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# Aptitude and Interest Measures Predictive of Ninth Grade Woodshop Performance

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APTITUDE AND INTEREST MEASURES PREDICTIVE  
OF NINTH GRADE WOODSHOP  
PERFORMANCE

by

Donald Joseph Racky

A Thesis Submitted to the Faculty of the Graduate School  
of Loyola University in Partial Fulfillment of  
the Requirements for the Degree of  
Doctor of Education

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## LIFE

Donald Joseph Racky was born in Chicago, Illinois, October 9, 1910.

He was graduated from Lindblom High School, Chicago, Illinois, June 1928, and from Chicago Normal College, Chicago, Illinois, June 1931, with a Manual Training Teaching Certificate. He was graduated from DePaul University, Chicago, Illinois, June, 1937, with the degree of Bachelor of Science in Education and from Loyola University, Chicago, Illinois, June 1941, with the degree of Master of Education.

From 1931 to 1937 the author taught in the Public Elementary Schools in the City of Chicago, Illinois. In 1937 he was assigned to teach Industrial Arts at Lindblom High School, Chicago, Illinois, and in 1939 at Gage Park High School, Chicago, Illinois. Since 1944 he has taught Woodworking at Harrison High School, Chicago, Illinois. In April, 1959, he was awarded the certificate of Principal in the Chicago Public Schools. He began his present graduate studies at Loyola University in February, 1954.

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## CHAPTER I

### INTRODUCTION

For American children who have "entered their teens" and left elementary school behind, further formal education takes on a new look. Previously, their learning experiences have followed routines and regulations which have been similar to most children of like age or grade. "Teen-age maturity", however, has evolved urgent and distinct "individual differences" which no longer can be satisfied by like training for all. Thus, educators have set a point at the end of eighth grade and about student age of fourteen as an appropriate and practical time, both in terms of individual psychological development and in administrative organization, to provide an adjusted educational program, designed to meet an ever increasing variety of demands for instruction on the "high school" level.

It is usually accepted that the growth of intellectual abilities, as reflected by a student's standardized test scores, has been "stabilized" at this age period to the extent that an eighth grade test is likely to prove almost as reliable as a twelfth grade test for evaluating innate individual potentials.<sup>1</sup>

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<sup>1</sup> Henry Chauncey, "The Identification and Education of the Academically Talented Student in the American Secondary School"; Conference Report, National Education Association, February, 1958, 32.



However, although young people's minds may be assumed to be approaching capacity development at this time, their judgments, which depend upon experience as well as interest, may not, at the same time, be assumed to be mature. Upon this premise our guidance motives are neither to hurry them into decisions nor to make decisions for them.

Generally, our American education system requires students to make differential curricular choices at the end of eighth grade. In consideration of vocational objectives, freshman offerings are confined along beginning lines of specialization through "courses of study" leading to the business world; to college and the professions; to college - or not - and technical fields; or elsewhere. Because these freshman decisions have important long-range implications in educational and vocational progress, adequate guidance is of precise importance to the beginning high student.

#### Purpose and Justification of the Study

This paper concerned freshman boys who have "chosen" woodshop classes at Harrison High School during a period of three semesters, from September, 1956, to January, 1958. Freshman woodshop memberships were studied in response to many nationwide claims; (1) the shop classes are being used widely as "dumping grounds" for slow learners or non-conformists;<sup>2</sup> (2) that, with respect to "technical course" assignments, high school "guidance" has failed largely in its

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<sup>2</sup> Donald B. McKay, "Realism in Industrial Arts", School Shop, Ann Arbor, XIII, March, 1954, 28.

most vital obligation -- discovery and development of ability.

This study is justified by the fact that shop teachers everywhere are in agreement that large numbers of boys yearly are wasting time in technical courses for which they are without aptitude or interest. Today, our nation no longer can afford to waste its natural resources - least of all its human ones - least of all the many young men who are being shunted into shop classes without appropriate discretion.

The assistant director of education for the American Federation of Labor claims that far too much of the so-called guidance has been a process of assigning the slow learners to shop classes and the more rapid learners to academic pursuits.<sup>3</sup> In California, Froehlich finds that vocational education courses are used as a "dumping grounds" for academic misfits where too often failures from social studies have been transferred to shop classes. He contends that such procedures are apparently based on the belief that if a person is not bright enough for the so-called academic courses, then he must be able to succeed in shop classes.<sup>4</sup> Bateson states that shop classes are made up of the low caliber students not selected for physics, French, math, history and like subjects.<sup>5</sup>

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3 John E. Cosgrove, "Labor Looks at Industrial Arts", School Shop, Ann Arbor, XVII, April, 1958, 12.

4 Clifford P. Froehlich, "The Weakest Link in the Chain", School Shop, Ann Arbor, XVII, October, 1956, 9.

5 Willard M. Bateson, "These Three Clues Can Mean a Good Drafting Student", School Shop, Ann Arbor, XVIII, September, 1958, 15.

The American Vocational Association objects to vocational education being the dumping ground for retarded students even though some of them might be able to profit if the work were confined to a limited number of manual skills.<sup>6</sup> Schuessler<sup>7</sup> feels that although the guidance given was well-intended, students are led to believe that they can achieve success in the technical field even though they have not the mental ability to succeed in academic work. A somewhat similar sentiment is embraced by Liska<sup>8</sup> whose study led him to conclude that many academic teachers feel that shop courses are designed for pupils of low mentality while most Industrial Arts instructors are of the opposite opinion, namely, that high degree of intelligence is needed to succeed in shop work.

In a Symposium on Industrial Education in Chicago, Woellner stated that it is not uncommon to find in our schools pupils unable to profit by further formal education, who are, therefore, assumed to be splendid prospects for trade training.<sup>9</sup>

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6 Vocational Education for American Youth, American Vocational Association, Washington, 1954, 7.

7 Carl Schuessler, The Correlation of Mental Ability with Mechanical Ability, Unpublished Masters' Thesis, DePaul University, Chicago, 1956, 1.

8 William Liska, The Correlation of Intelligence with Mechanical Aptitude, Unpublished Master's Thesis, DePaul University, Chicago, 1932, 3.

9 Illinois Industrial Education Association, ed, Industrial Education, Chicago, 1940, 43.

Although the trend of placing the pupil with low mental ability in shop appears to be nationwide, the author is immediately concerned with the transition of boys from the eighth grade of the elementary schools to the ninth grade in the public high schools in the City of Chicago. Based on their scores in reading, arithmetic and intelligence tests administered in the eighth grade, pupils are classified for entrance into high school Minimum Essentials, Regular or Honors program.

Certain criteria have been established for the enrollment in each of these programs.<sup>10</sup> Minimum Essentials classes for the slow learners, who are likely to be potential drop-outs, set an I.Q. below 90, reading score below 7.0 and mathematics score below 8.0. A typical program for a person in the first year of this Minimum Essentials program would consist of reading, essential mathematics, essential science, and shop. It is noted that while the English, mathematics and science classes are designated as minimum essential, no such classification is given to the shop.

A freshman student with an I.Q. of 115 or above and a reading score of 10.0 or above when he enters as a freshman would be placed in the Honors program. His schedule would consist of honors classes in English, algebra, and biology, but not honors shop. If he selects shop, he would be mixed in the same class as the minimum essentials pupil and the regular or average pupil.

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<sup>10</sup> High School Bulletin, Teacher's Guide for Program Placement of Pupils, Chicago, March 4, 1958.

The Honors Program is further extended to the One Hundred Program where the twenty-five best pupils from each semester are selected for college preparatory academic, non-technical courses.<sup>11</sup>

Here, then, is evidence that the nationwide trend is being practiced in Chicago: those pupils with low intelligence scores who are in the Minimum Essentials program are assigned shop work, while the average or regular pupils and the Honors pupils are allowed to select shop, but the twenty-five best pupils are given no shop at all.

The author feels that while some of the minimum essential boys will make a success of shop work, there are many who will be wasting time and might not succeed therein. Likewise, that of the boys in the regular and the honors program, some will advance rapidly while others will not succeed in shop. The purpose of this study, then, is to investigate the predictive value of certain pencil and paper tests in relation to woodworking achievement in order that more thorough guidance may be given to the eighth grade boys when they are preparing to enter high school. This study will consider the following questions:

1. What types of measurement are most appropriate in evaluating students' aptitudes for and interests in woodshop?
2. How valid are the various "measures" as criteria for estimating

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<sup>11</sup> Blanche B. Paulson, "Proposals for the Selection of Students in the 100 Program", Chicago Board of Education, 1958, 2.

- students' potentials for woodshop achievement?
3. What are the most effective means of employing scores or measures to obtain the most reliable predictions of shop success?
  4. How large are the errors of the obtained estimates?
  5. What recommendations can be made toward adequate programs of guidance for freshman high school students who enroll in woodshop classes?

#### Scope and Limits of the Study

Although this study attempted to investigate the predictive value of certain paper and pencil tests scores in relation to woodworking achievement, it has definite limitations. No attempt was made to classify the incoming freshmen into types of courses such as commercial, academic or technical. In the first two courses, shop work may be selected as an elective; in the technical course, three years of shop are required. Regardless of the course chosen, the predictive value should remain the same.

The investigation was based on the assumption that woodshop will be the beginning or first shop encountered by the freshmen as they enter high school. Should an individual school have a variation in the scheduling of shop sequence, the predictive value may differ. It must be realized that the generalizations of this study can be applied only to a limited extent to students enrolled under like circumstances in similar situations.

### Methods to be Used in the Study

Most of the studies concerning aptitude and interest testing have been essentially statistical studies touching only a few phases of this problem, and as a result have not covered the whole problem of prediction of high school woodshop success. A true evaluation of any prediction should include consideration of the many components which comprise the program; intelligence, interest, mechanical aptitude, age and certain biographical information. Therefore, it was the intention of the author to investigate the predictive value of the entire problem as it applies to freshman woodshop at Harrison High School in the City of Chicago, rather than a few isolated factors of the problem as shown in the methods to be used.

The procedure of predicting ninth-grade woodshop performance was approached by nine steps:

1. A review of previous research on the problem of predicting shop success by means of intelligence, mechanical aptitude, and interest tests.
2. Administering a battery of selected test materials; two intelligence tests, the Kuhlmann-Anderson Intelligence Test H and the S.R.A. Primary Mental Abilities Test AH, Ages 11 to 17; two mechanical aptitude tests, the S.R.A. Mechanical Aptitude Test AH and the MacQuarrie Test for Mechanical Ability; two interest inventories, the Garretson and Symonds Interest Questionnaire for High School Students and the Kuder Preference Record Vocational Form CH; and a personal data questionnaire devised by the author, to nine classes

of 215 freshman boys registered in the woodshop classes at the Harrison Technical High School in Chicago during the fall semester beginning September, 1956.

3. Setting up two woodworking projects common to the nine classes. A rating scale for evaluating the projects is to be set up. Each separate project is to be graded by three woodshop teachers. For the purpose of this study, the average of the mark will be accepted as the grade.
4. Obtaining the final class grade for each boy.
5. Studying the relationship between the predictor variables; intelligence quotient, mechanical aptitude score, interest score, age and questionnaire score; and the criterion variable, final class grade, by appropriate statistical technique with a view to optimum prediction and/or classification according to future performance in woodshop. The multiple regression technique was used.
6. Comparison of the test scores of the original group of 215 freshmen at Harrison High School with the scores obtained from a group of 30 general sequence, non-technical boys at Harrison High School.
7. Comparison of the test scores of the original group of 215 freshmen at Harrison High School with the scores obtained from a group of 43 boys in the Foundry Shop at Harrison High School.
8. Studying the relationship between the variables after administering the same battery of tests to 142 freshman boys in two other selected



Chicago High Schools during the spring semester beginning February, 1957.

9. Cross Validation of the obtained results with a second group of 79 freshman woodshop boys at Harrison High School one year later, September, 1957.

Since high school shop teachers have lamented that the school shops have been used as a dumping grounds for the slow learners and the non-conformists, it would seem more appropriate, instead, to select boys for woodshop on the basis of many factors, mechanical aptitude, interest, intelligence, and environmental items. In the following chapter, the status and present trend of woodshop will be more fully discussed.

## CHAPTER II

### STATUS AND PRESENT TRENDS IN WOODSHOP

#### Nature of Shop Instruction

The earliest attempts to include manipulative type work in the schools were designed to serve these two main purposes: to develop certain tool skills and to provide for constructive use of leisure time. Various supporters of manipulative work opened a number of industrial schools around Boston in about 1860. The classes, which were often held after regular school hours or on Saturdays, were not permitted to take the place of regular school attendance.<sup>1</sup>

The first industrial arts program was introduced into the public high schools in 1870. The introduction of the sloyd manual training program brought this about. Although there was some vocational value in the manual arts program, its chief justification was on disciplinary grounds. Later the program began to turn more and more in the direction of vocational values.<sup>2</sup>

In the early days of manual training the work a student performed

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1 C. J. Gerbracht, "Industrial Arts in Elementary Education", Industrial Arts and Vocational Education, Milwaukee, 45, January, 1956, 1.

2 Thomas C. Veneable, Patterns in Secondary School Curriculum, New York, 1958, 167.

very often did not result in a useful product, but only some sort of exercise, for example, a wood joint. In the later 1880's fairly small objects of value were produced. These were usually arranged in a series of increasing difficulty.

The term "manual arts" began to replace the term "manual training" between 1890 and 1910 in an attempt to rectify the three criticisms directed against the program: (1) too much emphasis on skill, (2) little concern to good design, (3) no relation to activities in the rest of the curriculum.<sup>3</sup>

The influence of Herbart was felt when handwerk construction activities were used to facilitate the teaching of the regular subjects. John Dewey's notion that school experiences should start with real activities cast doubt on the validity of a sequence of manipulative exercises of even useful products. These activities were later expanded to include appreciation and understanding of the industrial world and intelligent selection and use of industrial products.

The term, "manual arts", now seemed inadequate, since the products selected and used were rather the result of mechanical than of manual process, and since the many and varied industries to be studied became more and more mechanized. Since 1904, when it was first suggested, the new term, "industrial arts", has gained wide acceptance as properly describing the work done.

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<sup>3</sup> Gerbracht, "Industrial Arts in Elementary Education", Industrial Arts and Vocational Education, 45, 2.

As the industrial arts<sup>4</sup> concept replaced the manual arts concept, there was a general decrease in the amount of work done with machines. Herbert A. Sotzin says:<sup>5</sup>

Industrial Arts is that part of general education concerned with satisfying man's innate desire to construct with concrete materials and the development of an intelligent understanding of our modern industrial civilization and the problems which have resulted from it, through contacts and experiences and tools of manufacture.

Its function in the total school program is an integral part of general education. It occupies the same relationship to the school's curriculum as the areas which comprise social studies, health activities, fine arts, language studies, etc. It does not attempt to develop skills to earn a livelihood. This is left to another field of education known as vocational education.

According to a survey conducted in 1949, about 25.5 per cent of all pupils in grades seven through twelve in public schools are enrolled in industrial arts courses.<sup>6</sup> However, industrial arts is offered in only about

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4 Gilbert G. Weaver, "Definitions of Terms in Vocational and Practical Arts Education", American Vocational Association, Washington, 1954, 15. "Industrial Arts - instructional shopwork of a non-vocational type which provides general educational experiences centered around the technical aspects of life today and offers orientation in the areas of appreciation, production, consumption, and recreation through actual experiences with materials and goods. It also serves as exploratory experiences which are helpful in the choice of a vocation."

5 Herbert A. Sotzin, "A Comparison of Industrial Arts and Vocational Education", Industrial Arts and Vocational Education, XXXII, April, 1943, 152.

6 U. S. Office of Education, "Offerings and Enrollments in High School Subjects", Government Printing Office, Washington, 1951, 19.

half of the public secondary schools in the United States.<sup>7</sup> It is the smaller high schools which generally fail to provide an industrial arts program.<sup>8</sup>

The Chicago Board of Education offers three distinctly different shop services on the high school level. These are the general comprehensive high school, the technical high school, and the vocational high school. The general aim of all three categories is to teach good character building and knowledge and appreciation of the American way of life. These patterns of training will find reflections in human living from day to day.

The general comprehensive high school aims to help youth to discover and improve latent possibilities which may be suited toward useful human endeavors.

The technical high school, such as Harrison Technical High School, offers a general program with emphasis on knowledge, skill, and appreciation of technical training. Through experiences in many shop, drafting, and other related courses, students in these schools are prepared to enter technical fields of endeavor, or to enter general and engineering colleges.

The vocational high school in the Chicago program prepares youth for a specific vocational place in business and industrial economy.

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7 W. E. Warner, "A Directory of Industrial Arts Teacher-Education Programs and Personnel in the United States", American Industrial Arts Association, 1941, 11.

8 C. J. Gerbracht, "The Trend is Evident", School Shop, Ann Arbor, XIV, October, 1954, 13.

The relation of woodshop as a phase of the general education program in these various types of high schools in Chicago may be considered as:

(1) an elective course in a two year sequence in the general high school after the student has had a course in Industrial Arts, (2) a required course in a three year shop sequence in the technical high schools where it is considered to be the most adaptable of all shop courses for students without previous shop experience, (3) vocational in nature in the junior and senior years of the vocational high schools.<sup>9</sup>

The function of the shop in the various types of high schools determines the type of woodshop. At Harrison, woodshop would be classified as a limited general woodshop in which the activities and facilities are limited to working with a single basic material, wood, or to a closely related group or family of industries including such activities as cabinet making, carpentry, wood finishing, upholstery, wood carving, wood turning, model making, and pattern making.<sup>10</sup> This type of organization is in contrast to the comprehensive general shop which conducts a multi-activity program in which two or more areas are handled simultaneously in one shop by one teacher. The Industrial Arts

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<sup>9</sup> Hobart H. Sommers, "This is Vocational Education", Chicago Board of Education, Chicago, May, 1951, 37.

<sup>10</sup> Chris Groneman, "A Guide to Improving Instruction in Industrial Arts", American Vocational Association, Washington, June, 1953, 31.

Laboratory which operates in the comprehensive general high schools in Chicago is an example of this type of organization; or (2) the unit shop in which the activities are limited to a single industrial occupation, cabinet making, pattern making or carpentry. Such organization is found in the third and fourth years of the vocational high schools in Chicago.

### Objectives

For countless generations men have chosen, hewn, and cut many kinds of wood to house themselves and their possessions. Wood has been carved, fashioned, and shaped to satisfy practical and aesthetic needs for the homes of many people. Modern methods of enhancing its natural beauty, clever fabrication, and artistic styling have kept wood in a top ranking position over more recently developed building materials.

Woodshop seeks to acquaint young people with the mechanical and hand processes of the woodworking industry. This acquaintance, made through the use of well selected projects, related reading, and manipulative experiences, will give the young citizen important knowledge and some fundamental skills. The student's experiences in woodworking should result in an appreciation of the processes and methods through which crude materials are made usefully attractive and salable.

The materials of instruction outlined in the subsequent pages are designed for the total program of education in accordance with the philosophy and objectives of the Curriculum Council of the Chicago Public Schools. Aims

specifically relating to instruction in woodwork are as follows:<sup>11</sup>

- I. To introduce the student, who has little or no experience, to unit shopwork and to develop within the individual good shop habits.
- II. To develop the ability to care properly for tools and to use them with a reasonable degree of skill.
- III. To provide the opportunity for the students to work together and to develop safe work habits.
- IV. To allow machine experiences on such machines which can be safely operated by beginning students.
- V. To teach the basic related information pertaining to woodwork, and to provide experiences in the reading of plans and drawings.
- VI. To develop an interest in woodworking and to acquaint the student with vocational possibilities in the woodworking industries.

#### Ability Needed to Succeed

There is a definite need for a positive approach to the selection of students for technical work in our high schools. Our selection must reach out and identify those who can profit from shop training as well as to deny admission to those who are not qualified.

The lack of standards of admission has placed us in our present dilemma. As has already been noted on page 2, there has been a nationwide

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<sup>11</sup> "Woodwork, A Guide for Teachers in Chicago Public High Schools", Chicago Board of Education, 1954, 1.



trend to use the shops as a dumping ground for academic misfits. This problem can be met by doing away with the old concept of selection and by substituting the guidance process in its place.

The guidance phase is the primary concern of educators who must evaluate the student in terms of his ability to profit from the kind of training offered. They must be able to tell him what are his chances for success and how tough the competition is going to be. It must be recognized that each student has a different probability of success, that standards must be adjustable in terms of unique characteristics of each student.

To accomplish this task we must collect all the possible facts that may have meaning for the student as he makes his decisions and educational plans.

We can estimate to some degree the pupil's stability of purpose. How great is his desire to enroll in shop work? Is it based on the result of failure in academic subjects, or in long time interests in mechanical or industrial things? This stability of purpose which provides the drive or power of perseverance can be evaluated from interest inventories.

Since this chapter is concerned with collecting data for use by the school in its guidance activities, the significance of an individual pupil's intelligence quotient claims attention. Intelligence has frequently been defined as the ability to adjust to the environment or to learn from experience. For our present purposes one might say that intelligence is the ability to

succeed in school, or as many schools now refer to it as scholastic aptitude.<sup>12</sup> Meyers has presented evidence that a pupil's intelligence quotient must have an important relation to the amount of schooling which is practical for him to undertake.<sup>13</sup>

Another factor which claims attention in the list of psychological data needed for guidance purposes is the possession of special aptitudes which makes an individual better suited to one high school course than to another. It is well known that two people of approximately the same general ability differ a great deal in the ease and readiness with which they can learn shop-work. It is clear that there is something which, if discoverable and measurable in advance of vocational choice and preparation, should prove of great value in counseling.

However complete and accurate be the information gathered concerning an individual from tests, inventories, and other measuring instruments, it is still desirable to obtain considerable data concerning his social environment. These data are a valuable aid to understanding and interpreting the data from other sources. Moreover, they themselves give important suggestions as to what may be expected of an individual. What he will do in a particular situation often depends on conditions that belong to his social environment.

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12 Donald Super, Appraising Vocational Fitness, New York, 1949, 86.

13 George E. Meyers, Principles and Techniques of Vocational Guidance, New York, 1941, 177.

In this study a specially designed personal data questionnaire was used for the purpose of obtaining certain significant data concerning the individual's home and associations outside the home.

Finally, data are necessary concerning the individual's age. When a student enters high school at an age not within the normal expected range, the problem of the effect of experience enters in. Differences in maturity of individuals have always been observed. The effect of the role of maturation upon success in woodshop is the type of question that calls for attention here.

#### Materials of Instruction

In order to accomplish the objectives that are accepted for wood-working, it is necessary to use many instructional materials, techniques, and methods of procedure in presenting situations that are conducive to learning. The most frequently used are these:

1. Verbal material - including planned lectures, class discussion, and printed instructional materials.
2. Teacher demonstrations - including machine operation, safety precautions, handling of tools, the processing of materials, layout procedures, use of measuring instruments, and the interpretation of blueprints and sketches.
3. Visual and audio-visual aids - including charts, photographs, film-strips, models, field trips, exhibits, and motion pictures.

4. Laboratory practices - including the operation of machines, the use of tools, and a more comprehensive examination of materials by the students.

Each of the foregoing methods of instruction is of great importance. Each method however, should be evaluated in terms of what it will contribute to a given task before too much emphasis is placed on any one method or any combination of them.

In the school situation under consideration, the teacher must plan activities to fit into two periods of forty minutes each, plus an interval of four minutes when academic classes change rooms. This length of time seems quite adequate for shop classes even though at least fifteen minutes is consumed in the handling of tools and materials. This provides for sixty-nine minutes of actual class work.

After careful consideration of the characteristics of adolescents and of the objectives provided for them, it is suggested that 80 per cent of the class time be spent for manipulative work. Approximately 20 per cent of the time will be given over to related work and demonstrations.<sup>14</sup> This course of action will be followed except on occasions when motion picture films require the use of the entire 80 minutes to present and review a film.

The major influences favorable to providing a large proportion of

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<sup>14</sup> Louis V. Newkirk, "High School Course of Study in Industrial Arts", Board of Education, Chicago, 1940, 2.

the period for manipulative work may be listed as follows:<sup>15</sup>

1. The innate desire of human beings to create worthwhile objects;
2. The restlessness of adolescents when they are restrained from participating in activities which seem important to them;
3. The very nature of the course which demands such a procedure.

In order to avoid unnecessary loss of time, tools are mounted on wall panels so that the student may select and replace them rapidly. Necessary materials are rationed and made available to each student to provide for the least loss in time in issuing them.

Each pupil is assigned a permanent work station, and is expected to leave it clean and orderly at the end of the class period. This eliminates the necessity for making special daily assignments for this task.

As a means of recording classroom activities and progress of pupils, the following list of forms is used:

1. A record card listing certain personal data.<sup>16</sup>
2. A related lesson topic sheet to show dates of topics and demonstrations given.<sup>17</sup>
3. Individual project records for each pupil.<sup>18</sup>

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15 William L. Lewis, "A Two Year Industrial Arts Woodworking Course", Industrial Arts and Vocational Education, Milwaukee, 46, February, 1957, 42.

16 See Appendix 1, P 112.

17 See Appendix 2, P 113.

18 See Appendix 3, P 114.

Initially, shop work in the schools started as a manipulative activity, progressing from sloyd to manual training to the present industrial arts. The major difference between these activities is in the inclusiveness of the objectives; the latest trends shift from manipulative processes toward social adjustment. As the pendulum of educational philosophy swings, emphasis is now placed on that special education which at the present time is called "general education".

The teaching of woodshop involves class lectures, demonstrations, reading assignments, a system of records and tests, and many other devices, primarily, the manipulation of tools and materials suited to the mechanical and intellectual ability of the pupil and his span of interest. The way in which these various abilities affect shopwork will be clarified in the next chapter.

## CHAPTER III

### REVIEW OF THE LITERATURE

To understand children better, to guide them more intelligently, it is important to clarify the meanings of the factors that will be involved in this study. The first part of this chapter will deal with the clarification of these meanings, while the second part of the chapter will review a number of studies concerning the prediction of success in shopwork.

#### Survey of Psychological Data

##### Intelligence

One of the most important ways in which children differ is in intelligence. Although these differences are present at birth, they become easier to detect as children grow older. Yet, intelligence is not easy to define. Not all psychologists agree as to exact nature of intelligence. Terman says, "An individual is intelligent in proportion as he is able to carry on abstract thinking."<sup>1</sup> Van Wagenen treats intelligence as "capacity to learn and to adjust to relatively new and changing conditions."<sup>2</sup>

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1. L. M. Terman, "Intelligence and Its Measurement", Journal of Educational Psychology, March, 1921, 128.

2. M. J. Van Wagenen, "Intelligence and Its Measurement", in Readings in Educational Psychology, Charles Skinner, ed, New York, 1937, 401.

Boynton defines intelligence as "an inherited capacity of the individual which is manifested through his ability to adapt to and reconstruct the factor of his environment in accordance with the most fundamental needs of himself and his group".<sup>3</sup>

Spearman has presented what is called the "two-factor theory" of intelligence, one factor being general and the other specific.<sup>4</sup> Thurstone stressed the "multiple factor" theory which recognizes intelligence as consisting of several abilities, seven of which have been identified: (1) number ability, (2) word fluency, (3) space, (4) memory, (5) perceptual speed, (6) reasoning, and (7) verbal comprehension.<sup>5</sup>

While psychologists are agreed that it is quite impossible at any point in an individual's life to make clear-cut distinction between his native capacity and the effects of general environment and formal education upon that capacity, nevertheless, it has long been recognized that there are important differences among individuals with regard to such native capacity.<sup>6</sup> In this respect human beings are not born equal. They range from the helpless idiot on one hand to the most brilliant genius on the other. These two are at

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3. Paul L. Boynton, Intelligence: Its Manifestations and Measurements, New York, 1933, 19.

4. Charles Spearman, The Nature of Intelligence and the Principles of Cognition, New York, 1927, 342.

5. L.L. Thurstone, "A New Conception of Intelligence", Educational Record, XVII, July, 1936, 441.

6. Meyers, Principles and Techniques, 171.



birth equally helpless. One, lacking in native intellectual capacity, remains helpless as long as he lives, in spite of the best environment. The other child rich in this native capacity, develops rapidly under the influence of favorable environment until he is able to discharge life's most difficult situations efficiently. There is evidence to indicate that the native capacity of humans beings on the whole exhibit quite generally the fundamental characteristics of the normal curve of distribution.<sup>7</sup>

According to Burks, about 17 per cent of the differences in intelligence among individuals is due to differences in home environment, though "home environment in rare cases may account for as much as twenty points of increment above the expected level."<sup>8</sup> Bingham concludes that, according to evidence now available, there is about 1 chance in 22 that an I.Q. will increase or decrease as much as 12 per cent during a four year high school period.<sup>9</sup>

The traditional measure of intelligence is the general intelligence test that is used in many schools. Today's intelligence tests help to distinguish not only the mentally handicapped, but also the mentally gifted. These tests have become increasingly valuable to teachers in helping all.

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7. Anne Anastasi and John Foley, Differential Psychology, New York, 1949, 84.

8. Barbara Burks, "Nature and Nurture", Twenty-Seventh Yearbook National Society for the Study of Education, Bloomington, 1928, 308.

9. Walter V. D. Bingham, Aptitudes and Aptitude Testing, New York, 1937, 40.

children to succeed better in school, to outline their educational futures, to plan their careers, and to find satisfying leisure time activities.

Intelligence tests do not measure all of a person's ability. They do, however, give an estimate of one very important aspect of it, an aspect which is definitely related to academic success and, in a lesser degree, to achievement in most other fields. Intelligence tests have become, therefore, valuable instruments in education. The intelligence test is the best general measure of a pupil's capacity to succeed in his school work.<sup>10</sup>

### Special Aptitudes

Aptitudes may be considered to be a measure of present characteristics that have been found to be predictive of capacity to learn. English and English in their Comprehensive Dictionary of Psychological and Psychoanalytical Terms defines aptitude as: "The capacity to acquire proficiency with a given amount of training, formal or informal."

Bingham,<sup>11</sup> who gives the most comprehensive explanation of aptitudes, states: "In referring to a person's aptitude for mathematics or art or carpentry, we are looking to the future. His aptitude is, however, a present condition, a pattern of traits, deemed to be indicative of his potentialities."

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10. Arthur Gates, Arthur Jersild, T.R. McConnell, and Robert Challman, Educational Psychology, New York, 1948, 267.

11. Bingham, Aptitudes and Aptitude Testing, 16.

The student's readiness to develop an interest in his potential ability, his ability to become thoroughly engrossed in his work, and his ability to perform a satisfactory level of competence may be considered as measures of aptitude according to Bingham.<sup>12</sup>

Aptitude may be thought of as approximating a normal curve of distribution. With such a view, aptitude should be considered as being present in terms of degrees. There will be a few individuals who will show little or no aptitude, for instance, for woodshop. It would be justifiable to consider these people as occupying the lower end of the normal curve. At the upper end of the curve will be found, similarly, a small number of individuals whose aptitude for woodshop is exceptional in nature. Neither extreme is frequent. Generally, aptitude tests indicate that most students have average ability for a given activity.<sup>13</sup> An individual may or may not have an equal potential ability for all activities. He may have considerable aptitude for woodshop, but only a low degree of aptitude for music.<sup>14</sup> Aptitude can be thought of as an ability for a particular line of work. Some individuals have potential ability for numerous activities, while others possess ability for only a few activities.

One method of ascertaining an individual's aptitude for a particular activity is to set him at a definite assignment for a reasonable length of

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12. Ibid., 17.

13. J. Resnik, "Aptitude or Aptitudes", Education, 70, 1951, 606.

14. Ibid., 607

time and observe his efficiency. If, after an adequate amount of training, he shows poor performance, it can be assumed that this individual has little aptitude in this field.

Aptitude testing can often give an indication of possible success or failure in a specific vocation. Take as an example a student who wishes to be a cabinet maker. If his interests are mechanical in nature, his health good, past scholastic achievement satisfactory, ability relatively high, and aptitude and personality factors favorable, it may be assumed that the student would be more apt to succeed at his occupational choice than if he lacked these essential elements.

Available tests in mechanical abilities, as well as other abilities, are useful in distinguishing those who are markedly deficient; these tests have not been found adequate, however, to identify those who are markedly gifted. On a mechanical aptitude test a child whose score places him in the lowest 10 per cent of the population is quite certain never to become an expert mechanic. It is not possible to predict with absolute assurance that a child who places within the top 10 per cent, or even the top 1 per cent, will develop proficiency in mechanical work.<sup>15</sup>

The results of a mechanical aptitude test serve only as one possible source of information giving a general indication of an individual's degree of talent, but not as the sole criterion of his promise. Consideration must

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15. Test Service Bulletin, "Identification of the Gifted", World Book Co., 7, Yonkers-on-Hudson, 1947, 6.

be given both to the results of such tests and to other such data about the individual as intelligence test scores, interest test scores, and evidence concerning his personal and social life.

### Interest

Closely related to aptitude testing are the efforts that have been made to determine the interests of individuals. Interesting activities are pursued more vigorously and with greater satisfaction than uninteresting tasks. When boys and girls reach high school, their interests are a strong motivating force for learning. Their interests act as an incentive to do good work in English, in shop, and in other school subjects. In high school, boys and girls have many opportunities to select their own school subjects and activities. These subjects and activities are important because they provide experience in helping young people make career choices or choices of hobbies.

In every school there are many activities and electives that fit individual interests of the students. When we know the pupil's interests, we can suggest activities and courses that use these interests. We can thus make school more meaningful to children and give direction to their work. Interest inventories help us discover the degree to which a student possesses the general pattern of interests that characterize successful workers in a specific high school subject.

### Personal Data

The development of an individual is determined by the life-long interplay of heredity and environment of the individual. The richer a child's environment, the more likely he is to discover that his developing interests

and abilities have vocational possibilities. The more depraved his environment, the more deadening he will find it upon his interests and abilities. The use that an individual makes of his environment depends upon his interpretation of it, which in turn reflects the nature and extent of his personal development.

Attention should be given, therefore, to a group of items concerning each pupil's home environment. The relationship that exists between the various members of his family, whether his mother and father are living and/or living together with the rest of the family deserve consideration. The occupation of the parents indicate approximately their economic status, their cultural background, and the occupational contacts gained by the student in his home. The employment of the mother outside the home suggests lessened parental supervision of the activities of the pupil. It may also indicate a lower economic status.

The plans of the parents for their children are worthy of note. Parents are more vitally concerned than anyone else; they know their children well, and they know what they can do in helping the child to get started in life. In many cases, the plans of students are supported by the ambitions of parents, while in others they may be in conflict with the parent's desires.

The pupil's reactions of all kinds deserve attention. The amount and character of his voluntary reading, the type, extent, and setting of his social activities, his amusements and hobbies -- these should be considered.

The general type of neighborhood in which the pupil lives and finds his companions is an item which may exercise great influence on him. The clubs, "gangs", societies, and other neighborhood and school organizations .

of which the pupil is or has been a member, and the general characteristics of his friends should be taken into account.

### Achievement

The psychological characteristics of the individual pupil and the more significant environmental influences which affect him have been noted; his achievement also deserves consideration. What has he done?

The pupil's accomplishments in his school subjects have always been a matter of great concern. More care is usually taken to preserve the marks as permanent records than just what goes to make up a mark. A teacher's mark often represents not only achievement, but also the teacher's estimate of native ability, effort, attitude, and other similar factors.<sup>16</sup> It must also be kept in mind that standards for marking pupils differ for each individual teacher.

Moreover, it should not be forgotten that one single mark covering an entire semester's work does not always fairly represent the actual work done by the pupil. A pupil may deserve a poor mark on every unit except one, and an "A" on that one unit. This is especially true of shopwork.

In an effort to obtain greater reliability in pupil's marks, a Chicago high school pupil is rated by his teachers on personal traits of courtesy, dependability, leadership, and service independent of his achievement in that subject.

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16. Meyers, Principles and Techniques, 232.

The types of variables just mentioned, intelligence, aptitude, interest, personal data, and achievement represent important aspects -- all which should be represented in a multiple prediction type of analysis.

### Predictive Studies

Psychological testing has come into increasing use during the past two decades in both industry and education. One of the techniques which has been developed is that of administering a battery of psychological tests to a large number of individuals in an attempt to determine the pattern of abilities necessary for success in various fields of endeavor.

However, the problem of predicting success in high school shopwork has received relatively little attention. Van Winkle<sup>17</sup> found a dearth in prognostic studies at the ninth grade level.

One reason advanced for the relative paucity of good research applies to public vocational schools. Students are frequently assigned to shop classes because of inability to adapt to academic curriculum. Students are thus negatively selected; those unable to master academic subjects, who must or wish to remain in school are compelled to take vocational courses. The schools are not able to exercise any positive selection. This situation discourages research on the selection of vocational school students.<sup>18</sup>

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17. Keith Van Winkle, Predicting Achievement in Junior High School Required Industrial Arts, Unpublished Master's Thesis, Iowa State College, 1950, 5.

18. C. H. Patterson, "Predicting Success in Trade and Vocational School Courses", Educational and Psychological Measurement, XVI, Autumn, 1956, 353.



Numerous studies have borne out the fact that intelligence, as measured by intelligence tests, is rather closely associated with general scholastic success, especially in subjects that demand linguistic ability and the acquisition and manipulation of abstract ideas.<sup>19</sup>

When comparisons of different vocations are made, there is a definite tendency for vocations that require facility in dealing with words and symbols to stand higher on the intelligence scale than those that require aptitude for manipulative things and mechanisms. The clerical workers in general excel those engaged in mechanical occupations. The more skilled workers appear to stand higher on the test than the less expert.<sup>20</sup>

In a group as a whole, within similar occupational lines, intelligence, (as measured by tests) is associated with levels of proficiency. This phenomenon is probably due in part to the fact that the better the position the greater is the need for ability to deal with abstract facts, and in part to the fact that the higher the position the more is education required of those placed in that position. Students in engineering are in the top section of the list with an I.Q. of 124 to 129, whereas electricians, foremen and mechanics are below 115; the general electrician and the machinist helper are below 110; workers in specific tasks (e.g., carpenter, plumber, welder) are below 100; unskilled laborers are at the bottom of the list.<sup>21</sup>

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19. Gates, Educational Psychology, 249

20. Ibid., 250.

21. Naomi Stewart, "A.G.C.T. Scores of Army Personnel Grouped by Occupation", Occupations, XXVI, October, 1947, 5.

Gates,<sup>22</sup> in reporting a study by Burt, claims that general intelligence, as measured by intelligence tests, corresponds rather closely to the success of children in the conventional school program; that general intelligence indicates the level, difficulty, or complexity of mental functions which can be acquired, and the rate at which acquisition within these limits may go on. As evidence the correlation between intelligence and various school subjects is cited:

Intelligence and composition	$r = .63$
Intelligence and reading	$r = .56$
Intelligence and arithmetic	$r = .55$
Intelligence and handwork	$r = .18$

This correlation is impressive for all but for handwork, where the relationship is almost negligible.

Horning and Lenard<sup>23</sup> discovered little correlation between mental ability as measured by the Terman Group Test of Mental Ability and mechanical ability as measured by the MacQuarrie Test of Mechanical Ability. The correlation was .02. When, however, the MacQuarrie was correlated with excellence, speed and accomplishment on a project in electrical construction, the correlation ran .66 with excellence, .72 with speed, and .79 with accomplishment.

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22. Gates, Educational Psychology, 253.

23. S. D. Horning and Ruth Lenard, "Testing Mechanical Ability by the MacQuarrie Test", Industrial Arts Magazine, XV, 1926, 384.

Sutherland<sup>24</sup> in summarizing his findings on 210 college freshmen at Iowa State College stated:

1. That the chances against a boy rated as inferior in intelligence doing superior shopwork are about ten to one.
2. That nine out of ten boys of below average intelligence receive shop grades of average or below.
3. That of every two bright students, one will do superior work.
4. That in a group of ten boys of "average" mental capacity, six boys will do average in shopwork.
5. The chances against poor shop grades being received by a student of superior mental capacity are about eight to one; with the inferior student, three to one.
6. But -- that 70 per cent, seven out of ten, of these dull students received shop grades that were better than "just passing".

In attempting to determine the usefulness of five factors in achievement in industrial arts, Van Winkle<sup>25</sup> found that for the prediction of industrial arts marks from a single variable the correlations attained were these:

Intelligence and Industrial Arts marks	.36
Mechanical Aptitude and Industrial Arts marks	.41
Mechanical Interest and Industrial Arts marks	.11
Manipulative Interest and Industrial Arts marks	.09

The, variable, mechanical interest and manipulative interest, failed to prove

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24. S.S. Sutherland, "Correlation Between Intelligence and Skill in Shopwork", Industrial Arts Magazine, XVII, 1928, 204.

25. Van Winkle, Predicting Achievement in Junior High School, 38

significant as predictive factors for industrial arts marks, therefore, these two variables were dropped from the study.

A better prediction was made from the remaining two variables, intelligence and mechanical aptitude. An increase in size of the coefficient of correlation indicates that a significantly better prediction of industrial arts marks can be made when two independent variables are employed; however, the advantage of both over mechanical aptitude alone is not great; the coefficient of correlation was raised from .41 to .46.<sup>26</sup>

In a study of seventy-three senior high school boys at Crane Technical High School in Chicago, Liska<sup>27</sup> obtained the following correlations:

Otis Intelligence and Stenquist Mechanical Aptitude #1	.11
Otis Intelligence and Stenquist Mechanical Aptitude #2	.06
Otis Intelligence and Stenquist Assembling Test	.32
Otis Intelligence and Academic Achievement	.41
Otis Intelligence and Industrial Arts Achievement	.36
Stenquist Mechanical Aptitude #1 and Academic Achievement	.04
Stenquist Mechanical Aptitude #1 and Industrial Arts Achievement	.21
Stenquist Mechanical Aptitude #2 and Academic Achievement	.11
Stenquist Mechanical Aptitude #2 and Industrial Arts Achievement	.41
Stenquist Assembling Test and Academic Achievement	.34

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26. Ibid., 40.

27. Liska, Correlation of Intelligence, 51.

28. Ibid., 47.

## Stenquist Assembling Test and Industrial Arts Achievement

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He summarizes his conclusions as follows:<sup>28</sup>

1. The students of highest mental ability received grades relatively high in their academic achievement.
2. The students of highest mental ability did not, in general, rank highest on tests of mechanical aptitude. They did rank in the upper half of the class.
3. The students who ranked low on mental ability were uniformly low on all other data considered.
4. Of the students who ranked high on all of the Stenquist tests and on achievement in Industrial Arts subjects, the evidence is that their ranks classify them in the upper half of the class on mental ability and academic achievement.
5. Of the students who ranked low on shop achievement and mechanical aptitude scores, the data show a correspondingly low score on mental ability and academic achievement.

Kefauver<sup>29</sup> studied Smith-Hughes students who had been enrolled in the Fresno Technical School a year or more when tested. The criterion consisted of teachers' ranking of products, speed, initiative, dependability, independence and "other qualities required for success in the vocation". Correlation of the Terman IQ was .58 for electrical workers, but not significant for auto mechanics, machine shop or mill cabinet students. The Stenquist Picture I and II correlated .65 for machine shop students, while the MacQuarrie correlated .63 for mill cabinet students.

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28. Ibid., 47.

29. G. N. Kefauver, "Relationship of the Intelligence Quotient and Scores on Mechanical Tests with Success in Industrial Subjects", Vocational Guidance Magazine, XII, 1929, 198.

Barden<sup>30</sup> reports a study in which the Terman Group Test of Mental Ability and the Stenquist Picture Test I were given to two groups of junior high school boys, one group of 100 and another group of 57 for whom senior high school shop grades were later available. Terman I.Q. correlated .24 and .14 with shop grades for the groups respectively. The Stenquist Test had correlations of .06 and .15 with shop grades for the two groups.

A study was made by Novak and Scheuhing<sup>31</sup> of 234 boys in 10th to 12th grade auto and electric shops in Philadelphia. A comparison between the Philadelphia Verbal Ability Test and the senior high school shop grades yielded an r of .19 (137 auto shop students) and .28 (97 electric shop students). They concluded that the Philadelphia Verbal Ability Test score has little value in predicting shop success.

Stenquist<sup>32</sup> in working with 7th and 8th grade boys in Minneapolis in the early 20's found the relationship between the Stenquist Mechanical Assembling Test Series I and I.Q. to be .23 for 267 boys; for the Stenquist Mechanical Assembling Test Series II r = .24 for 100 boys; and for the Stenquist Picture Test II r = .34 for 296 boys. He concluded (1) that in a typical school, at least 20 per cent of the pupils who are below average in general abstract intelligence are above average in the kind of ability required

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30. H. E. Barden, "The Stenquist Mechanical Aptitude Test as a Measure of Mechanical Ability", Journal of Juvenile Research, XVII, 1933, 94.

31. B. J. Novak and Mary Scheuhing, "Predicting Success in High School Industrial Courses", Industrial Arts and Vocational Education, XL, 1951, 391.

32. J. L. Stenquist, "The Case of the Low I.Q.", Journal of Educational Research, IV, November, 1921, 241.

in mechanical tests; (2) that 49 per cent were above average in intelligence. This group was subdivided into below average mechanically and above average mechanically, the percentages being 23 and 26 per cent respectively of the total group tested; and (3) that 31 per cent of all cases were below average mechanically and intellectually.

In working with 171 students in the 7th and 8th grades of the Fontana Junior High School, Hasty<sup>33</sup> was concerned with the mechanical aptitude of boys to see how this measure could be related to the guidance program. By using shop grades as the criterion, he found the following relationships with:

Total I.Q.	.57
Non Language I.Q.	.36
Stenquist Mechanical Ability Test #1	.43
Stenquist Mechanical Ability Test #2	.47
Reading age	.27
Arithmetic reasoning	.33

Between the Stenquist Mechanical Ability Test #1 and I.Q., he found  $r = .19$ .

He concluded that: (1) intelligence as a single factor could not be taken as a measure of probable mechanical aptitude, (2) arithmetic reasoning could not be taken as a measure in predicting mechanical aptitude; (3) reading age has about the same relationship with mechanical aptitude as does intelligence; not of any value in predicting mechanical aptitude; (4) scores on the

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33. Frederick Hasty, An Analysis of Factors Predictive of Mechanical Abilities at the Junior High School Level, Unpublished Master's Thesis, Claremont College, Claremont, California, 1949, 57.

Stenquist test are high enough to be used as part of the measure to predict mechanical ability.

Warner<sup>34</sup> felt that he would be able to save much of the time junior high school boys wasted on their try-out experiences in different fields if he could discover their aptitudes. Working with 60 boys in the Enterprise Junior High School at Compton, California, he collected data on chronological age, I.Q., Shop grade, and three mechanical aptitude tests. The results are as follows:

	I.Q.	Shop Grade	MacQuarrie Test	Stenquist Test	Detroit Test
Chronological Age	-.31	-.21	.15	.13	.09
I.Q.		.18	.37	.26	.33
Shop Grade			.49	.54	.57
MacQuarrie Test				.27	.31
Stenquist Test					.29

Warner made these conclusions:

1. Chronological age showed a negative correlation with shop grades. There is no justification for an assumption that older students might make the best grades in shopwork.
2. A low positive correlation on mechanical test scores showed that older boys benefited by experience and mature physical development.
3. The intelligence quotient is not a reliable base for predicting a boy's success.

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34. Ralph L. Warner, An Experimental Investigation of the Mechanical Abilities of Shop Students in the Junior High School, Unpublished Master's Thesis, University of Southern California, Los Angeles, 1933, 73.



In a study of machine shop work of twenty-five unselected vocational students, Bird<sup>35</sup> found that the correlation of general intelligence with mechanical aptitude was .14. The student that ranked fourth lowest in IQ ranked first in shop attainment, while the student with the highest IQ (range 111 to 71) ranked fourteenth in shop attainment. When Schuessler,<sup>36</sup> on the other hand, in measuring machine shop achievement correlated two of the factors, space and reasoning, from the SRA Primary Mental Abilities Test with project grades, he found the relationships to be .30 and .33 respectively (N = 33).

There was very little difference in the average grade received in shop work when the group was divided according to IQ. The low group with an average IQ of 95.6 received an average shop grade of 79.73 while the high group with an average IQ of 116.6 received an average shop grade of 79.44 in an investigation by Gordon<sup>37</sup> involving 150 boys with an average IQ of 100.6.

Freeman<sup>38</sup> in summarizing a series of studies by Stenquist, Vanuxem, Carter and McElmel states, "The relationship between ability in tests of mechanical aptitude and verbal mental tests have (sic) shown only a very mild degree of correspondence; a correlation coefficient in the vicinity of .30."

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35. Verne A. Bird, "A Study in the Correlation of General Intelligence Quotient to Their Grades in the High School Shops", Industrial Education Magazine, September, 1922, 67.

36. Schuessler, Correlation of Mental Abilities, 29.

37. George Gordon Jr., "The Relationship of Pupil's Intelligence Quotient to Their Grades in the High School Shops", Industrial Education Magazine, January, 1929, 249.

38. Frank Freeman, Individual Differences, New York, 1934, 301.

A revealing study was made of 86 pupils in the 10th and 11th grades of Edison Technical and Industrial High School in Rochester, New York. The investigator, Beach<sup>39</sup> attempted to determine some of the factors, characteristics, aptitudes, traits or abilities that may differentiate the pupils receiving high marks from the pupils receiving low marks in courses involving mechanical abilities. On tests involving muscular coordination or spatial relations, i. e., Minnesota Rate of Manipulation Test, Minnesota Spatial Relations Test, or Grifford Tridimensional Test, little difference was found between the high group and the low group. A significant difference between the groups was found where reasoning and past experience play an important part, as determined by the Minnesota Assembly Test. General intelligence as measured by the A.C.E. Psychological Examination, did not indicate a significant difference between the two groups. It did indicate that general intelligence played a part in school success. Its greatest value, however, seemed to be in the location of individuals at the extreme ranges, particularly those pupils with an IQ below 90. In discussing the MacQuarrie, the Minnesota Mechanical Analysis and the Minnesota Paper Form Board, Beach discovered that none of these three tests showed a significant difference between the high and low group; the MacQuarrie showed the greatest difference. He also found that spatial relations have little relation to success or failure of pupils in shop courses.<sup>40</sup>

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39. Charles Beach, Prediction of Success in Shop Courses in a Technical and Industrial School, Unpublished Doctoral Dissertation, Cornell University, 1941, 129.

40. Ibid., 132

The pupils who received low marks in shop courses in Beech's study tended to receive low marks in their other courses. Those who received high marks in the mathematics and science in schools previously attended would tend also to receive high marks in the industrial and technical school. The pupils in the low group had slightly less job experience, tended to be less concerned about their future and their vocational success, tended to be interested in people and activities of a social nature rather than of technical nature, and tended to dislike the school subjects of mathematics, science, and English when compared with those in the high group.<sup>41</sup>

Novak<sup>42</sup> studied 165 boys in mechanical trade courses in the Marrell Dobbins Vocational School in Philadelphia using the first year grades as the criterion. Ratings based on a selection interview given by the shop teacher showed the highest validity. Assuming intelligence to be within the normal limits, over 90, the IQ score was not a critical factor in predicting success, even though there was a slight decrease in the median IQ with a decrease in the shop mark. On the Stenquist Test I, the "average" student showed a wide range in scores while the best students showed a comparatively small range. The average score of the failing student was 19 points lower than that of the "excellent" students. Novak states that "this seems to be significant", but no test of significance was applied. In commenting about the relationship between

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41. Ibid., 75.

42. B. J. Novak, "How Effective is Selection of Students for Vocational Schools?", Education, LXI, 1941, 533.

shop grades and age, he states that "entry into specialized preparation should not begin too early". He gives similar treatment to the effect of attendance on grades, where he shows that the failure averaged over twice as many absences per term as the honor roll students.

Fleming<sup>43</sup> studied the relation of age, I.Q., and previous grades to persistence and success in vocational high school courses. He concluded that students of the 14-15 year old group spent on the average a longer period of time in trade school than any other age group. In the combined woodworking trade group, the 14 year old pupils achieved a higher grade than the 15 or the 16 year old pupil. I.Q. was related to persistence. At the end of the fifth semester, less than 10 per cent of the below normal students remained in school, 17 per cent of the normal, and 27 per cent of the above normal. The correlation of IQ. with achievement in shop work at the end of the first semester was +.127, while at the end of the third semester, the correlation was +.231. He concluded that boys with better than normal intelligence have better chances for making higher marks in shopwork than boys with below normal intelligence.

Hankin<sup>44</sup> studied 226 students in machine design and drafting in the Dobbins School of Philadelphia, using grades and persistence as criteria. The interview, as was determined also in Novak's study, showed the greatest relationship with grades. Previous school grades, too, were significant. Mental

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43. J. W. Fleming, "Predicting Trade School Success," Industrial Arts and Vocational Education, XXVII, 1938, 315.

44. E. K. Hankin, "Student Characteristics and Progress", Industrial Arts and Vocational Education, XXXVII, February, 1948, 43.

ability between 91 to 148 IQ was a minor factor as was mechanical ability in differentiating among degrees of achievement. A negative correlation was found between entrance age and shop marks; the younger pupils earning somewhat better marks. A negative correlation between entrance age and tenure was also found. The pupils entering after the age 16 showed little chance for success in terms of tenure.

A part of Novak's<sup>45</sup> study dealt with the interests of students as measured by the Kuder Preference Record. Although the leading area of interest was mechanical, except those students obtaining shop grades of E or F, there was little relation with shop success. The matter of irregular attendance was found to interfere with shop achievement. While there was a tendency for the students earning the higher grades to have better record of attendance, the distribution of grades obtained did not warrant any very definite assumption in this regard.

The Kuder Preference Record was also used by Engelbrecht<sup>46</sup> in predicting achievement in woodworking at the Iowa State College. The correlation between the Kuder mechanical interest and achievement in woodworking ( $r = .134$ ) failed to reach the 5 per cent level of significance. When mechanical interest was correlated with aptitude, scholastic and mechanical, a significant level was reached, presumably the 5 per cent level. The correlations obtained for

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45. Novak, "Predicting Success", 393.

46. Roger Engelbrecht, Usefulness of the Kuder Preference Record for Predicting Achievement in Woodworking at Iowa State College, Unpublished Master's Thesis, Iowa State College, Ames., 1950, 31.

these areas are:

Mechanical interest and ACE  $r = .22$

Mechanical interest and Minnesota Paper Form Board  $r = .49$

Mechanical interest and Owens-Bennett Mechanical Comprehension  
 $r = .31$

The following correlations also reached the 5 per cent level of confidence:

ACE and Minnesota Paper Form Board  $r = .30$

ACE and Owens-Bennett Mechanical Comprehension  $r = .36$

In testing the stability of measured interests, Fox<sup>47</sup> tested a group of fifty-eight boys in the Southport High School in Indianapolis. Several months later he retested the same group finding a substantial amount of stability,  $r = .73$ . Although there was an increase in the mean during the experiment, there was a decrease in the variability.

Super<sup>48</sup> reports quite different results with these same tests. Between the Owens-Bennett Mechanical Comprehension Test and the mechanical scale of the Kuder, a correlation of .13 and .15 respectively were obtained. They were high enough to show some relationship, but too low to make the relationship important practically.

A study of the relationship between mechanical interest and the Minnesota tests given by Hubbard is reported by Fryer<sup>49</sup> as follows:

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47. William Fox, "The Stability of Measured Interests", Journal of Educational Research, December, 1947, 305.

48. Super, Appraising Vocational Fitness, 448.

49. Douglas Fryer, Measurement of Interests, New York, 1931, 205.

Interest score with Spatial Relations	$r = +.46$
Interest score with Minnesota Assembling Test	$r = +.42$
Interest score with Minnesota Paper Form Board	$r = +.39$

These relationships more closely approach those reported by Engelbrecht.

Examination of various investigations concerned with the relationship of interest to achievement reveals that there is considerable divergence of opinion. A conservative estimate based on the reports of these investigators in the field of interest-achievement relationship would place the correlation between these two variables at .10.<sup>50</sup>

Of the factors related to vocational interests, Berdie<sup>51</sup> concludes:

"The available evidence indicates, however, that a person's ability is not a very important factor in determining his interests, and although a relationship can be found between these two factors, this relationship is so small that we must look further if we are to understand the source of vocational interests."

In non-vocational shopwork, there is need for recognizing other results of effort than what might be realized on a finished article. Although there is some divergence as to the percentage of the total score to be allocated to each of the various factors that make up a grade, the investigators in the field do come to a common agreement as to items which should be considered in the makeup of a shop grade. These factors may be summed up as follows:

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50. J. W. Rothney, "Interests of Public Secondary School Boys", Journal of Educational Psychology, XXVIII, November, 1937, 561.

51. R. F. Berdie, "Factors Related to Vocational Interests", Psychological Bulletin, 41, New York, 1944, 137.

1. Quality of Work (Accuracy and Workmanship) Opinion is divided on this point as to whether or not quality should be stressed first in manipulative work, with the idea that quantity or speed will come with added practice.

2. Quantity of work accomplished (speed) Success in most lines of work depends upon the ability to produce in quantity.

3. Effort put forth. Effort and application are general success qualities which can be encouraged in the school shop. Some students who try hard may be less successful in producing work than others who apply themselves less constantly. Their effort should be given consideration to the greatest possible extent.

4. Knowledge acquired and applied. Determining the acquisition of definite items of knowledge, in addition to the manipulative experience and its use and application to the problems at hand, should be a definite part of the grading scheme. This knowledge would be that of the related for informational type, acquired through the study of text-book, references, demonstrations and lectures.

5. Proper attitude. There is a variety of personal qualities which the school should recognize and develop. The attitude toward equipment toward work, and toward fellow students are success qualities, not only in school but in occupational life.

The percentage of the total grade for each of these five areas varies for each of the following three investigators:



	Houston <sup>52</sup>	Falgren <sup>53</sup>	Ericson <sup>54</sup>
1. Quality	25	21	25
2. Quantity	12	14	25
3. Effort	20	22	20
4. Knowledge	23	25	20
5. Attitude	20	18	10

Ericson suggested that regularity in attendance and tardiness should be considered in the total mark, but not in the grading of a single job. He felt that if habits of irresponsibility and lack of punctuality were tolerated and developed in school, difficulties would arise later, when the students were rated by business or industry.<sup>55</sup> Houston<sup>56</sup> and Falgren<sup>57</sup> both included attendance and tardiness as part of effort and desirable habit formation.

An examination of various investigations of the relationship between interest and achievement would place the correlation between these two variables between .10 and .20; between IQ and achievement the correlation would be between .20 and .30; and between mechanical aptitude and achievement, the correlation would be between .30 and .40.

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52. Tony Houston, Current Trends in Grading Industrial Arts Students, Unpublished Master's Thesis, Texas A&M College, 1954, 12.

53. Leo Falgren, "Grading Industrial Arts Courses", Industrial Arts and Vocational Education, XXIX, February, 1950, 41.

54. Emanuel Ericson, Teaching Problems in Industrial Arts, Peoria, Illinois, 1930, 223.

55. Ibid., 226.

56. Houston, Current Trends, 18.

57. Falgren "Grading", 44.

## CHAPTER IV

### INVESTIGATIONAL PROCEDURES

In no instance while reviewing the literature on shop prediction, as described in Chapter III, did the author encounter any study that he felt examined all the necessary ingredients for success in high school woodshop; i.e., intelligence, mechanical aptitude, interest, age, and environmental data. There were many studies indicating the simple relationship of any two of these factors. In only one study was there found a regression of three of the factors, aptitude, intelligence, and shop success.<sup>1</sup> Patterson,<sup>2</sup> after reviewing a great many studies, felt that it would be possible to select a battery of tests which would combine to yield fair prediction of success in any public or private school. The nature of such a battery, he suggests, might possibly consist of a verbal intelligence test, a test of mechanical information, a test of spatial ability, and possibly an interest test. This author believes that such a battery of tests as suggested by Patterson is far better than any he has reviewed, but the author also believes that it does

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1 Van Winkle, Predicting Achievement, 40.

2 Patterson, "Predicting Success in Trade and Vocational School Courses", 390.

not go far enough. The extension of such a battery to include two additional factors, age and pertinent personal data, was felt to be more satisfactory.

#### Description of the Variables

With this arrangement in mind, five independent variables were used in this study to predict achievement in high school woodworking. The measures that would be available before taking the woodshop course which are the independent variables selected for this study were the following:

1. Intelligence
2. Mechanical Aptitude
3. Mechanical Interest
4. Age
5. Personal Data

The variables to be predicted, or the achievement that is known on each individual only after he has participated in the woodworking course is the criterion variable or, more simply, the criterion. The semester mark average constitutes the criterion for this study.

#### Collection of the Data

Because of the many standardized tests available for the independent variables of intelligence, mechanical aptitude, and interest, two tests were selected for each of these variables to be able to determine which test of a pair of similar tests was the better predictor.

### Scholastic Aptitude

The decision as to the selection of a pair of intelligence tests offered little difficulty. At the time under consideration, the elementary public schools in Chicago were almost always using the S.R.A. Primary Mental Abilities Test as their sole source of information for the I.Q. It was, therefore, decided to adopt the same test, Intermediate Form AH, Ages 11 to 17, for this study. This test offered the possibility of using the sub scores from the five separate abilities, verbal meaning, space, reasoning, number, and word fluency, as well as the complete score. A secondary source of information for the I.Q. in the public elementary and public high schools in Chicago was the Kuhlmann-Anderson Intelligence Test. The high school equivalent of the test, Booklet H, Grade IX to Maturity, was, therefore, selected.

### Mechanical Aptitude

Early in the Spring of 1956, the writer was faced with the problem of selecting mechanical aptitude tests which would be suitable for the study. Many tests were examined. These tests were given on a trial basis to two beginning woodshop classes at that time in an effort to determine ease of administration, scoring, and interpretation. Two tests, the S.R.A. Mechanical Aptitude Test, Form AH and the MacQuarrie Test for Mechanical Ability were finally chosen. The S.R.A. test was chosen upon the following basis:

1. Included in the single test booklet were three major components of mechanical aptitude; mechanical knowledge, space relations, and shop arithmetic.
2. A total score or any of the three part scores may be used as an estimate of the individual's mechanical aptitude.
3. Norms are given for each year of high school, ninth, tenth, eleventh, and twelfth grades.
4. A reliability coefficient, computed by the Kuder-Richardson formula, of .81 is reported in the manual for ninth grade high school boys.
5. The administration and scoring of the test is quite simple.

The MacQuarrie test was chosen on the following basis:

1. The test is an overall measure of mechanical aptitude.  
Although, it is not a test of mechanical comprehension as such, its seven sub-tests measure spatial visualization, manual dexterity, and perceptual speed and accuracy.
2. The scores of the sub-tests may be used apart from the total score.
3. The test was originally designed for use with adolescent boys and girls.
4. Reliability ranging from .72 to .86 is reported for the seven sub-tests, but with the total score, the reliability is

increased to .90.<sup>3</sup>

5. Validity coefficients reported range as high as .79.<sup>4</sup>
6. Norms are given for the ages of 10 through 16, an age range inclusive enough for this study.

### Interests

Of the interest inventories believed to be appropriate for this study, the Kuder Preference Record, Vocational Form OH and the Garretson and Symonds Interest Questionnaire for High School Students were chosen.

The writer decided to administer the Kuder for the following reasons:

1. The test items were so written and the contents was selected for its familiarity to adolescents as well as to adults.<sup>5</sup>
2. It is one of the most widely used interest tests as evidenced by the amount of research done with it.
3. It measures interest in ten areas, one of which, mechanical, is the area under consideration in this study.
4. It contains a built-in validity measure or verification scale, intended to identify persons who have responded carelessly or insincerely.

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3 June Duran, Summary of Investigations, Number Two, MacQuarrie Test for Mechanical Ability, California Test Bureau, Los Angeles, 1950, 3.

4 Ibid., 6.

5 Super, Vocational Fitness, 445.

5. The reliability of the test ranges from .84 to .93.<sup>6</sup>

The Garretson Interest Questionnaire was selected because:

1. It is a questionnaire developed to analyze the interests of high school boys.<sup>7</sup>
2. It is adapted for use in the eighth and ninth grades.
3. The test aims to answer only one question, "How interested would this boy probably be in each of three types of curriculum?"<sup>8</sup> One common interest considered in the questionnaire and in this study is the technical interest.
4. The reliability coefficient using the Spearman-Brown formula is .953 for the measure of technical preference.<sup>9</sup>
5. The validity of the questionnaire was determined by the computation of the bi-serial r. For the technical curriculum the validity was found to be .868.

#### Age

The chronological age of the student being tested was expressed in number of months rather than in years and months. This was done for

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6 Frederick Kuder, Examiner Manual for the Kuder Preference Record, Vocational Form C, Chicago, 1956, 21.

7 Leonard Kocs, and Grayson Kefauver, Guidance in Secondary Schools, New York, 1937, 343.

8 Bingham, Aptitudes, 360

9 Oliver Garretson, and Percival Symonds, Manual of Directions, Interest Questionnaire for High School Students, New York, 1942, 1.

ease of handling the figures on the IBM machine. The student's age was recorded as his age at the time of enrollment in the woodshop course at the beginning of the semester in which he was tested.

#### Personal Data

In addition to the data gathered from the respondent's age and from the six standardized tests, further personal information concerning each student was obtained from responses to a Personal Data Questionnaire<sup>10</sup> devised and administered by the author of the present study. It was felt that the other data did not adequately explore personality factors of the pupil or the influence of environment upon him. The items in the Questionnaire were developed from the observation of boys in the ninth grade, exploring their in-school and out-of-school activities, their ambitions, and backgrounds. Its items were devised so that the answers would indicate such information as the following:

1. Favorable mechanical interest or environment.
2. The student's choice for mechanical over non-mechanical activities both in and out of school.
3. The student's mechanical ambitions.
4. The students' general family background.

The preliminary draft contained many more items than the final form. After careful study and conferences with various school officials,

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<sup>10</sup> See Appendix 4, P 116.



those items which appeared to be superficial to the study were eliminated. The revised questionnaire was then submitted to two woodworking classes that were not included in the testing program of September 1956. Their criticisms and evaluation of several important items were incorporated in the final form.

On the basis of the final shop grade obtained by the upper and lower 27 per cent of the pupils, the questions on the Questionnaire were given weights, thus yielding a total score for each individual.<sup>11</sup>

The procedure used in determining a score for the Personal Data Questionnaire was described by the Industrial Relations Center of the University of Minnesota. In a bulletin published by the center, a means of evaluating applicants is described in detail. The procedure described by the authors is given in this manner:

By identifying on the application blank those personal history items which successfully differentiate between groups of desirable and undesirable employees in a given occupation, and by mathematically determining the predictive power of each item, it is possible to assign numerical "weights" or scores to each possible answer. Weights for these items may then be totaled for each individual, and a minimum total score established which, if used at the time of hiring, will eliminate the maximum number of undesirable candidates with a minimum loss of desirable candidates.<sup>12</sup>

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<sup>11</sup> Josephine Welch, C. Harold Stone and Donald G. Patterson, "How to Develop a Weighted Application Blank", Research and Technical Report 11, Industrial Relations Center, University of Minnesota, February, 1952, 1.

<sup>12</sup> Welch, Weighted Application Blank, 1.

By adapting this procedure to the present study, it was possible to make a quantitative difference in the scores of the pupils on the basis of their responses to the Questionnaire.

Certain items showed no discrimination between high and low scores. The following items were, therefore, eliminated in the scoring of the responses.

Which grade did you repeat in the elementary school?

Of what clubs are you a member in school?

If yes, what book? (Mechanical type read since September)

Do you have a place to work with tools?

After eliminating the above items, the remaining items yielded weights used to formulate the total score. The following items and their indicated responses have an assigned weight of two:

1. With whom do you live? (Mother and father)
2. Did you repeat any grades in the elementary school? (No)
4. Do you plan to go to any kind of school after high school? (Yes)
5. If you know the name of the school you plan to go, list it.  
(Technical)
14. Do you work outside of school? (Yes)
16. What are some of the things you do with your money? (Model making, electronics)
- 17B. Of what clubs are you a member outside of school? (One)
18. Do you have a T.V. in your home? (Yes)
19. Average number of hours per week spent watching T.V.?  
(Less than 15)

21. Do you frequently watch the Uncle Walt program sponsored by the Edward Hines Company? (Yes)
22. Have you visited a library in the past month? (Yes)
23. What book have you read in the past month? (One)
24. Have you read a book that related specifically to mechanical things since school started in September? (Yes)
29. Do you have tools at home that you can use? (Yes)
31. Do you have a place to work with tools? (Yes)
34. For what kind of work would you like to prepare? (Engineering, definite trade)
35. School subject you like best? (Technical sequence type)
36. School subject you like least? (Non-technical)
38. If woodshop was not your first choice, what was your first choice? (Machine shop, electric shop)
39. Has your father ever encouraged you to take woodshop? (Yes)
45. Why did you select woodshop? (A good reason)
46. Why did you select the technical sequence? (A good reason)

A number of the items which could not be separated into a dichotomy were assigned weights of zero, one, or two depending upon the answer given. The following items are so arranged in value:

6. Father's education through high school, one point value, through college, two points value.
7. Mother's education through elementary school, zero, through

- high school, one point value; through college, two points value.
8. Kind of work done by father, professional, clerical or skilled work, two points value; service work, one point value.
10. What other kind of work did your father do, skilled or semi-skilled work, one point value; professional, clerical or service occupation, two points value.
13. What other kind of work did your mother do, skilled or semi-skilled, one point value; unskilled, two points value.
15. What kind of work do you do outside of school, skilled, semi-skilled, or professional, two points value; clerical work, one point value.
20. Type of program liked most on T.V., quiz, feature film, fix-it, two points value; detective, sports, or comedy, one point value.
26. What magazines have you read since school started in September?; four or five, two points value; two or three, one point value; two, three or four mechanical magazines, two points value.
27. Of these, what magazines do you read regularly?; one, one point value; two, two points value; one or two mechanical magazines, two points value.
28. What hobbies do you have?; one hobby, one point value; two hobbies, two points value; one or two mechanical hobbies, two points value.
30. Name the kind of tools you have; three or four, one point value; five or six, two points value; more than one electrical

tool, two points value.

33. For what kind of work would your parents like you to prepare; whatever I want, one point value; a definite choice of job, two points value.

### Performance

The criterion against which each of the psychological test scores was to be evaluated was the semester's grade on the course. Basic to an understanding of the grade is the manner in which the grade was derived.

At the beginning of the semester each boy was given a list of the projects to be made during the semester, an estimation of the length of time the average boy should take to construct the projects, and a schedule of the week of the semester the project was due. All projects could be constructed with the simple hand tools available to any beginning woodworking class. Several woodturning projects were placed at intervals during the semester. The only machines available for use on the projects were the jig saw and the drill press. The woodturning lathe was available for the turning projects and the grinder for grinding plane blades.

At the beginning of the semester each boy was given a list of the related materials to be covered during the semester, the week of the semester these materials would be discussed, a workbook developed by the author from which the material may be found, and a set of objective lessons for each topic.

A determined effort was made to keep all grades as objective as

possible. Standards for the project grades were set up in advance. Each project was graded on four points. To each of these four points was assigned a percentage of the total mark depending upon the relative importance of the item as shown in Table I.

TABLE I  
EVALUATION OF PROJECTS

Item of Evaluation	Percent of Total Mark
Squaring	75
Accuracy of size	15
General appearance	5
Finish	5

The largest percentage of the total mark, 75, was assigned to the squaring process. It was felt that this function was basic to all beginning woodworking projects. Accuracy of size was given 15 per cent of the total. The accuracy in which the work is laid out as a guide for the use of the fundamental tools and the degree of accuracy the student keeps to his plan in working with the tools is deserving of the second largest consideration.

A well constructed and accurate project may result in a poor general appearance if the student is not careful in his handling of it. Careless handling that results in scratches, dents, nicks or chips that mar

or detract from the overall looks may cause as much as 5 per cent difference in the total grade. Quite related to the general appearance, but an item to be rated for its own value, is the finish to be applied to the project. Although allocated the smallest amount of the total, 5 per cent, the following of the directions and the application of the finish is a distinct operation in itself. The application of the type of finish (sanding, staining, shellacing, varnishing) increases in difficulty with the increase in the difficulty of the project.

The grading system established by the Chicago Board of Education for use in the public high schools was used in assigning grades or marks to each of the projects and for the final grade. In order to arrange this data in a form which would lend itself to the calculation of correlation coefficients, the raw scores were converted to normalized scores<sup>13</sup> which would vary from twenty-five for failure to progressively higher numbers for increasing amounts. When the individual projects were graded, a plus or minus grade was given on occasions. A project grade of G- may be interpreted numerically as eighty-one, while a project grade of G may be interpreted as eighty-seven. Although no final grades were given with a plus or minus value, the regression value found for an individual may fall within such a plus or minus range. A true interpretation of a predicted score must be defined within certain limits for each letter grade. These limits as well

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<sup>13</sup> Kenneth Anderson, Robert Gray, Einar Kullstedt, "Tables for Transmutation of Orders of Merit into Scores of Amount or Scores", Journal of Experimental Education, 22, March, 1954, 247.

as the letter grade, numerical equivalent, and the T score used for assigning values to the raw scores are shown in Table II.

**TABLE II**  
**GRADE EQUIVALENTS**

Letter Grade	Description	Numerical Value	T Score	Limits of T Score
S	Superior	95 - 100	75	100.0 - 67.0
E	Excellent	88 - 94	60	66.0 - 55.5
G	Good	81 - 87	50	54.5 - 45.5
F	Fair	75 - 80	40	44.5 - 34.0
D	Failure	0 - 74	25	33.0 - 0.0

### Analysis of the Data

#### Relations Between Predictor Variables and Criterion

The next step was to determine the coefficient of correlation between each of the thirty-four scores and the semester's grade. The Pearson product-moment method was used. The coefficients which were calculated are listed in Table III. Twenty-two of these correlations thus obtained were significant at the one per cent level; three additional scores were significant at the five per cent level, while nine failed to meet the test of significance even at the five per cent level.

Many of the tests were selected for more detailed study using



**TABLE III**  
**COEFFICIENTS OF CORRELATION BETWEEN PSYCHOLOGICAL**  
**TEST SCORES AND SEMESTER'S GRADES**

Test	Coefficient of correlation
Age	-.1819
S. R. A. Mechanical Aptitude	
Mechanical Knowledge	.3374
Space	.2732
Arithmetic	.1767
Total Score	.3400
MacQuarrie Test of Mechanical Ability	
Tracing	.1904
Tapping	.2026
Dotting	.1157
Copying	.3694
Location	.3813
Block	.2334
Pursuit	.3464
Total Score	.4157
Garretson Interest Questionnaire	
Technical	.3163
Academic	-.1504
Commercial	-.2144

0.134 is significant at the five per cent level

0.176 is significant at the one per cent level

TABLE III (continued)

COEFFICIENTS OF CORRELATION BETWEEN PSYCHOLOGICAL  
TEST SCORES AND SEMESTER'S GRADES

Test	Coefficient of correlation
<b>Kuder Preference Record</b>	
Outdoor	.0826
Mechanical	.2732
Computational	.0216
Scientific	.0670
Persuasive	-.0892
Artistic	.1248
Literary	-.1602
Musical	-.1770
Social Science	-.1319
Clerical	.0097
<b>S. R. A. Primary Mental Abilities</b>	
Verbal	.1848
Space	.2261
Reasoning	.1888
Numbers	.0604
Words	.1462
Total Score	.2569
<b>Kuhlmann-Anderson Intelligence</b>	.2264
<b>Personal Data Questionnaire</b>	.5173

0.134 is significant at the five per cent level

0.176 is significant at the one per cent level.

the coefficient of multiple correlation<sup>14</sup> to indicate the strength of relationship that exists between one dependent variable and two or more independent variables taken together. It was hoped to be able to determine which interest test, Kuder or Carretson; and which intelligence test, Kuhlmann-Anderson or S.R.A. Primary Mental Abilities in combination with the S.R.A. Mechanical Aptitude or mechanical knowledge score showed the better relationship to the final grade. The most favorable results were obtained from the Kuder Mechanical score and the S.R.A. Mechanical Knowledge sub-test score with the final grade ( $r = .4149$ ). The combination of the S.R.A. Primary Mental Abilities and the S.R.A. Mechanical Knowledge scores with the final grade correlated best in this grouping ( $r = .3549$ ). The complete comparisons are given in Table IV.

Six of the sub-tests of the MacQuarrie Test that correlated at the five per cent level of significance were analysed by means of the Du Bois method,<sup>15</sup> yielding a multiple R as shown in Table V. The predictive efficiency of the six sub-tests, all of which were significant at the one per cent level, was .4737. When three of the sub-tests, Tracing, Tapping, and Block, were removed, the coefficient is reduced by only .0061.

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<sup>14</sup> J. P. Guilford, Fundamental Statistics in Psychology and Education, New York, 1950, 427.

<sup>15</sup> Philip H. Du Bois, Multivariate Correlational Analysis, New York, 1959, 9.

TABLE IV  
COEFFICIENT OF MULTIPLE CORRELATION BETWEEN  
FINAL GRADE AND SELECTED VARIABLES

Variable	Coefficient of Multiple Correlation
Final grade, Kuder Mechanical, SRA Mechanical Aptitude Test	.3880
Final grade, Kuder Mechanical, SRA Mechanical Knowledge	.4149
Final grade, Garretson Technical, SRA Mechanical Aptitude Test	.3924
Final grade, Garretson Technical, SRA Mechanical Knowledge	.3892
Final grade, Kuhlmann-Anderson, SRA Mechanical Aptitude Test	.3471
Final grade, Kuhlmann-Anderson, SRA Mechanical Knowledge	.3536
Final grade, SRA, PMA, SRA Mechanical Aptitude Total	.3466
Final grade, SRA, PMA, SRA Mechanical Knowledge	.3549

**TABLE V**  
**COEFFICIENT OF MULTIPLE CORRELATION BETWEEN**  
**FINAL GRADE AND MACQUARRIE SUB-TESTS**

Sub-test	Coefficient of Multiple Correlation
Location, Copying, Pursuit, Blocks, Tapping, Tracing	.4737
Location, Copying, Pursuit, Blocks, Tapping	.4698
Location, Copying, Pursuit, Blocks	.4688
Location, Copying, Pursuit	.4676
Location, Copying	.4396
Location	.3813

The three areas of the Kuder Preference Record that showed a significant correlation at the five per cent level with the semester's grades were also subjected to the Du Bois method to yield the multiple R of .3033 as shown in Table VI. If only the mechanical interest area were correlated with the criterion, instead of adding the two additional areas of musical interest and literary interest to the battery, a difference in the coefficient of multiple correlation would have been but .0301 less.

TABLE VI  
 COEFFICIENT OF MULTIPLE CORRELATION BETWEEN  
 FINAL GRADE AND KUDER INTEREST AREAS

Interest Area	Coefficient of Multiple Correlation
Mechanical, Musical, Literary	.3033
Mechanical, Musical	.2906
Mechanical	.2732

The tests, S. R. A. Mechanical Aptitude total score, Kuder Preference Record Mechanical Interest Area, and the Kuhlmann-Anderson Intelligence, were calculated by the Du Bois method, giving a multiple R of .3947 shown in Table VII. The S. R. A. Mechanical Knowledge sub-test was later substituted for the entire S. R. A. Mechanical Aptitude Test. The multiple R of .3957 for this arrangement is given in Table VIII. It would appear that the shorter Mechanical Knowledge sub-test has an advantage in this battery over the total score of the SRA Mechanical Aptitude Test in predictive efficiency of .0010 and in economy of time.

TABLE VII

**COEFFICIENT OF MULTIPLE CORRELATION BETWEEN  
FINAL GRADE AND CERTAIN TESTS**

Test	Coefficient of Multiple Correlation
SRA Mechanical Aptitude Total Score, Kuder Mechanical Interest, Kuhlmann-Anderson	.3947
SRA Mechanical Aptitude Total Score, Kuder Mechanical Interest	.3911
SRA Mechanical Aptitude Total Score	.3400

TABLE VIII

**COEFFICIENT OF MULTIPLE CORRELATION BETWEEN  
FINAL GRADE AND SELECTED TESTS**

Test	Coefficient of Multiple Correlation
SRA Mechanical Knowledge, Kuder Mechanical Interest, Kuhlmann-Anderson	.3957
SRA Mechanical Knowledge, Kuder Mechanical Interest	.3749
SRA Mechanical Knowledge	.3374

It often happens that a limited number of variables can be selected that will have a multiple R almost as high as that of a total group of predictors. An economy arises from the use of fewer independent variables. In this study, where three pairs of tests were administered, the question arises as to which test is of the least value. Selection is accomplished by a process essentially identical with that used in the Wherry-Doolittle method, but within the framework of the Du Bois method.<sup>16</sup> In the selection process, variables which duplicate the functions of variables already chosen tend to drop out. By beginning with the test showing the highest correlation with the final grade and adding one test at a time while examining the coefficient of multiple correlation, it was found that a correlation of .4762 was obtained in a four-test battery composed of the MacQuarrie Test, the SRA Mechanical Aptitude Test, the Garretson Interest Questionnaire, and the Kuder Mechanical Interest, but when the fifth test, the S. R. A. Primary Mental Abilities Test, was added to the battery the coefficient of correlation remained the same, .4762. The sixth test, Kuhlmann-Anderson Intelligence Test, raised the correlation to .4795. The results of the selection process is shown in Table IX.

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<sup>16</sup> Du Bois, Multivariate, 36.



TABLE IX

ELIMINATION OF THE TEST OF LEAST VALUE BY MEANS OF  
 MULTIPLE CORRELATION OF THREE PAIRS OF TESTS  
 WITH FINAL GRADE

Tests	Coefficient of Multiple Correlation
MacQuarrie, SRA Mechanical Aptitude, Garretson Technical Interest Questionnaire, Kuder Mechanical Interest, SRA Primary Mental Abilities, Kuhlmann-Anderson Intelligence	.4795
MacQuarrie, SRA Mechanical Aptitude, Garretson Technical Interest Questionnaire, Kuder Mechanical Interest, SRA Primary Mental Abilities	.4762
MacQuarrie, SRA Mechanical Aptitude, Garretson Technical Interest Questionnaire, Kuder Mechanical Interest	.4762
MacQuarrie, SRA Mechanical Aptitude, Garretson Technical Interest Questionnaire	.4675
MacQuarrie, SRA Mechanical Aptitude	.4578
MacQuarrie	.4157

When four of the five predictors were decided upon, the choice between the two interest tests still remained. In order to help make this choice, the battery of five predictors using the Garretson Interest Questionnaire was selected for multiple correlation with the final grade using the Du Bois method. Table I shows the results of the correlation. The Garretson test was then removed from the battery and the Kuder Mechanical Interest Test

was substituted. The Du Bois method of multiple correlation was again used. These results are given in Table XI. Both correlations were then compared. Even though there were minor fluctuations between the two correlations when two, three, or four predictors were used, the final five predictor battery using the Garretson test gave a multiple correlation of .6841 only .0018 lower than the correlation given when the Kuder test was used.

**TABLE X**  
**COEFFICIENT OF MULTIPLE CORRELATION BETWEEN**  
**FINAL GRADE AND A BATTERY OF**  
**POSSIBLE PREDICTORS**

Test Battery	Coefficient of Multiple Correlation
Battery A	.6841
Battery B	.5670
Battery C	.5664
Battery D	.5642
Battery E	.5173

  

<u>CODE</u>	
Battery A:	Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability, Garretson Interest Questionnaire Technical Score, Kuhlmann-Anderson Intelligence Test, Age.
Battery B:	Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability, Garretson Interest Questionnaire Technical Score, Kuhlmann-Anderson Intelligence Test.
Battery C:	Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability, Garretson Interest Questionnaire Technical Score.

Battery D: Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability.

Battery E: Personal Data Questionnaire.

A final battery, composed of five predictor variables, was selected by eliminating those tests which showed high intercorrelations with other tests in the battery. The Du Bois method was employed to calculate the differential weights for each of the five predictors for use in a multiple regression equation. The multiple regression equation shown below was derived.

$$\begin{aligned} \text{Predicted grade} = & .4229 \text{ (Personal Data Questionnaire Score) -} \\ & .0709 \text{ (MacQuarrie Total Score) -} \\ & .0870 \text{ (Kuder Mechanical Interest Score) -} \\ & .2095 \text{ (Kuhlmann-Anderson I.Q.) -} \\ & -.6128 \text{ (Age in months) -} \\ & 99.903 \end{aligned}$$

The above equation for the five-predictor battery is presented in this simplified form:

$$x = .4229x_5 = .0709x_4 - .0870x_3 - .2095x_2 - (-.6128)x_1 - 99.903 \text{ where:}$$

$x$  = Predicted Grade

$x_5$  = Personal Data Questionnaire

$x_4$  = MacQuarrie Test of Mechanical Ability

$x_3$  = Kuder Mechanical Interest

$x_2$  = Kuhlmann-Anderson I.Q.

$x_1$  = Age in months

Using this equation, predicted grades were calculated for the last three students in the group, students numbers 226, 227, and 228. These students received a predicted grade of 48.8805, 53.4247, and 42.3588 respectively. The actual grades received by these three students were G, G, and F as expressed in letter grades or as expressed in T scores of 50, 50, and 40 respectively. A comparison of the predicted grades with the T score range as shown in Table II, page 65, will disclose that the predicted grades fall within the range allowed for the given letter grades.

The coefficient of multiple correlation between the final battery of predictors and the semester's grades was determined and presented in Table XI.

TABLE XI  
COEFFICIENT OF MULTIPLE CORRELATION BETWEEN  
FINAL GRADE AND A BATTERY OF  
THE FINAL PREDICTORS

Test Battery	Coefficient of Multiple Correlation
Battery A	.6859
Battery B	.5701
Battery C	.5694
Battery D	.5477
Battery E	.5173

CODE

- Battery A:** Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability, Kuder Mechanical Score, Kuhlmann-Anderson I.Q., Age in months.
- Battery B:** Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability, Kuder Mechanical Score, Kuhlmann-Anderson I.Q.
- Battery C:** Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability, Kuder Mechanical Score.
- Battery D:** Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability.
- Battery E:** Personal Data Questionnaire.

Intercorrelations of Predictor Variables

Intercorrelations were computed between the predictor variables

TABLE XII  
MATRIX OF INTERCORRELATIONS

	Questionnaire	MacQuarrie	Kuder Mechanical	Kuhlmann-Anderson	Age	Mean	Standard Deviation
Semester's grade	.5173	.4157	.2732	.2264	-.1819	44.023	11.329
Questionnaire		.4051	.3236	.2840	-.2154	44.786	11.507
MacQuarrie			.2686	.3737	-.1796	162.511	34.851
Kuder Mechanical				.1087	-.0601	43.144	12.606
Kuhlmann-Anderson I.Q.					-.5072	93.362	13.435
Age						180.753	8.209

and are shown in Table XII. The mean and standard deviation of each of the variables were included in the matrix. An examination of Table XII disclosed that the only variable to correlate negatively with the other variables was the pupil's age which ranged from  $-.0601$  for mechanical interest, the smallest correlation in the entire matrix, to  $-.5072$  for the I.Q. All the remaining correlations were positive; the greatest correlation,  $.5173$ , was between the Personal Data Questionnaire and the semester's grade.

Comparisons with Non-technical and Foundry Groups.

Using the same five final predictors, a comparison was made for significance between each of the variables of the original group of 215

TABLE XIII

MEAN AND STANDARD DEVIATION OF A NON-TECHNICAL  
GROUP AND A FOUNDRY GROUP OF BOYS AT  
HARRISON HIGH SCHOOL

Variable	Non-technical		Foundry	
	Mean	Standard Deviation	Mean	Standard Deviation
Questionnaire	38.100	9.002	44.813	7.944
MacQuarrie	148.533	29.215	158.372	32.180
Kuder Mechanical	34.033	12.424	43.604	10.242
Kuhlmann-Anderson	97.166	15.705	96.627	11.356
Age	177.900	8.035	174.697	8.086

technical students at Harrison High School and (1) a group of thirty non-technical students that entered Harrison the same semester and (2) a group of Forty-three technical students enrolled in the Foundry shop at Harrison High School. Table XIII shows the mean and the standard deviation for the latter two groups. The mean and the standard deviation for the original group was previously given in Table XII.

A striking contrast among the three groups was in the differences in the I.Q. The boys in the woodshop, with a mean I.Q. of 93.362, were the lowest of the three groups, while the non-technical group was 3.804 points

TABLE XIV

t TEST FOR SIGNIFICANCE BETWEEN ORIGINAL  
GROUP AND A NON-TECHNICAL GROUP AND  
A FOUNDRY GROUP OF BOYS

Variable	<u>t</u> Ratio for Original Group and Non-technical Group	<u>t</u> Ratio for Original Group and Foundry Group
Questionnaire	3.080	0.730
MacQuarrie	2.190	0.750
Kuder Mechanical	3.740	0.220
Kuhlmann-Anderson	3.804	1.430
Age	1.805	4.485

CODE

1.970 is significant at the five per cent level

2.597 is significant at the one per cent level

higher. The mean I.Q. for the Foundry group was slightly lower than the non-technical group. In mechanical aptitude, mechanical interest, and personal data the non-technical group was definitely lower than either of the other two groups while the Foundry group showed very little variation in these two items.

When the t test for significance was applied to these groups, the non-technical group was found to differ significantly in each of the five variables while the Foundry group differed from the original sample only in the matter of age. The results are shown in Table XIV.

#### Comparisons With Other High Schools

Comparisons were made with boys enrolled in woodworking in two additional Chicago Public High Schools, Lane Technical High School and Fenger High School. Intercorrelations of the variables, t test for significance, and multiple correlations were calculated for a group of seventy-three boys enrolled in the woodshop at Lane Technical High School and for a group of sixty-nine boys enrolled in the woodshop at Fenger High School. The inter-correlations, means, and standard deviations for the group at Lane High School are shown in Table XV.

Here, as in the original sample, age correlates negatively with all the variables. The largest inter-correlation,  $-.6129$ , was between I.Q. and age; the lowest inter-correlation,  $.0017$ , was between I.Q. and mechanical interest.

Higher means were found for Lane High School in four of the six variables. The increases ranged from  $.338$  points for the MacQuarrie test



to 14,131 points for I.Q. Lower means were found for Lane Technical High School for the Kuder Mechanical Interest and for Age; the difference being 1,008 points and 9.781 months respectively.

TABLE XV  
MATRIX OF INTERCORRELATIONS AT LANE HIGH SCHOOL

Questionnaire	MacQuarrie	Kuder Mechanical	Kuhlmann-Anderson	Age	Mean	Standard Deviation	
Semester's grade	.3099	.3269	.3393	.1669	-.4424	49.246	8.139
Questionnaire	.1236	.2503	.1812	-.3123	46.657	9.550	
MacQuarrie		.1383	.3427	-.2701	162.849	32.228	
Kuder Mechanical			.0017	-.0999	42.136	8.713	
Kuhlmann-Anderson I.Q.				-.6129	107.493	11.017	
Age					170.972	5.382	

The relative positions of the five predictor variables shifted considerably in obtaining the coefficient of multiple correlation for the Lane High School group when compared with the original sample at Harrison. The variable, Age, correlated the lowest of the five predictors at Harrison, while at Lane, it was the largest correlation with the final grade. A multiple R was obtained for the entire battery at Lane. This was .0896 points lower than the results obtained for the same battery when it was

given at Harrison High School.

The coefficient of multiple correlation between the battery of final predictors and the semester's grades for the group of seventy-three boys at Lane High School is given in Table XVI.

TABLE XVI

COEFFICIENT OF MULTIPLE CORRELATION BETWEEN FINAL GRADE AND  
A BATTERY OF FINAL PREDICTORS AT LANE HIGH SCHOOL

Test Battery	Coefficient of Multiple Correlation
Battery A	.5963
Battery B	.5744
Battery C	.5629
Battery D	.5325
Battery E	-.4424

CODE

Battery A: Age, Kuder Mechanical, MacQuarrie Test of Mechanical Ability, Personal Data Questionnaire, Kuhlmann-Anderson I.Q.

Battery B: Age, Kuder Mechanical, MacQuarrie Test of Mechanical Ability, Personal Data Questionnaire.

Battery C: Age, Kuder Mechanical, MacQuarrie Test of Mechanical Ability.

Battery D: Age, Kuder Mechanical.

Battery E: Age.

The means and the standard deviation of the variables for the Lane group were previously given in Table XV. These results are compared with the original sample from Harrison High School, using the t test for significance. Table XVII which gives these comparisons shows a significant difference at the one per cent level in the variables, Age, Personal Data Questionnaire, and Final Grade. The actual difference of .0896 points in the multiple R obtained for the entire battery that was rated on page 77, however, is not significant.

TABLE XVII

t TEST FOR SIGNIFICANCE BETWEEN ORIGINAL  
GROUP AND A GROUP AT LANE HIGH SCHOOL

Variable	<u>t</u> ratio
Questionnaire	1.259
MacQuarrie	0.070
Kuder Mechanical	0.630
Kuhlmann-Anderson	7.801
Age	9.495
Final grade	3.661
Complete battery of five predictors	1.114

CODE

1.971 is significant at the five per cent level.

2.599 is significant at the one per cent level.

Applying the multiple regression equation to students numbered 385, 386, and 387, the grades of 62.9127, 52.4735, and 48.2343 respectively were predicted. The actual final grades received by these three students were E, G, and G as expressed in letter grades or as expressed  $t$  scores of 60, 50, and 50 respectively. A comparison of the predicted grades with the  $t$  score range as shown in Table II, page 65, will disclose that the predicted grades fall within the range for the given letter grades.

In comparing the group of sixty-nine boys at Fenger High School with the original test group at Harrison High School, the same method of

TABLE XVIII

## MATRIX OF INTERCORRELATIONS AT FENGER HIGH SCHOOL

	Questionnaire	MacQuarrie	Kuder Mechanical	Kuhlmann-Anderson	Age	Mean	Standard Deviation
Semester's grade	.4694	.3104	.2532	.1853	-.3195	45.507	10.773
Questionnaire		.1507	.0252	.2536	-.0943	46.840	9.523
MacQuarrie			.2429	.2341	-.1235	155.927	27.388
Kuder Mechanical				.1828	-.1133	43.710	10.523
Kuhlmann-Anderson					-.4673	92.811	10.880
Age						174.202	6.713

comparison was used, intercorrelations of the variables, t test for significance, and multiple correlations. Table XVIII gives the intercorrelations, means, and standard deviations for the group at Fenger High School. The Questionnaire, when given to the group at Fenger High School, retained the same importance as it did when given at Harrison; i.e., the variable with the largest correlation with the criterion. Age, which correlated

TABLE XIX

COEFFICIENT OF MULTIPLE CORRELATION BETWEEN FINAL GRADE AND  
A BATTERY OF FINAL PREDICTORS AT FENGER HIGH SCHOOL

Test Battery	Coefficient of Multiple Correlation
Battery A	.6208
Battery B	.6082
Battery C	.5848
Battery D	.5447
Battery E	.4694

CODE

- Battery A: Personal Data Questionnaire, Age, MacQuarrie Test of Mechanical Ability, Kuder Mechanical, Kuhlmann-Anderson.
- Battery B: Personal Data Questionnaire, Age, MacQuarrie Test of Mechanical Ability, Kuder Mechanical.
- Battery C: Personal Data Questionnaire, Age, MacQuarrie Test of Mechanical Ability.
- Battery D: Personal Data Questionnaire, Age.
- Battery E: Personal Data Questionnaire.

negatively in both cases, was of considerable more importance ( $r = -.3195$ ) at Fenger than it was at Harrison ( $r = -.1819$ ).

Three of the means obtained at Fenger -- those for Final Grade, Kuder Mechanical, and Questionnaire -- were greater than the comparable means obtained at Harrison. Three other means -- MacQuarrie, Kuhlmann-Anderson, and Age -- were lower than those obtained at Harrison.

The coefficient of multiple correlation between the battery of final predictors and the semester's grades for the group of sixty-nine boys at Fenger High School is given in Table XIX. The composition of the inter-

TABLE XX

t TEST FOR SIGNIFICANCE BETWEEN ORIGINAL GROUP AND  
A GROUP AT FENGER HIGH SCHOOL

Variable	<u>t</u> ratio
Age	6.009
MacQuarrie	1.485
Kuder Mechanical	0.337
Kuhlmann-Anderson	0.280
Questionnaire	1.341
Final Grades	0.940
Complete Battery of five predictors	0.165

CODE

1.969 is significant at the five per cent level.

2.593 is significant at the one per cent level.

mediate batteries differs with this group at Fenger High School as it did with the group at Lane High School. The final battery of five predictors gave a multiple R of .6208. This is somewhat closer to the multiple R of .6859 obtained from the same battery given at Harrison High School than were the results that were obtained at Lane High School. However, when the means and standard deviations that are given in Table XVIII were used to apply the t test for significance between the original group of 215 boys and the group of sixty-nine boys at Fenger High School, the difference was insignificant. Table XI also discloses that all of the remaining variables with the exception of Age are also not significant.

Applying the multiple regression equation to students numbered 375, 376, and 377, the grades of 58.0755, 52.2987, and 59.2572 respectively were predicted. The actual grades received by these three students were E, G, and E as expressed in letter grades or as expressed in T scores of 60, 50, and 60 respectively. A comparison of the predicted grades with the T score range as shown in Table II, page 65, will disclose that the predicted grades fall within the range for the given letter grades.

#### Cross-Validation

To test the validity of the obtained multiple regression equation with its differentiated weights for each of the five predictors, the equation was applied to a new sample of seventy-nine boys enrolled in September, 1957, in the woodshop at Harrison High School one year later than the original sample.

The coefficient of multiple correlation between the final predictors and the semester's grade is presented in Table XXI. The sequence of the predictors varies in the several intermediate batteries just as they did for the previous multiple R's that were given in Tables XI, XVI, and XX. The coefficient of multiple correlation for the entire battery was .5924, somewhat lower than the original multiple R, but as will be disclosed later in Table XXIII, this difference is not significant.

TABLE XXI

COEFFICIENT OF MULTIPLE CORRELATION BETWEEN FINAL GRADE AND  
A BATTERY OF PREDICTORS FOR THE CROSS-VALIDATION GROUP

Test Battery	Coefficient of Multiple Correlation
Battery A	.5924
Battery B	.5919
Battery C	.5916
Battery D	.5311
Battery E	.4259

CODE

- Battery A: MacQuarrie Test of Mechanical Ability, Kuder Mechanical, Personal Data Questionnaire, Kuhlmann-Anderson, Age.
- Battery B: MacQuarrie Test of Mechanical Ability, Kuder Mechanical, Personal Data Questionnaire, Kuhlmann-Anderson.
- Battery C: MacQuarrie Test of Mechanical Ability, Kuder Mechanical, Personal Data Questionnaire.
- Battery D: MacQuarrie Test of Mechanical Ability, Kuder Mechanical.
- Battery E: MacQuarrie Test of Mechanical Ability.



The intercorrelations between the variables in the cross-validation group along with the means and standard deviations are shown in Table XXII. In all five predictors and in the criterion the mean is slightly higher than in the original sample. The relative importance of these differences will be brought out in the next table.

TABLE XXII

## MATRIX OF INTERCORRELATIONS FOR CROSS-VALIDATION GROUP

	Questionnaire	MacQuarrie	Kuder Mechanical	Kuhlmann-Anderson	Age	Mean	Standard Deviation
Semester's grade	.4110	.4259	.4111	.2733	-.0559	46.582	13.723
Questionnaire		.1705	.3266	.2957	-.1763	45.645	10.641
MacQuarrie			.2424	.4757	-.0531	167.430	31.764
Kuder Mechanical				.2180	-.2221	46.265	9.983
Kuhlmann-Anderson					-.2784	95.506	9.781
Age						181.531	10.555

A comparison of the variables was made between the cross-validation group and the original test sample using the  $t$  test for significance.

Table XXIII shows the comparisons. Only in the one variable, Kuder Mechanical Interest, was there a significant difference between the two groups. This difference lost its identity when the entire battery of five predictors

was used.

Applying the multiple regression equation to students numbered 467, 468, and 469, the grades of 54.5092, 55.6735, and 49.7379 respectively were predicted. The actual grades received by these three students were G, E, and G, as expressed in letter grades or as expressed in T scores of 50, 60, and 50 respectively. A comparison of the predicted grades with the T score range as shown in Table II, page 65, will disclose that the predicted grades fall within the range for the given letter grades.

TABLE XXIII

t TEST FOR SIGNIFICANCE BETWEEN ORIGINAL GROUP  
AND CROSS-VALIDATION GROUP

Variable	<u>t</u> ratio
Age	0.666
MacQuarrie	1.141
Kuder Mechanical	1.995
Kuhlmann-Anderson	1.115
Questionnaire	0.581
Final grade	1.627
Complete battery of five predictors	1.195

CODE

1.968 is significant at the five per cent level.

2.593 is significant at the one per cent level.

## CHAPTER V

### INTERPRETATION OF RESULTS

At the outset of the present study, tests of mental ability, mechanical aptitude, and interests, together with the variables of the pupil's age in months and a personal data questionnaire, were selected for comparison with success in high school woodshop. An examination of Table III reveals that the S.R.A. Mechanical Aptitude total score and three sub-scores; the MacQuarrie Test of Mechanical Ability total score and six sub-scores; the Garretson Interest Questionnaire with its three areas of technical, academic, and commercial interest; three interest areas of the Kuder Preference Record, mechanical, literary, and musical; the S.R.A. Primary Mental Abilities total score and four sub-scores; the Kuhlmann-Anderson Intelligence test; the Personal Data Questionnaire; and the pupil's age in months -- all showed significant correlation at the five per cent level of probability. Validity of each of the tests is discussed in Chapter IV. If the assumption is made that the tests are valid, that is, that they do measure the hypothetical qualities which they were designed to measure, then it may be inferred that mental ability, mechanical aptitude, interest, age, and pertinent environmental data play a large part in success in a high school woodshop course.

The MacQuarrie sub-test, Dotting, shows a negligible correlation with the criterion. This is in accord with Bingham's statement that the

Dotting sub-test "is more strictly a motor activity, a rough appraisal of manual ability"; that "a person with good motor coordination may learn to excel in routine work"; but "manual aptitudes are not enough." <sup>1</sup>

A further explanation of the low correlations between the MacQuarrie Dotting sub-test and success in woodshop may be found in the analysis of the course itself. Since the objective of a woodshop course is not to prepare pupils especially for skilled trades, but rather to "offer orientation through actual experiences with materials and goods", <sup>2</sup> one might reasonably expect that dexterity would play a relatively small part in the determination of woodshop grades.

Table III indicates the existence of some significant relationships between the criterion and interests as measured by the Kuder Preference Record. The mechanical score on the Kuder shows correlation beyond the one per cent level of probability. Due to the nature of the woodshop course, strong mechanical interests might logically be expected to contribute to success. More difficult to understand is the relationship of literary and musical scores to the criterion. The negative coefficients obtained for these scores tend to indicate that lack of literary and musical interests correlates significantly with high grades in woodshop, or, conversely, that possession of literary and

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1. Bingham, Aptitude, 137

2. Weaver, "Definition of Terms", 15

musical interests correlates with low grades on the course. Such areas of interest as outdoor, computational, scientific, persuasive, artistic, social service, or clerical show no significant relationships to success in woodshop. Indications are that interest does play some part in the grade received in woodshop.

Table III also indicates the existence of additional significant relationships in interest as measured by the Garretson Interest Questionnaire. The technical score shows correlation beyond the one per cent level of probability. Here too, due to the nature of the woodshop course, strong technical interests might be expected to contribute to success. Here, also, the negative coefficients obtained for the academic and for the commercial interests tend to indicate that lack of academic and commercial interests correlates significantly with high grades in woodshop. On the basis of this study, interest, as expressed by the Garretson Interest Questionnaire, does play a part in the grade received in woodshop.

Of the Primary Mental Abilities, the only mental ability that failed to show any significant correlation with the criterion is the numbers ability. The possibility of lack of interest in this area as expressed in the Kuder computational correlation of practically zero might account for the low correlation in the numbers area.

The results shown in Table III might be summarized by saying that pertinent environmental data, as measured by the Personal Data Questionnaire, and mechanical aptitude, as measured by the MacQuarrie Test of Mechanical

Ability or by the S.R.A. Mechanical Aptitude Test, have a far greater influence on woodshop grades than any of the other factors measured; they show that mental ability, as measured by the Kuhlmann-Anderson Intelligence Test or by the S.R.A. Primary Mental Abilities Test, that interests measured by the Kuder or Garretson test, and that age as expressed in months shows some relationship to grades.

One may make some interesting interpretations of the coefficients of multiple correlation obtained for various combinations of tests. In a two battery test of interest and mechanical aptitude or of intelligence and mechanical aptitude with the criterion, it was found that, of the four pairs of combinations, the S.R.A. Mechanical Knowledge sub-test made a better prediction in three out of the four cases than the total S.R.A. Mechanical Aptitude Test, even though the total score showed a better correlation with the criterion than did the mechanical knowledge sub-score. The same results are verified in a three test battery illustrated in Table VII. The S.R.A. Mechanical Knowledge gave a slightly higher multiple R (.3957) than did the S.R.A. Mechanical Aptitude total score (.3947). Economy of time with equally effective results may be effected by using only the mechanical knowledge sub-test instead of the total S.R.A. Mechanical Aptitude Test.

Economy of time may also be effected by using only three of the sub-tests, Location, Copying, and Pursuit, of the MacQuarrie Test of Mechanical Ability; better correlation with the criterion than the total MacQuarrie score (.4676 as opposed to .4157) can still be obtained. By adding the additional

sub-tests of Blocks, Tapping, and tracing, the correlation is only increased from .4676 to .4737, an increase of only .0071, not enough to justify their inclusion.

The mechanical interest score of the Kuder test is nearly as effective when used alone with the criterion as when used in combination with the musical area, or with the musical and literary areas. An R of .2732 is obtained between the mechanical interest and the criterion, as compared to a multiple R of .2906 and .3033 respectively with the second and third combinations.

In the original testing program three pairs of psychological tests were given, two tests each of intelligence, mechanical aptitude, and interest. The question arises as to which test of these six is the least effective in prediction and, therefore, may be eliminated from the final battery. By a process described by Du Bois in connection with his multivariant method of correlation, variables which duplicate the functions of variables already chosen tend to drop out. It was, therefore, evident that the S.R.A. Primary Mental Abilities Test contributed the least of the six tests and was eliminated from future consideration.

In order to determine which interest test is the better test to use, a battery of five possible predictor variables, Personal Data Questionnaire, MacQuarrie Test of Mechanical Ability, Garretson Interest Questionnaire Technical Score, Kuhlmann-Anderson Intelligence Test, and Age in months, was correlated by the Du Bois method to give a multiple R of .6841. A multiple R

of .6859 was obtained from a similar battery, except that the Kuder Mechanical Interest Test was substituted for the Garretson test. It may be said that either interest test is as effective as the other for predictive purposes; the slight advantage of .0018 of the Kuder seems negligible. The predictive efficiency of the five test battery finally selected is .6859.

By administering this five test battery to a group of non-technical boys, it was found that the boys who did not select shopwork differed significantly in four of the five areas tested. Only in the matter of age was there no difference in the groups. These non-technical boys showed a significant difference from the technical boys in mechanical ability, mechanical interest, intelligence, and environmental factors at the five, one, one, and one per cent level of probability respectively.

In comparing the original test group with a group of technical boys in the Foundry shop, it was found that the boys in the Foundry differed in no respect from the original group except in age. This can be accounted for easily enough. For three years immediately preceding the testing program the total number of shop classes was slightly reduced in number, due to extensive rebuilding of many portions of the school building. A partial vacuum was created during this time, when the incoming freshmen were not given any shop. The available number of shop stations was reserved for the upper-classmen instead. At the time the Foundry group was tested, the first semester freshmen were again given the opportunity to have shop. The boys in the woodshop group, although six months older, were taking shop for the first time in high school.



The answer to the question, "Do the boys in the woodshop at Harrison High School differ from boys taking woodshop in other Chicago high schools?" is obtained by comparing the results at Harrison with the results of the same battery of five predictors as given to seventy-three boys at Lane High School and to sixty-nine boys at Fenger High School. At Lane High School, a significant difference at the one per cent level of probability is noted for the variables of age, Kuhlmann-Anderson I.Q., and final grade. The difference between the mean of ages at Harrison, 180.753, and the mean of ages at Lane, 170.972, is 9.781 months. A difference of six months may be accounted for in the manner in which the difference in ages between the test group and the Foundry group was accounted for in the preceding paragraph. The other 3.781 months may possibly be due to fewer failures in elementary school for the boys at Lane, as compared to the boys at Harrison. It is evident that there is a significant difference in the Mean I.Q.; Lane High School boys are a total of 13.740 points higher than the group tested at Harrison. Since the I.Q. is one of the best predictors of academic success, it is, therefore, logical to believe that the group with the higher I.Q. would encounter less academic difficulty, and, thus, less elementary school failure. With a significant difference between two of the five predictors, it was expected that there would be a difference in the final grade, which in this case is also significant at the one per cent level of probability. However, the complete battery of the five predictors revealed a multiple R of .5963, as compared to .6859 at Harrison. When the t test is applied to these two correlations, the difference

was found to be non-significant. The regression formula, as worked out for the original test group, will also apply to this sample at Lane High School.

When the same battery of five predictors is applied to a second high school woodshop group, a group of sixty-nine boys at Fenger High School, a significant difference at the one per cent level of probability between them and the original test group was found in only one of the five predictors, age. The difference between the mean of ages of 180.753 at Harrison and 174.203 at Fenger is 6.551 months. Six of these months are attributed to the deferment of shopwork at Harrison because of the extensive building rehabilitation program carried on at the time of testing. If the physical facilities of the school were available at the time to allow shopwork in the first semester of the first year, there would have been no difference in the ages. The results of the remaining five predictors, in questionnaire, mechanical aptitude, mechanical interest, I.Q., and final grade showed no significant difference from the results of the original test group. Even the complete battery, which revealed a predictive coefficient of  $R = .6208$  as compared to  $R = .6859$  of the original test group, was well below the five per cent level of significance. The regression formula as worked out for the original test sample is also valid when applied to this sample at Fenger High School.

In September, 1957, one year after the original sample was tested, the same five predictors were administered to a second group of seventy-nine woodshop students at Harrison High School to test the validity of the original sampling. In one variable only, under mechanical, was there a

difference significant at the five per cent level of probability. The remaining five variables, age, mechanical aptitude, I.Q., questionnaire, and final grade, showed no significant difference, each one being below the five per cent level of probability. When the t test was applied to the multiple R of .5924 for the battery of five predictors as opposed to a multiple R of .6959 for the original battery, the difference was found to be non-significant. The regression formula with the weights assigned to the various variables has stood the test of cross-validation.

## CHAPTER VI

### SUMMARY AND CONCLUSIONS

Three pairs of psychological tests, of mental ability, mechanical aptitude, and interest, along with a personal data questionnaire, were administered to 215 pupils in ninth grade woodshop course at Harrison High School in Chicago, Illinois. The pupils' ages at the beginning of the semester were recorded. The semester's grade on the course for each pupil was obtained. The six psychological test scores, the questionnaire score, and the pupil's age in months were compared with the semester's grades by the Pearson product-moment method of correlation.

Statistically significant correlations were obtained between the semester's grades and the S.R.A. Primary Mental Abilities Test; the Kuhlmann-Anderson Intelligence Test; the S.R.A. Mechanical Aptitude Test; the MacQuarrie Test of Mechanical Ability; the Garretson Interest Questionnaire for High School Students; the Kuder Preference Record mechanical interest, literary interest, and musical interest; the Personal Data Questionnaire; and the pupil's age in months. Correlation for the Kuder literary and musical interests, for the Garretson Commercial curriculum and Academic curriculum, and for the pupil's age in months, although significant, were negative instead of positive. Even though the total score on the MacQuarrie test and on the S.R.A. Primary

Mental Abilities Test was significant, all of the sub-tests did not meet this requirement. The Dotting sub-test of the MacQuarrie and the Numbers sub-test of the Primary Mental Abilities Test failed to reach the five per cent level of significance.

Examination of the coefficients of correlation led to the following conclusions: (1) pertinent environmental information as measured by the Personal Data Questionnaire and mechanical aptitude as measured by the MacQuarrie Test of Mechanical Ability have a greater influence on woodshop grades than any of the other factors measured; (2) interests as measured by the technical curriculum of the Garretson Interest Questionnaire or by the Kuder Preference Record mechanical area, mental ability as measured by the S.R.A. Primary Mental Abilities Test, or the Kuhlmann-Anderson Intelligence Test, and Mechanical Aptitude as measured by the S.R.A. Mechanical Aptitude Test, have a definite significant relationship to the grades; and (3) interest as measured by the Kuder Preference Record for the outdoor, computational, scientific, persuasive, artistic, social service, or clerical areas is not significantly related to the grades.

By using multiple correlation<sup>1</sup> for a series of two-predictor variables and the Du Bois multivariate correlational analysis<sup>2</sup> for three predictor variables, the S.R.A. Mechanical Knowledge sub-test provided just

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1 Guilford, Fundamental Statistics, 427.

2 Du Bois, Multivariate, 12.

as effective a prediction of woodshop grades as the entire S.R.A. Mechanical Aptitude Test.

✓ A higher correlation with the criterion may be obtained by using only three sub-tests of the MacQuarrie test, the Location, the Copying, and the Pursuit sub-tests, instead of the total score. An economy of time is thus effected.

✓ The mechanical interest area of the Kuder Preference Record is nearly as effective with the criterion when used alone as it is when used in combination with the musical and/or literary interest areas, the respective correlations being .2732, .2906, and .3303.

✓ The least effective of the six psychological tests under consideration was the S.R.A. Primary Mental Abilities Test. The fact became evident through an additional process of selecting a reduced number of predictors in connection with the Du Bois multivariate method of correlation.

The technical curriculum score of the Garretson Interest Questionnaire obtained a multiple R of equal predictive effectiveness ( $R = .6841$  as compared with  $R = .6859$ ), as did the mechanical area of the Kuder test when used in a battery along with the Personal Data Questionnaire, the MacQuarrie Test of Mechanical Ability, the Kuhlmann-Anderson I.Q., and the student's age in months.

✓ Using a five-test battery, consisting of the Personal Data Questionnaire, the MacQuarrie Test of Mechanical Ability, the Kuder mechanical interest, the Kuhlmann-Anderson I.Q., and the student's age in months, a coefficient of

multiple correlation was found to be .6859. A multiple regression equation was derived from the battery of predictors.

Non-technical students were found to differ significantly from the technical students in four of the five areas tested, in mechanical aptitude, in mechanical interest, in I.Q., and in environmental factors.

Boys who selected Foundry shop differed significantly from those who selected woodshop in one factor only, in age. However, this difference lost its importance when it was explained that the physical rebuilding of parts of the school had eliminated shop during the first semester in high school in order to favor the upper-classmen for a period of several years.

When the test sample was compared with a sample from a second Chicago high school, Lane, a significant difference was found between the two groups in ages, I.Q., and in final grade. Nevertheless, when the t was applied to the multiple correlation of .5963 for the five-predictor battery, no significant difference was found. It was, therefore, concluded that the regression formula is satisfactory for this group also.

The same final conclusion concerning the regression formula was reached when a sample from a third Chicago high school, Fenger, was compared with the original test sample, because no significant difference was found when the t test was applied to the multiple correlation of .6208.

(To test the validity of the obtained regression formula with its assigned weights, a second sample was tested at Harrison High School one year later.) No significant difference was found in any of the variables used

as predictors, the Personal Data Questionnaire, the MacQuarrie Test of Mechanical Ability, the Kuder Mechanical Interest, the Kuhlmann-Anderson Intelligence Test, and the pupil's age in months. There was no significant difference found in the criterion, the final grade, between the two groups, nor in the multiple correlation of .5924 obtained from the entire battery of predictors. The regression equation with its assigned weights, it may be concluded, has withstood the test of cross-validation and may, therefore, be used again in similar situations.

While the predictor value of the battery would not be sufficiently high to justify selection and elimination of pupils on the basis of scores obtained, the information provided by the tests would be of diagnostic value to the teacher, as it would indicate which pupils might experience difficulty in the course so that special attention might be given to these pupils.

The author of this study collected more data than was found practical to use. Such material gives rise to further research. The pupil's elementary school, public or parochial, the race classification of each pupil, or personality trait ratings given each pupil by his teacher near the end of the semester, all of which could cause pupils to differ from one another in grades, were not measured by any of the variables employed in this study. Research to determine the effect of these factors would be desirable.



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APPENDIX I

RECORD CARD

1. Name _____	12. Drawing Taken	Grades
2. Address _____	a. _____	_____
3. Telephone _____	b. _____	_____
4. Date of Birth _____	c. _____	_____
5. School Last Attended _____	d. _____	_____
6. Div. _____ Period _____	13. Shop Fee _____	
7. Guardian _____	14. Movie Fee _____	
8. Occupation _____	15. Failure Notice _____	
9. Business Address _____	16. Fail. Not. Ret'd _____	
10. Course _____	17. Parent Visited _____	
11. Shops Taken	18. Key No. _____	Grades
a. _____	19. Bench No. _____	_____
b. _____	20. Note Book _____	_____
c. _____	21. Plane No. _____	_____
d. _____	22. Notes _____	_____
e. _____		_____

APPENDIX II

RELATED LESSONS

Title	Page in Workbook	Week of Semester
1. Squaring	9-10	1
2. Sharpening	7-8	2
3. Tools	4-5	3
4. Turning	15	5
1st Marking Period		
5. Finishing	16-17	7
6. Safety	1-2-3	8
7. Machine	6	10
2nd Marking Period		
8. Rule	14	12
9. Board Measure	18	13
10. Wood Sample	12	15
3rd Marking Period		
11. Sandpaper	11	17
12. Fasteners	13	18
4th Marking Period		



APPENDIX III

INDIVIDUAL PROJECT RECORDS

Project	No. of Weeks	Date Started	Date Finished	Grade	Check
1. Note Book	1				
2. Plane Blade					
3. Peg Board	2				
4. Tie Rack	3				
<hr/>					
	6th Week				
5. Shield	2				
6. Salt & Pepper Shakers	1				
<hr/>					
	9th Week				
7. Shelf	4				
<hr/>					
	13th Week				
8. Book Rack	4				
9. Sharpen Lathe Tool					
10. Lathe Work	1				
a. Bowl					
b. Lamp					
c. Mallet					
d. Gavel					

## 11. Special

a. Pump Lamp 2

b. Taboret 5

## APPENDIX IV

### PERSONAL DATA QUESTIONNAIRE

Each test that you have taken this semester has been given to secure a particular type of data. In order to know you better, there is need for additional information not included in these tests.

Answer the following questions as you think they should be answered, not as you think your teacher would like to have them answered. Your answers will be kept confidential. They will in no way affect your grade. Be sure to answer every question. Do not skip any, nor leave any blanks.

1. With whom do you live? (Check one)

Mother and Father

Step Mother

Mother only

Step Father

Father only

Other (brother, sister, aunt, uncle, or guardian)

2. Did you skip any grades in the elementary school? Yes No Which grade?

3. Did you repeat any grades in the elementary school? Yes No Which grade?

4. Do you plan to go to any kind of school after high school? Yes No

5. If you know the name of the school where you plan to go, list it here  
, or if you do not know the name, but do know the kind of school list it here

6. Father's education (Circle the highest grade completed) Elementary 1 2 3 4  
5 6 7 8, High School 1 2 3 4, College 1 2 3 4 5

7. Mother's education (Circle the highest grade completed) Elementary 1 2 3  
4 5 6 7 8, High School 1 2 3 4, College 1 2 3 4 5
8. Kind of work done by father
9. Has your father always done this kind of work? Yes No
10. If no, what other kind of work has he done?
11. Kind of work done by mother
12. Has your mother always done this kind of work? Yes No
13. If no, what other kind of work has she done?
14. Do you work outside of school? Yes No
15. If yes, what kind of work?
16. What are some of the things you do with your earnings? (List below)
17. Of what clubs are you a member?
- |                |             |
|----------------|-------------|
| In school      | Office held |
| Outside school | Office held |
18. Do you have a T.V. in your home? Yes No
19. Average number of hours per week spent watching T.V. (Check one)
- 0 1 5 10 15 20 25 30
20. Type of program liked most on T.V. (Check one)
- |                          |            |                   |
|--------------------------|------------|-------------------|
| Western movie            | Quiz shows | Detective stories |
| Feature film             | News       | Sports            |
| Fix-it-yourself programs | Comedy     |                   |
21. Do you frequently watch the Uncle Walt program sponsored by the Edward Hines Company? Yes No
22. Have you visited a library in the past month? Yes No
23. What book have you read in the past month?

24. Have you read a book that related specifically to mechanical things since school started in September? Yes No
25. If yes, what book?
26. What magazines have you read since school started in September? List below
27. Of these, what magazines do you read regularly? (List the names)
28. What hobbies do you have?
29. Do you have tools at home that you can use (such as electric drill, circular saw, jig saw, sander, hand tools)? Yes No
30. If yes, name the kind of tools you have:
31. Do you have a place to work with tools? Yes No
32. If yes, where? (Be definite)
33. For what kind of work would your parents like you to prepare?
34. For what kind of work would you like to prepare? (List in order of choice)
35. School subject you like best.
36. School subject you like least.
37. Was Woodshop your first choice of shop in high school? Yes No
38. If no, what was your first choice?
39. Has your father ever encouraged you to take Woodshop? Yes No
40. Has your mother ever encouraged you to take Woodshop? Yes No
41. Has your brother or sister encouraged you to take Woodshop? Yes No
42. Did someone outside the family encourage you? Yes No
43. Do you intend to take a second semester of Woodshop? Yes No
44. Would you recommend Woodshop to your friends? Yes No
45. Why did you select Woodshop?
46. Why did you select the technical sequence?

47. your name is

APPROVAL SHEET

The dissertation submitted by Donald Joseph Racky has been read and approved by five members of the Department of Education.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content, form, and mechanical accuracy.

The dissertation is therefore accepted in partial fulfillment of the requirements for the Degree of Doctor of Education.

7/5/60  
Date

Samuel T. May  
Signature of Adviser