mathematics teacher to provide application of the concepts of mathematics. Teaching aids for mathematics could be made in the industrial arts classes. This practice would benefit all the mathematics students and especially the industrial arts students who made the teaching aids.

10. Authors have incorporated little mathematics into the industrial arts textbooks. In previous years the catalogs of publishers often cited the small amount of mathematics involved in the use of the textbooks.

11. The colleges preparing industrial arts teachers do not require mathematics to the extent that the data of the study would recommend. To do so might force the student to omit courses from his program which are considered desirable.

12. The average mathematical background of the outstanding industrial arts teachers was more extensive than the current requirements of the colleges would provide.

Implications for Further Research

Questions arose throughout the study which suggested the following investigations:

1. This study concerned the formal or conventional mathematics courses. A study to determine the type of mathematics course, the extent of the contents of the course, and the amount of application provided in the course, seems desirable. Many changes have occurred in the content of the mathematics courses. Would some of these new courses provide a more suitable background for industrial arts teachers? Are the formal courses in plane and solid geometry most appropriate for industrial arts teachers?

2. A study of the existing confusion regarding intermediate and college algebra.

3. A study involving the refinement of a check list or the development of other instruments that might be used to determine mathematical backgrounds. The responses to some of the items of the present check list seemed to indicate the items did not discriminate

between mathematics courses; i.e., between mensurations problems in arithmetic and Euclidean proof of plane geometry.

4. An intensive study of the effect of the mathematical background of the college professors on the mathematics used in their classes.

5. A study to determine the effects of mathematical usage in the teacher-preparation classes upon the mathematical usage by the teachers in public schools who had participated in these college classes.

6. A study of the effect of public attitude toward mathematics upon the college admission policies regarding mathematics.

7. A similar study of in-college mathematical requirements.

8. A similar study of the effects of the public attitude toward mathematics upon the tendency of the teacher to exaggerate the use of mathematics in his teaching.

9. A follow-up study, similar to the present one, when the public interest in mathematics is less accentuated than during the time of this study.

10. The extent of the mathematical background of the public school teachers of the study poses the question: Are these teachers outstanding because of their extensive background in mathematics? This question may have several ramifications.

11. A study of the traits or attributes of the public school teachers that prompted the chairmen of the college industrial arts departments to select them as outstanding teachers of industrial arts in their state.

Recommendations

As the author attempted to tabulate the mathematical requirements for the industrial arts teacher curricula, it soon became evident there was no similarity or rational pattern to the requirements. Apparently each college had formulated its policies concerning the mathematical requirements without regard for research, teacher needs, or the consensus of those directly connected with the preparation of industrial arts teachers. These policies might have been the result of these factors: uninformed administrative directives, the compulsion-to-report complex of committee action, an aggressive student-recruitment policy, of tradition, or a rebellion against the traditional mathematics courses.

The mathematical requirement policies of a college may be strengthened by the aggressiveness, the cooperativeness, or the popularity of the mathematics department. Conversely, the tendency of college departments to promote the inclusion of their courses, as requirements for the different curricula, may have excluded mathematics from the requirements for industrial arts teacher education. Regardless of the background of these requirements, both for admission and graduation of industrial arts teacher-preparation students, the variation in, or lack of, the mathematical requirements was amazing.

In view of the mathematics required by the colleges, the professors' recommendations and the class usage seemed refutatory. The authors of industrial arts textbooks also recommended more courses in mathematics than the colleges or universities now require for the preparation of industrial arts teachers. The writer was surprised at the number of mathematics courses which had been taken by the public-school industrial arts teachers, and also at the amount of mathematics used in the industrial arts classes of these teachers. The similarity between the professors' and authors' recommendations and the mathematical background which the teachers considered adequate for their work was interesting.

Agreement among college industrial arts departments. The study presented data indicating the mathematical requirements established by the colleges were less than the mathematics needed by the public-school industrial arts teachers. Before these requirements can be raised to what they should be, there must be agreement among the departments concerning the mathematics desirable for the industrial arts teacher-education student. The study indicated agreement among the professors who responded to the study. Their opinions should be further synthesized, publicized, and promoted.

Agreement among teacher-preparation colleges. Any effort to raise the mathematical requirements of industrial arts teacher education to that recommended or to conform to the needs as shown by the study would have little effect unless these requirements were adopted by most of the colleges.

Adopt realistic standards for graduation in the industrial arts teacher curriculum. The colleges and universities do not require the mathematics that the industrial arts teacher may need. All colleges should require those mathematical competencies necessary to provide the background that may be needed by their graduates.

Raise the standards for certification of industrial arts teachers. Most college departments are attempting to raise the minimum standards for certification to teach in their field. To deter teaching with substandard qualifications is commendable. Industrial arts should attempt to raise its standards for certification. One of these standards should be sufficient mathematical ability to meet the recommendations indicated in the study.

Improve the effectiveness of industrial arts education. A good mathematical background would promote better insight into our scientific society. Another approach to greater effectiveness of industrial arts would be to encourage cooperation among the science, mathematics, and industrial arts departments. This would be possible, and much more likely to occur, if the industrial arts teacher had an adequate mathematical background.

Encourage functional mathematics at the lower mathematical level. Mathematics can be taught as theoretical or pure mathematics and with little attention to its application. The industrial arts teacher should point out the need for functional mathematics in industrial arts education. Encourage the construction of teaching aids for the mathematics classes, either by the industrial arts students or in cooperation with the mathematics department.

Mathematics requirements and industrial arts specialization. The differences in mathematical usage for the areas of specialization used in the study were not great. However, the line and figure mathematics courses--the geometries and trigonometry--were used to a greater extent by teachers of drafting and woodwork than were the algebraic courses. The opposite was true for the teachers of electricity. Metalwork involved both types of mathematics.

Several comments accompanying the responses of the teachers cited the difference in mathematical usage among elementary, junior, and senior high school industrial arts. If industrial arts teacher education specializes according to the grade level of teaching, due consideration should be given to the mathematical requirements for each level.

Mathematical background recommendations. The recommendations of the college industrial arts professors, the authors of industrial arts textbooks, and those of the outstanding industrial arts teachers indicate the mathematical background of the industrial arts teacher-education graduate should include: a good foundation in arithmetic, elementary algebra, plane geometry, intermediate or third-semester algebra, solid geometry, and trigonometry. These courses were recommended for the industrial arts teacher and were shown to be used in teaching industrial arts in the public schools. They should be required of all industrial arts teacher-education students.

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APPENDIXES

APPENDIX A

DATA AND OTHER INFORMATION CONCERNING MATHEMATICS ADVISORY COMMITTEE AND MATHEMATICS PROFESSORS

Personal Data Concerning the Three Members of the Mathematics Advisory Committee

The advice of these men has been very helpful in the planning of the study, in the selection of the items of the check list, and in many details concerning current practices in mathematics education. They have voluntarily devoted many hours, both individually and as a committee, to the structure and organization of the study. They have made their personal libraries available. They have also made available the library and computing machines of the mathematics department. Their assistance has been invaluable.

Member A

Associate professor, currently acting head of the department, whose field is calculus and shop mathematics. He received his A.B. from Hope College, 1933; A.M. from University of Michigan, 1939; and additional study at Michigan State University, University of Michigan, and University of Wisconsin. He has taught two years in the secondary schools in Michigan, and for the past twenty years, in the mathematics department of Central Michigan College.

Member B

Head of the Department of Mathematics and currently on leave as a recipient of a National Science Foundation Faculty Scholarship and is in attendance at the University of Chicago. He received the A.B. from Central Michigan College, 1934; A.M. from University of Michigan, 1940; and Ph.D. from University of Michigan, 1952. He has taught seven years in the public schools of Michigan, three years in college in Minnesota, and four years at Central Michigan College. His area is mathematics education.

Member C

Assistant professor, whose specialty is statistics. A.B. from Buena Vista College, 1947; A.M. from Drake University, 1950; Ed.D.

from University of Wyoming, 1956. He has taught eight years in the public schools of Iowa and four years in colleges in Wyoming and Michigan.

Copy of Letter to Mathematics Professors

Dear Mathematics Professor:

I am enclosing a rough draft of a mathematical check list I wish to submit to industrial arts teachers to determine their mathematical background and the mathematics they use in their classes.

The items used in the check list were selected from texts, used prior to 1950, in the following mathematics classes:

1. Arithmetic
2. First-Year Algebra
3. Plane Geometry
4. Third-Semester Algebra
5. Solid Geometry
6. Fourth-Semester or College Algebra
7. Trigonometry
8. Analytic Geometry

No attempt has been made to include all the skills, abilities, or concepts of each course. Such a listing would have been too long to be practical. Effort has been made to list some of the proficiencies which could be used in industrial arts classes.

In the study it will be desirable to have agreement as to the mathematics courses in which a student would gain working proficiency in the competencies represented in the check list. Will you give me the benefit of your education and experience by indicating which of the above courses would, or should, provide the knowledge and ability needed for the item? In many instances the skill may occur in more than one class. In such cases, please indicate the class in which a student would first encounter the skill with sufficient intensity to gain adequate proficiency. It will be more efficient to use the numbers 1 to 8, as used above.

The author would greatly appreciate your comments concerning the wiseness of selection to represent each class, the clearness of presentation of the skill, any ambiguity or difficulty in classification, or any other criticism or suggestion you may have for improving the list.

Thank you for your time and the courtesy in helping me with the check list.

Sincerely

James E Bowman

James E. Bowman, Assistant Prof.
Industrial Arts Department
Central Michigan College
Mt. Pleasant, Michigan

TABLE XVII

DATA CONCERNING PROFESSORS WHO IDENTIFIED ITEMS IN THE CHECK LIST

Classification	College A	College B	College C
Rank:			
Instructor		2[a]	1
Assistant professor	1	7[b]	2
Associate professor	1	3	
Professor	1	2	1
Total	3	14	4
Degree:			
Bachelor's			1
Master's	2	11	2
Doctor's	1	3	1
Teaching range	6-36	4-31	1-27
Experience average	17.3	22.4	13.0

[a]These two teachers are supervising teachers in the student teaching of mathematics. They do not hold professorial status.

[b]Two of the seven shown are supervising teachers but do have professorial rank.

College A is a denominational liberal arts college with an enrollment of approximately seven hundred students.

College B is a state-supported college with an enrollment of about four thousand students, half of whom are in education.

College C is a state-supported college with an enrollment of about two thousand students. It is primarily a technical college. It provides for a bachelor's degree.

APPENDIX B

DATA AND OTHER INFORMATION CONCERNING COOPERATING INSTITUTIONS, DEPARTMENT CHAIRMEN, AND INDUSTRIAL ARTS PROFESSORS

Colleges and Universities Cooperating in the Study

Alabama
- Alabama Polytechnic Institute
- University of Alabama

Arizona
- Arizona State College

Arkansas
- Agricultural, Mechanical and Normal College
- Arkansas Agricultural and Mechanical College
- Arkansas State Teachers College

California
- Fresno State College
- Long Beach State College
- Pacific Union College
- San Diego State College
- San Francisco State College
- San Jose State College
- University of California, Santa Barbara College

Colordao
- Adams State College
- Colorado Agricultural and Mechanical College

Florida
- Florida Agricultural and Mechanical University
- Florida Southern College
- Florida State College
- University of Florida
- University of Tampa

Georgia
- Berry College
- Georgia Teachers College
- University of Georgia

Idaho
- Ricks College
- University of Idaho

Illinois
- Bradley University
- Chicago Teachers College
- Eastern Illinois State College
- Illinois State Normal University
- Northern Illinois State Teachers College
- Southern Illinois University
- Western Illinois State College

Indiana
- Ball State Teachers College
- Indiana State Teachers College
- Purdue University

Iowa
- Iowa State College
- Iowa State Teachers College

Kansas
- Bethel College
- Fort Hays Kansas State College
- Kansas State College
- Kansas State Teachers College--Emporia
- Kansas State Teachers College--Pittsburg
- McPherson College

Kentucky
- Eastern Kentucky State College
- Kentucky State College
- Murray State College
- Western Kentucky State College

Louisiana
- Louisiana State University
- Northwestern State College

Maine
- Gorham State Teachers College

Maryland
- Maryland State College
- University of Maryland

Michigan
- Central Michigan College
- Eastern Michigan College
- Michigan State University
- Northern Michigan College
- University of Michigan
- Wayne State University
- Western Michigan University

Minnesota
- Bemidji State Teachers College
- Mankato State Teachers College
- Moorhead State Teachers College
- State Teachers College
- University of Minnesota
- University of Minnesota, Duluth Branch
- Winona State Teachers College

Mississippi
- Mississippi State College

Missouri
- Central Missouri State College
- Lincoln University
- Northwest Missouri State College
- Northeast Missouri State Teachers College
- Southeast Missouri State College
- Southwest Missouri State College
- University of Missouri

Montana
- Northern Montana College
- Rocky Mountain College
- Western Montana College of Education

Nebraska
- Nebraska State Teachers College
- Nebraska State Teachers College at Chadron
- Nebraska State Teachers College--Peru

Nebraska (Continued)
- Nebraska State Teachers College--Wayne
- Nebraska Wesleyan University
- University of Nebraska
- University of Omaha

New Hampshire
- Keene Teachers College

New Jersey
- New Jersey State Teachers College at Newark
- State Teachers College of New Jersey

New Mexico
- Eastern New Mexico University
- New Mexico Western College
- University of New Mexico

New York
- New York University
- State University of New York, College for Teachers
- State University of New York, Teachers College

North Carolina
- East Carolina College
- North Carolina State College
- Western Carolina Teachers College

North Dakota
- University of North Dakota

Ohio
- Bowling Green State University
- Central State College
- Kent State University
- Miami University
- Ohio University
- The Ohio State University
- Wilmington College

Oklahoma
- Cameron State Agricultural College
- Central State College
- East Central State College
- Eastern Oklahoma Agricultural and Mechanical College
- Langston University
- Northeastern State College
- Oklahoma State University
- Southeastern State College
- Southwestern State College
- University of Oklahoma

Oregon
- Oregon State College

Pennsylvania
- Cheyney State Teachers College
- State Teachers College
- State Teachers College at California
- The Pennsylvania State University

South Carolina
- State Agricultural and Mechanical College

South Dakota
- General Beadle State Teachers College
- Northern State Teachers College
- Southern State Teachers College
- University of South Dakota

Tennessee
- Austin Peay State College
- East Tennessee State College
- Middle Tennessee State College
- Tennessee Polytechnic Institute
- University of Tennessee

Texas
- East Texas State Teachers College
- North Texas State College
- Prairie View Agricultural and Mechanical College
- Sam Houston State Teachers College
- Sul Ross State College

Texas (Continued)

- Texas College of Arts and Industries
- The A. and M. College of Texas
- University of Houston
- West Texas State College

Utah

- Brigham Young University
- Dixie College
- Utah State Agricultural College

Virginia

- Virginia Polytechnic Institute
- Virginia State College

Washington

- Central Washington College of Education
- State College of Washington
- University of Washington
- Western Washington College of Education

West Virginia

- Fairmont State College
- West Virginia Institute of Technology
- West Virginia University

Wisconsin

- The Stout State College

Wyoming

- University of Wyoming

Mount Pleasant, Michigan

Letter to Chairmen of Industrial Arts Departments

I am attempting to secure data concerning the mathematical needs and usage of high school industrial arts teachers as a part of my doctoral work at Michigan State University. The purpose of the study is to determine the mathematical proficiencies needed to pursue the college industrial arts classes and to teach most effectively the industrial arts in high school.

Enclosed are four copies of a questionnaire by which I hope to secure the opinions of experts concerning the mathematical abilities required to perform the college industrial arts assignment in the areas of wood, metal, electricity, and drafting. Would you please give a questionnaire to your best qualified man in each of the above areas and ask him kindly to supply the information requested? An envelope is provided for each questionnaire.

I want to identify the present practices concerning the mathematical requirements for graduation as industrial arts teachers on the secondary level. Will you supply the data on the accompanying sheet?

I need to contact some of the outstanding industrial arts teachers in the high schools of your state who have taught for five years or more. I would appreciate your selection of these men. Would you, or your secretary, kindly supply their mailing addresses?

Thank you for the many courtesies and the time involved in answering my requests.

Sincerely,

James E. Bowman

James E. Bowman, Asst. Prof.
Industrial Arts Education
Central Michigan College
Mt. Pleasant, Michigan

Data Concerning the College or University

Name of College or University ---

Name of Respondent --

Number of teachers in Industrial Arts Department ----------------------------------

Mathematical Entrance Requirements

Please indicate the number of units of high school mathematics required for admission, or that must be taken as deficiencies, before graduation as a major in your department.

General Mathematics ------; Algebra ------; Geometry ------; Other --------------

----

College Mathematics Required for Graduation
in Industrial Arts

Please show the number of semester, or term, (underline) hours required for graduation as an industrial arts teacher.

Algebra -------; Trigonometry -------; Analytic Geometry -------; Calculus -------;

Other --

Comments: ---

Outstanding High School Industrial Arts Teachers of (state) ---------------------------

Name	Address of School	City
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Please return, in the accompanying envelope, to:

James E. Bowman
Central Michigan College
Mt. Pleasant, Michigan

Mount Pleasant, Michigan

Questionnaire for Professors Included in Letter to Departments

Dear Fellow Professor:

I asked your department head to present this questionnaire to you for this reason. To give him the opportunity to select his most qualified man to supply the information I am seeking.

This data is part of my doctoral degree work at Michigan State University. I am hoping to determine the mathematical proficiencies recommended by experts in the field of metal, electricity, wood, and drafting. Three of your colleagues are responding in the other three fields.

Preliminary surveys seem to indicate little agreement among industrial arts teacher-preparation colleges or universities as to the mathematical requirements for admission and for graduation as industrial arts teachers on the secondary level. Also very little information is available as to the mathematical abilities needed in the different areas of industrial arts. This information is what I am requesting you to supply. Will you check the high school mathematics courses you feel a student should have had prior to admission to college and give the number of semester, or term (please underline) hours you feel should be taken by a student prior to graduation?

Arithmetic ----; Algebra ----; Plane Geometry ----; Third Semester Algebra ----; Solid Geometry ----; College Algebra ----; Trigonometry ----; Analytic Geometry ----; Calculus ----; Other --

Will you also check the examples on the succeeding pages, if that type of problem presents itself in your college class work?

In order to acknowledge the source of the information provided, will you supply the following:

Area of your specialization: - - - - - - - - - ____________

Your professorial rank: - - - - - - - - - ____________

Highest degree held, plus additional hours: - - - - - - ____________

Number of years teaching experience: - ____________

Thank you for your courtesy and cooperation in providing the enclosed information.

Sincerely,

James E. Bowman

James E. Bowman, Asst. Professor
Industrial Arts Education
Central Michigan College
Mt. Pleasant, Michigan

Mathematical Usage in College

Industrial Arts

DOES YOUR CLASSWORK INVOLVE THE FOLLOWING TYPES OF MATHEMATICS?

1. Changing from fractions to decimals. ______
   Ex: 57/64 is equal to what decimal?

2. Solving problems in which a value in the answer may be imaginary. ______
   Ex: Solve for R in $R^2 + 1 = 0$

3. Plotting an ellipse from an equation. ______
   Ex: Plot the ellipse represented by $16x^2 + 9y^2 = 36$

4. Using the slide rule. ______
   Ex: To use the slide rule for more efficient solution of problems.

5. Determining the probability. ______
   Ex: If ten coins are tossed in succession, what is the probability that exactly three will be heads?

6. Using logarithms of the trigonometric functions of angles. ______
   Ex: To use the table of the log function of angles.

7. Finding of areas and volumes of common geometric shapes. ______
   Ex: To find the number of square inches in a triangle or other form.

8. Using literal or negative exponents. ______
   Ex: $(x^{2a} + x^{-2a} - 2)(2 + x^{2a} + x^{-2a})$

9. Proving or deriving a formula involving three dimensions. ______
   Ex: To show students HOW the volume of a right cylinder equals the area of the base times the altitude, *i.e.* $V = \pi R^2 H$

10. Using the locus of points or lines in two dimensions. ______
    Ex: A point moves such that it is equidistant from the sides of an angle. *i.e.* The bisector.

11. Solving an equation by the use of the quadratic equation formula. ______
    Ex: To find the value of x in $2x^2 + x = 7$

12. Doing multiplication and division of decimals. ______
    Ex: 3.67 divided by .024

13. Using logarithms, (base 10). ______
    Ex: The use of logarithms in solving problems.

14. Involving the focus-directrix properties of conic sections. ______
    Ex: To plot or discuss a hyperbola or ellipse in terms of the focus or directrix.

15. Extracting square root. ______
    Ex: To obtain the square root of 15129 or similar quantities.

16. Computing the sizes of spheres that could be cut from cubes, or rectangular solids from cylinders.
    Ex: To find the sizes of square or hexagonal bars that could be cut from round stock.

17. Multiplying and dividing mixed numbers.
    Ex: $3\frac{3}{4}$ times $5\frac{1}{2}$

18. Solving simultaneous equations.
    Ex: To find the dimensions of a rectangle whose width is 2/3 of its length, and the perimeter is 80 yards.

19. Understanding the properties of tangents to a circle.
    Ex: The use of the center-head square to find the center of round bars.

20. Solving fractional equations.
    Ex: To find the value of x in $\frac{5}{3} = \frac{x + 2}{x}$

21. Solving problems in which lines meet a plane at specified angles.
    Ex: The construction of braces for an upright.

22. Using determinants.
    Ex: Find, by determinants, the area of a triangle having the vertices: $(-1, -2), (3, -2), (1, 5)$.

23. Deriving or showing the relationships of the sides of common figures.
    Ex: To prove that the area of a triangle is the product of one-half of the base times the altitude.

24. Multiplying or dividing denominate numbers.
    Ex: To find the number of board feet in a piece of wood 1 ft. 4 in. wide and 3 ft. 7 in. long.

25. Using the properties of isosceles triangles.
    Ex: Constructing the bisectors of lines or angles.

26. Solving quadratic equations by factoring.
    Ex: Factor to find the value of x in $x^2 - 7x + 12 = 0$

27. Determining percentage relationships.
    Ex: 4 is what percent of 56?

28. Using the theory of equations.
    Ex: To find, by synthetic division, the quotient of $(2x^4 + 6x^3 - 8x + 10) \div (x + \frac{1}{2})$

29. Using the relationships of similar shapes, such as triangles, squares, circles, or other shapes.
    Ex: To construct a larger triangle similar to a given triangle.

30. Using the equation $y^2 = 4px$ to describe or plot a parabola.
    Ex: To plot or describe the figure represented by the equation $y^2 = -8x$

31. Constructing equal or proportional parts or ratios.
    Ex: To divide a board into three equal widths.

32. Using radians.
    Ex: To find the number of degrees in 2.3 radians.

33. Solving problems relating to conic frustums. ______
Ex: To find the area of the side of a funnel or the side of a conventional pail.

34. Finding the areas of triangles by the use of the tables of the trigonometric functions of angles. ______
Ex: To find the area of a triangle when you know two angles and a side of the triangle.

35. Expanding a binomial by the use of the theorem. ______
Ex: To expand or multiply out the following expression by the use of the binomial theorem. $(A - 1)^6 =$

36. Using relationship of the altitudes and the areas of sections formed by the intersection of planes parallel to the base of pyramids. ______
Ex: To find the dispersion or intensity of light, sound, or other forms of radiation at given distances from the source.

37. Finding the angles or sides of obtuse triangles. ______
Ex: To find the other sides of a triangle when you know two angles and an adjoining side.

38. Recognizing and manipulating of monomial factors. ______
Ex: To factor expressions similar to $3\pi + 6\pi^2$

39. Determining the slope of a line from its coordinates. ______
Ex: To find the slope of a line from the expression $M = \frac{Y - Y_1}{X - X_1}$

40. Adding and subtracting mixed numbers. ______
Ex: To add 3 2/3, 4 1/3, and 5 1/3.

41. Solving of right triangle problems using the trigonometric function of the angles. ______
Ex: Finding the taper angle.

42. Solving first degree equations. ______
Ex: To solve for x in $5x - 1 = 3x + 7$

43. Using graphic solution of systems of non-linear equations. ______
Ex: To graph two second degree equations on the same axes to determine the common values of x and y.

44. Involving complex numbers. ______
Ex: To represent, graphically, such quantities as $2\sqrt{3} + 2i$

45. Using letters to represent unknown values. ______
Ex: To use 3L plus ¾" to represent the length needed for three pieces L inches long and the allowance for kerf and finishing.

46. Recognizing or plotting of curves involving a table of the trigonometric function of angles. ______
Ex: The plotting of such curves as those representing the alternating current cycle.

47. Adding and subtracting of fractions when they must be changed to a common denominator. ______
Ex: to add 3/4, 1/2, and 1/16.

48. Using fundamental operation involving literal terms. ______
Ex: The addition, subtraction, multiplication, or division of values represented by letters.

TABLE XVIII

PERSONAL DATA CONCERNING INDUSTRIAL ARTS PROFESSORS

Classification	Drafting		Electricity		Metalwork		Woodwork	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Rank:								
Instructor . . .	24	24.2	21	33.4	30	28.6	30	29.4
Assistant professor . .	26	26.3	23	36.5	40	38.0	31	30.4
Associate professor . .	22	22.2	14	22.2	22	21.0	26	25.5
Professor . . .	27	27.3	5	7.9	13	12.4	15	14.7
Degree:								
Bachelor's . . .	9	9.1	8	12.7	13	12.4	12	11.6
Master's	62	62.6	41	65.2	68	64.8	70	68.0
Doctor's	28	28.3	14	22.1	24	22.8	21	20.4
Range of teaching experience:	1-46		1-48		1-46		1-48	
1-9	30	30.3	33	53.3	34	32.1	34	33.0
10-19	32	32.4	17	27.4	38	35.8	35	34.0
20-29	24	24.2	10	16.1	25	23.6	22	21.4
30 and over . .	13	13.1	2	3.2	9	8.5	12	11.6
Average	17.2		12.2		15.7		15.4	

Mount Pleasant, Michigan

Follow-up Letter to Chairmen of Departments

Approximately three weeks ago I sent out requests for data on mathematic requirements to all industrial arts teacher preparation colleges or universities in the United States. The response has been excellent and a great deal of interest has been shown. In view of the public interest in mathematics at this time, many industrial arts departments are studying their mathematic requirements. A great many have asked for the results of the study.

Will you accept my thanks and extend them to the men in your department who have been so cooperative? In a few instances individuals may have been too busy to complete the forms. If so, I will gladly wait. Because of the interest shown I want to make this study as nation-wide as possible.

I appreciate the addresses of the outstanding industrial arts teachers in the high schools. I feel the chairmen and department heads are the most qualified to make the selection in their state.

Again, my sincere thanks to you and your men.

Cordially yours,

James E. Bowman

James E. Bowman
Industrial Arts Education
Central Michigan College
Mt. Pleasant, Michigan

APPENDIX C

DATA AND OTHER INFORMATION CONCERNING PUBLIC-SCHOOL INDUSTRIAL ARTS TEACHERS

Mount Pleasant, Michigan

Questionnaire to Public School Industrial Arts Teachers

To an Outstanding Industrial Arts Teacher:

Because you have established yourself as an outstanding industrial arts teacher, one or more heads of the industrial arts departments of your state colleges have provided me with your name and address. Congratulations on your success and recognition.

I need data concerning the mathematical abilities and usage of the outstanding industrial arts teachers in each state as part of a doctoral study at Michigan State University. The opinions of several groups, connected with industrial arts teaching, have been obtained. Now, as a major part of the study, I want to know the mathematical skills that outstanding, experienced teachers, like yourself, actually HAVE USED. Opinions are desirable but actual usage seems to be more significant.

To acknowledge the source of my information, I need:

Name of college from which you graduated ____

Degree held, plus semester or term (underline) hours ________________________________

Number of years teaching experience ____

Now teaching mainly in area of: Wood ____, Metal ____, Electricity ____, Drafting ____.

Please check the mathematics courses taken prior to graduation:

Ninth Grade Algebra ___, Plane Geometry ___, Solid Geometry ___, Third Semester Algebra___,

Trigonometry ___, Analytic Geometry ___, College Algebra ___, Calculus ___, Shop Math.___,

Other ____

Do you feel you should have taken more college mathematics in place of some of the other courses? More ____, Less ____.

Thank you for the time and effort involved in answering this request.

Sincerely,

James E. Bowman

James E. Bowman, Asst. Professor
Industrial Arts Education
Central Michigan College
Mt. Pleasant, Michigan

Mathematical Usage in High School Industrial Arts

Scoring:

E **Represents a situation in which the skill is encountered, but the students are able to do the mathematics, and no time or effort on the teacher's part is required.**

T **Is when you must stop and TEACH the mathematical ability before the students are able to progress to new assignments. More comprehension and skill are required in this situation.**

R **Is when you encounter the mathematics in your related READING. More complex mathematics may be involved in this case.**

Will you please ENCIRCLE the letters representing the situation in which the mathematics was encountered? You might encircle E or T and R in any or all of the subject matter areas. Blank spaces signify the mathematics was not encountered. Have you used this mathematical skill?

	Wood	Metal	Electricity	Drafting
1. Changing from fractions to decimals. Ex: 57/64 is equal to what decimal?	E T R	E T R	E T R	E T R
2. Solving problems in which a value in the answer may be imaginary. Ex: Solve for R in $R^2 + 1 = 0$	E T R	E T R	E T R	E T R
3. Plotting an ellipse from an equation. Ex: Plot the ellipse represented by $16x^2 + 9y^2 = 36$	E T R	E T R	E T R	E T R
4. Using the slide rule. Ex: To use the slide rule for more efficient solution of problems.	E T R	E T R	E T R	E T R
5. Determining the probability. Ex: If ten coins are tossed in succession, what is the probability that exactly three will be heads?	E T R	E T R	E T R	E T R
6. Using logarithms of the trigonometric functions of angles. Ex: To use the table of the log function of angles.	E T R	E T R	E T R	E T R
7. Finding of areas and volumes of common geometric shapes. Ex: To find the number of square inches in a triangle or other form.	E T R	E T R	E T R	E T R
8. Using literal or negative exponents. Ex: $(x^{2a} + x^{-2a} - 2)(2 + x^{2a} + x^{-2a})$	E T R	E T R	E T R	E T R
9. Proving or deriving a formula involving three dimensions. Ex: To show students HOW the volume of a right cylinder equals the area of the base times the altitude, *i.e.* $V = \pi R^2 H$	E T R	E T R	E T R	E T R
10. Using the locus of points or lines in two dimensions. Ex: A point moves such that it is equidistant from the sides of an angle. *i.e.* The bisector.	E T R	E T R	E T R	E T R
11. Solving an equation by the use of the quadratic equation formula. Ex: To find the value of x in $2x^2 + x = 7$	E T R	E T R	E T R	E T R
12. Doing multiplication and division of decimals. Ex: 3.67 divided by .024	E T R	E T R	E T R	E T R
13. Using logarithms, (base 10). Ex: The use of logarithms in solving problems.	E T R	E T R	E T R	E T R
14. Involving the focus-directrix properties of conic sections. Ex: To plot or discuss a hyperbola or ellipse in terms of the focus or directrix.	E T R	E T R	E T R	E T R
15. Extracting square root. Ex: To obtain the square root of 15129 or similar quantities.	E T R	E T R	E T R	E T R

	Wood	Metal	Electricity	Drafting
16. Computing the sizes of spheres that could be cut from cubes, or rectangular solids from cylinders. Ex: To find the sizes of square or hexagonal bars that could be cut from round stock.	E T R	E T R	E T R	E T R
17. Multiplying and dividing mixed numbers. Ex: 3¾ times 5½	E T R	E T R	E T R	E T R
18. Solving simultaneous equations. Ex: To find the dimensions of a rectangle whose width is 2/3 of its length, and the perimeter is 80 yards.	E T R	E T R	E T R	E T R
19. Understanding the properties of tangents to a circle. Ex: The use of the center-head square to find the center of round bars.	E T R	E T R	E T R	E T R
20. Solving fractional equations. Ex: To find the value of x in $\frac{5}{3} = \frac{x+2}{x}$	E T R	E T R	E T R	E T R
21. Solving problems in which lines meet a plane at specified angles. Ex: The construction of braces for an upright.	E T R	E T R	E T R	E T R
22. Using determinants. Ex: Find, by determinants, the area of a triangle having the vertices: (−1, −2), (3, −2), (1, 5).	E T R	E T R	E T R	E T R
23. Deriving or showing the relationships of the sides of common figures. Ex: To prove that the area of a triangle is the product of one-half of the base times the altitude.	E T R	E T R	E T R	E T R
24. Multiplying or dividing denominate numbers. Ex: To find the number of board feet in a piece of wood 1 ft. 4 in. wide and 3 ft. 7 in. long.	E T R	E T R	E T R	E T R
25. Using the properties of isosceles triangles. Ex: Constructing the bisectors of lines or angles.	E T R	E T R	E T R	E T R
26. Solving quadratic equations by factoring. Ex: Factor to find the value of x in $x^2 - 7x + 12 = 0$	E T R	E T R	E T R	E T R
27. Determining percentage relationships. Ex: 4 is what percent of 56?	E T R	E T R	E T R	E T R
28. Using the theory of equations. Ex: To find, by synthetic division, the quotient of $(2x^4 + 6x^3 - 8x + 10) \div (x + \frac{1}{2})$	E T R	E T R	E T R	E T R
29. Using the relationships of similar shapes, such as triangles, squares, circles, or other shapes. Ex: To construct a larger triangle similar to a given triangle.	E T R	E T R	E T R	E T R
30. Using the equation $y^2 = 4px$ to describe or plot a parabola. Ex: To plot or describe the figure represented by the equation $y^2 = -8x$	E T R	E T R	E T R	E T R
31. Constructing equal or proportional parts or ratios. Ex: To divide a board into three equal widths.	E T R	E T R	E T R	E T R
32. Using radians. Ex: To find the number of degrees in 2.3 radians.	E T R	E T R	E T R	E T R

	Wood	Metal	Electricity	Drafting
33. Solving problems relating to conic frustums. Ex: To find the area of the side of a funnel or the side of a conventional pail.	E T R	E T R	E T R	E T R
34. Finding the areas of triangles by the use of the tables of the trigonometric functions of angles. Ex: To find the area of a triangle when you know two angles and a side of the triangle.	E T R	E T R	E T R	E T R
35. Expanding a binomial by the use of the theorem. Ex: To expand or multiply out the following expression by the use of the binomial theorem. $(A - 1)^6 =$	E T R	E T R	E T R	E T R
36. Using relationship of the altitudes and the areas of sections formed by the intersection of planes parallel to the base of pyramids. Ex: To find the dispersion or intensity of light, sound, or other forms of radiation at given distances from the source.	E T R	E T R	E T R	E T R
37. Finding the angles or sides of obtuse triangles. Ex: To find the other sides of a triangle when you know two angles and an adjoining side.	E T R	E T R	E T R	E T R
38. Recognizing and manipulating of monomial factors. Ex: To factor expressions similar to $3\pi + 6\pi^2$	E T R	E T R	E T R	E T R
39. Determining the slope of a line from its coordinates. Ex: To find the slope of a line from the expression $M = \frac{Y - Y_1}{X - X_1}$	E T R	E T R	E T R	E T R
40. Adding and subtracting mixed numbers. Ex: To add 3 2/3, 4 1/3, and 5 1/3.	E T R	E T R	E T R	E T R
41. Solving of right triangle problems using the trigonometric function of the angles. Ex: Finding the taper angle.	E T R	E T R	E T R	E T R
42. Solving first degree equations. Ex: To solve for x in $5x - 1 = 3x + 7$	E T R	E T R	E T R	E T R
43. Using graphic solution of systems of non-linear equations. Ex: To graph two second degree equations on the same axes to determine the common values of x and y.	E T R	E T R	E T R	E T R
44. Involving complex numbers. Ex: To represent, graphically, such quantities as $2\sqrt{3} + 2i$	E T R	E T R	E T R	E T R
45. Using letters to represent unknown values. Ex: To use 3L plus ¾" to represent the length needed for three pieces L inches long and the allowance for kerf and finishing.	E T R	E T R	E T R	E T R
46. Recognizing or plotting of curves involving a table of the trigonometric function of angles. Ex: The plotting of such curves as those representing the alternating current cycle.	E T R	E T R	E T R	E T R
47. Adding and subtracting of fractions when they must be changed to a common denominator. Ex: to add 3/4, 1/2, and 1/16.	E T R	E T R	E T R	E T R
48. Using fundamental operation involving literal terms. Ex: The addition, subtraction, multiplication, or division of values represented by letters.	E T R	E T R	E T R	E T R

TABLE XIX

EDUCATION AND EXPERIENCE OF PUBLIC-SCHOOL TEACHERS

Area	No.	Pct.	Avg. Hours Beyond	Avg. Teach. Exper.
		Bachelor's Degree		
Drafting[a]	32	42.7	10.1	15.6
Electricity	13	56.5	8.4	12.9
Metalwork[b]	33	43.5	12.1	11.8
Woodwork	54	54.0	11.3	15.4
		Master's Degree		
Drafting[a]	42	56.0	2.5	14.3
Electricity	10	43.2	1.6	10.2
Metalwork[b]	42	55.3	3.1	17.2
Woodwork	46	46.0	3.6	14.3

Note: The percentages refer to the ratio of the number to the total respondents in the teaching area.

[a]One drafting teacher had earned the Doctor of Education degree. He had nine years' teaching experience.

[b]One teacher of metalwork had not earned a college degree. He had earned sixty-two semester hours of college credit. He had taught for twenty years.

TABLE XX

SITUATIONS IN WHICH EXAMPLES OF MATHEMATICS COURSES WERE USED

Mathematics Course	Situation[a]	Drafting		Electricity		Metalwork		Woodwork	
		No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Arithmetic	E	49	65.4	3	13.0	55	72.5	61	61.0
	T	72	97.3	18	78.4	67	88.2	82	82.0
	R	17	22.6	4	17.4	19	25.0	17	17.0
Elementary algebra	E	17	22.6	3	13.0	14	18.5	18	18.0
	T	42	56.0	8	34.8	34	44.8	47	47.0
	R	10	13.3	3	13.0	15	19.8	9	9.0
Plane geometry	E	22	29.4			10	13.2	17	17.0
	T	65	86.7	3	13.0	61	80.4	81	81.0
	R	11	14.7	2	8.7	15	19.8	12	12.0
Intermediate algebra	E	4	5.3			1	1.3		
	T	27	36.0	9	39.2	20	26.4	29	29.0
	R	11	14.7	2	8.7	12	15.8	9	9.0
Solid geometry	E	14	18.7			11	14.5	11	11.0
	T	52	69.3	3	13.0	40	52.7	50	50.0
	R	9	12.0	4	17.4	13	17.1	11	11.0
College algebra	E			2	8.7			3	3.0
	T	6	8.0	3	13.0	6	7.9	4	4.0
	R	14	18.7	4	17.4	14	18.5	10	10.0
Analytic geometry	E	5	6.7			3	3.9		
	T	27	36.0	4	17.4	11	14.5	15	15.0
	R	11	14.7	2	8.7	9	11.8	8	8.0

[a]Situations: E = a situation in which the skill was encountered, but the students were able to do the mathematics with no time or effort on the teacher's part. T = a situation in which the teacher found it necessary to stop and teach the mathematical ability before the students were able to progress to new assignments. R = a situation in which the skill was treated in the related reading.

TABLE XXI

RESPONSES OF OUTSTANDING INDUSTRIAL ARTS TEACHERS

State	Names Received	Question-naires Sent	Responses
Alabama	18	10	2
Arizona	10	10	5
Arkansas	22	10	4
California	42	10	6
Colorado	5	5	1
Florida	30	10	4
Georgia	14	10	5
Idaho	10	10	3
Illinois	21	10	4
Indiana	18	10	9
Iowa	10	10	8
Kansas	17	10	5
Kentucky	40	10	6
Louisiana	10	10	2
Maine	5	5	4
Maryland	19	10	6
Michigan	47	10	8
Minnesota	47	10	5
Mississippi	10	10	3
Missouri	48	10	5
Montana	25	10	5
Nebraska	48	10	4

TABLE XXI (Continued)

State	Names Received	Question-naires Sent	Responses
New Hampshire	10	10	8
New Jersey	5	5	2
New Mexico	29	10	7
New York	26	10	5
North Carolina	22	10	6
North Dakota	3	3	0
Ohio	36	10	3
Oklahoma	51	10	4
Oregon	8	8	4
Pennsylvania	15	10	8
South Carolina	10	10	2
South Dakota	1	1	0
Tennessee	20	10	2
Texas	64	10	7
Utah	13	10	7
Virginia	19	10	5
Washington	9	9	3
West Virginia	19	10	5
Wisconsin	10	10	4
Wyoming	6	6	3
Total for 42 states	892	382	189

APPENDIX D

LETTER TO PUBLISHING COMPANIES AND

QUESTIONNAIRE TO INDUSTRIAL ARTS

TEXTBOOK AUTHORS

Gentlemen:

As part of a doctoral study at Michigan State University I need to contact the authors of industrial arts textbooks that are suitable for use in high schools in the areas of drafting, electricity, metalwork, and woodwork. I have secured the following names of authors for which you are listed as the publisher. Would you supply me with their mailing addresses? I would also appreciate the names and addresses of any authors or co-authors in the above classification that I may have inadvertently omitted.

Name	Street	City	State

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____
11. ____
12. ____

Thank you for the courtesy in supplying this information.

Sincerely,

James E. Bowman

James E. Bowman
Industrial Arts Education
Central Michigan College
Mt. Pleasant, Michigan

CENTRAL MICHIGAN COLLEGE

Mount Pleasant, Michigan

Questionnaire Sent to Industrial Arts Textbook Authors

Dear Sir:

I am attempting to secure data concerning the mathematical needs and usage of high school industrial arts teachers as part of my doctorate work at Michigan State University. As one approach to the problem I need the expert opinion of the authors of text books used in high school industrial arts classes in the areas of metalwork, woodwork, electricity, and drafting.

The accompanying list of mathematical abilities are typical of those required of industrial arts students while in college. Will you, as author or co-author, of ------------------------------------ give me your opinion concerning the abilities you consider essential for the teacher to possess in order to obtain the maximum benefits from the use of your book as a reference or text? Will you check (√) those abilities you think the teacher should have when using your book as a text or reference?

For what grade level was your book written? ----------------------------

What formal mathematics courses do you assume the student to have had prior to the use of your book as a text? ------------------------------------

Thank you for your time and courtesy in supplying this information.

Sincerely,

James E. Bowman

James E. Bowman, Asst. Prof.
Industrial Arts Education
Central Michigan College
Mt. Pleasant, Michigan

Mathematics Needed to Use
High School Industrial Arts
Text Books

DOES YOUR BOOK INVOLVE MATHEMATICS OF THE FOLLOWING TYPES?

1. Changing from fractions to decimals. ______
   Ex: 57/64 is equal to what decimal?

2. Solving problems in which a value in the answer may be imaginary. ______
   Ex: Solve for R in $R^2 + 1 = 0$

3. Plotting an ellipse from an equation. ______
   Ex: Plot the ellipse represented by $16x^2 + 9y^2 = 36$

4. Using the slide rule. ______
   Ex: To use the slide rule for more efficient solution of problems.

5. Determining the probability. ______
   Ex: If ten coins are tossed in succession, what is the probability that exactly three will be heads?

6. Using logarithms of the trigonometric functions of angles. ______
   Ex: To use the table of the log function of angles.

7. Finding of areas and volumes of common geometric shapes. ______
   Ex: To find the number of square inches in a triangle or other form.

8. Using literal or negative exponents. ______
   Ex: $(x^{2a} + x^{-2a} - 2)(2 + x^{2a} + x^{-2a})$

9. Proving or deriving a formula involving three dimensions. ______
   Ex: To show students HOW the volume of a right cylinder equals the area of the base times the altitude, *i.e.* $V = \pi R^2 H$

10. Using the locus of points or lines in two dimensions. ______
    Ex: A point moves such that it is equidistant from the sides of an angle. *i.e.* The bisector.

11. Solving an equation by the use of the quadratic equation formula. ______
    Ex: To find the value of x in $2x^2 + x = 7$

12. Doing multiplication and division of decimals. ______
    Ex: 3.67 divided by .024

13. Using logarithms, (base 10). ______
    Ex: The use of logarithms in solving problems.

14. Involving the focus-directrix properties of conic sections. ______
    Ex: To plot or discuss a hyperbola or ellipse in terms of the focus or directrix.

15. Extracting square root. ______
    Ex: To obtain the square root of 15129 or similar quantities.

16. Computing the sizes of spheres that could be cut from cubes, or rectangular solids from cylinders. ______
    Ex: To find the sizes of square or hexagonal bars that could be cut from round stock.

17. Multiplying and dividing mixed numbers. ______
    Ex: 3¾ times 5½

18. Solving simultaneous equations. ______
    Ex: To find the dimensions of a rectangle whose width is 2/3 of its length, and the perimeter is 80 yards.

19. Understanding the properties of tangents to a circle. ______
    Ex: The use of the center-head square to find the center of round bars.

20. Solving fractional equations. ______
    Ex: To find the value of x in $\frac{5}{3} = \frac{x + 2}{x}$

21. Solving problems in which lines meet a plane at specified angles. ______
    Ex: The construction of braces for an upright.

22. Using determinants. ______
    Ex: Find, by determinants, the area of a triangle having the vertices: $(-1, -2), (3, -2), (1, 5)$.

23. Deriving or showing the relationships of the sides of common figures. ______
    Ex: To prove that the area of a triangle is the product of one-half of the base times the altitude.

24. Multiplying or dividing denominate numbers. ______
    Ex: To find the number of board feet in a piece of wood 1 ft. 4 in. wide and 3 ft. 7 in. long.

25. Using the properties of isosceles triangles. ______
    Ex: Constructing the bisectors of lines or angles.

26. Solving quadratic equations by factoring. ______
    Ex: Factor to find the value of x in $x^2 - 7x + 12 = 0$

27. Determining percentage relationships. ______
    Ex: 4 is what percent of 56?

28. Using the theory of equations. ______
    Ex: To find, by synthetic division, the quotient of $(2x^4 + 6x^3 - 8x + 10) \div (x + \frac{1}{2})$

29. Using the relationships of similar shapes, such as triangles, squares, circles, or other shapes. ______
    Ex: To construct a larger triangle similar to a given triangle.

30. Using the equation $y^2 = 4px$ to describe or plot a parabola. ______
    Ex: To plot or describe the figure represented by the equation $y^2 = -8x$

31. Constructing equal or proportional parts or ratios. ______
    Ex: To divide a board into three equal widths.

32. Using radians. ______
    Ex: To find the number of degrees in 2.3 radians.

33. Solving problems relating to conic frustums.
    Ex: To find the area of the side of a funnel or the side of a conventional pail.

34. Finding the areas of triangles by the use of the tables of the trigonometric functions of angles.
    Ex: To find the area of a triangle when you know two angles and a side of the triangle.

35. Expanding a binomial by the use of the theorem.
    Ex: To expand or multiply out the following expression by the use of the binomial theorem. $(A - 1)^6 =$

36. Using relationship of the altitudes and the areas of sections formed by the intersection of planes parallel to the base of pyramids.
    Ex: To find the dispersion or intensity of light, sound, or other forms of radiation at given distances from the source.

37. Finding the angles or sides of obtuse triangles.
    Ex: To find the other sides of a triangle when you know two angles and an adjoining side.

38. Recognizing and manipulating of monomial factors.
    Ex: To factor expressions similar to $3\pi + 6\pi^2$

39. Determining the slope of a line from its coordinates.
    Ex: To find the slope of a line from the expression $M = \frac{Y - Y_1}{X - X_1}$

40. Adding and subtracting mixed numbers.
    Ex: To add 3 2/3, 4 1/3, and 5 1/3.

41. Solving of right triangle problems using the trigonometric function of the angles.
    Ex: Finding the taper angle.

42. Solving first degree equations.
    Ex: To solve for x in $5x - 1 = 3x + 7$

43. Using graphic solution of systems of non-linear equations.
    Ex: To graph two second degree equations on the same axes to determine the common values of x and y.

44. Involving complex numbers.
    Ex: To represent, graphically, such quantities as $2\sqrt{3} + 2i$

45. Using letters to represent unknown values.
    Ex: To use 3L plus ¾" to represent the length needed for three pieces L inches long and the allowance for kerf and finishing.

46. Recognizing or plotting of curves involving a table of the trigonometric function of angles.
    Ex: The plotting of such curves as those representing the alternating current cycle.

47. Adding and subtracting of fractions when they must be changed to a common denominator.
    Ex: to add 3/4, 1/2, and 1/16.

48. Using fundamental operation involving literal terms.
    Ex: The addition, subtraction, multiplication, or division of values represented by letters.