VALIDITY AND RELIABILITY FOR THE INDUSTRIAL ARTS APTITUDE BATTERY: POWER MECHANICS TEST

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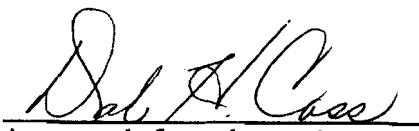
This 1977 study was undertaken to establish validity and reliability for the Industrial Arts Aptitude Battery: Power Mechanics Test. The concurrent validation method was used. In this method a test which has shown validity is compared against the test to be validated. If a high relationship is found between the two, validity may be inferred. The Bennett Mechanical Comprehension and the DAT Mechanical Reasoning had both shown predictive validity for auto mechanics training in previous studies. The researcher elected to use the Kuder-Richardson formula 20 method to establish reliability.

Six tests were administered to two groups of twenty students each. The experimental group consisted of twenty students in an auto mechanics training program at the Flint Hills Area Vo-Tech School in Emporia, Kansas. The control group consisted of twenty general education students from Emporia High School. The six tests were: (1) the Industrial Arts Aptitude Battery: Power Mechanics Test, Form A; (2) the DAT Mechanical Reasoning, Form L; (3) the DAT Abstract Reasoning,

Form L; (4) the DAT Space Relations, Form L; (5) the Bennett Mechanical Comprehension, Form S; and (6) the Otis-Lennon Mental Ability Test, Form J. Intercorrelations were calculated between all testing instruments using the Pearson Product-Moment Method.

The Industrial Arts Aptitude Battery: Power Mechanics Test was compared against the DAT Mechanical Reasoning and the Bennett Mechanical Comprehension. The correlation between the Power Mechanics Test and the DAT Mechanical Reasoning (.82) was significant at the .01 level. The correlation between the Power Mechanics Test and the Bennett (.71) was also significant at the .01 level. Both relationships were considered high. The reliability coefficient was .97 for the Power Mechanics Test.

The high relationship between the Industrial Arts Aptitude Battery: Power Mechanics Test, the DAT Mechanical Reasoning and Bennett Mechanical Comprehension establishes validity for the Power Mechanics Test. A reliability coefficient of .97 shows that 97 percent of the variance measured was due to the actual trait measured.



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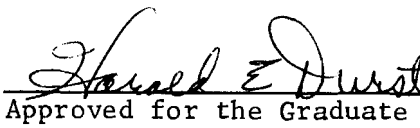

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I also wish to extend my gratitude to Dr. Elton Amburn who nurtured me through each stage of this investigation. His assistance was sage and his spirit steadfast.

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Chapter 1

INTRODUCTION

Aptitude has been defined as "the ability to acquire new knowledge and proficiency with training."[1] This ability is considered to be a combination of inborn ability and/or acquired skills.[2] Anastasi[3] discussed "special aptitude tests" to draw more precisely the distinction between technical aptitudes and the scholastic aptitude measured by intelligence tests. The importance of aptitude to an educator, guidance counselor, or personnel administrator lies in his capability to predict its presence. A great deal of time and effort is wasted when those with low specific aptitudes are placed in a program or position in which their lack of aptitude contributes to failure.

An aptitude test, which is "one intended to predict success in some occupation or training course",[4] provides the most objective means for measurement. In order to use a test successfully for prediction it must be both reliable and valid. Reliability means that the test consistently measures what it is purported to measure. Without

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[1]Louis J. Karmel, Measurement and Evaluation in the Schools (New York: The Macmillan Company, 1970), p. 465.

[2]Ibid.

[3]Anne Anastasi, Psychological Testing (3d ed.; New York: The Macmillan Company, 1968), p. 13.

[4]Lee J. Cronbach, Essentials of Psychological Testing (3d ed.; New York: Harper and Row, 1970), p. 38.

reliability, test scores would deviate to an extent which would cause prediction to be miscalculated. For example, if a subject scored 90 on a scale of 100 and at a later date scored 50 on the same scale, it would be very difficult to predict from these scores. Validity, on the other hand, specifies the extent to which a test measures what it claims to measure. If a test does not measure what it claims, then it is without value for prediction.

Generalized aptitude measures, e.g., the Differential Aptitude Tests, have been shown to have highly differing relationships with various areas within vocational-technical training.[5] It becomes evident that specific areas in vocational-technical training require specific tests. The area of auto mechanics has only one such aptitude test listed in the Seventh Mental Measurements Yearbook and no research is stated for that specific test. Some related literature is discussed in the Review of Literature. The development of the Industrial Arts Aptitude Battery: Power Mechanics Test contributes greatly to this area and this research provides a new basis for further study.

Purpose of the Study

The purpose of the study was threefold. The first part of the problem involved establishing norms for the Industrial Arts Aptitude Battery: Power Mechanics Test (hereafter referred to as the IAAB:PMT). In regard to norms Anastasi has said the following:

> . . . test norms represent the test performance of the standardization sample. The norms are thus empirically

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[5]Leroy David Unruh, "An Inquiry into the Relationship Between Certain Differential Aptitude Test Scores and Grades Earned in Junior and Senior High School Industrial Arts (unpublished Master's thesis, Kansas State Teachers College, 1964).

> established by determining what a representative group of persons actually do on the test. Any individual's raw score is then referred to the distribution of scores obtained by the standardization sample, to discover where he falls in that distribution.[6]

Thus, with a set of norms a subject's test score can be given some interpretative meaning by comparing it to the norms.

The second part of the problem was to establish validity for the IAAB:PMT. The method used for this procedure is called concurrent or predictive validity. In discussing concurrent validity Cronbach has said that "the designer of a new test will suggest its validity by comparing it concurrently with an established test."[7] To define more specifically he said:

> If the existing method is considered useful for decision making, it is appropriate to ask whether the new test agrees with the present source of information. In this comparison, the existing procedure is accepted as giving the information desired. If there is agreement, the test measures what the other procedure does. If there is little agreement, the test may have value but it is not equivalent to the original procedure.[8]

Although this could simply be called concurrent validity, Cronbach stated that "logically, predictive and concurrent validation are the same, and most writers apply the term predictive to both."[9]

The third and final aspect of the problem was to establish reliability for the IAAB:PMT. The method chosen was the Kuder-Richardson formula 20. This procedure gives a measure of inter-item consistency of the content sampling and a measure of the heterogeneity of the behavior domain sampled.

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[6]Anastasi, op. cit., p. 39.

[7]Cronbach, op. cit., p. 122.

[8]Ibid.

[9]Ibid.

THE PROBLEM

The problem for this study was to determine the relationship of the IAAB:PMT and its subtests to the Otis-Lennon Mental Ability Test, the Differential Aptitude Tests (DAT), and the Bennett Mechanical Comprehension Test. The subtests of the IAAB:PMT were Vocabulary, Comprehension, and Analogies. The total of these scores was also used. The only subtest selected from the Differential Aptitude Tests to be used individually was the Mechanical Reasoning. The total of the Space Relations, Mechanical Reasoning, and Abstract Reasoning subtests was utilized, also. Another part of the problem for this study was to determine the relationship between the test items on the IAAB:PMT.

Statement of the Problem

What relationship exists among the subtests and total of the IAAB:PMT and the Otis-Lennon Mental Ability Test?

What relationship exists among the subtests and total of the IAAB:PMT and the total of the Space Relations, Mechanical Reasoning, and Abstract Reasoning subtests of the DAT?

What relationship exists among the subtests and total of the IAAB:PMT and the score from the Bennett Mechanical Comprehension Test?

What relationship exists among the test items of the IAAB:PMT?

Statement of the Hypotheses

There are no significant relationships among the subtests and total of the IAAB:PMT and the Mechanical Reasoning subtest of the DAT.

There are no significant relationships among the subtests and total of the IAAB:PMT and the score from the Bennett Mechanical Comprehension Test.

There are no significant relationships among the subtests and total of the IAAB:PMT and the total of the Space Relations, Mechanical Reasoning, and Abstract Reasoning subtests of the DAT.

There are no significant relationships among the subtests and total of the IAAB:PMT and the Otis-Lennon Mental Ability Test.

There are no significant relationships among the test items of the IAAB:PMT.

DEFINITION OF TERMS

A large number of terms and abbreviations are used in this study. For the purpose of improving readability and increasing understanding some of those terms are defined as follows.

Abstract Reasoning. The Abstract Reasoning subtest of the Differential Aptitude Tests. It is a non-verbal measure of the ability to perceive relationships in abstract figure patterns.

Auto Mechanics Aptitude. An individual's potential ability to acquire knowledge and proficiency in the field of auto mechanics.

Auto Mechanics Training. Study of the automobile, including theory of operation, preventive maintenance, and diagnosis and repair of the mechanical units.

DAT. The Differential Aptitude Tests. A generalized aptitude battery including eight tests to be administered individually or as a group. The tests include Verbal Reasoning, Numerical Ability, Abstract Reasoning, Clerical Speed and Accuracy, Mechanical Reasoning, Space Relations, Language Usage I: Spelling, and Language Usage II: Grammar.

IAAB:PMT. The Industrial Arts Aptitude Battery: Power Mechanics Test. An aptitude test for the purpose of measuring aptitude in the specific area of auto mechanics. It includes three subtests: Vocabulary, Analogies, and Comprehension. It is a seventy-five item, multiple choice, group-administered test.

I.Q. A value representative of a person's verbal-educational mental capacity as measured by the Otis-Lennon Mental Ability Test.

Mechanical Comprehension. An understanding of general mechanical concepts as measured by the Bennett Mechanical Comprehension Test.

Mechanical Reasoning. The Mechanical Reasoning subtest of the Differential Aptitude Tests. A group of pictorially-presented mechanical situations which requires an understanding of mechanical concepts to answer correctly.

Space Relations. The Space Relations subtest of the Differential Aptitude Tests. It requires the ability to visualize a constructed object from a picture of a pattern and to imagine how an object would appear if rotated in various ways.

Vo-Tech. The area of vocational-technical training which includes the area of auto mechanics.

LIMITATIONS OF THE STUDY

The first and foremost limitation of this study was the sample size, forty. This sample size limits the conclusions which can be drawn. The limitation on the sample size was necessitated by the number and nature of the tests administered.

Secondly, the population sample was drawn from Emporia and the surrounding area. This limits the conclusions which can be drawn to that area.

Finally, there is the limitation imposed by the original predictive value of the testing instruments which were used. Even a perfect correlation between the IAAB:PMT and one of those tests produces only the predictive validity of the original. These limitations should be considered when interpreting the results of this study.

Chapter 2

REVIEW OF THE LITERATURE

A review of the related literature showed that there was no prior research on the IAAB:PMT. There was one auto mechanics aptitude test, the Short Occupational Knowledge Test for Auto Mechanics, listed in the Seventh Mental Measurements Yearbook. No research was cited for this test and the reported validity was established through content validation. By taking the test items from professionals the test maker claimed the test to be content validated.

A search of the literature also disclosed that studies had been done on the DAT, the Bennett Mechanical Comprehension Test, and the Otis-Lennon Mental Ability Test in comparison to auto mechanics training and vocational-technical training in general. It was found that there were three studies relating to the DAT and auto mechanics training. There was one study done that related the DAT to vocational-technical training in general. One study was found that related the Bennett Mechanical Comprehension Test to auto mechanics training and there was one study that related the Otis-Lennon to the area of vocational-technical training.

The DAT samples "narrow segments of aptitude with the intent of predicting success in a relatively-narrow field of vocational endeavor."[1]

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[1]George K. Bennett, Harold G. Seashore, and Alexander G. Wesman, Manual for the Differential Aptitude Tests (4h ed.; New York: The Psychological Corporation, 1966), pp. 1-2.

Some of these areas have been shown to have predictive value within the area of auto mechanics and vocational-technical training in general.

The Bennett Mechanical Comprehension Test measures an understanding of mechanical concepts. It has also been shown effective for prediction within the area of auto mechanics training.

The Otis-Lennon Mental Ability Test covers the verbal-educational half of mental capacity as opposed to the practical-mechanical half.[2] This test was utilized to discover if there were much overlap in either the measurement of these variables or in the skills required for auto mechanics. More precisely, it was hoped to discover the extent of the importance of verbal-educational mental capacity to auto mechanics training.

The DAT and Auto Mechanics Training

In 1954, Doppelt, Shore, and Odgens[3] conducted a study in seven vocational schools in Ohio. For a criterion the authors used a rating system in which each subject was rated on Understanding of Trade Information, Job Know-How, Quality of Work, and Quantity of Work. The authors compared the Differential Aptitude Tests with these ratings to determine to what extent the tests were useful in predicting success in the vocational-technical areas.

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[2]John E. Milholland, The Seventh Mental Measurement Yearbook, ed. Oscar K. Burros (Highland Park, N.J.: The Gryphon Press, 1972), p. 690.

[3]Jerome E. Doppelt, Harold G. Seashore, and John G. Odgens, "Validation of the Differential Aptitude Tests for Auto Mechanics and Machine Shop Students," Personnel and Guidance Journal, XXXVII (May, 1959), 648-55.

Out of the 285 total subjects in the vocational-technical area, 116 of those tested in the eleventh grade were in the auto mechanics area and 88 were retested at the end of the twelfth grade. The decrease in subjects was due to students being lost from the program.

The more promising relationships between grade eleven ratings and DAT scores were Understanding Trade Information and Spelling (r=0.35), Quantity of Work and Mechanical Reasoning (r=0.36), Quantity of Work and Abstract Reasoning plus Mechanical Reasoning (r=0.38), Total Rating and Abstract Reasoning (r=0.35). The highest correlations between twelfth grade ratings and DAT scores were in Understanding Trade Information and Spelling (r=0.38), and Understanding Trade Information and Abstract Reasoning (r=0.36). In their summary the authors stated that "the prediction of over-all accomplishment of Auto Mechanics students was not satisfactory."[4]

Another study was done by Foote[5] for his dissertation in 1960. The author administered a group of tests (including the DAT) to 435 beginning students in an automotive vocational high school. The results were evaluated by statistical procedures against two dichotomous criteria and ten continuous criteria to determine predictions of success:

> The dichotomous criteria consisted of (1) Graduate vs. Non-Graduate, and (2) Continuing into the second half of the curriculum vs. Leaving or retardation. Individual biserial correlation analysis and multi-variable discriminant analysis were used with both criteria. Six continuous criteria were obtained at the end of the three-year curriculum: four term grade averages of

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[4] Ibid., p. 655.

[5] Richard Paul Foote, "The Prediction of Success in Automotive Mechanics in a Vocational-Industrial Curriculum on the Secondary School Level," Dissertation Abstracts, XXI (1960), 3014-15.

> academic subjects, related technical subjects, shop and total combined averages; instructors' rankings and practical performance test scores. Four continuous criteria were obtained at the midpoint of the curriculum: term grade averages of academic subjects, related technical subjects, shop and total combined grade averages. Linear, multiple regression, and Wherry-Doolittle analysis techniques were used for each continuous criterion.[6]

The findings of this study revealed that the DAT Mechanical Reasoning test was significant in the prediction of both dichotomous criteria and two of the continuous criteria. The dichotomous criteria were graduation from the automotive curriculum and continuing into the second half of the curriculum. The two continuous criteria were performance test scores and related technical subject term grade averages.

Yet another study was done by Unruh[7] in 1964. In his study he compared the Mechanical Reasoning, Space Relations and Abstract Reasoning tests from the DAT against high school grades for courses in drafting, metalworking, woodworking, and auto mechanics. His samples used from eleven to one hundred sixteen students from junior high schools and high schools in Shawnee Mission, Kansas.

The study of high school auto mechanics students included forty-three subjects. He found there was a correlation between Mechanical Reasoning and auto mechanics grades of .447. That correlation was significant at the 1 percent level. There was also a correlation of .376 between the total of Abstract Reasoning, Space Relations, and Mechanical Reasoning and auto mechanics grades which was significant at the 5 percent level.

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[6] Ibid., p. 3014.

[7] Unruh, op. cit.

The DAT and Vocational-Technical Training

In 1955, Stoughton[8] wished to discover the differential predictive value of the DAT for his dissertation. The DAT was administered to all ninth grade boys in ten Connecticut technical schools. The criteria of success were grade nine and grade eleven student marks in general education subjects and in five major shop areas. General education courses included English, social studies, science, mathematics, and blue print reading; shop areas were auto, carpentry, drafting, electrical, and machine. Stoughton's findings were that:

> The Abstract, Space, and Mechanical tests are more useful for predicting shop success than for predicting general education success. Relative values of these tests for predicting success in the various shops indicate that they can be used with caution for differential prediction in these schools.[9]

The Bennett Mechanical Comprehension Test and Auto Mechanics Training

A study done by Littleton[10] compared the validities of two similar mechanical aptitude batteries with that of a combination of four selected single tests. He also wished to determine the value of the tests and batteries in predicting success in training in courses in auto mechanics and auto body repair and painting in a technical trades school.

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[8]Robert Wetmore Stoughton, "The Differential Predictive Values of the Differential Aptitude Tests in the Connecticut Technical Schools," Dissertation Abstracts, XV (1955), 1355-56.

[9]Ibid., p. 1355.

[10]Isaac T. Littleton, "Prediction in Auto Trade Courses," Journal of Applied Psychology, XXXVI (February, 1952), 15-19.

The two aptitude test batteries included the SRA Mechanical Aptitudes Form AH, and the California Prognostic Test of Mechanical Abilities Form A. The single tests included the Bennett Test of Mechanical Comprehension, Form AA; the Revised Minnesota Form Board, Series MA; the Purdue Industrial Training Classification Test, Form A; and the O'Rourke Survey Test of Vocabulary, Form X4. The subjects in this study were students in the Knoxville Trade School in Knoxville, Tennessee, training for the trades of auto mechanics and auto body repair and painting.

The findings of this study were that for both groups the highest correlation between any single test or subtest and the criterion (success as measured by ranking) was established by the Bennett Test of Mechanical Comprehension. The correlation between the Bennett and the criterion was .62 for auto mechanics trainees.

The Otis-Lennon Mental Ability Test and Vocational-Technical Training

For his dissertation in 1957, Long[11] devised a method of forecasting academic success in the technical-vocational areas. His methods of prediction were the grade point averages from junior high school, the California Reading Test for reading vocabulary and reading comprehension, I.Q. test scores from the Otis Quick-Scoring Test of Mental Ability, and the Science Research Associates Primary Mental Abilities Test. The criteria used were high school grade point averages in the areas of

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[11]James Robert Long, "Academic Forecasting in the Technical-Vocational High School Subjects at West Seattle High School," Dissertation Abstracts, XVII (1957), 1951-52.

mathematics, science, business education, industrial arts and home economics.

His findings were that the I.Q. test scores were better predictors than the reading vocabulary scores, but not as good an overall predictor as was mathematics grade point averages or reading comprehension scores. Long recommended that "the use of I.Q. score as a predictor of academic success be discontinued in favor of more meaningful variables in the different subject areas."[12]

SUMMARY OF THE LITERATURE REVIEWED

The literature on the DAT points, although not unanimously, to the success of using the Mechanical Reasoning subtest for prediction in the vocational-technical area and, more specifically, in the area of auto mechanics. Two of the three studies between the DAT and auto mechanics showed significance for the Mechanical Reasoning subtest. The one study (Doppelt, Seashore, and Odgens) which did not report significance used criteria (job know-how, quality of work, etc.) which were highly subjective and open to arbitrary interpretation.

A more general, but relevant, relationship was found between the DAT and school courses. The Abstract Relations, Space Relations, and Mechanical Reasoning subtests were found to be more useful for predicting shop success than for predicting general education success.

The one study done between the Bennett Mechanical Comprehension Test and auto mechanics training showed a substantial relationship (.62).

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[12]Ibid., p. 1952.

The Otis-Lennon was found to be less than adequate for success prediction in vocational-technical schools. The one strong relationship which seems to recur in the area of auto mechanics aptitude is with an instrument which measures some form of mechanical reasoning. The Mechanical Reasoning subtest of the DAT was found significant in three of four studies. The Bennett Mechanical Comprehension Test was highly significant in the investigation done on it. Following this reasoning, any test which agrees to a high degree with the Mechanical Reasoning subtest of the DAT and the Bennett Mechanical Comprehension Test should be a good predictor of success in the area of auto mechanics training.

Chapter 3

METHODS AND PROCEDURES

The problem for this study was to explore the relationship between a new auto mechanics aptitude test and some recognized instruments in aptitude prediction. To accomplish this end certain methods and procedures were followed. This chapter covers the population and sampling, the materials and instruments used for data collection, the design of the study, the data collection, the method of analysis of the data, and the acceptance level for the hypotheses.

Population and Sampling

The population for this study consisted of forty students ranging from sixteen to nineteen years of age. The students were randomly selected from the Flint Hills Area Vocational-Technical School and from Emporia High School.

Twenty students were selected from the Flint Hills Area Vocational-Technical School in Emporia, Kansas. The students were all enrolled in an Auto Mechanics major program. All of the students were simultaneously attending the regular high school classes at Emporia High School. This group, the experimental group, consisted of twelve juniors and eight seniors. These students were assumed to have some degree of interest in auto mechanics training because of participation in this technical area.

There were two prerequisites for the selection of the control group. One was that none of the students were, or had been, in an auto mechanics program. The other prerequisite was that the same number of juniors and seniors as were in the experimental group be used. The control group's interest in auto mechanics was assumed to be less since they had not chosen to participate in that vo-tech program.

Materials and Instruments

The instruments used in this study were the Industrial Arts Aptitude Battery: Power Mechanics Test, the Differential Aptitude Tests, the Otis-Lennon Mental Ability Test, and the Bennett Mechanical Comprehension Test.

The IAAB:PMT is a group administered test and consists of three twenty-five question subtests. The subtests are Analogies, Comprehension, and Vocabulary. The time limit allotted for the IAAB:PMT is fifty-five minutes. This test was developed with the intent of measuring aptitude in the area of auto mechanics.

The Differential Aptitude Tests were developed in 1947 to provide an integrated, scientific and well-standardized instrument for measuring the abilities of boys and girls in grades eight through twelve for purposes of educational and vocational guidance. While the tests were constructed primarily for this purpose, they have been used also in the educational and vocational counseling of young adults out of school and in the selection of employees.[1]

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[1]Bennett, Seashore, and Wesman, op. cit., pp. 1-2.

The Otis-Lennon Mental Ability Test Advanced Level is an eighty-item, multiple-choice test which may be group administered. There is a forty-minute time limit on the advanced level.

The Otis-Lennon was designed to provide a comprehensive, carefully articulated assessment of the general mental ability, or scholastic aptitude, of students in American schools. Emphasis was placed on measuring the individual's facility in reasoning and in dealing abstractly with verbal, symbolic, and figural test content sampling a broad range of cognitive abilities.[2]

Three types of reliability were reported for the Otis-Lennon: split-half, Kuder-Richardson formula 20, and alternate-forms. The split-half and Kuder-Richardson reliability coefficients ranged from .94 to .96. The alternate-forms reliability ranged from .92 to .94 for grades ten, eleven, and twelve.

The Bennett Mechanical Comprehension Test has questions which give a drawing depicting physical forces at work or mechanical situations and a question with three possible answers. There are sixty-eight items on the Bennett Mechanical Comprehension Test and a time limit of thirty minutes. This test may be group administered. Bennett has said that this test is to "measure the ability to perceive and understand the relationship of physical forces and mechanical elements in practical situations."[3]

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[2]Arthur S. Otis and Robert T. Lennon, Otis-Lennon Mental Ability Test Manual for Administration, Forms J & K (New York: Harcourt, Brace, and World, Inc., 1967).

[3]Milholland, op. cit., p. 1485.

Design

The school superintendent of the Lyon County School District #253 was approached with a synopsis of the study. Permission was granted to test the individuals with a minimum of interference with their scheduled school classes or activities. It was agreed that all test scores would be kept confidential. The tests were administered to each group (experimental and control) in two sessions. The first session included: (1) the IAAB:PMT, (2) the DAT Mechanical Reasoning, and (3) the DAT Spatial Relations. The second session involved the following tests: (1) DAT Abstract Reasoning, (2) the Otis-Lennon Mental Ability Test, and (3) the Bennett Mechanical Comprehension Test. All tests were administered to the experimental group first before testing the control group.

All tests were administered between May 9, 1977, and May 27, 1977. No student was given a test against his will and a maximum effort was made to provide for adequate testing conditions.

Data Collection

Complete explanations were given for each test before administration. The procedures and rules for the administration of all instruments as stipulated in the manuals were followed. The answers for all tests were placed on separate answer sheets and were scored by hand.

Data Analysis

There were three steps utilized in the analysis of data gathered for this study. The first was the calculation of individual correlation coefficients. This included the calculation of multiple correlations between all factors. The second step was to find Kuder-Richardson

reliability for the IAAB:PMT. The third step involved the calculation of item analysis for the IAAB:PMT.

Calculation of correlation coefficients. After all tests were scored correlation coefficients were computed between each of the factors named in the Statement of the Hypothesis. The Pearson Product-Moment method (formula #30)[4] was used for the calculation of all correlation coefficients. All correlations are designated by the letter r which represents the small case Greek letter rho. The Pearson formula is:

$$r = \frac{N\Sigma XY - \Sigma X \times \Sigma Y}{\sqrt{N\Sigma X^2 - (\Sigma X)^2 \quad N\Sigma Y^2 - (\Sigma Y)^2}}$$

where N = the number of subjects in the population

X = the mean raw score of the first factor to be correlated

Y = the mean raw score of the second factor to be correlated

Σ = the symbol for "the sum of"

The population size used in all calculations was forty. All of the relationships were analyzed in a linear fashion. These calculations were performed by a computer programmed to process the data using the above formula.

Kuder-Richardson reliability. Kuder-Richardson formula 20 reliability was calculated for the IAAB:PMT by using the following formula:

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[4]Henry E. Garrett, Statistics in Psychology and Education (6h ed.; New York: David McKay Company, Inc., 1966).

$$r_{11} = \left(\frac{n}{n-1} \right) \frac{\sigma_t^2 - \Sigma pq}{\sigma_t^2}$$

where r_{11} = the reliability coefficient of the whole test

n = the number of items in the test

σ_t = the standard deviation of total scores on the test

Σpq = a total found by tabulating the proportion of persons who pass (p) and the proportion who do not pass (q) each item. The product of p and q is computed for each item, and the products are then added for all items to give the total.[5]

The aforementioned calculations were programmed into a computer and processed by the computer. The resulting r was the reliability for the Industrial Arts Aptitude Battery: Power Mechanics Test. Reliability is best defined by Anastasi:

> Any reliability coefficient may be interpreted directly in terms of the percentage of score variance attributable to different sources. Thus, a reliability coefficient of .85 signifies that 85 percent of the variance in test scores depends on true variance in the trait measured and 15 percent depends on error variance.[6]

Item analysis for the IAAB:PMT. The process of item analysis ranks all subjects by their scores on the IAAB:PMT. The top 27 percent of the subjects are used and their answers are compared to the lowest 27 percent. The level of difficulty is computed by figuring the percentage of both the top and bottom 27 percent which give the answer correctly. In regards to item difficulty Anastasi has reported the following:

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[5]Anastasi, op. cit., p. 85.

[6]Ibid., p. 87.

> Obviously if no one passes an item, it is excess baggage in the test. The same is true of items that everyone passes. Neither of these types of items provides any information about individual differences. Conversely, the closer the difficulty level approaches .50, the more differentiations the item can make. It is best to choose items with a moderate spread of difficulty level, but whose average difficulty is .50.[7]

The level of discrimination is another item analysis measure. The discrimination index is derived by subtracting the low-scoring group percentage from the high-scoring group percentage. Garrett has reported that for decision purposes "items with validity indices of .20 or more are regarded as satisfactory; but items with lower indices will often serve if the test is long."[8]

Acceptance of Hypotheses

The hypotheses tested in this study were accepted or rejected at the .05 level of significance. This specifically means that if the correlation found for each hypothesis could be expected to occur by chance less than five times out of one hundred then the correlation can be accepted as a valid indicator of what it claimed to be. The critical values used to determine these significance levels were taken from Statistics in Psychology and Education by Garrett.[9]

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[7]Garrett, op. cit., p. 363.

[8]Anastasi, op. cit., pp. 163-4.

[9]Garrett, op. cit., p. 461.

Chapter 4

ANALYSIS OF THE DATA

Chapter 4 covers the process in which the data were analyzed. This consists primarily of the analysis of the relationships between the factors which are named in the Statement of the Hypotheses.

Analysis of the Factors

For the purpose of analysis, four tables were constructed which correspond to the first four hypotheses. As each hypothesis is analyzed the table can be consulted to give a statistical indication of significance.

Tables 1 and 2 cover the first two hypotheses. Those two hypotheses are the primary data for establishing validity for the IAAB: PMT. Tables 3 and 4 are supplementary data which will provide additional findings on instruments which have shown mixed results in the previous literature (Chapter 2, p. 14).

Statistical Analysis

Correlational coefficients were calculated for all ten variables (testing instruments) and those data are presented in Table 7 in Appendix A, p. 45. All forty subjects were used in all calculations. The Pearson Product-Moment method was used as described in Chapter 3, p. 20.

Tables 1 through 4 used the same measurement criteria for determining the significance of each correlation. The significance level was found by consulting Table 25, Correlation Coefficients at the 5% and 1%

Levels of Significance, Garrett.[1] Since there were forty subjects, 38 degrees of freedom (N-2) were used for all calculations. The table showed the level for 1 through 30 degrees of freedom in 1 degree increments. The degrees of freedom from 30 through 50 were in 5 degree increments. There was a level shown for 35 degrees of freedom and a level shown for 40 degrees of freedom. Therefore, the method of interpolation was used to find the level of significance for 38 degrees of freedom. A value greater than $\pm$ .312 was necessary for significance at the .05 level of confidence. A value greater than $\pm$ .403 was necessary for significance at the .01 level of confidence.

Garrett also has stated that "it is customary in mental measurement to describe the correlation between two tests in a general way as high, marked or substantial, low or negligible."[2] Thus, a correlation from .00 to $\pm$ .20 denotes an indifferent or negligible relationship. A correlation from $\pm$ .20 to $\pm$ .40 denotes a low correlation. A correlation between $\pm$ .40 and $\pm$ .70 shows a substantial or marked relationship. A correlation above $\pm$ .70 is considered high.

Another consideration in judging the relationship is the nature of the variables which are being dealt with. Garrett has suggested that the r's between test batteries for vocational testing (IAAB:PMT) and measures of aptitude (DAT and Bennett) rarely rise above .50. Correlations above that figure are considered exceptionally promising, and smaller r's are often serviceable.

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[1] Garrett, op. cit., p. 201

[2] Ibid., p. 175.

Validation against the DAT Mechanical Reasoning and Bennett Mechanical Comprehension

Table 1 shows the correlations between the IAAB:PMT, its subtests and the DAT Mechanical Reasoning. By following the line marked Mechanical Reasoning across to the IAAB:PMT a correlation of .82 is found between these two instruments. The other three correlations are for the subtests of the IAAB:PMT.

Table 1

Correlation Coefficients Between the DAT Mechanical Reasoning and the IAAB:PMT and its Various Subtests

	IAAB:PMT	Vocabulary	Analogy	Comprehension
Mechanical Reasoning	.82**	.82**	.74**	.76**

*Significant at the .05 level
**Significant at the .01 level

The correlation between the DAT Mechanical Reasoning and the IAAB:PMT was .82. That correlation is significant at the .01 level and indicates a high relationship between the two instruments. The three subtests, Vocabulary, Analogies, and Comprehension, had correlations of .82, .74, and .76 respectively with the DAT Mechanical Reasoning. Those correlations are all significant at the .01 level and signify high relationships.

Table 2 shows the correlations between the IAAB:PMT, its subtests and the Bennett Mechanical Comprehension Test. By following the line marked Bennett across to the IAAB:PMT a correlation of .71 is found.

The .71 correlation between the Bennett and the IAAB:PMT is significant at the .01 level and denotes a high relationship between the two. The correlations with the subtests continued to run within .08 of the correlation for the cumulative total. The three subtests, Vocabulary, Analogies, and Comprehension, had correlations of .63, .69, and .67 respectively with the Bennett. Those correlations are all significant at the .01 level and indicate substantial or marked relationships.

Table 2

Correlation Coefficients Between the Bennett Mechanical Comprehension Test, and the IAAB:PMT and its Various Subtests

	IAAB:PMT	Vocabulary	Analogy	Comprehension
Bennett	.71**	.63**	.69**	.67**

*Significant at the .05 level
**Significant at the .01 level

The IAAB:PMT and the Cumulative Total of the DAT Mechanical Reasoning, Abstract Reasoning, and Space Relations

Table 3 shows the correlations between the cumulative total of the DAT Space Relations, Mechanical Reasoning and Abstract Reasoning and the IAAB:PMT and its subtests. By following the line marked Total SR-MR-AR across to the IAAB:PMT a correlation of .83 is found.

A correlation of .83 is significant at the .01 level and signifies a high correlation. The IAAB:PMT subtests all correlated within .09 of the total (.72, .81, and .80) and were significant at the .01 level.

Table 3

Correlation Coefficients Between the Cumulative Total of the DAT Space Relations, Mechanical Reasoning, and Abstract Reasoning, and the IAAB:PMT and its Various Subtests

	IAAB:PMT	Vocabulary	Analogy	Comprehension
Total SR-MR-AR	.83**	.72**	.81**	.80**

*Significant at the .05 level
**Significant at the .01 level

The IAAB:PMT and the Otis-Lennon Mental Ability Test

Table 4 shows the correlations between the Otis-Lennon and the IAAB:PMT and its subtests. By following the line marked Otis-Lennon across to the IAAB:PMT a correlation of .53 is found.

Table 4

Correlation Coefficients Between the Otis-Lennon Mental Ability Test, and the IAAB:PMT and its Various Subtests

	IAAB:PMT	Vocabulary	Analogy	Comprehension
Otis-Lennon	.53**	.30	.65**	.51**

*Significant at the .05 level
**Significant at the .01 level

A correlation of .53 is significant at the .01 level and denotes a marked relationship. The Vocabulary subtest of the IAAB:PMT had a correlation of .30 with the Otis-Lennon. That correlation was not significant. It denotes a low correlation. The Analogies and Comprehension subtests of the IAAB:PMT had correlations of .65 and .51 respectively with the Otis-Lennon. Both those correlations (.65 and .51) are

significant at the .01 level and indicate marked or substantial relationships.

Item Analysis for the IAAB:PMT

Table 5 shows the results of the item analysis. The difficulty and discrimination of the seventy-five test items were calculated by a computer. Each item is listed by number. By following the line across from the item number, the difficulty and discrimination indices are found.

Test items number 4, 12, 14, 15, 16, and 32 had discrimination indices below .20. That is six out of the seventy-five test items (8 percent) which did not discriminate well enough. None of the item difficulties was above 96 percent or below 23 percent. All items with difficulty levels above 90 percent (4, 12, 14, 15, and 16) were items with discrimination levels below .20. The average difficulty level for all test items was 58 percent. Reliability was also computed during item analysis. The Kuder-Richardson formula 20 method was used as outlined in Chapter 3, p. 21. The reliability was .97 for the sample group used.

Norms for the IAAB:PMT

Tables 8, 9, and 10 in Appendix B, pgs. 47, 48, and 49, show the norms for the IAAB:PMT. Table 8 contains the frequency distribution and percentile ranks for the experimental group. The experimental group consisted of twenty high school age boys who had participated in an auto mechanics training program in Emporia, Kansas. Table 9 contains the frequency distribution and the percentile ranks for the control group. The control group consisted of twenty high school age boys in a general

Table 5

Item Analysis for the IAAB:PMT

Item #	Difficulty	Discrimination	Item #	Difficulty	Discrimination	Item #	Difficulty	Discrimination
1	86%	.27	26	77%	.45	51	55%	.90
2	55%	.36	27	59%	.63	52	50%	1.00
3	68%	.63	28	55%	.72	53	64%	.72
4	96%	.09	29	50%	.63	54	55%	.72
5	77%	.45	30	64%	.54	55	46%	.72
6	64%	.72	31	41%	.45	56	32%	.45
7	68%	.45	32	46%	.18	57	50%	.81
8	77%	.45	33	64%	.54	58	46%	.90
9	73%	.54	34	50%	.81	59	55%	.90
10	77%	.45	35	32%	.45	60	64%	.54
11	64%	.54	36	59%	.81	61	32%	.63
12	91%	.18	37	32%	.63	62	64%	.72
13	59%	.81	38	59%	.45	63	59%	.81
14	91%	.18	39	23%	.27	64	59%	.63
15	91%	.18	40	41%	.27	65	50%	.81
16	96%	.09	41	46%	.54	66	68%	.63
17	68%	.63	42	59%	.27	67	55%	.90
18	73%	.54	43	55%	.90	68	55%	.90
19	59%	.81	44	50%	.63	69	55%	.72
20	64%	.36	45	50%	.63	70	64%	.72
21	77%	.45	46	55%	.72	71	50%	1.00
22	41%	.63	47	36%	.36	72	59%	.81
23	41%	.45	48	32%	.27	73	55%	.72
24	41%	.81	49	64%	.36	74	55%	.90
25	59%	.63	50	46%	.72	75	59%	.81

Average Difficulty 58%
Reliability .97

Standard Error of Measurement 3.44

education high school program. The control group had no auto mechanics training. Table 10 contains the frequency distribution and percentile ranks for all forty high school age boys in the sample.

A Comparison Between the DAT Standardization Sample and a Sample of Forty Boys

For purposes of standardization of the DAT a sample of 913 boys was taken from the United States population. The mean test scores for the Mechanical Reasoning, Abstract Reasoning, and Space Relations are shown in Table 6. The standard deviations for the standardization sample are shown too.

Also listed in Table 6 are the mean test scores and standard deviations for the DAT Mechanical Reasoning, Abstract Reasoning, and Space Relations for the sample of forty boys used in this study. Comparisons may be made from this table.

Table 6

Comparison of Mean Scores and Standard Deviations Between a Study with 913 Boys and a Study with 40 Boys

DAT subtests	913 Boys		40 Boys	
	Average mean	Average SD	Average mean	Average SD
MR	47.4	8.8	48.6	9.9
AR	32.0	9.6	28.3	10.9
SR	31.1	12.1	29.1	13.4

SUMMARY OF THE ANALYSIS OF THE DATA

The data from the first four tables produced the following quantitative analysis. A total of sixteen relationships were examined. Fifteen of the sixteen relationships (94 percent) were significant at the .01 level of confidence.

Table 1 contained correlations among the IAAB:PMT and its various subtests, and the DAT Mechanical Reasoning. All four of those relationships were significant at the .01 level of significance.

Table 2 contained correlations among the IAAB:PMT and its various subtests, and the Bennett Mechanical Comprehension Test. All four of those relationships were significant at the .01 level of significance.

Table 3 contained correlations among the IAAB:PMT and its various subtests, and the cumulative total of the DAT Space Relations, Mechanical Reasoning, and Abstract Reasoning. All four of those relationships were significant at the .01 level of significance.

Table 4 contained the correlations among the IAAB:PMT and its various subtests, and the Otis-Lennon Mental Ability Test. This table showed three relationships which were significant at the .01 level and one relationship which was not significant.

Table 5 showed the results of an item analysis for the seventy-five test items of the IAAB:PMT. Six of the seventy-five test items had discrimination indices below .20. The average difficulty was 58 percent and the reliability was .97.

Table 6 showed a comparison between the forty boys for this study and a standardization sample for the DAT of 913 boys. This comparison included average means and standard deviations for both groups.

The IAAB:PMT and its subtests (Vocabulary, Comprehension, and Analogies) demonstrated significance in all relationships with the DAT Mechanical Reasoning, the Bennett Mechanical Comprehension and the cumulative total of the DAT Mechanical Reasoning, Abstract Reasoning and the Space Relations. The IAAB:PMT and its subtests demonstrated significance in three out of four relationships with the Otis-Lennon Mental Ability Test.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

This study was initiated for the purpose of establishing validity and reliability for a new auto mechanics aptitude test (Industrial Arts Aptitude Battery: Power Mechanics Test). The method used for validation was concurrent validity. The literature was searched and studies were found which showed predictive validity for auto mechanics training. Two instruments had been shown to have substantial predictive validity: the DAT Mechanical Reasoning and the Bennett Mechanical Comprehension Test. The Otis-Lennon Mental Ability Test and the cumulative total from the DAT Mechanical Reasoning, Abstract Reasoning, and Space Relations had mixed or negligible results in the previous literature.

It was hypothesized that if a high relationship was found between the IAAB:PMT and the Bennett Mechanical Comprehension Test then there would be evidence of concurrent validity. By checking correlations between the IAAB:PMT and the Otis-Lennon and DAT cumulative total supplementary findings were uncovered.

The reliability was established by use of the Kuder-Richardson formula 20 method. This method produces an inter-correlation of all test items.

There were forty subjects used in this study. They were randomly selected from two educational institutions in the Emporia, Kansas vicinity.

There were twenty students selected from the Flint Hills Area Vo-Tech School in Emporia. These students were all enrolled in an auto mechanics training program. This program consisted of training in all areas of auto mechanics. This group consisted of only males. It was designated as the experimental group.

Twenty students were also selected from Emporia High School. These students were all enrolled in a general high school program and were all males. They were designated as the control group.

There was a total of six instruments administered. The six instruments were the Industrial Arts Aptitude Battery: Power Mechanics Tests (IAAB:PMT), the Bennett Mechanical Comprehension Test, the DAT Mechanical Reasoning, the DAT Abstract Reasoning, the DAT Space Relations, and the Otis-Lennon Mental Ability Test. Each instrument was administered to all forty of the students.

Testing was accomplished for each group (control and experimental) by using two two-hour sessions. The experimental group was tested first and the control group secondly after being matched to the experimental group. With each group, the first session involved administration of the IAAB:PMT, the DAT Mechanical Reasoning, and the DAT Space Relations. The second testing session involved the administration of the DAT Abstract Reasoning, the Otis-Lennon Mental Ability Test, and the Bennett Mechanical Comprehension. All tests were administered in the same order to both research groups.

Results of the calculations (Table 7) showed that out of forty-five relationships forty-four (97.9 percent) were significant at the .05 level of confidence. Forty-three of the total forty-five relationships (95.6 percent) were significant at the .01 level of confidence.

The correlations between the IAAB:PMT and the DAT Mechanical Reasoning were all significant at the .01 level. There were four correlations in this group and they all denoted high relationships.

The correlations between the IAAB:PMT and the Bennett Mechanical Comprehension Test were all significant at the .01 level. The total score for the IAAB:PMT and the Bennett had a correlation which indicated a high relationship. The subtests of the IAAB:PMT and the Bennett had correlations which signify substantial relationships.

The correlations between the IAAB:PMT and the cumulative total of the DAT Mechanical Reasoning, Abstract Reasoning, and Space Relations were all significant at the .01 level. There were four correlations in this group and they all denoted high relationships.

The correlations between the IAAB:PMT and the Otis-Lennon Mental Ability Test had mixed results. The Analogies, Comprehension, and total from the IAAB:PMT had correlations with the Otis-Lennon which were significant at the .01 level. Those correlations were indicative of substantial or marked relationships. The Vocabulary subtest from the IAAB:PMT was not significantly correlated with the Otis-Lennon.

An item analysis was run on the seventy-five test items of the IAAB:PMT. Six of the seventy-five items (8 percent) were found to have discrimination levels below an acceptable level. There was an average difficulty of 58 percent. The Kuder-Richardson reliability was .97.

CONCLUSIONS

Validation of the IAAB:PMT

The IAAB:PMT is an aptitude test which was designed to measure the aptitude for auto mechanics training. The method chosen for

validation was concurrent validation. By comparing the new test to a test which has already been established as valid, validation may be suggested.

Two instruments were discovered in a search of the literature which had been shown to have predictive validity for auto mechanics training. The DAT Mechanical Reasoning was found in three studies which were related to auto mechanics training. Two of those three studies found the DAT to be significantly predictive for auto mechanics training. The Bennett Mechanical Comprehension Test was investigated in a study which predicted success in auto mechanics training. The Bennett was found to be substantially correlated with success as measured by ranking.

In the present study the DAT Mechanical Reasoning and the Bennett were administered and correlated with the IAAB:PMT. The results showed high correlations between both the DAT Mechanical Reasoning and the IAAB:PMT (.82), and the Bennett and the IAAB:PMT (.71). These findings suggest that the IAAB:PMT would be as good a predictor of success in auto mechanics training as were the DAT Mechanical Reasoning or Bennett Mechanical Comprehension.

The IAAB:PMT and the Cumulative Total of the DAT Mechanical Reasoning, Abstract Reasoning, and Space Relations

The IAAB:PMT had a high relationship with the DAT Cumulative Total (.83). That relationship indicates that those two instruments are interchangeable to a high degree. With the validity already established by the DAT Mechanical Reasoning, three tests would merely be extra work to attain the same results.

The IAAB:PMT and the Otis-Lennon Mental Ability Test

The Otis-Lennon provided somewhat different results than the previous instruments. Since the Otis-Lennon measures scholastic aptitude, one can find similarities and differences between it and the IAAB:PMT. The total score for the IAAB:PMT had a marked relationship with the Otis-Lennon which indicates some relationship between auto mechanics aptitude and scholastic aptitude. The relationship was similar between the Otis-Lennon and two of the IAAB:PMT subtests (Comprehension and Analogies). Interestingly, though, there was no significance between the Otis-Lennon and the IAAB:PMT Vocabulary subtest. The correlation between those two signified a low correlation (.30). There appears to be very little relationship between scholastic aptitude and the acquisition of a technical vocabulary.

Item Analysis for the IAAB:PMT

The item analysis for the IAAB:PMT showed six test items with discrimination levels below the recommended cut off level. That represents only 8 percent of the total test items. The average level of difficulty was 58 percent. That level is very close to the recommended level of 50 percent. The reliability of the test was .97. That indicates that 97 percent of the variance in test scores depends on true variance in the trait measured. Only 3 percent of the variance is caused by error variance.

The item analysis shows strength in every area for the IAAB:PMT. Those item analysis strengths support the validity and reliability of the IAAB:PMT.

Significance with Another Study

Table 6 in Chapter 4 showed a comparison of the present study with a study used for the standardization of the DAT. The standardization study for the DAT consisted of a sample of 913 boys. By comparing the average means and standard deviations for both studies it is evident that they are very similar. This lends support to the size of the present study. Although the present study used only forty boys for its sample, it seems to be as representative as even a much larger sample.

RECOMMENDATIONS

It is recommended that the IAAB:PMT be administered to a larger population to expand the usefulness of that instrument. This instrument has shown strengths in all areas of test validation and reliability. It is limited, though, since the standardization group represents only the Emporia, Kansas, area.

It is recommended to the test maker of the IAAB:PMT that items numbered 4, 12, 14, 15, 16, and 32 be rewritten or omitted from the test. Those items demonstrated discrimination indices below the acceptable level and contribute little or nothing to the usefulness of the instrument.

Lastly, it is recommended that the use of the IAAB:PMT be tempered with a knowledge of the decision-making process. This instrument can show an individual's aptitude as ranked against his/her peers. This instrument does not measure the motivation or perseverance which is also an indication of possible success in a training program or school program. With that thought in mind and the IAAB:PMT in hand prediction should be improved in the decision-making process.

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BIBLIOGRAPHY

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APPENDIXES

APPENDIX A

Intercorrelations for All Variables Investigated

KEY TO TABLE 7

Factor Number	Factor Description
1	IAAB:PMT Total
2	Bennett Mechanical Comprehension Test
3	Otis-Lennon Mental Ability Test
4	DAT Mechanical Reasoning
5	DAT Abstract Reasoning
6	DAT Space Relations
7	Cumulative Total of the DAT MR-AR-SR
8	IAAB:PMT Vocabulary
9	IAAB:PMT Analogies
10	IAAB:PMT Comprehension

Table 7

Correlation Coefficient Between
All Variables Investigated

(see previous page for
listing of variables)

	1	2	3	4	5	6	7	8	9
1									
2	.708*								
3	.527	.472							
4	.824	.844	.339						
5	.632	.565	.538	.535					
6	.768	.659	.404	.737	.694				
7	.831	.776	.482	.843	.836	.937			
8	.896	.633	.302	.822	.446	.654	.721		
9	.934	.686	.649	.740	.682	.746	.805	.756	
10	.963	.665	.509	.758	.624	.742	.796	.790	.862

*A coefficient of $\pm$ .312 is needed for significance at the .05 level.

A coefficient of $\pm$ .403 is needed for significance at the .01 level.

APPENDIX B

Tables Showing Norms

for the IAAB:PMT

Table 8

Norms from a Sample of Auto Mechanics Students in Emporia, Kansas on the IAAB:PMT

Score	Frequency	Percentile rank	Score	Frequency	Percentile rank
75			44		
74			43		
73			42		
72	1	98	41		
71	2	90	40	1	13
70			39		
69	1	83	38		
68	1	78	37		
67	1	73	36		
66	2	65	35		
65	1	58	34		
64			33		
63	1	53	32		
62	1	48	31	1	8
61			30		
60			29		
59			28		
58			27		
57			26		
56	1	43	25	1	3
55	2	35	24		
54			23		
53			22		
52	1	28	21		
51			20		
50			19		
49			18		
48	1	23	17		
47			16		
46	1	18	15		
45					

Number of students	20
Mean score	57.40
Standard deviation	13.55

Table 9

Norms from a Sample of High School Students in Emporia, Kansas on the IAAB:PMT

Score	Frequency	Percentile rank	Score	Frequency	Percentile rank
75			44		
74			43		
73			42		
72			41		
71			40		
70			39	1	88
69			38	1	83
68			37		
67			36	1	78
66			35		
65			34		
64			33	1	73
63			32	1	68
62			31	1	63
61			30	1	58
60	1	98	29		
59			28	2	50
58			27		
57			26	1	43
56			25		
55			24		
54			23	1	38
53			22	1	33
52			21	1	28
51			20	2	20
50			19		
49			18	1	13
48			17		
47			16	1	8
46			15	1	3
45	1	93			

Number of students	20
Mean score	29.05
Standard deviation	10.97

Table 10

Norms from a Sample of Forty High School Age Boys in Emporia, Kansas on the IAAB:PMT

Score	Frequency	Percentile rank	Score	Frequency	Percentile rank
75			44		
74			43		
73			42		
72	1	99	41		
71	2	95	40	1	51
70			39	1	49
69	1	91	38	1	46
68	1	89	37		
67	1	86	36	1	44
66	2	83	35		
65	1	79	34		
64			33	1	41
63	1	76	32	1	39
62	1	74	31	2	35
61			30	1	31
60	1	71	29		
59			28	2	28
58			27		
57			26	1	24
56	1	69	25	1	21
55	2	65	24		
54			23	1	19
53			22	1	16
52	1	61	21	1	14
51			20	2	10
50			19		
49			18	1	6
48	1	59	17		
47			16	1	4
46	1	56	15	1	1
45	1	54			

Number of students	40
Mean score	43.23
Standard deviation	18.58