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THE RELATIONSHIP BETWEEN
PSYCHOMOTOR ABILITY AND CRITICAL OBSERVATION AND
EVALUATION ABILITY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in the Graduate School of The Ohio State University

By

Richard A. Kruppa, B.S., M.S.

* * * * * *

The Ohio State University
1970

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CHAPTER I
INTRODUCTION

Certain branches of study have as primary or secondary goals the
development of psychomotor or manipulative abilities. These abilities
are usually developed upon a base of cognitive knowledge and/or affec­tive competencies or they may be developed concurrently with these
other abilities. Additionally, these psychomotor abilities are usu­ally developed through practice. Branches of study within institu­tionalized American education which have such goals include, among
others, music, physical education, business studies, and industrial
arts. Examples of manipulative development of the type referred to
above include learning to play a musical instrument, use a typewriter,
perform a gymnastic feat, and use a circular saw. The focus of
this study will be upon psychomotor abilities in industrial arts.

Background of the Problem

Over the years curriculum proposals for industrial arts have been
developed, adopted and modified, or discarded. Recently, a number of
new proposals have been or are being developed. Towers, Lux, and Ray
(1966) reviewed a number of these in A Rationale and Structure for
Industrial Arts Subject Matter. Unlike many of the earlier proposals,
some of these contemporary efforts have conceptualized "industry"
according to a rationale derived by philosophical and logical analysis. The conceptual framework was then used as a guide to develop instructional programs. The well-known curricula developed by the Industrial Arts Curriculum Project is an example of such an endeavor. Typically, the earlier proposals merely reflected a few selected crafts or occupations and emphasized the importance of skill development. Schmitt and Pelly (1966) in a national survey conducted during the 1962-63 school year, concluded that the greatest emphasis in industrial arts instruction was "... to develop a measure of skill in the use of common tools and machines (p. 45)." Industrial arts has a heritage of tool skill development dating back to its origin. Micheels and Sommers (1958) noted the strength of this thrust in industrial arts as they stated their first assumption regarding industrial education in the future.

Direct, first-hand experience in working with tools, materials and ideas will continue in the educational offerings of our schools, both as a part of general education experiences and for vocational purposes (p. 23).

While many of the contemporary approaches are emphasizing the study of conceptualized industry, laboratory activity involving the use of tools is also included. This writer suspects that instruction in the proper use of common tools will continue for many years in industrial arts.

The accepted method utilized in assessing psychomotor ability is the performance test. This procedure requires the student to demonstrate his developed ability to execute certain psychomotor tasks
under controlled conditions. Performance testing can yield assessments of quality, technique, and speed (Newkirk and Green, 1935, p. 47).

Seldom, however, is this kind of testing practiced in industrial arts. The reasons are many. Administering a performance test can be a time-consuming process. Often, only one student at a time can be tested. Since it is not uncommon for the public school industrial arts teacher to instruct over a hundred students each day, the constraint of time makes the administration of such examinations on a one-at-a-time basis difficult, if not out of the question. Additionally, the administration of such an instrument in the public school setting can cause a discipline problem when students become restless. Junior high school students, for example, may have difficulty sitting quietly while one student at a time is tested. In the colleges and universities this method of testing manipulative ability is, again, uncommon. Time would appear to be the primary reason that this method of evaluation is used infrequently. University students become fatigued and restless also while waiting their turn to be tested.

As a result of the difficulties inherent in administering performance tests, they are seldom used. As a substitute method of assessing psychomotor growth instructors usually evaluate the quality of a student's project work and assume that it represents a valid sample of his tool-skill ability. A number of problems may confound an accurate assessment when reviewing project work in this manner. There is no assurance that the work is exclusively that of the student. Often the student will secure help and guidance from the instructor and his fellow students. Additionally, the manipulative tasks required to complete the
Developing a performance test is not an easy task. The tasks to be evaluated must be analyzed for their criterion constituents. Devices to measure various aspects of performance must be fabricated, tested, and modified. Setting up the instrument, alone, can take hours. Consequently, Micheels and Karnes (1950) have suggested that, as a result of these and other problems, teachers often ignore evaluating the psychomotor domain altogether and adjudge cognitive performance with a paper and pencil test (p. 325).

The situation described above presents a dilemma for educators. A common objective of industrial arts instruction is to develop manipulative skills with tools and machines, yet only the cognitive aspect of the total performance behavior a student displays is evaluated. How, then, shall industrial educators reconcile their performance objectives with non-performance evaluation? A proposal is stated in the investigator's hypothesis.

**Statement of the Problem**

It is often assumed that an individual who has developed a certain manipulative ability is a better judge of that ability in others than a person who has not developed similar powers. A concert pianist would, therefore, be presumed to be a more critical observer of a person's piano technique than would a beginning piano student. Likewise, a highly skilled auto mechanic would be a more critical and accurate judge of a person's competency in tuning an automobile engine than
would be a motoring hobbyist. Accordingly, educators make application of this notion. The best football player is predicted to become a good coach. Similarly, the best teachers are selected by teacher educators to be cooperating teachers, because they can observe teaching behavior, evaluate it, and suggest more effective variations. If one were to seek golf instruction, he would probably attempt to secure the services of a good golfer so that he could "see what he was doing incorrectly" and prescribe change for improvement.

Kerlinger (1967) suggests that a problem statement inquires about the relationship between variables (p. 20). Consequently, the writer asks what relationship exists between an individual's manipulative ability and his accuracy at critically observing that skill in others? The study shall inquire into the validity of the presumed relationship between the variables discussed above as they relate to industrial arts work. Does, in fact, the student who displays a great degree of psychomotor skill also have high powers of critical observation and evaluation? Is the reverse true for students who possess little psychomotor ability?

Statements of the Hypotheses

The investigator's main hypothesis is that an individual's manipulative ability in industrial arts woodworking and his ability to observe and evaluate critically those skills in others are related. It is further hypothesized that the nature of the relationship is positive and linear. Accordingly, the null hypothesis is that there is no relationship between an individual's manipulative ability in industrial
arts woodworking and his ability to observe and evaluate critically those skills in others ($H_0: r = 0$).

**Objectives of the Study**

In quest of verifying the hypothesis, three objectives for the study were generated.

1. To develop a valid and reliable instrument to assess student's actual performance ability with selected basic woodworking tools and machines.
2. To develop a valid and reliable instrument to assess student's ability to observe and evaluate critically the proper use of selected basic woodworking tools and machines.
3. To determine what relationship exists between the student characteristics assessed by the above two instruments.

Psychomotor skill can be assessed by the use of a performance test as described earlier. Critical observation ability can be evaluated in one of two ways:

1. Have a participant watch an individual perform a psychomotor skill and have him evaluate it.
2. Show the performance by some visual means (film or television), and have each participant evaluate it.

The second method seems to be more viable than the first as all participants view an identical performance. Also, either film or videotape may be edited at will. Videotape appears to be more versatile than film, however, since any image may be easily erased and re-recorded.
Definition of Terms

Several significant terms are used in this study. To facilitate understanding, they are defined below.

1. Psychomotor ability-- The terms "psychomotor ability" and "manipulative ability" are used herein interchangeably. They refer to "... manipulation of material and objects, or some act which requires a neuromuscular coordination (Krathwohl et al., 1964, p. 7)."

2. Industrial arts woodworking-- The concern of this study is with certain tool and machine processes typically found in university level industrial arts woodworking courses. These processes could, however, be found as a part of the structured content of numerous kinds of industrial arts and non-industrial arts curricula in the public schools as well as at the university.

3. Critical observation ability-- A person's ability to identify performance which he has learned is correct is referred to as his critical observation ability. The behavior displayed by gymnastics judges and state driving test administrators could be considered as critical observation ability.

Assumptions

Several fundamental assumptions are made at the outset of this study.

1. Since participants in the study have been students in industrial arts woodworking courses, they have received some amount
of instruction in the safe and proper use of woodworking tools and machines.

2. Critical observation ability among participants will vary.

3. Participants in the study will display varying levels of achievement in the safe and proper use of the tools and machines.

4. Participants may have developed either performance or observation ability from non-academic activity. Work and/or teaching experience may have contributed to their ability to manipulate or to observe. Still other factors such as type of instruction received, amount of practice, native ability, maturity, and interest may have contributed to each participant's ability to perform and observe performance critically.

5. The amount of performance ability among participants may be roughly determined by the number of years in industrial arts. Nominal categorizations, such as "entry-level," "intermediate," and "advanced" may be used to identify students who have had little, some, or much opportunity through course work to become skilled in the use of woodworking tools and machines.

6. Adherence to specified standards of procedure will assure validity of the outcome of the study.

7. Performance displayed on a television screen is an adequate means—providing the image is clear; the performance in question is shown; and the participants have a clear, unobstructed view of the screen.
8. Appraising manipulative performance is professionally valid as suggested by Whitesel (1956).

The industrial arts teacher should have developed a fair amount of appreciation of skill through the development of technical competencies himself in working with tools, machines, and problems of our modern technology (p. 89).

Limitations of the Study

1. The study is limited to performance in university level woodworking tasks.
2. The students selected for participation will be pre-service industrial education teachers from Bowling Green State University, Bowling Green, Ohio.
3. The study shall take place during the 1969-70 academic year.
4. The breadth and depth of the study shall be limited to the objectives stated earlier.

Educational Significance of the Study

The implications of this study may be numerous whether or not the investigator's hypothesis is rejected.

As stated previously, a number of subject areas within the school and the university are concerned, in varying degrees, with psychomotor development. A number of non-school agencies also have as an objective such development. Among these are the various branches of the military and industrial training enterprises. The extent of the training (much of which is psychomotor) performed by business and industry alone is vast.

Performance testing is often difficult and uneconomical to admin-
ister. If the hypothesis proposed by the writer is not rejected, and if the stated relationship can be determined in typical educational environments using accepted media and methodology, then the applications could be numerous. It is not unlikely to suppose that brief, mass-administered examinations in driving ability could be developed to adjudge that skill. Industrial educators could, likewise, administer to groups an instrument that would appraise the manipulative growth of students. Though such broad extrapolations could conceivably be made as a result of the outcome of this and other studies, it is the scope of this effort to take the "first step" to attempt to determine if the hypothesized relationship does exist and if so, to what extent.

If the investigator's hypothesis is rejected, knowledge has been generated in two ways.

1. The relationship between critical observation ability and psychomotor skill does not exist within the conditions tested, and therefore, judgments made on the basis of the presumed relationship stated earlier may be invalid.

2. A performance test has been developed which can be used to assess manipulative ability.

Summary

The investigator has stated the problem by asking what relationship exists between an individual's psychomotor ability and his ability to observe and evaluate critically that same ability in others. The investigator will test this presumed relationship by developing a performance test that assesses manipulative ability with selected
woodworking tools and machines and a videotape instrument that may be used to measure an individual's ability to assess psychomotor performance of others. The investigator will then determine the relationship between the two characteristics.
CHAPTER II
REVIEW OF THE LITERATURE

Literature within three topical areas was considered relevant to the study. These topics include: visual forms of testing, manipulative performance testing, and the psychomotor domain of educational endeavor. These will be reviewed in turn.

Visual Forms of Testing

The visual forms of testing referred to here are those that rely on dynamic visual images which are mechanically reproduced.

Breadth of Research

Over the years a number of experiments using visual means for test administration have emerged. Most of these efforts have utilized the medium of film. Virtually no reported testing has occurred using videotape. Perhaps the most notable characteristic of the literature concerning this kind of testing is its scarcity. Seibert (1965), in the most comprehensive review of cine-psychometry to date, noted that the application of film (and television) to testing has been rare because educators have concentrated mainly on applying media to instruction (p. 141). Seibert and Snow (1964) commented that:

The capabilities of the motion picture are such that it can be seriously considered for use in psychological measurement. In fact, it seems surprising that few attempts have been made to study or to employ film in psychometric research (p. 1).
Additionally, the scarcity of motion picture test experiments is described by Schalock et al. (1964):

The methodology of film testing per se has received relatively little attention in the past. Representational pictures or slides have been used to measure abilities, personality, motivation, and appreciation, but motion pictures have had extremely limited application to the process of measurement (p. 11).

Perhaps the most striking display of the lack of work in this area is made by Seibert and Snow (1964). They point out, by listing a literature review of only seven studies,¹ that the literature on film research in testing is scattered and slight.

Hainfield (1968) suggests that a reason for the lack of visual testing is that:

Much effort has been made by the producers of educational films to show correlation of their moving pictures to the textbooks used in our classrooms... Little has been done to produce audiovisual tests (p. 718).

Early Studies

Visual testing (film), according to Seibert (1965), extends back to 1909 and Boa's clinical work. "Modern" use of cinematic forms of testing, however, began in 1942 with the work of J. J. Gibson, J. C. Flanagan, F. A. Geldard, and R. M. Gagné at the Perceptual Research Unit of the Army Air Force (p. 145).

These tests were concerned primarily with aptitudes which might be involved in motion and distance perception.

¹The studies included by Seibert and Snow are as follows: Gibson's during WWII; Roff, Fruchter and Mahan's research repeating the earlier film tests in 1952; Heider and Simmel's 1944 study of social perception; Ray's 1947 study of memory events; Thurstone's 1958 and McIntyre's 1954 studies of personality characteristics; the 1954 study by Carpenter et al. of mechanical ability; and the study of teacher performance by Schalock et al. (1964).
Frequently, they represented complex, sequential, and dynamic identification tasks (p. 147).

The significance of the work of Gibson *et al.* has been expressed by Seibert and Snow (1964) in saying that "... film provided both unique medium and unique test form... (p. 2)."

Gibson (1947) and his team at the Psychological Test Film Unit explored the notion that cinema:

... provides the opportunity of testing for the ability to learn a specified procedure, not by verbally memorizing series of names or written descriptions but by actually visualizing the series of acts as they naturally occur (p. 24).

The researchers had at their disposal the film studios of Hollywood, professional cameramen, and other technicians, for their effort took place when many of the nation's resources were directed toward the war effort.

Early in their study, the team suggested that the cost of motion picture testing was greater than that of paper and pencil types. Accordingly, they did not suggest that this "new" form become a replacement for the traditional form, but be used where valid results could not be secured by paper and pencil forms (Gibson, 1947, p. 9). Gibson's team developed cinematic forms of tests dealing with dynamic pattern perception, runway approach pattern, depth perception, gunnery analysis of moving targets, and others.

The tests of Gibson *et al.* were prepared by selecting film clips already in existence or shooting new material and editing it. Validity was determined by "showing" the tests to "sophisticated" or "test-wise" observers (Gibson *et al.*, 1947, p. 34). Reliability was assessed by
administering the instruments to "unsophisticated" viewers (members of the population) and by conducting an item analysis (Gibson et al., 1947, p. 35). Additionally, the Psychological Test Film Unit conducted research on viewing and test answering conditions during its existence. Thousands of subjects participated in their conditions-of-viewing experiments. Their findings included:

1. A dimmed room can be used successfully for showing motion pictures—the room need not be completely dark.
2. All students must have an equivalent view of the screen. Students should be seated no closer than two nor farther than six picture widths from the screen and within an included angle of 60 degrees.

Gibson (1947), in his report, suggested a type of cinematic testing similar to that being pursued by this writer. In doing so, he said:

... a sequence of responses (i.e., a procedure) would be presented visually on the screen and also orally by means of the sound track, to be followed by another sequence showing an individual following the procedure (e.g., adjusting knobs in a certain order) with certain errors. The errors in the visually presented procedure would be identified by letters and recorded on a standard answer sheet (p. 24).

The Psychological Film Test Unit did not, however, pursue this method of testing critical observation ability.

The tests developed by the researchers were administered to thousands of military trainees during the war. No visual testing effort since their work has been as vast. The team generated two "advantages" of cinematic testing that best summarize their work.

1. Film testing is more similar to a real situation than is a written examination.
2. Filmed performance tests (of the types they developed) can be successfully administered to audiences rather than on an individual basis (Gibson et al., 1947, p. 99-100).

General Findings

This portion of the literature review will be devoted to various studies involving visual forms of testing and their generalized findings.

Utley (1946), working with speechless youngsters, prepared a standardized lip reading test using film as the medium. The test showed various people talking. The individuals being examined were expected to answer questions about stories that were read. The technique of testing them was having the testees read the lips of the person asking the questions. They responded on a paper answer sheet. Utley established no criterion measure and concluded that requiring students to lip-read sentences was more valid than to lip-read individual words.

Seibert and Snow (1964) investigated the cognition and memory ability of university freshmen. Over 90 different film tests were administered to 100 students. The investigators utilized some of Gibson's et al. early filmed tests and produced the remainder. The significance of their work was that they established a classification system for film tests and item presentation technique. Film tests were classified into two types.

1. The "unitized film test" (U.F.T.) presents some body of information and is then followed by printed questions related to it.
2. The "itemized film test" (I.F.T.) shows short sequences and is followed by questions or alternatives on film.

Seibert and Snow (1964) classified various techniques of filmed item presentation as follows:

1. "Live action" (L.A.) shows real action and events on the screen.

2. "Animation" (AN.) consists of a series of still images photographed separately and combined to give the illusion of motion.

3. "Serial still" (S.S.) images are motion picture presentations of still images on the screen (p. 25).

Curtis and Kropp (n.d.) contributed data regarding the effectiveness of projected standardized tests versus paper and pencil forms. The test items were transmitted over closed circuit television to high school students. The investigators, working with static images (slides) rather than dynamic ones, concluded:

1. Projected tests yield a greater amount of coverage than the traditional method (Curtis and Kropp projected each item only once).

2. Projected tests with sound and projected silent tests yielded results that were not different from scores of achievement tests of the traditional type. The authors suggest, however, their feeling that the audio along with the video slowed bright students and helped students with reading problems.

3. "The projected mode of test presentation appears to be
feasible for the administration of tests of cognitive abilities (p. 79)."

Carpenter et al. (1954), closely approached the notion of this writer's study but did not report data pertinent to it. It is reviewed here because it is unique in its similarity to the investigator's study. The study involved the Track Vehicle Repairman course at the Ordnance School, Aberdeen Proving Ground, Maryland. The investigators prepared three types of visual tests using the medium of film. The first utilized the showing of situation problems. Following the problems, the testees were asked questions and given four verbal choices. The type of testing that is similar to the approach taken by this writer, the second type of questions, showed mechanics removing a tank's powerplant. The mechanics wore coveralls that had letters on them so that they could be identified. The testees were asked to identify safety violations they saw, note the use of incorrect tools, and suggest unnecessary work being done. The powerplant removal procedure was evaluated in ten steps across the three criteria and across the four mechanics shown. Type three questions asked the testees to adjudge the procedure and accuracy of trouble-shooting the removal of a tank from a ditch. The population was 316 graduates of the military course with below average intelligence and mechanical aptitude. The criterion measure was the student's weekly grades (reliability coefficient .80). The correlation between the performance on the type one test (reliability .92) and the criterion was .73. Analysis of types two and three tests (procedural analyses) was not reported. Carpenter et al. concluded:
1. Film tests can achieve very high reliability measures.

2. Performance rather than verbal criterion should be used.

3. Film tests are practical to administer.

Gould (1960) developed a Film Test of Observational Skills and used it as a device to measure teacher behavior. He concluded that although the instrument was able to discern gross differences in perceptual acuity among university students learning to teach, "... this measure of perceptual acuity was not sufficiently sensitive to the outcome of observation (p. 98)."

Schalock et al. (1964) investigated the notion that if test stimuli closely represent the stimuli present in a real-life teaching situation, the responses by the participants will accurately predict their behavior in the real-life situation (p. 8). The investigators suggested that:

... tests which utilize stimuli corresponding closely to actual situations should prove to be more effective predictors because simultaneously they will (1) call forth responses that are more like those occurring in a life situation, and (2) make available for measurement a greater number of the factors affecting complex behavior (p. 4).

The significance of their work was that they:

... were able to demonstrate multiple correlations of .69 to .87 between scores on a battery of situational-response tests (tests which use motion picture representations of classroom situations as test stimuli) administered prior to student teaching and observational measures of their behavior in the classroom during student teaching (p. 64).

However, in an expanded replication study Schalock et al. (1968) gathered new data that varied from that collected earlier. The outcome

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2 This writer's criterion measure will be actual performance ability.
showed a decreased effectiveness of the simulation to be the most accurate predictor of performance. Thus, this later study cast some doubt on the adequacy of their original hypothesis.

**Characteristics of Visual Forms of Testing**

Although the advantages of visual forms of testing are dealt with here as a separate entity, they necessarily interface with forthcoming comments regarding performance testing of psychomotor skills.

**Advantages**

Of the writers reviewed, Carpenter et al. (1954) described the most comprehensive set of advantages of visual modes of testing over static traditional paper and pencil forms. They were categorized as follows:

1. They realistically represent "action and movement."

   Most performance or work requires perception of the performer's actions in relation to his job or perception of and adjustments to actions of other persons operating machines. To the extent that actions and movements are involved, test media may appropriately include them (p. 510).

2. "Spatial-time" elements of manipulation can be shown. In other words, sequential performance of men and/or machines can be shown.

3. "Concreteness-specificity" may be advantageous over verbal explanations. For example, the phraseology of the test writer must be interpreted by the test reader and transformed in his mind in a verbal test. "Such testing [visual form] also reduces the demands on the abstraction or language abilities of subjects (p. 511)."
4. "Sound" may be added to the visual form in three ways:
   a. A commentary that enhances the visual presentation can be incorporated.
   b. Verbalization similar to that in the field, such as the unique vocabulary of mechanics, can be used.
   c. Environmental sounds can be made a part of the presentation.
5. "Control of exposure time" to the stimuli and response time is assured.
6. "Order of presentation" of showing a sequence as it occurs in real-life is assured if that factor is important to the application.
7. "Color" may be added over monochromatic stimuli when that may be important.
8. The method is "practical and economical to administer" since large groups can be tested at once. This advantage is particularly cogent when performance testing is normally required. Curtis and Kropp (n.d.), additionally, have suggested that the use of closed circuit television for projecting images, perhaps of standardized tests, requires a low outlay for test materials and distribution costs throughout an entire school (or even an entire State).

To the above advantages Seibert and Snow (1965) add the following:

9. Visual testing media can provide a simulation of an actual situation which examinees must judge in some way.
10. The control of standard test conditions (in terms of time and physical setting) is assured (p. 142).
Limitations

Along with the advantages, visual testing has limitations compared to the traditional written form. Carpenter et al. (1954) included the following.

1. Film production can be very costly. Note, however, that videotape did not exist at the time of the study. This medium may offer lower production costs, particularly at the local level as a result of such inherent characteristics as erasability.

2. As a result of its high visual fidelity, abstractions may be difficult to portray.

3. Visual tests may be difficult to score quantitatively.

4. Due to the nature of the medium, items are not easily changed once the test is produced. Again, the inherent qualities of videotape, unlike film, may reduce the validity of this limitation.

Conclusions Regarding Research on Visual Testing

The literature seems to reveal that the accumulated knowledge concerning visual forms of testing is slight, spotty, and scattered. One observer, Hainfield (1968), expressed a need for master's and doctoral research and foundation funding to add to the literature on visual forms of testing. Though appropriate literature is sparse, some generalizations can be drawn.

To this date visual testing is not being used to assess manipulative abilities in the ways suggested in the investigator's hypothesis.
The main application of visual testing has been as a substitute for traditional verbal instruments. Visual testing forms have advantages which appear useful to determine critical observation ability, yet the limitations do not appear to jeopardize their advantages. Literature describing videotape as a visual testing medium has not yet been made available. However, there is no reason to suspect that videotaped television images would yield results significantly different from those reported in the foregoing research. Videotape, as well, has several advantages not possessed by film. Some of these are as follows:

1. Videotape can be re-recorded.
2. The recorded image can be quickly viewed since no processing is involved.
3. Scenes can be edited and re-edited without the necessity of splicing.

Depending upon the quality of the equipment selected, videotape may be more expensive than film, however.

In general, the research suggests that broad implications can be drawn for potential uses of visual forms of testing. In industry tests could be utilized in the following ways as suggested by Carpenter et al. (1954):

1. Evaluating worker constancy.
2. Worker performance proficiency.
3. Safety principle application.
4. Administrative personnel proficiency.
5. Extensions or replacement of oral trade tests.
Imaginitive thought could create many other applications for industry, business, military, and education. Unlike paper and pencil forms of testing, visual modes allow the presentation of dynamic images and sound. Additionally, unlike performance tests, the visual forms can be administered to large groups of individuals at one time. Finally, as Fruchter and Mahan (1952) have pointed out, "Perceptual abilities are one area where the unique advantages of motion picture tests are especially useful (p. 435)."

Manipulative Performance Testing

The Need for Performance Tests

In a broad sense all testing is performance testing. A manipulative performance test is, however, "... a test designed to analyze and measure the student's skill in the performance of selected operations under rigidly controlled conditions (Micheels and Karnes, 1950, p. 326)."

As stated in Chapter I by Micheels and Karnes (1950):

The development of skill in the performance of certain manipulative operations is one of the stated and acceptable objectives for almost every practical arts and vocational course and for certain phases of other courses in the curriculum (p. 325).

Manipulative skill development makes up a significant portion of instruction in many non-public school enterprises as well. The military, business, and industry and others have developed programs of instruction in skill development.

An admitted problem faced by individuals who have responsibility for assessing this performance is presented by the use of written tests
to evaluate manipulative ability. As Micheels and Karnes (1950) stated:

Written tests are not valid for the measurement of manipulative skills. The fact that a student can supply flawless answers to questions about how to cut a mortise and tenon joint does not constitute positive proof that he can actually cut the joint with any acceptable degree of skill. His failure to answer questions satisfactorily would not prove his inability to cut the joint (p. 325).

Other problems exist with written tests used as performance measures as Hainfield (1968) pointed out. "Most tests administered in school, for employment and entering the Armed Forces depended on reading ability (p. 717)." Hainfield thus concluded that the "Validity of the test will depend on reading ability, and not necessarily on knowledge and information (p. 717)."

The validity of Hainfield's conjecture is reinforced by a study performed by Kipnis and Glickman (1962). These writers substituted a series of psychomotor task tests in place of cognitive paper and pencil tests and found that the tests were better predictors of performance in several Navy trades (aviation machinist, radioman, and nuclear power personnel) than the Navy's basic test battery.

The significance of the need for performance tests in performance situations is concluded by Ahmann and Glock (1967):

It is clear that attempts to predict the quality of a performance involving physical activity on the basis of verbal and mathematical knowledge are often unsuccessful, not only in everyday experiences but also in the classroom. If we wish to gain information concerning the pupil's ability to perform, we must do so by direct inspection of the quality of that performance. This means that the student must be given an opportunity to perform under suitable conditions (p. 213).
Classification of Tests

Over the years writers have classified performance instruments according to various factors. A review of some of these yielded a scheme for considering instruments for the study. Newkirk and Greene (1935) in an early discussion of performance testing in industrial education implied measures of accuracy and quality in shopwork.

Quality of shop work may be rated by inspection, by actual measurement of dimensions, and by judgments based on quality scales. Actual measurement of the physical qualities (dimensions, etc.) is probably the most objective. However, there are certain other qualities in shop products which are not mere matters of dimensions or accuracy of toolwork. The evaluation of such qualities require the use of a rating scale (p. 148).

The qualities discussed were qualities of the finished product, not the quality of technique or the performance of manipulative tasks.

Micheels and Karnes (1950) grouped performance testing according to their intended assessment of speed, quality, and procedure (p. 366).

Ahmann and Glock (1967) classified performance tests into four categories—ranking, rating, checklists, and anecdotal records.

The most comprehensive classification appears to be that of Ryans and Frederiksen (1951). An analysis of their scheme may be seen in Figure 1. These writers established two basic kinds of performance tests—achievement and aptitude. Two sub-types of aptitude performance tests were identified—non-verbal and other types of achievement testing instruments. Three types of achievement performance tests were discussed—recognition tests, simulated conditions tests, and work sample tests. The investigator will use the first and third types of achievement performance tests in this study. The development of the
Aptitude Performance Tests | Achievement Performance Tests
---|---
The purpose is to assess "... the capacity or potential of an individual for a particular kind of behavior (Ryans and Frederiksen, 1951, p. 456)." | The purpose is to "... provide objective means for estimating the proficiency with which a task is performed (Ryans and Frederiksen, 1951, p. 457)."

<table>
<thead>
<tr>
<th>Types</th>
<th>Types</th>
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| 1. **Non-verbal tests of capacity to learn.** | 1. **Recognition tests** "... attempt to measure the individual's ability to recognize essential characteristics of a performance or product of performance, or to identify objects such as geological or botanical specimens (Ryans and Frederiksen, 1951, p. 458)."
| 2. **Other tests of capacity for training in specific skills.** | 2. **Simulated conditions tests** "... copy or simulate the life-like situations or operations that the test is devised to measure (Ryans and Frederiksen, 1951, p. 459)."
| 3. **Work sample tests** "... a 'controlled' tryout under actual conditions of the work situation (Ryans and Frederiksen, 1951, p. 461)." |
| | a. Objectively scored.
| | b. Subjectively scored.

Fig. 1.—Analysis of Ryans and Frederiksen's Classification of Performance Tests
instruments, however, is discussed in Chapter III.

Greene (1963) equated Ryans and Frederiksen's categorizations to their intended mode of measurement—procedure or technique, product of an effort, and both of these. Procedural assessments are made by asking students to perform in a simulated situation. Evaluation of product is made by having students identify components or other significant items. Both performance and product may be adjudged by obtaining some work sample. Such a sample may be obtained when the task of changing a spark plug is evaluated.

Advantages and Limitations of Performance Testing

Numerous writers point up the fact that, unlike written forms, performance instruments yield valid measures of performance abilities. Written tests, they argue, "... are not highly correlated with actual performance (Greene, Jorgensen, and Gerberich, 1954, p. 199)." Performance tests, they submit, can be highly related to performance ability. In addition to providing a valid assessment of factors intended to be measured, Greene, Jorgensen, and Gerberich (1954) emphasized that these instruments can be highly diagnostic as well (p. 204).

Along with the advantages are found some limitations too. Some of these have been described and discussed earlier in Chapter I. In fact, the limitations of performance testing influenced the development of this study. Carpenter (1954) and others have suggested the time-consuming and costly nature of performance instruments as possible severe limitations. The "simulated conditions" type of
instrument may help to lessen these limitations, however. Lien (1967) has identified a number of other factors that limit the usefulness of these instruments, particularly where observation is required. These include the use of casual rather than systematic observation and the selection of unreliable criteria. Another limitation is implicit in the definition of a performance test used earlier in this chapter—controlled conditions. These conditions may be difficult to obtain.

**Psychomotor Domain of Educational Endeavor**

Much of the literature available on the psychomotor domain originated from the field of physical education. Singer (1968) provided a comprehensive discussion of current thoughts related to motor skill.

We usually use performance as representing the amount of learning that has occurred, for the process of learning must be inferred on the basis of observations of change in performance. We can measure what a person does directly, but what he learns is subject only to indirect estimates. ...Performance scores reflect the best means [of assessing learning] at the present time (p. 4).

Performance, concludes Singer, is represented by skill. "... Muscle movement or motion of the body required for the successful execution of a desired act is termed motor skill (p. 6)." "High degrees of motor skill coincide with high degrees of spatial precision and timing (p. 5)."

These skills are affected by four separate variables—

1. **Speed**— A skill may be required to be performed within a time limit.

2. **Accuracy**— The accuracy affects the successful achievement of the act.
3. **Form**—The motor act should be accomplished with greatest economy and efficiency of motion.

4. **Adaptability**—The act may have to be performed under varying conditions. A welder, for example, may have to weld in different positions.

Psychomotor skills are high-level motor skills—those requiring higher levels of perception and complex motion. Walking is a motor skill, whereas flying an airplane requires psychomotor skill. Singer points out, however, that these terms are often used interchangeably.

The kinds of motor abilities developed by industrial arts instruction has been investigated by Thomas (1968). Students enrolled in high school metalworking and woodworking courses served as the participants for his study. Using tests on two groups, he determined that the abilities of manual dexterity and finger dexterity were significantly developed after one year of instruction. After two years wrist-finger speed and aiming were significantly developed. None of the following skills, however, were significantly developed: response orientation, arm-hand steadiness, multi-limb coordination, speed of arm movement, reaction time, or control precision.

Fuzak (1958) correlated the grip strength of junior high school industrial arts students and found that it was positively and highly correlated with the ability they displayed performing manipulative tasks.

Simpson (1966) developed a taxonomy of educational objectives for the psychomotor domain. The taxonomy in its entirety is shown in Figure 2. **Perception**, the lowest level of the psychomotor domain,
Domain—Psychomotor

1.0 Perception
   1.1 Sensory stimulation.
   1.2 Cue selection.
   1.3 Translation.

2.0 Set
   2.1 Mental set.
   2.2 Physical set.
   2.3 Emotional set.

3.0 Guided Responses
   3.1 Imitation.
   3.2 Trial and error.

4.0 Mechanism

5.0 Complex Overt Response
   5.1 Resolution of uncertainty.
   5.2 Automatic performance.

Fig. 2.—Simpson's Taxonomy of Educational Objectives
deals with awareness of stimuli through the sense organs. **Set**, the next higher level, refers to an individual's readiness to perform a motor task. Each higher level of the taxonomy, it should be noted, is achievable only when the lower level(s) have been attained. **Guided responses** are simple abilities that are teacher directed. This level is accomplished when an individual is able to repeat a performance in a manner shown. **Mechanism**, the second highest level, is made up of combinations of guided responses performed in an habitual manner. The motion required to swing a hammer in order to hit a nail successfully is a guided response. When one makes this motion time after time, a nail will be successfully and completely driven. The driving of nails is a mechanism. The highest level of psychomotor performance is the complex overt response. At this level, tasks are very complex and require efficiency in their execution. The abilities shown by a machinist in setting up and operating a milling machine are representative of complex overt responses. This taxonomy is a companion to similar structures devised for the cognitive and affective domains and is especially useful to those charged with the responsibility of devising instructional activities for the psychomotor domain.

Whereas Simpson's taxonomy reflects the complexity of psychomotor skills, Kingsley and Garry (1957) analyzed changes that occur as an individual develops motor skills. Their analysis includes seven elements.

1. **Changes in task**—The task appears to change and eventually "drop out" as repetition increases.

2. **Changes in perception**—With practice, perception decreases.
"In nonhabituated activity, perception plays an important role (p. 299)."


4. Changes in feeling tone— Feeling of like and/or dislike will change as repetition increases.

5. Integration of movements— Clumsiness and jerkiness decrease as repetition increases.

6. Speed and accuracy— Both increase.

7. Fatigue effects— Increase trials decrease fatigue on single tasks.

While Simpson's taxonomy has certain important implications for instruction and evaluation, the analysis of Kingsley and Garry highlights influencing factors on skill development not accounted for in the former scheme.

The effect of practice on the development of a motor skill is well known. The effect of mental practice upon the development of these skills is not so well known. However, Start (1960) reviewed literature by Vandell, Twining, and Morrison which suggested that mental practice significantly improved subjects' ability to perform motor skills. To do so, the participants were asked to "picture themselves" performing the task of throwing a basketball. Nine mental practice sessions of five minutes duration were conducted. Start attempted to determine if the above technique could significantly increase skill. He concluded that it did.
Conclusions Regarding Performance Testing and Psychomotor Performance

The usual role of the performance test is to assess an individual's ability to perform a manipulative task. A performance test must be administered under controlled conditions. The literature has shown it to be valid, but costly and time consuming. Greene (1963) has concluded that:

It is apparent that knowledge and the successful application of knowledge in performance do not always correlate highly. It is certain, though, that those who apply knowledge in successful performance have achieved a higher degree of learning than that represented by the mere retentive grasp of knowledge; therefore, instruments which measure performance also give, by inference, measurement of the essential knowledge and skills (p. 42).

Psychomotor skill development, as has been shown, depends upon a number of variables and likely interactions among them. Additionally, psychomotor development does not, in a practical situation (as in school learning), take place or exist exclusive of other domains. These manipulative abilities involve, as Seibert and Snow (1965) have mentioned, "... sequential cognitive and accumulative memory processes... (p. 149)," as well. Similarly, as in the cognitive and affective domains, psychomotor skills have been taxonomized.

Summary

This chapter has set forth the major contributions to the literature of research and writing about three topics which are important to the conduct of this study—visual forms of testing, performance testing, and psychomotor performance. The literature has indicated that visual forms of testing are virtually unexplored and that little descriptive data has been generated. The literature encourages
research with visual means of testing and attributes the lack of knowledge to the fact that most of the effort with visual stimuli has been directed toward instruction rather than evaluation.

The literature on performance testing suggests that these devices provide more valid assessments of skill than instruments relying upon verbalization. Writers classified performance tests according to varying schemes. A number of these have been reviewed. The most comprehensive system appeared to be that by Ryans and Frederiksen (1951) which established a dichotomy—aptitude and achievement performance tests.

Psychomotor skills are high-level motor abilities that involve cognitive processes. Terminological confusion has resulted in the interchangeable use of the terms motor and psychomotor. The psychomotor domain has been taxonomized by Simpson (1966) into five contingent levels. Studies have inquired into psychomotor development occurring in industrial arts instruction.
CHAPTER III
METHODOLOGY OF THE STUDY

The purpose of this chapter is to present a detailed discussion of the important aspects involved in developing and administering the study. The topics discussed include the hypothesis, the design strategy, the development and revision of the testing instruments, conducting pilot and regular administrations, and the nature and selection of the sample.

Hypotheses

The discussion in Chapter I suggested that an individual who has developed a high level of manipulative skill is a better judge of that skill in others than a person who has developed lesser abilities. Ahmann and Glock (1967) support this hypothesis while attempting to make another point.¹ In so doing they insist that the student must actually perform to show his ability when tested, yet it is assumed that the teacher can assess the performance merely by observing it. It is assumed that the teacher, since he already possessed the skill being taught, can adequately evaluate the student. Therefore, why cannot the student's performance ability be evaluated by having him evaluate someone performing the tasks being assessed? Statements and thinking similar to these

¹The statement referred to is quoted in Chapter II, page 25.
have prompted the investigator to postulate the following hypothesis. An individual's manipulative ability in industrial arts woodworking and his proficiency at critically observing and evaluating that skill in others are related. It was further hypothesized that the nature of the relationship is positive and linear. Accordingly, the operational or null hypothesis states that there is no relationship between an individual's manipulative ability in industrial arts woodworking and his ability to observe and evaluate critically those skills in others. Symbolically, the null hypothesis is represented as follows: \( H_0: r = 0 \).

**Design of the Study**

Figure 3 illustrates the operational plan or design of the study. Briefly, the following phases were identified as essential to the conduct of the research.

1. **Develop two instruments**—The first would provide an evaluation of an individual's ability to manipulate woodworking saws, and the second would evaluate an individual's ability to assess accurately another's skill with the saws. The first of these was termed the work sample instrument (WSI). The second was called the recognition instrument (RI).

2. **Administer the instruments**—A sample of seventy-seven university students was selected. The WSI and RI were pilot tested, revised, and administered to the sample. Following the administrations data were collected and analyzed.
Fig. 3.—Design of the Study
The Instruments

The number and kind of woodworking tools and equipment found in a typical collegiate industrial arts laboratory number in the hundreds. The decision was made not to attempt to apply the hypothesis to the use of all tools and machines. To do so, it was reasoned, was not necessary since the hypothesized trait should exist in the use of any or all of the devices. Thus, one group of tools and machines, saws, was selected on the basis that:

1. They are found commonly and in great diversity in all woodworking laboratories.
2. A great variation of skill requirements may be observed as one manipulates saws that range from hand to power-operated.
3. The proper and safe use of saws is commonly taught to students in industrial arts.

Five kinds of saws were selected which represented diversity and differing skill requirements. They were the circular saw, band saw, jig or scroll saw, radial arm saw, and hand saw.

Content

Ryans and Frederiksen's (1951) scheme for performance test development was followed when appropriate in developing the WSI and RI (p. 483). A diagramatic representation of the process is shown in Figure 4.

Catalogs prepared by all industrial arts textbook publishers were reviewed. Every textbook dealing with woodworking was considered as a possible source of content for a "job analysis" of the saws listed above. A number of the texts were then eliminated from further consideration.
Fig. 4.—Steps in Developing a Performance Test

because they were intended for elementary or junior high school use. Those textbooks remaining were then reviewed, analyzed, and considered the source of content for the "job analysis" of the sawing tasks. This analysis generated the criterion items which became a checklist rating form for each sawing task (WSI).

Most individual criterion items were established by reviewing each author's description of the proper and safe operation of the saws. Those procedures which were commonly recommended were then selected. Some variation from this procedure occurred, however, because the authors varied their emphasis from time-to-time. In such cases the investigator relied upon his background and experience as well as that of his colleagues at the university. The checklist items were written as statements of the correct or proper means of performing each phase
of the operation of the saw. As recommended by Ahmann and Glock (1967), the items were arranged in the approximate order of performance to serve as brief, checklist statements beside "yes" and "no" columns.\(^2\)

Raters were necessary to administer the WSI. The device was administered by having the raters observe the participants manipulating the woodworking saws. Raters checked either the "yes" or "no" column for each of the checklist criteria.

The RI was a videotape recording. The content criterion items from the WSI were analyzed, and from these a series of scenes was recorded. The scenes showed the various sawing criteria—some being performed properly, some improperly.\(^3\)

The RI was administered by showing the videotape to the participants. They judged each scene as "proper" or "improper" according to questions asked before each scene. The RI made each participant, in effect, a rater.

Both the WSI and RI were constructed at the same time to insure item-to-item relevancy for each criterion.

Presumably, if the instruments were adequate, the WSI would provide an assessment of "actual" manipulative ability, while the RI would provide a measure of each participant's ability to observe and evaluate the same manipulative performance.

**Validity**

The problem of validity is not as serious with performance tests as

\(^2\)This organization may be seen in Appendix D.

\(^3\)A script of the RI may be seen in Appendix D.
with other forms, as noted by Ryans and Frederiksen (1951).

The ideal method of investigating the validity of a performance test is, as is true of any achievement test, to study its relationship to a suitable criterion measure. The difficulty, of course, is that a criterion that is more satisfactory than the performance test results themselves is usually lacking (p. 469).

A number of techniques were employed contributing to the likelihood that the instruments would measure what they were intended to measure. The investigator reasoned, for example, that the criteria were valid since they were derived directly from current textbooks written by recognized experts in the field. Another indication of the content validity was the consistency of agreement on the safe and proper operation of the saws from book to book. An additional check on validity was employed, too. Micheels and Karnes (1950) indicated that one "... can submit the test to several competent people who are thoroughly familiar with the content field being tested (p. 108)." Accordingly, the instruments were submitted to a jury of six staff members in the Department of Industrial Education and Technology at Bowling Green State University, Bowling Green, Ohio. Validity data were gathered by having each jury member respond to a validity statement for each instrument. An analysis of this data is presented in Chapter IV. Their professional opinions regarding the adequacy of the instruments were considered as the instruments were developed and revised.

Reliability

Reliability was assessed using a split-half determination of internal consistency. Test halves were generated using the odd-even method. The resulting coefficients were corrected with the Spearman-
Brown prophecy formula. This technique projects a coefficient for a test twice as long as the odd or even halves. The procedure was selected because the nature of the performance checklist suggested that a great variation in item difficulty would occur. Since procedural criteria were identified in the WSI, certain steps would be required if the examinee were to complete the task at all. Other criteria might or might not be performed and still allow this task to be completed. Ebel (1965) suggested that the commonly used Kuder-Richardson formula 20 assumes fairly uniform difficulty and formula 21 yields an underestimate of reliability (p. 318-19). Therefore, these measures were not used. The appropriate data for the regular administration is reported in Chapter IV, while data for the pilot administration is reported later in this chapter.

Raters

The raters who conducted the WSI had extensive backgrounds in industrial arts woodworking. All were graduate teaching assistants or faculty at Bowling Green State University who, during the pilot administration, demonstrated a high level of reliability as raters of skill performance. The raters participated in constructive criticism and review of the instrument during its developmental period and were trained in administering the device.

The Sample

Students enrolled in courses in the Department of Industrial Education and Technology, Bowling Green State University, were selected for the sample. The sample size for the pilot administration was n=12. The
regular administration had a sample size of \( n=77 \), which was more than 30% of the total population of all industrial education students at the above institution. The participants for the pilot administration will be discussed under that section heading.

Participants for the regular administration were selected on a "nonprobability" basis (Downie and Heath, 1970, p. 156). Unlike random selection, nonprobability selection is performed so that various significant portions of a population are represented. The participants selected were chosen purposively to insure covering a range of ability in saw use. Two main rationales guided this decision.

1. The study was descriptive in nature rather than experimental, in as much as it attempted to determine the relationship between developed abilities. Each participant's level of developed manipulative ability was identified by the criterion measure. Consequently, the investigator was measuring the participants on the variables he was interested in and disregarding the variables he was not interested in. There would have been no advantage to random sampling in this study. In fact, randomization could have prevented the collection of data descriptive of a range of student manipulative abilities. This rationale supported nonprobability sampling. The reader will note that the participants in this study were neither part of an experimental nor control group. In a sense "they were their own controls," for each had his own criterion of performance measured. Other assessments were compared to it.

2. The investigator was interested in securing data about
performance by individuals who collectively possessed a vast range of abilities. For this reason purposive sampling was made of individuals who, presumably due to variations in academic preparation and experience, represented levels of abilities from "beginner" to "teacher-in-the-field."

Selection was by intact groups of students enrolled in industrial education courses during the spring quarter of 1970 at the University. The n of 77 was achieved by selecting students typical of these categories:

1. **Entry level students**— Students in this group were experiencing their first collegiate level woodworking course or had recently completed it. They were primarily freshman or sophomores.

2. **Intermediate students**— These participants were students who had had two collegiate level woodworking courses. There were a few sophomores included but mainly juniors and seniors.

3. **Advanced students**— The advanced group was made up of seniors and graduate students who, it was assumed, were those most exposed to the course work and teaching experiences.

Table I discloses descriptive data that was collected from the sample. As can be seen, the students participating represented varying degrees of experience in woodworking. While some had completed only a few weeks of work in their first course, others were public school teachers enrolled in the graduate program. The rest represented various intermediate levels of preparation.

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4Detailed normative data on participants may be found in Appendix B.
TABLE I

INDUSTRIAL COURSEWORK AND TEACHING
EXPERIENCE OF PARTICIPANTS

<table>
<thead>
<tr>
<th>Months of Industrial Arts Woodworking Coursework</th>
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<tbody>
<tr>
<td>Less Than Three</td>
<td>15</td>
<td>19</td>
<td>43</td>
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<tr>
<td>Three to Eight</td>
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<td></td>
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<tr>
<td>Nine or More</td>
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<tr>
<td>Total</td>
<td>77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Months of Teaching and Industrial Work Experience with Woodworking Saws</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Less Than Three</td>
<td>49</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Three to Eight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nine or More</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Pilot Administration

The pilot administration was conducted with a group of twelve undergraduate students in the Department of Industrial Education and Technology at Bowling Green State University. The participants were enrolled in an entry-level course where each student received basic instruction in the proper and safe operation of basic woodworking machines.

The purposes of administering the instruments in pilot form were to determine problems in operation, performance of raters, and length of time required to administer the tests, as well as to gather data with regard to the reliability of the instruments for revision. The pilot administration was made by first subjecting each participant individ-
ually to the WSI. Every participant passed through seven stations, each requiring the performance of a stated sawing task. The tasks were described on cards. Two raters manned each station. No interaction was permitted between the raters or between the raters and participants. The participants required about thirty minutes to complete the seven tasks.

Following the performance of the WSI, all participants viewed the RI at the same time. They recorded on an answer sheet their judgment about samples of performance shown on the videotape. The investigator and two assistants prepared the videotape using an Ampex VR 6000 recorder and one-inch tape. The tape was recorded one scene at a time, since no provision was made for tape editing. Each question sequence followed a common pattern.

1. An announcer asked a specific question about a specific sawing criterion, such as, "The operator is beginning his cut. Is his procedure proper or improper?"
2. A procedure was shown on the screen. The scene length was determined by the complexity of the procedure involved.
3. Following each scene the announcer read "Mark your answer sheet" and a card reading the same appeared on the screen. Approximately five seconds was given for marking the answer sheet in every scene.

During the waiting period between the administration of the instruments and while waiting for the first instrument, a strict "no interaction" rule was in force and monitored by a proctor. In addition, all

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5 Samples can be found in Appendix C.
students were given a problem assignment completely unrelated to the instruments to be completed during their wait.

Both instruments administered in the pilot study contained seven sets of tasks or questions relating to the five saws. Two of the seven saws, the circular saw and hand saw, had two sets of questions and tasks. These items dealt with crosscutting and ripping. The WSI contained 71 items, and the RI contained 73 items.\(^6\)

A statistical analysis of the pilot forms of the instruments yielded the following information. The inter-rater reliability was \( r = .936 \) on the WSI. Instrument reliability data is shown in Table 2. The correlation between the WSI and the RI was .776.

The Regular Administration

The pilot administration yielded valuable information that was incorporated by revisions in the instruments and procedure.

Instrument and Procedure Modification

The number of raters at each task station of the WSI was reduced from two to one. This was done on the strength of a .936 rater reliability from the pilot administration.

The instruments were modified to include five sawing tasks instead of seven. The ripping tasks involving the hand and circular saws were eliminated. This was done following an analysis of the pilot WSI which showed that all but one item of the handsaw ripping were identical to those selected for crosscutting. The criterion item that differed was

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\(^6\)Copies of both pilot instruments may be found in Appendix D.
TABLE 2
PILOT INSTRUMENTS
RELIABILITY INDEXES

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Split-Half Reliability with Spearman-Brown Prophecy Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot</td>
<td></td>
</tr>
<tr>
<td>WSI</td>
<td>.824</td>
</tr>
<tr>
<td>Pilot</td>
<td></td>
</tr>
<tr>
<td>RI</td>
<td>.883</td>
</tr>
</tbody>
</table>

sawing angle. A similar analysis of the circular saw ripping and crosscut sawing tasks revealed two sawing checklist criterion items which were different from those used to evaluate the crosscut task.

The sequences recorded on the RI varied little from the WSI as the scenes were developed from that instrument's checklist criterion items. The investigator concluded that since the crosscutting and ripping tasks included primarily the same criteria, one of the tasks could be eliminated. The ripping task was chosen for deletion because the crosscutting task was considered safer to administer on the circular saw and less time consuming with the handsaw. A further advantage was seen, too, from the reduced time required to administer a shorter instrument. The reduction amounted to two-sevenths—or an estimated ten minutes—lowering the thirty-five minute testing time to twenty-five minutes. Although reduced instrument reliability could be expected, more participants could be processed in the same amount of time. This technique allowed the investigator to gather more data and helped to insure less participant fatigue at the same time.

Another change made in the regular administration was a uniform
Distractive treatment for all participants. Each individual was required to read *The Story of the Plastics Industry* (Masson, 1968) prior to and between the test administrations. This scheme assured the investigator that the participants were not likely to interact with each other out of curiosity or boredom while waiting for their turns to provide the work sample and participate in the recognition test. It also helped to put students in a similar frame of mind as they were tested. Although the reading assignment was used to control interaction, proctors were assigned to monitor the participants as well. Following the testing, many of the participants remarked that they studied the plastics book diligently for they assumed that they would be tested on its content.

**The Administration**

The sessions were conducted as follows. In groups, participants received instructions at the beginning of the session. Participants were told that they were involved in the development of a new type of testing instrument. They were told that they should read the plastics booklet carefully and that it was important that they did not interact with anyone.\(^7\) One at a time the individuals were taken from the room to a woodworking laboratory where they were read the general instructions for the WSI. The instructions told them that they would be asked to use five different kinds of woodworking saws, that they should use the tools as they normally would, and that the person at each task station (rater) would tell them what to do following the performance of each task. The

\(^7\)The script of all the instructions read to the participants can be found in Appendix E.
task instructions were printed on cards at the task stations. Accompanying each written task instruction was an illustration of the task.8

Before the participants arrived at the work sample stations, the raters prepared the stations according to conditions specified on the rating checklist.9 The participants found identical conditions, tools, and machine adjustments as they arrived at each task station. Raters marked their checklists as inconspicuously as possible to avoid cuing the participants as to what kind of evaluation was taking place. Consequently, it was expected that the participants did not attempt to perform the tasks in some seemingly appropriate, novel manner.

When each participant completed all five tasks, he was sent to the room in which the RI was to be given. The participants were, however, unaware of what was to follow. The individuals continued to read the plastics booklet when they reached the new location. When the room was filled to its planned viewing capacity (approximately seven participants) the proctor collected the plastics readers and distributed mark-sensitive answer sheets and data collection forms. These forms were used to collect data regarding the participants' experience in woodworking and affiliated activities. Data were collected regarding months of course-work, industrial and teaching experience.10 The proctor then read the directions regarding these materials.11

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8 See these cards in Appendix C.
9 The WSI checklists may be found in Appendix F.
10 See Appendix B.
11 Samples of the data collection form can be found in Appendix G.
Following the initial procedures, the television monitor was turned-on and the videotape playback unit started. Recorded on videotape was an introduction given by the investigator, followed by the RI. The participants watched the instrument as a group and responded on their individual answer sheets simultaneously. No participant-participant interaction was permitted during the RI.

At the conclusion of the RI, the participants were thanked for their help and told that the investigator would be happy to discuss the testing with them at a later time. The participants were excused and the testing was concluded.

**Summary**

Checklists for the proper and safe use of five woodworking saws were developed, and two testing instruments were prepared—the Work Sample Instrument (WSI) and the Recognition Instrument (RI). These instruments were used to assess each participant's manipulative ability and critical observation ability with five saws. University students were selected on a nonprobability basis for both the pilot and regular administrations. Following the pilot administration, both instruments were revised for the regular administration.

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12 Appendix H contains the script and visuals for the RI.
CHAPTER IV
PRESENTATION OF THE DATA

In this chapter the writer reports the data that have been collected with regard to the adequacy of the instruments and to the relationships among the variables under study.

The Instruments

Work Sample Instrument (WSI) Analysis

A number of statistical analyses were performed on the WSI and RI. The results follow.

Content Validity. As was mentioned in the last chapter, the instrument checklist was subjected to the rigor of examination and criticism of a jury of experts in the field. In addition to a subjective judgment of the validity of the instrument, a more objective analysis was attempted. Each judge was asked to respond to the statement, "Does this checklist, in fact, determine an individual's ability to operate five woodworking saws safely and properly?" The experts were asked to rate the adequacy of the instrument with regard to the above validity statement on a 0-10 scale. Zero represented complete disagreement with the statement; and 10, complete and strong agreement. The jury responded as shown in Table 3.
TABLE 3

JURY'S VALIDITY ANALYSIS OF TWO INSTRUMENTS—WSI AND RI

<table>
<thead>
<tr>
<th>Jury Member</th>
<th>Work Sample Instrument</th>
<th>Recognition Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

The mean response for the WSI was 8.833.

Reliability. The split-half reliability coefficient, computed on the odd-even basis, was .706. When corrected with the Spearman-Brown prophecy formula, the reliability coefficient became .822. These and other related data are shown in Table 4.

Discrimination and Difficulty. The top and bottom 27% of the participants responses were analyzed to yield discrimination and difficulty indexes. The mean item discrimination for the work sample instrument was .237. Mean item difficulty was .662.¹

¹The complete analysis for each item may be found in Appendix I.
TABLE 4

RELIABILITY ANALYSES OF TWO INSTRUMENTS—WSI AND RI

<table>
<thead>
<tr>
<th></th>
<th>Work Sample Instrument</th>
<th>Recognition Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Items (K)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Mean (X)</td>
<td>32.701</td>
<td>37.233</td>
</tr>
<tr>
<td>Standard Deviation (s)</td>
<td>5.114</td>
<td>3.182</td>
</tr>
<tr>
<td>Split-half Correlation by odd-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>even method (r_{ih})</td>
<td>.706</td>
<td>.195</td>
</tr>
<tr>
<td>Split-half Correlation Corrected with Spearman-Brown Prophecy Formula (r_{1})</td>
<td>.822</td>
<td>.326</td>
</tr>
</tbody>
</table>

Recognition Instrument (RI) Analysis

As described for the work sample instrument, similar analyses were performed for the recognition test.

**Content validity.** The jury that adjudged the validity of the former instrument did the same with the recognition test in response to the question: "Does this instrument, in fact, display safe and proper operation of five woodworking saws?" The mean rating of the five judges was 9.000 based upon the same scale as described earlier for the former instrument. Table 3 contains the judges' ratings.

**Reliability.** As with validity, above, reliability of the tele-
vised RI was analyzed using the split-half method. Table 4 shows the data collected for this and the prior instrument. The split-half correlation coefficient, calculated on an odd-even basis, was .195, which when corrected by the Spearman-Brown formula increased to .326. The reader will note upon inspection of Table 4 that the range of scores on this instrument was low—31 to 44 while K=50.

**Discrimination and Difficulty.** An index of the item discrimination for each of the 50 RI items was .142. Mean difficulty was .750.²

**Relationships**

The proposed hypothesis suggests that a relationship exists between two variables—manipulative ability and critical observation ability. Instruments were thus designed to assess these abilities.

**Primary and Secondary Variables**

Upon reflection, the investigator questioned whether other variables associated with the college student were related to performance or critical observation ability. Consequently, the investigator gathered descriptive data for each participant. The descriptive data collected included: American College Testing Program (ACT) scores—an estimate "... of a student's academic and non-academic potential. ... (American College Testing Program, 1969, p. 2);" accumulated grade point average—a measure of ability to earn grades in university work; and previous association with saw-related course work and/or prior experience with the devices. The first two sets of data were

²The entire item analysis of the RI may be found in Appendix J.
gathered from university records, and the third from a questionnaire administered during the testing period.

The three secondary variables and the two primary variables under study were analyzed using zero-order correlations, multiple correlations, and partial correlational techniques.

**Zero-order Correlations (r)**

Table 5 is a correlation matrix for five variables, n=77. The reader will note that the correlation coefficient between the two testing instruments is .297, which is significant at the .01 level (Downie and Heath, 1970, p. 318). The coefficient of determination is .088.

Of the four variables—RI, ACT score, grade point average, and previous experience—the RI was significantly correlated with the WSI with a coefficient of .297. Grade point average and WSI were correlated .264, while previous experience and WSI were .156. Virtually no relationship existed between ACT scores and the WSI with a correlation of -.008. Comparisons of the four variables to variable 2, the RI, shows a correlation of .223 with previous experience, .104 with ACT scores, and .061 with grade point average.

**Multiple Correlations (R)**

Multiple correlations show the combined relationships of two or more variables with another variable. Tate (1955) has suggested that:

The multiple coefficient indicates the extent to which variation of $X_1$ is associated with the joint variation of the independent variables. Thus the square of $R$ indicating the proportion of variance of $X_1$ is accounted for by $X_2$, $X_3$, . . . (p. 309).
TABLE 5

CORRELATION MATRIX FOR FIVE VARIABLES (n=77)

<table>
<thead>
<tr>
<th></th>
<th>Work Sample Instrument (WSI), Variable 1</th>
<th>Recognition Instrument (RI), Variable 2</th>
<th>ACT Score, Variable 3</th>
<th>Grade Point Average, Variable 4</th>
<th>Previous Experience, Variable 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Sample Instrument (WSI), Variable 1</td>
<td>1.000</td>
<td>.297</td>
<td>-.008</td>
<td>.264</td>
<td>.156</td>
</tr>
<tr>
<td>Recognition Instrument (RI), Variable 2</td>
<td>.297</td>
<td>1.000</td>
<td>.104</td>
<td>.061</td>
<td>.223</td>
</tr>
<tr>
<td>ACT Score, Variable 3</td>
<td>-.008</td>
<td>.104</td>
<td>1.000</td>
<td>.197</td>
<td>-.042</td>
</tr>
<tr>
<td>Grade Point Average, Variable 4</td>
<td>.264</td>
<td>.061</td>
<td>.197</td>
<td>1.000</td>
<td>.422</td>
</tr>
<tr>
<td>Previous Experience, Variable 5</td>
<td>.156</td>
<td>.233</td>
<td>-.042</td>
<td>.422</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Table 6 shows the multiple correlation effect of variables 2, 3, 4, and 5 (independent variables) upon 1 (dependent variable).

### TABLE 6
**MULTIPLE CORRELATION COEFFICIENTS**  
**WITH VARIABLE 1 (WSI) AS THE DEPENDENT VARIABLE**  
($R_1$)

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Multiple Correlation Coefficient ($R$)</th>
<th>Coefficient of Determination ($R^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 3</td>
<td>.299</td>
<td>.089</td>
</tr>
<tr>
<td>2, 3, 4</td>
<td>.395</td>
<td>.156</td>
</tr>
<tr>
<td>2, 3, 4, 5</td>
<td>.397</td>
<td>.158</td>
</tr>
<tr>
<td>3, 4</td>
<td>.271</td>
<td>.073</td>
</tr>
<tr>
<td>3, 4, 5</td>
<td>.274</td>
<td>.075</td>
</tr>
<tr>
<td>4, 5</td>
<td>.268</td>
<td>.072</td>
</tr>
</tbody>
</table>

As suggested by Tate (1955), "... $R^2$ indicates the proportion of variance of the dependent variable which is explained or accounted for by the independent variables (p. 316)." Stated in another way, variables 2, 3, 4, and 5 represent 15.8% of the variance of 1 (WSI). Analysis of variance for this multiple correlation coefficient yields 3.359 (significant beyond .05) as seen in Table 7.

It is interesting to compare the correlation between variables 1 and 2 and the resulting coefficient of determination and multiple correlation data for them with the additional variables that the
TABLE 7
ANALYSIS OF VARIANCE FOR THE MULTIPLE
LINEAR REGRESSION

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to Regression</td>
<td>4</td>
<td>312.561</td>
<td>78.140</td>
<td>3.36*</td>
</tr>
<tr>
<td>Deviation about Regression</td>
<td>72</td>
<td>1675.189</td>
<td>23.267</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>1987.750</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Sig. at .05 level $F_{4, 70} .05=2.50$ $F_{4, 7} .01=3.60$

investigator identified (variables 3, 4, and 5). Table 8 shows the coefficients and resulting coefficients of determination. If we desire to predict sawing performance from other capabilities, then knowledge of grade point average, ACT scores, and previous experience allows us to double the accountability resulting from our information—from 08.8% to 15.7%.

Partial Correlations

The computation of partial correlations allows an investigator to partial-out the effect of variables that are common within the relationship between two other variables. Tate (1955) noted:

The chief use of partial correlation [5] is that of determining what the correlation between two
variables would be if a third variable were not interfering with the relationship (p. 302).

TABLE 8
COEFFICIENTS OF DETERMINATION

<table>
<thead>
<tr>
<th></th>
<th>Correlation Coefficient (r) and (R)</th>
<th>Coefficient of Determination (r²) and (R²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>r₁₂</td>
<td>.297</td>
<td>.088</td>
</tr>
<tr>
<td>R₁.2345</td>
<td>.397</td>
<td>.158</td>
</tr>
</tbody>
</table>

Table 9 lists the partial correlations for variables 3, 4, and 5 upon r₁². The most notable partial coefficient is r₁₂.₄ which was .288. Variable 4 was grade point average. The effect of removing variables 3 and 5 is minute at -.051 and .042 respectively. Variable 3 represents the effect of ACT scores and variable 5 is prior experience with saws.

TABLE 9
THE PARTIAL r FOR THREE VARIABLES--ACT SCORES, GRADE POINT AVERAGE, AND PREVIOUS EXPERIENCE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Partial r's (First Order)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>-.051 r₁₂.3</td>
</tr>
<tr>
<td>4</td>
<td>.228 r₁₂.4</td>
</tr>
<tr>
<td>5</td>
<td>.042 r₁₂.5</td>
</tr>
</tbody>
</table>
Linearity of Relationships

A portion of the hypothesis stated that the relationship between the two primary variables—sawing performance and critical observation of sawing performance—would be positive and linear. This proposition was based upon an intuitive feeling, which was seemingly substantiated by informal observation. One result of a nonlinear relationship would be that individuals would increase their ability to observe manipulative skills critically to some point. Their observation ability would then decrease as their manipulative ability continued to increase. This kind of relationship is shown, graphically, in Figure 5.

Conversely, individuals with minimal manipulative ability might have great observation ability, while individuals with medium manipulative ability might have minimal observation ability, and individuals with great manipulative ability have great observation ability. Such a relationship could appear as shown in Figure 6.

The number of non-linear relationships is infinite. No others will be suggested here, for all non-linear relationships of the variables under study seem inappropriate.

Dubois (1965) reported:

Up to the present time, however, age is perhaps the only variable showing consistent curvilinear relationships with psychological variables. Excluding relationships with age, most correlations so far found appear to be linear (p. 127).

Nunnally (1959) discusses the requirements and means of determination of linearity.

Technically the relationship is linear if the mean assessment score for each array falls exactly on the best-fit line.
Fig. 5.—Hypothetical Relationship of Manipulative Ability to Critical Observation Ability

Fig. 6.—Hypothetical Relationship of Manipulative Ability to Critical Observation Ability
It is expected that the array of means will diverge from the line of best-fit by small amounts if only because of sampling error. However, in the use of psychological tests it is rare to find that the array means show a systematic trend other than a straight-line function (p. 82).

Nunnally further suggests a procedure to determine linearity of a relationship—namely, inspection of the scatter diagram (p. 83). Figure 7 is a diagram of the relationship between WSI scores and RI scores and includes regression lines. Although the variability of the data is consistent with their relationship \((r = 0.297)\), the data appears, visually, to be linear, and is unquestionably positive. Visually, homoscedasticity is also present.

A more accurate method of determining linearity is described by Walker and Lev (1953). They provide a test for linearity of regression

![Diagram of WSI and RI scores with regression lines and equations: \(X = 32.714\), \(Y = 37.234\), \(r = 0.297\).](image)
using an F ratio (Walker and Lev, 1953, p. 278). Using this test, the WSI and RI data achieved an F of .858, which was not significant at the .05 level (1.94 was required to achieve .05 significance). Consequently, the data were statistically judged to be linear.

Summary

Data of two kinds were analyzed in accordance with the objectives stated in Chapter I. Data regarding the adequacy of the WSI and RI and data reflecting the relationship between the characteristics measured by the instruments were treated. Content validity of both instruments was adjudged high, but the WSI out-performed the RI in reliability and item discrimination. The correlation between the two instruments was linear, positive, and statistically significant beyond the .01 level.

In addition to zero-order correlations, multiple and partial correlations were performed. Also attenuation, ANOV of the multiple regression, calculations of coefficient of determination, and an F-test of linearity were applied.
CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

In this chapter the writer will review the hypothesis and nature of the study, suggest several conclusions as a result of the data collected, and make his recommendations to those who may desire to continue or replicate this study.

Summary

Certain branches of study have as primary or secondary goals the development of psychomotor or manipulative abilities. Branches of study within institutionalized American education which have such goals include, among others, music, physical education, business studies, and industrial arts. The focus of this study was upon these abilities in industrial arts.

The Problem and Hypotheses

It is often assumed that an individual who has developed a certain manipulative ability is a better judge of that ability in others than a person who has not developed similar powers. A concert pianist would, therefore, be presumed to be a more critical observer of a person's piano technique than would a beginning piano student. Likewise, a highly skilled auto mechanic would be a more critical judge of a person's competency in tuning an automobile engine than would be a
motoring hobbyist. Consequently, this writer asked what relationship exists between an individual's manipulative ability and his accuracy at critically observing that skill in others?

The investigator's main hypothesis was that an individual's manipulative ability in industrial arts woodworking and his ability to observe and evaluate critically those skills in others are related. It was further hypothesized that the nature of the relationship is positive and linear.

Methodology

The investigator prepared, validated, trial administered, and revised two instruments. The Work Sample Instrument (WSI) was a performance checklist of criteria of work samples of five common woodworking saws. The criteria for developing the checklist items were derived from textbooks commonly used for college-level instruction in the safe and proper use of the woodworking saws. Validation was determined by subjecting the device to a jury of experts. The Recognition Instrument (RI) was constructed to assess critical observation ability. The items were parallel forms of the checklist that made up the WSI. The completed instrument was in the form of a series of questions about sequences of sawing performances recorded on videotape.

A pilot study using twelve university students was completed to determine any problems that might occur in the management of the testing procedure. The data were used to revise instruments and operational procedures.

The instruments were administered to 77 undergraduate and graduate
students at Bowling Green State University, Bowling Green, Ohio. The sample was a deliberate nonprobability type so that a great range of participant abilities and experiences could be assured. The individuals selected represented students who had only a few weeks of formal instruction and no experience, to students with many years of teaching and/or industrial work experience and several courses that included instruction in the use of the saws.

Each participant was first asked to perform five sawing tasks, was observed in the process and rated from the checklist in regard to his proper and safe operation of the tool or machine. Raters were college instructors who were experienced operators of the saws and had been trained by the researcher to observe the tasks. Following the administration of the WSI, groups of participants watched the videotaped RI. They viewed on the screen samples of the performance they had just been asked to perform. Questions were asked about specific criteria, and the respondents identified whether the performance they were observing was "proper" or "improper" by responding on a machine-scoring, mark-sensitive answer sheet. The participants were excused following the recognition instrument.

Data Analysis

Data of two kinds were analyzed—data dealing with instruments, and data dealing with the relationship between the two instruments. The first category asked how adequate the two instruments performed. Appropriate data are shown in Table 10. Validity ratings for the two tests were about the same and quite high. Otherwise, the WSI was superior in estimates of reliability and discrimination. The limited
TABLE 10

SUMMARY OF DATA FOR THE WSI AND RI INSTRUMENTS

<table>
<thead>
<tr>
<th></th>
<th>Work Sample Instrument (WSI)</th>
<th>Recognition Instrument (RI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jury Content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Validity Rating—max. 10.000</td>
<td>8.833</td>
<td>9.000</td>
</tr>
<tr>
<td>Split-Half Correlation Corrected with Spearman-Brown Formula</td>
<td>.822</td>
<td>.326</td>
</tr>
<tr>
<td>Mean Discrimination (d)</td>
<td>.237</td>
<td>.142</td>
</tr>
</tbody>
</table>

range of scores on the recognition instrument hindered its performance in the above analyses. The second type of analysis concerned the relationship between the two testing instruments. In addition to the two major parameters under study—manipulative ability and critical observation ability—data reflecting three others, considered minor but possibly related, were collected. These secondary variables were accumulated university grade point average, American College Testing, Program (ACT) scores, and previous experience in coursework, teaching and industrial work in which saws were involved. The analysis disclosed some interesting relationships. For example, more than any of the other variables, critical observation ability was correlated with manipulative performance ability (.297). Correlated nearly as highly,
however, was grade point average at .264. The multiple correlation of all four variables (Recognition Instrument, ACT score, grade point average, and previous experience) with the work sample was .396, which accounted for 15.7% of the effect of the four variables upon manipulative performance. The relationship between critical observation ability and manipulative performance was significant beyond the .01 level.

Conclusions

The investigator's conclusions will be made, first, by evaluating the objectives set forth in Chapter I. These were:

1. To develop a valid and reliable instrument which would assess the student's actual performance ability with selected woodworking tools.
2. To develop a valid and reliable instrument which would assess the student's ability to observe and evaluate critically the proper use of selected common woodworking tools.
3. To establish the relationship existing between the characteristics assessed by the above two instruments.

Conclusions with Regard to Objective One

The writer concluded that, given the limitations of this study, a valid and reliable instrument had been devised to measure the characteristics set forth by this objective. The conclusion was reached on the strength of a mean content validity rating of 8.833 on a 10 point scale and reliability coefficient of .822 (odd-even comparison corrected with the Spearman-Brown prophecy formula). The WSI was considered particularly strong in the light of the discussion by Ryans and
Frederiksen (1951).

Perhaps the essential difficulty in the development of performance tests of high reliability is that relatively few tasks or items are likely to be involved in the testing. In cases where many short simple operations are required, as in operating a typewriter, it is not difficult to build tests of satisfactory reliability; but in any operation relatively long, complex tasks, such as in the assembly of an engine or the construction of a woodworking sample, the performance test is likely to be of a lower reliability unless it is an exceptionally lengthy one (p.483).

Conclusions with Regard to Objective Two

Unlike the instrument described above, the RI's performance is less conclusive. While the validity rating of the instrument was high (9.000 on a 10 point scale) the indicated reliability was low (r=.326, split-half analysis with Spearman-Brown correction). There is little question that the limited range of the instrument lowered its reliability. The range of the instrument was 31-44 (K=50) as compared to 20-43 (K=50) for the former instrument. In addition, the instrument was shorted about twenty items from its original pilot form. The shortening would, theoretically, lower the reliability. Although, the short form of the WSI did not yield a markedly lower reliability.

The item discrimination for the RI was .142, hardly a strong discrimination coefficient.

Overall, the investigator concluded that an instrument of this type is more difficult to prepare than the work sample variety and that criteria shown on a television screen may be interpreted differently by the testee than the tester. Somewhat baffling is the comparison of the instrument's performance in its trial form to the regular administra-
tion. The investigator can only conjecture that one or more sources of error variance mitigated against higher reliability. Perhaps the participants became fatigued. Perhaps the change in test-taking environment from the WSI to RI may have contributed to the error component. The participants may have guessed considerably.

Conclusions with Regard to Objective Three

Objective #3 called for establishing the relationship existing between the traits measured by the two instruments. The null hypothesis stated that there was no relationship between an individual's manipulative ability in industrial arts woodworking and his ability to observe and evaluate those skills critically in others (H₀: r=0). On the basis of r=.297 (sig. .01) between the above variables, the null was rejected.

The investigator accepted his original hypothesis that the above relationship exists and is positive and linear. The significant question is: "Is the strength of the relationship such that it could have educational value?" Downie and Heath (1970) discussed this matter as it relates to correlation coefficients:

... the size of the correlation itself is not the most important thing about it, but it is the situation in or purpose for which it is being used that determines how we evaluate it. We expect high correlation coefficients for some situations and can tolerate much lower ones in others (p. 102).

In light of this argument, the low correlation would not allow one to predict accurately manipulative ability from observation ability.

Applying correction for attenuation as recommended by Guilford (1954, p. 400) the correlation is raised to .573. This manipulation
suggests that the above coefficient is the relationship between the "true" variance of the two traits under investigation. Although controversial, the correction for attenuation suggests a viable correlation. If we assume that more precise, stronger instruments could be devised to yield a correlation about the size of that above, we could begin to make rough predictions about groups. This would be particularly so if the added strength of multiple correlation among the primary and secondary variables were considered.

The reader must recall that these conclusions are based upon data gathered from a nonprobability sample. The conclusions, therefore, cannot safely be made beyond the sample itself. The investigator feels compelled to remind the reader again, though, that the size of the sample and basis for selection were such that it is expected that the results would be "typical" of a randomly selected sample in which the range of abilities within the population would be great and well represented. Said another way, there was no systematic selection influence known to the investigator that would tend to yield results different from those obtained from an infinitely large sample.

In conclusion, the investigator believes that the data support the hypothesis under investigation. He believes, too, that more reliable instrumentation may yield a greater correlation.

**Implications**

As a result of the study a number of educational and non-educational implications can be drawn. A vast, new, empirically verified means of educational evaluation has been identified. The investigator's
hypothesis—that psychomotor and visual observation abilities are related—was not rejected. In fact, a significant correlation exists between these traits and suggests a need for additional study to develop testing instruments which will vicariously assess psychomotor performance. The direct implication to industrial educators, and to others who evaluate psychomotor performance, is that a viable means exists to determine total performance—psychomotor and cognitive—as easily as cognitive performance is now measured. Assumed here is Greene's (1963) conjecture that "...instruments which measure performance also give, by inference, measurement of the essential knowledge and skills (p. 42)." Performance tests may now be developed which could eliminate the need of waiting by participants, of fatigue, and of the consumption of hours of testing time. Costly duplication of equipment and simulation devices could be eliminated.

Outside of formal education an implication exists for business, industry, and the military to consider the merit of investing in developing observational instruments to assess the myriad kinds of total performance with which they deal. For example, this revolutionary change in testing procedure could save countless man-hour and equipment costs. Innumerable applications for these enterprises could be imagined from driver testing to pilot testing, from time-study applications to clerical evaluation.

The study yields implications for those who conduct research with educational media, for an entirely new vista has become available. Now, various media—film, television, and static types—can be investigated for efficiency in assessing performance. As noted in the review of
literature, a number of writers have pointed-up the lack of media involvement in test development. Media research, they contend, has been directed toward instruction rather than evaluation. An even greater need for media research now exists as a result of this study.

Finally, implications are clear for test developers, both commercial and non-commercial. Needed now is knowledge regarding development of effective items, formats, and contents, so that valid and reliable instruments can be prepared with the ease and organization of current cognitive inventories.

These implications have been identified to serve as stimuli to others who may follow this initial research. In doing so, the investigator has not intended to suggest that all of the above implications are directly founded upon evidence verified in this study.

Recommendations

Based upon the findings reported herein, the following recommendations are made:

1. The instrumentation designed to measure manipulative and critical observation abilities needs to be refined and strengthened. Knowledge regarding visual means of testing needs to be enlarged.

2. Study of segments of the range of abilities between great and small needs to be made. It may be, for example, that the correlation between the two traits is great among individuals with a high degree of manipulative skill, such as concert pianists, tool and diemakers, etc., but low among individuals
with little manipulative skill.

3. Study needs to be made to determine if instrumentation can be devised that will finely discriminate among individuals whose abilities are not grossly different.

4. Study should inquire about the traits in individuals of age groups other than the collegiate level.

5. If replication of this study were to be performed the kinds of manipulative tasks under study need to be broadened to include tasks involved in operating other tools.

6. Some procedural modifications might be considered if the study were to be replicated. The instrument's validity analysis might be made more complete if each item were analyzed by a jury rather than the instruments as a whole. A different type of reliability analysis might be made which would, perhaps, be more useful in judging the instruments.
APPENDIX A

TEXTBOOKS REVIEWED TO DETERMINE

CRITERION ITEMS FOR SAW USE
TEXTBOOKS REVIEWED TO DETERMINE
CRITERION ITEMS FOR SAW USE

Cramlet, Ross C.  Woodwork Visualized.  Milwaukee, Wisconsin: Bruce

A. Bennett Co., Inc., 1963.


Groneman, Chris H.  General Woodworking, 3d ed.  New York: McGraw-

Hammond, James J.  Woodworking Technology, 2d ed.  Bloomington,

Hjorth, Herman, and Holtrop, William F.  Operation of Modern
Woodworking Machines.  Milwaukee, Wisconsin: Bruce Publishing

Wagner, Willis H.  Modern Woodworking.  Homewood, Illinois:
NORMATIVE PARTICIPANT DATA

DISTRIBUTION OF PARTICIPANTS YEAR RANK

<table>
<thead>
<tr>
<th>Freshmen</th>
<th>Sophomores</th>
<th>Juniors</th>
<th>Seniors</th>
<th>Graduate Students</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>28</td>
<td>17</td>
<td>23</td>
<td>7</td>
<td>77</td>
</tr>
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</table>

ACT SCORE RANGE AND MEAN

<table>
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<tr>
<th>Range</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-28</td>
<td>21</td>
</tr>
</tbody>
</table>

GRADE POINT AVERAGE RANGE AND MEAN

<table>
<thead>
<tr>
<th>Range</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.72 - 3.86</td>
<td>2.52</td>
</tr>
</tbody>
</table>
APPENDIX C

SAMPLE TASK CARDS
TASK - GIVEN THE PIECE OF STOCK AND THE TOOLS
AND EQUIPMENT PRESENT, CUT OFF A ONE-INCH
PIECE SUCH THAT THE END OF THE STOCK IS
SQUARE TO ONE SIDE WHEN FINISHED.
STATION 3

TASK - GIVEN THE PIECE OF STOCK, THE TOOLS AND MACHINES PRESENT, CUT OFF THE STOCK TO THE LINE. ASSUME THAT THE LARGER PORTION OF THE STOCK IS TO BE THE FINISHED SECTION, AND THAT THE SMALLER SECTION IS TO BE WASTE.
APPENDIX D

PILOT WORK SAMPLE INSTRUMENT (WSI)

AND RECOGNITION INSTRUMENT (RI)
PILOT INSTRUMENT

WORK SAMPLES OF SAWING TASKS

(WSI)

RICHARD A. KRUPPA
Tool- hand rip saw

Illustration-

Pre-test conditions-
1. rip saw provided
2. cross-cut saw provided
3. try square provided
4. 12" steel rule provided
5. furniture clamp provided
6. saw horse provided
7. bench hook provided

Evaluation-

<table>
<thead>
<tr>
<th></th>
<th>yes</th>
<th>no</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>secures stock in some way for sawing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>measures and marks stock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>selects the correct saw</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>grasps saw with index finger and thumb extended</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>stands so that forearm and shoulder are in line with cut</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>starts saw with two or three upward strokes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>deepens groove with a few short downward strokes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>makes main part of cut with long, smooth strokes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>cuts on waste side of line</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>holds saw at about a 60° angle to stock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>makes cutting strokes at a medium speed</td>
</tr>
</tbody>
</table>

Rater ___
Student Name __________________________ Student Number ________________

Tool- hand crosscut saw  Task- cutting-off a piece of stock

Illustration-  

3/4th.

Pre-test conditions-

1. rip saw provided
2. cross-cut saw provided
3. try square provided
4. 12" steel rule provided
5. furniture clamp provided
6. saw horse provided

Evaluation-

<table>
<thead>
<tr>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
<td></td>
</tr>
</tbody>
</table>

- secures stock in some way for sawing
- measures and marks stock
- selects the correct saw
- grasps saw with index finger and thumb extended
- stands so that index finger and arm are in line with cut
- starts saw with two or three upward strokes
- deepens groove with a few short downward strokes
- cuts on waste side of line
- holds saw at about 45° angle to stock
- makes cutting strokes at a medium speed
- ends the cut with short easy strokes
- holds piece of stock being cut off

Rater ____
### Machine
- radial arm saw

### Task
- cutting off

### Illustration
- 3/4th.

### Pre-test conditions
1. blade set slightly above table
2. small woodworking clamp provided
3. try square on table
4. 12" steel rule on table
5. all other machine settings normal

### Evaluation

<table>
<thead>
<tr>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>adjusts blade height</td>
</tr>
<tr>
<td>checks squareness of blade to guide strip with square or by cutting</td>
</tr>
<tr>
<td>checks squareness of stock</td>
</tr>
<tr>
<td>allows blade to reach speed before cutting</td>
</tr>
<tr>
<td>holds stock firmly against guide strip with left hand</td>
</tr>
<tr>
<td>makes cut from back toward front</td>
</tr>
<tr>
<td>feeds blade smoothly at a medium speed</td>
</tr>
<tr>
<td>locks motor unit when cut is complete</td>
</tr>
<tr>
<td>cuts on waste side of line</td>
</tr>
<tr>
<td>stays with machine until blade stops</td>
</tr>
</tbody>
</table>

Rater ___
Student Name ___________________________ Student Number ____________

Machine- band saw
Task- making an irregular cut to a pattern

Illustration-

Pre-test conditions-
1. guide post set 2\" above table
2. all other settings normal

Evaluation-

<table>
<thead>
<tr>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Procedure</td>
</tr>
<tr>
<td></td>
<td>adjusts the guide post to give about 1/4&quot; clearance to stock</td>
</tr>
<tr>
<td></td>
<td>allows machine to reach speed before sawing</td>
</tr>
<tr>
<td></td>
<td>feeds stock smoothly at a medium speed</td>
</tr>
<tr>
<td></td>
<td>cuts on waste side of line</td>
</tr>
<tr>
<td></td>
<td>does not back out saw (except for relief cuts)</td>
</tr>
<tr>
<td></td>
<td>makes relief cuts for sharp curve</td>
</tr>
<tr>
<td></td>
<td>does not place fingers near blade to clear away cuttings</td>
</tr>
<tr>
<td></td>
<td>stops saw before leaving</td>
</tr>
</tbody>
</table>

Rater _____
Machine- jig saw
Illustration-

Pre-test conditions-
1. hold down foot 1" above table
2. all other settings normal

Evaluation-  
<table>
<thead>
<tr>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>adjusts hold down foot to proper pressure</td>
</tr>
<tr>
<td>revolves machine one revolution by hand to check blade tension</td>
</tr>
<tr>
<td>feeds stock smoothly and at a medium speed</td>
</tr>
<tr>
<td>cuts on waste side of stock</td>
</tr>
<tr>
<td>does not place fingers near blade to remove cuttings</td>
</tr>
</tbody>
</table>

Rater ___
Student Name ________________________  Student Number _____________

Machine- circular saw  
Task- ripping a piece of stock  

Illustration-  

Pre-test conditions-

1. both blades below table  
2. both fence and mitre gauge in place  
3. 12" steel rule on table  
4. try square on table  
5. push stick on table  
6. guard in position  
7. all other machine settings normal  

Evaluation-

<table>
<thead>
<tr>
<th>yes</th>
<th>no</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>selects proper blade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sets fence to proper width</td>
</tr>
<tr>
<td></td>
<td></td>
<td>clamps fence when set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adjusts blade to proper height (1/8-1/4 above stock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>removes guard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>allows blade to reach speed before sawing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>stands to one side of stock while sawing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>feeds stock smoothly at a medium speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>uses push stick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cuts on waste side of line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>feeds stock all the way through the blade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>does not reach across the turning blade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>does not leave machine until blade stops revolving</td>
</tr>
</tbody>
</table>

Rater _____
Student Name ___________________________ Student Number ________________

Machine- circular saw               Task- cutting off a piece of stock
Illustration-                          3/4th.

Pre-test conditions-

1. both blades below table
2. both fence and mitre gauge in place
3. 12" steel rule on table
4. try square on table
5. push stick on table
6. 2 x 2 x 3/4 block of wood on table
7. small clamp on table
8. guard in position
9. all other settings normal

Evaluation-

  yes  no  Procedure

selects proper blade
adjusts fence with clearance block to proper setting
does not use fence
adjusts blade to proper height (1/8-1/4 above stock)
places guard in position
checks squareness of stock with square or by cutting off the end
allows blade to reach speed before sawing
feeds stock with a mitre gauge
feeds stock smoothly at a medium speed
cuts on waste side of line
feeds stock all the way through the blade
(Machine- circular saw    Task- cutting off a piece of stock con't.)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

does not reach across the turning blade

does not leave machine until blade stops revolving

Rater ___
PILOT INSTRUMENT

RECOGNITION INSTRUMENT OF SAWING (RI)

(SCRIPT OF VIDEOTAPE)

Richard A. Kruppa
Introduction

This is a test of your ability to observe critically the skill with which others are able to operate selected woodworking saws. You will see many scenes that show people using saws. In some of the scenes the operator will be using the saw properly. In others, he will be using the saw improperly.

The factors making an operation proper or improper may result from accuracy, safety practice, sequence of operations, or the selection of devices or aids.

You are to rate each scene as proper or improper. Use your own knowledge and experiences of operating the tools and machines as your guide in determining whether what you see is "proper" or "improper."

Darken the space on the answer sheet in the following way. If your answer is "proper," darken the space under "a." If your answer is "improper," darken the space under "e."
Let's try an example. I will drive a nail with a claw hammer. You determine if my procedure is "proper" or "improper." I drove the nail "improperly," because I held the hammer near the head the whole time. Had I done it properly, I would have moved my hand away from the head once I had the nail started.

Darken choice "e." after #1 on the answer sheet.

You will note that not all of my hammering performance was improper. I started the nail correctly. However, since part of the performance was incorrect, the whole thing was considered "improper." Use this general rule throughout the test. If any part of a scene is improper, the correct response is "improper." Note also that the test answer sheet numbers go from left to right across the sheet. We are now ready to begin. Watch each scene carefully for none will be repeated. Mark your answer when told to do so. Remember, if the scene is "proper," mark letter "a." If it is "improper," mark "e."
The first series of scenes will deal with using the hand rip saw.

2. The operator has chosen a saw for ripping. Is the saw he chose proper or improper?

Mark your answer sheet now.

3. The operator is securing the stock. Is he doing it properly or improperly?

Mark your answer sheet now.
4. Is this method of securing the stock proper or improper?

Mark your answer sheet.

5. We are now ready to begin cutting. Is the operator holding the saw properly or improperly?

Mark your answer sheet.

6. The operator is now ready to begin the cut. Is this a proper or improper way to begin sawing?

Mark your answer sheet.
7. Is the following a proper or improper way to begin sawing?

Mark your answer sheet.

8. Now that the cut is started, is this a proper or improper way to deepen the cut groove?

Mark your answer sheet.

9. The main part of the cut is now being made. Is the angle of the blade to the stock proper or improper?

Mark your answer sheet.
10. Is this sawing angle proper or improper?

Mark your answer sheet.

11. Is this sawing angle proper or improper?

Mark your answer sheet.

12. Is the rate of this sawing speed proper or improper?

Mark your answer sheet.
13. The operator was asked to remove a one inch strip from the board. Accordingly, is he cutting on the proper or improper side of the line?

Mark your answer sheet.

14. Is the length of the operator's sawing strokes proper or improper?

Mark your answer sheet.

"cross-cut sawing"

The next series of scenes deal with hand cross-cut sawing.

15. The operator has chosen a saw for cross-cutting. Has he chosen a proper or improper one?
16. He is securing his stock for cutting. Is he doing it properly or improperly?

17. Is this method of securing the stock proper or improper?

18. The operator is marking the board so as to cut-off about one inch and square-off the stock at the same time. Is his procedure proper or improper?
19. He is now ready to begin cutting. Is the saw being held properly or improperly?

20. The operator is beginning his cut. Is his technique for starting a cut proper or improper?

21. Is this saw starting procedure proper or improper?
22. The board has been sawn part way through. Is the operator using proper or improper strokes?

23. Is the saw angle proper or improper?

24. Is this saw angle proper or improper?
25. Is the operator cutting on the proper or improper side of the line?

Mark your answer sheet.

26. The end of the cut is near. Is it being performed properly or improperly?

Mark your answer sheet.

27. Is the ending of this cut proper or improper?
28. Is the end of the cut proper here?

Mark your answer sheet.

29. The operator has selected this blade for ripping. Is it a proper or improper one?

Mark your answer sheet.
30. The operator is setting the fence for a one inch cut. Is he setting it properly or improperly?

Mark your answer sheet.

31. Is this setting proper or improper for a one inch cut?

Mark your answer sheet.

32. The operator is beginning his cut. Is his procedure proper or improper?

Mark your answer sheet.
33. The cut is now underway. Is the blade set properly or improperly?

Mark your answer sheet.

34. Is the guard set properly or improperly here?

Mark your answer sheet.

35. Is the guard set properly or improperly here?

Mark your answer sheet.
36. Is the operator standing in a proper or improper position?

Mark your answer sheet.

37. Is the stock being fed at a proper or improper rate of speed?

Mark your answer sheet.

38. Is the operator feeding the stock in a proper or improper way?

Mark your answer sheet.
39. Has the operator fed the stock a proper or improper distance beyond the blade?

Mark your answer sheet.

40. The operator will pick-up the stock when the cut is complete. Is his procedure proper or improper?

Mark your answer sheet.

The next series of scenes deals with cutting-off on the circular saw.

41. Has a proper or improper blade been selected?
42. Is this a proper or improper blade for cross-cutting?

43. Is this a proper or improper way to check the squareness of the miter gauge?

44. Is this method of checking the squareness of the blade to the miter gauge proper or improper?
45. Is this a proper or improper method of gauging the amount of material to be cut-off?

Mark your answer sheet.

46. Is this a proper or improper method of gauging the amount of material to be cut-off?

Mark your answer sheet.

47. Is the blade clearance set properly or improperly here?
48. Is the guard positioned properly or improperly for cutting-off?

49. Is this a proper or improper way to begin the cut?

50. Is this a proper or improper way to feed the stock?
Mark your answer sheet.

51. Is this cut being made on the proper or improper side of the line for a one inch cut?

Mark your answer sheet.

52. Is this a proper or improper way to end the cut?

Mark your answer sheet.

The next series of scenes are about the use of the band saw.
53. The operator is going to cut to the line on this piece of stock. Is he setting the guide post properly or improperly?

Mark your answer sheet.

54. The first cut can now be made. Is the operator beginning properly or improperly?

Mark your answer sheet.

55. Is the operator using the proper or improper technique to make this cut?

Mark your answer sheet.
56. Is he cutting on the proper or improper side of the line?

Mark your answer sheet.

57. Is he feeding the stock at a proper or improper rate of speed?

Mark your answer sheet.

58. Is a proper or improper method of cutting small radius turns being made?

Mark your answer sheet.
59. Is this a proper or improper method of removing waste cuts from near the blade?

Mark your answer sheet.

60. Is this a proper or improper way of leaving the machine after a cut?

Mark your answer sheet.

The next series of scenes is about the use of the jig saw.

61. The hold-down foot has been adjusted. Is it proper or improper for the stock shown?
Mark your answer sheet.

62. Once the hold-down foot is adjusted, is this the next step?

Mark your answer sheet.

63. Is this a proper or improper way to feed the stock?

Mark your answer sheet.

64. Is this a proper or improper way to hold the stock during cutting?
Mark your answer sheet.

65. Is the operator cutting on the proper or improper side of the line?

Mark your answer sheet.

66. Is this a proper or improper way to remove cutting from around the blade?

Mark your answer sheet.

"radial arm saw" The next series of scenes is about cutting-off with the radial arm saw.
67. Is this a proper or improper way of determining the squareness between the blade and the guide strip?

Mark your answer sheet.

68. Is this a proper or improper way to determine the squareness?

Mark your answer sheet.

69. The squareness has been established. Is this a proper or improper way to begin the cut?

Mark your answer sheet.
70. Is this a proper or improper way to hold the stock while cutting?

Mark your answer sheet.

71. Is this a proper or improper rate of speed with which to make the cut?

Mark your answer sheet.

72. The operator has finished his cut. Is this a proper or improper way to leave the machine?

Mark your answer sheet.
73. Is this the proper or improper way of leaving the machine?

Mark your answer sheet.

The test is over. Make sure your student number and your name are on the answer sheet. Make sure you left no stray pencil marks on the answer sheet.
### Key to Pilot Recognition Instrument (RI)

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APPENDIX E

INSTRUCTIONS FOR TEST ADMINISTRATION
GENERAL INSTRUCTIONS FOR ADMINISTRATION OF THE EXAMINATIONS

1. To whole group as testing begins

You have been selected to participate in a research project which is attempting to develop a new type of testing instrument. Your complete attention and adherence to instructions is imperative. In other words, to make this session meaningful, you must follow instructions exactly as given.

This session will take about an hour at which time you will be excused.

The first thing you are to do is to remove all items from your desks. I will distribute a copy of The Story of the Plastics Industry which you are to begin reading. While you are reading each of you will be taken from this room to an examination room one at a time. As you are called, bring your plastics reader and all your other belongings with you for you will not return to this room. You will need safety glasses. If you do not have a pair with you, we will furnish them. It is absolutely necessary that from this time on that you talk to no one, for doing so could influence the outcome of this research. In addition, since other selected groups will be involved in this research, do not discuss the testing with anyone until Thursday.

We are now ready to begin. Read carefully. If you finish the booklet, look it over a second time.

REMEMBER, PLEASE DO NOT TALKING FROM THIS POINT ON.
2. To individuals prior to the Work Sample Instrument (WSI)

You will proceed through five stations where you will be asked to use five different kinds of saws. Do not talk to the individuals at the stations unless you have a question about safety. When you have finished each task, say "I am finished" to the individual who is at the station. The person will then give you an instruction. As you arrive at each station, read the card and follow the instructions. Have you any questions? Proceed to the "start" sign.

3. The instructions within frames were presented on cards.
General Rules for the Exam

PLEASE READ CAREFULLY

1. Do not talk to the observer. He will not talk to you.

2. Do what the card tells you to do at each station.

3. Perform each task as you normally would.

4. If you cannot perform some of the tasks, do not. Take no chances!

5. Take a copy of the test booklet. Fill in your name and student number. Do not look inside. Give the booklet to Mr. Kruppa.
6. When you have finished each task, say "I am finished" and wait until told to move to the next station.

7. Proceed to Station #1.

4. To individuals following the WSI

You are now finished with this part of the test. Go to the reading room and continue reading the plastics booklet. It is absolutely essential that you do not talk to anyone in the room about any of the tasks you just performed. Take your belongings and plastics booklet with you.

5. To groups prior to the administration of the Recognition Instrument (RI)

Please turn in your plastics booklet and take a data collection form and an IBM answer sheet. Answer the four questions on the data collection form at this time. Please print.
Now take the IBM answer sheet and, using a pencil, fill in your name and student number. Your student number should go in the vertical row of boxes under the arrow. Darken the space to the right of each number that corresponds to the number. Are there any questions? The rest of your instructions will appear on the television screen. (Note to vtr technician—collect and examine all data collection forms while TV test is running. If any is incomplete, have the student fill it in later).

6. To groups following RI

Before you turn in your IBM answer sheets, make sure that you have no stray pencil marks on the paper. Examine it carefully. Pass your answer sheets forward.

Please leave the building at this time, and please do not talk to anyone about these tests until Thursday, for others who have not yet taken the tests could be influenced by what you might say. Thank you for your help and kind cooperation. If you would like to know about the purpose of this research, you may see Mr. Kruppa anytime after Thursday. You are excused.
APPENDIX F

WORK SAMPLE INSTRUMENT CHECKLISTS

(WSI)
NAME ________________________________

STUDENT NUMBER ____________________
Tool: hand cross-cut saw

Task: cutting off a piece of stock square to one side

Illustration:

Pre-test conditions:
1. rip saw provided
2. cross-cut provided
3. try square provided
4. 12" steel rule provided
5. furniture clamp provided
6. saw horse provided
7. workbench and vise provided

Evaluation:

<table>
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Procedure
-secures stock in some proper way for sawing
-measures and marks stock square to one edge
-selects the correct saw
-grasps saw with index finger and thumb extended
-stands so that index finger and arm are in line with cut
-starts saw with a few upward strokes
-deepens groove with a few short downward strokes
-cuts on waste side of line
-holds saw at about 45° angle to stock
-makes cutting strokes at a medium speed
-ends the cut with short easy strokes
-holds piece of stock being cut off

Rater ___

___total
Machine- circular saw  

Task- cutting off a piece of stock square to one side

Illustration- 

![Diagram of a piece of stock being cut](image)

Pre-test conditions- 

1. both blades below table
2. both fence and mitre gauge in place
3. 12" steel rule on table
4. try square on table
5. push stick on table
6. 2 x 2 x 3/4 block of wood on table
7. small c-clamp on table
8. guard in position
9. all other saw settings normal

Evaluation- 

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Procedure

- selects proper blade
- adjusts fence with clearance block to proper setting
- does not use fence alone as a depth guide
- adjusts blade to proper height up to 1/2" above stock
- places guard in position
- checks squareness of stock with square or by cutting off the end
- allows blade to reach speed before sawing
- feeds stock with a mitre gauge
- feeds stock smoothly
- feeds stock at a medium speed
- cuts on waste side of line
- feeds stock all the way through the blade

Rater ___
(Machine- circular saw    Task- cutting of a piece of stock square to one side con't.)

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does not reach across the turning blade

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</table>
Machine - band saw

Task - making an irregular cut to a line

Illustration -

Pre-test conditions -

1. guide post set 2" above table
2. all other settings normal
3. guard in place

Evaluation -

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<td>adjusts the guide post to give up to a maximum of 1/4&quot; clearance to stock</td>
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<tr>
<td></td>
<td>allows machine to reach speed before sawing</td>
</tr>
<tr>
<td></td>
<td>feeds stock smoothly</td>
</tr>
<tr>
<td></td>
<td>feeds stock at a medium speed</td>
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<td></td>
<td>cuts on waste side of line, but does not touch line</td>
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<td></td>
<td>does not back out stock from saw except for relief cuts</td>
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<td></td>
<td>makes relief cuts for sharp curve</td>
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<td>does not place fingers near blade when feeding stock or clearing away cuttings</td>
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<td>stops saw before leaving or puts guard in place</td>
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</table>

__total__
Machine- jig saw

Illustration-

Pre-test conditions-
1. hold down foot 1" above table
2. all other settings normal

Evaluation-

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<tr>
<td>yes</td>
<td></td>
<td>adjusts hold-down foot to proper pressure</td>
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<tr>
<td></td>
<td></td>
<td>revolves machine one revolution by hand to check blade tension</td>
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<td></td>
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<td>feeds stock smoothly</td>
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<td></td>
<td></td>
<td>feeds stock at a medium speed</td>
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<td>cuts on waste side of stock, but does not touch line</td>
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<td>does not place fingers near blade to remove cuttings</td>
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___ total
Machine- radial arm saw  

Task- cutting off a piece of stock square to one side

Illustration-

Pre-test conditions-

1. blade set 1" above table
2. all other machine settings normal
3. small woodworking clamp provided
4. try square on table
5. 12" steel rule on table

Evaluation-

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<td></td>
<td></td>
<td>adjusts blade height</td>
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<td>checks squareness of blade to guide strip with square or by cutting</td>
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<td></td>
<td>checks squareness of stock</td>
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<td>holds stock firmly against guide strip with left hand</td>
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<td>makes cut from back toward front</td>
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<td></td>
<td>cuts on waste side of line</td>
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<td>feeds blade smoothly at a medium speed</td>
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<td>locks motor unit when cut is complete</td>
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<td>stays with machine until blade stops</td>
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Rater ___
APPENDIX G

DATA COLLECTION FORM
DATA COLLECTION FORM - Respond To All Items

1. Name (last, first, m.i.) ______________ ______________ ___

2. Student Number (s.s.#) ______________

3. How many months have you been in courses (at the university level and in the public schools) in which you studied and/or practiced using woodworking saws?

4. How many months of teaching and/or industrial work experience have you had that dealt with instruction or use of woodworking saws?

   _______
APPENDIX H

RECOGNITION INSTRUMENT

(RI)
RECOGNITION INSTRUMENT

(RI)

(SCRIPT OF VIDEOTAPE)
Introduction

This is a test of your ability to observe critically the skill with which others are able to operate selected woodworking saws. You will see many scenes showing saws in use. In some of the scenes the saws will be used properly, in others the saw will be used improperly.

The factors making the operation of the saws proper or improper refer to accurate use of the tools and machines, safety practice, sequence of operations, or the selection of devices or aids to assist in the cutting.

You are to rate each scene as proper or improper. Use your knowledge and experience from using the machines and tools as your guide in determining if what you see is proper or improper.

Look at your answer sheet. If your answer to a question is proper, darken the space in column a. If your answer is improper, darken the space in column e.
Try this example. I will drive a nail with a claw hammer. You determine if I do it properly or improperly.

I drove the nail improperly, so darken the space in column e at number 1. Again, darken space e for question number 1. Do that now. My hammer driving performance was improper because I did not move my hand away from the hammer head as I drove the nail.

Note that not all of my hammer driving was improper. I started the nail in the proper manner. However, since part of it was wrong, the whole thing was considered improper. Use this general rule throughout the test.

If any part of what you see with regard to the question is improper, mark your answer sheet improper.

Watch each scene carefully, for none will be repeated. Do not mark your answer sheet until told to do so. Note that you proceed left to right on the answer sheet.

We are now ready to begin. The first scene that you see will correspond to number two on the answer sheet.

The first series of scenes deal with hand cross-cut sawing.
The operator has chosen a saw for cross-cutting. Has he chosen a proper or improper one?

Mark your answer sheet.

He has secured his stock for cutting. Has he done it properly or improperly?

Mark your answer sheet.

Is this method of securing the stock proper or improper?

Mark your answer sheet.
The operator is marking the stock so that he may cut off one inch and square the stock at the same time. Is his procedure proper or improper?

Mark your answer sheet.

He is now ready to begin cutting. Is the saw being held properly or improperly?

Mark your answer sheet.

The operator is beginning his cut. Is his technique for starting a cut proper or improper?

Mark your answer sheet.
Is this saw starting procedure proper or improper?

Mark your answer sheet.

The board has been sawed part way through. Is the operator using proper or improper strokes?

Mark your answer sheet.

Is the saw angle proper or improper?

Mark your answer sheet.
Is the saw angle proper or improper here?

Mark your answer sheet.

Is this saw angle proper or improper?

Mark your answer sheet.

Is the operator cutting on the proper or improper side of the line?

Mark your answer sheet.
Is the operator's cutting speed proper or improper as he completes the cut?

Mark your answer sheet.

Is the operator handling the stock properly or improperly as he completes the cut?

Mark your answer sheet.

The next series of scenes deals with cutting-off or cross-cutting on the circular saw.

Has a proper or improper blade been selected?
Mark your answer sheet.

Is this a proper or improper blade for cross-cutting?

Mark your answer sheet.

Is this a proper or improper way to check the squareness of the miter gauge?

Mark your answer sheet.

Is this method of checking the squareness of the blade to the miter gauge proper or improper?
Mark your answer sheet.

Is this a proper or improper method of gauging the amount of material to be cut off?

Mark your answer sheet.

Is this a proper or improper method of gauging the amount of material to be cut off?

Mark your answer sheet.

Is the blade clearance set properly or improperly?
Mark your answer sheet.

Is the guard positioned properly or improperly for cutting-off?

Is this a proper or improper way to begin the cut?

Is this a proper or improper way to feed the stock?
Mark your answer sheet.

Is this cut being made on the proper or improper side of the line for a one inch cut?

Mark your answer sheet.

Is this a proper or improper way to end the cut?

Mark your answer sheet.

The next series of scenes are about the use of the band saw.
The operator is going to cut the line on this piece of stock. Is he setting the guide post properly or improperly?

The first cut can be made. Is the operator beginning properly or improperly?

Is the operator using the proper or improper technique to make this cut?

Mark your answer sheet.
Assuming that the material to the right of the line is waste, is he cutting on the proper or improper side of the line?

Mark your answer sheet.

Is he feeding the stock at a proper or improper rate of speed?

Mark your answer sheet.

Is a proper or improper method of cutting small radius turns being used?

Mark your answer sheet.
Is this a proper or improper method of removing waste cuts from near the blade?

Mark your answer sheet.

Is this a proper or improper way of leaving the machine after a cut?

Mark your answer sheet.

This series of scenes is about the use of the jig saw.

The hold-down foot has been adjusted. Is it proper or improper for the stock shown?
Mark your answer sheet.

Once the hold-down foot is adjusted, is this the next step?

Mark your answer sheet.

Is this the proper or improper way to feed the stock?

Mark your answer sheet.

Is this a proper or improper way to hold the stock during cutting?
Mark your answer sheet.

Is the operator cutting on the proper or improper side of the line?

Mark your answer sheet.

Is this a proper or improper way to remove cutting from around the blade?

Mark your answer sheet.

The next series of scenes is about cutting-off with the radial arm saw.
Has the blade depth been set properly or improperly?

Mark your answer sheet.

Is this a proper or improper way of determining the squareness between the blade and the guide strip?

Mark your answer sheet.

Is this a proper or improper way to determine the squareness of the blade to the guide strip?

Mark your answer sheet.
The squareness has been established. Is this a proper or improper way to begin the cut?

Mark your answer sheet.

Is this a proper or improper way to hold the stock while cutting?

Mark your answer sheet.

Is this a proper or improper rate of speed with which to make the cut?

Mark your answer sheet.
Is the operator cutting in the proper or improper direction.

Mark your answer sheet.

Is this a proper or improper way to leave the machine when the cut is through?

Mark your answer sheet.

Is this a proper or improper way to leave the machine when the cut is through?

Mark your answer sheet.
Is this the proper or improper way of leaving the machine?

Mark your answer sheet.

The test is over. Make sure your student number and your name are on the answer sheet. Make sure you left no stray pencil marks on the answer sheet.
Key to Recognition Instrument (RI)

1. -e (Is not scored) 25. -e
2. -a 26. -e
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50. -e
51. -e
APPENDIX I

ITEM DISCRIMINATION AND DIFFICULTY ANALYSIS OF WORK SAMPLE INSTRUMENT (WSI)
ITEM DISCRIMINATION AND DIFFICULTY ANALYSIS
WORK SAMPLE INSTRUMENT (WSI)

Upper & Lower 27% of Participants*

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*Three participants in the lower group were dropped as a result of not completing one of the tasks. Accordingly, three participants were drawn at random from the upper group and eliminated from the calculations. As a result n = 18.

Item Discrimination for this Instrument = .237
Item Difficulty for this Instrument = .662
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APPENDIX J

ITEM DISCRIMINATION AND DIFFICULTY ANALYSIS
RECOGNITION INSTRUMENT (RI)
ITEM DISCRIMINATION AND DIFFICULTY ANALYSIS
RECOGNITION INSTRUMENT
(RI)

Upper & Lower 27% of Participants - n = 21

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RECOGNITION INSTRUMENT
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Towers, Edward R., Lux, Donald G., and Ray, Willis E. *A Rationale and Structure for Industrial Arts Subject Matter*. Columbus, Ohio: The Ohio State University/The Industrial Arts Curriculum Project, 1966. (Mimeographed.)


