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USING PROGRAMMED INSTRUCTION WITH AND WITHOUT SELF-INSTRUCTIONAL PRACTICE TO TEACH PSYCHOMOTOR SKILLS. FINAL REPORT.

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The purpose of the study was to experimentally test the theory that programed instruction can satisfactorily teach psychomotor tasks which primarily require the learning of cognitive knowledge in order to properly utilize motor skills already possessed. A programed unit on regrinding drills was selected, and a dexterity test and self-instructional materials were developed. A cluster sample of 146 ninth, 10th, and 11th grade vocational agriculture students, selected from 21 New York schools, was tested on reading ability and dexterity, assigned to arbitrary levels based on scores, paired according to skill levels, and randomly assigned to experimental and control treatment groups. The control group had only programed instruction and the experimental group had both programed instruction and self-instructional practice. Both groups were given a performance test, and the control group was given a performance retest. Analysis of covariance procedures were used to analyze the data. The data failed to support the theory. Self-instructional practice used to supplement the programed materials did not produce significant benefit over use of the program alone. Findings clearly indicated a significant relationship between student dexterity and ability to learn psychomotor skills effectively through use of programed materials. A bibliography is included. This PhD. thesis was submitted to Cornell University. (JM)

C. 1

FINAL REPORT

BOR - 9

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Division of Agricultural Education
Department of Education
New York State College of Agriculture
Cornell University, Ithaca, New York

The University of the State of New York
The State Education Department
Bureau of Occupational Education Research

June 1967

Using Programed Instruction With and Without Self-Instructional Practice to Teach Psychomotor Skills

Project BOR-9

Robert E. Norton, Principal Investigator
Frederick K. T. Tom, Project Director

June 1967

The research reported herein was performed pursuant to a grant with the Bureau of Occupational Education Research, The State Education Department, The University of the State of New York. Researchers undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official State Education Department position or policy.

Cornell University

Ithaca, New York

USING PROGRAMED INSTRUCTION WITH AND WITHOUT

SELF-INSTRUCTIONAL PRACTICE TO

TEACH PSYCHOMOTOR SKILLS

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University for the Degree of

Doctor of Philosophy

by

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September 1967

VITA

The author was born in Elba, New York, on May 28, 1937. He attended Elba Central School and was graduated from there in June, 1955.

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He and Judith D. Danielson, of Frewsburg, New York, were married in April, 1964, and they have one son.

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Dr. Frederick K. T. Tom, Professor of Agricultural Education, Chairman.

Dr. Stanley W. Warren, Professor of Farm Management.

Dr. William W. Reeder, Professor of Rural Sociology.

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CHAPTER I

INTRODUCTION

Never before has a method of instruction come into use surrounded by so much research activity as has programed instruction. Today professional literature in education and industry abounds with research reports and articles on training programs involving programed instruction. Many studies have shown programed instruction to be a very effective method of teaching. Reports indicate that persons learn from programs equally as well or better than from conventional methods of teaching. Encouraged by these findings, the public schools and industry have been quick to try-out and often adopt programed instruction as part of their educational program. As a result, the use of programed instruction is rapidly becoming more prevalent today.

There have been several factors motivating educational researchers who have investigated the area of programed instruction. Probably the most important factor has been what educators have long recognized as a need for training techniques which offer greater flexibility and adaptation of instruction to the ability of the individual receiving it. Because it enables students to proceed independently and at their own pace, programed instruction is the first teaching technique that permits breaking the traditional classroom lockstep procedure. By permitting flexibility that was before unavailable, programed instruction makes possible an enormous stride toward the goal of individualizing instruction.

Further motivation has been provided by Congress and state legislatures who in recent years have been giving increased attention to the problems involved in manpower training and retraining required by a rapidly accelerating technology. Such recognition has resulted in greatly increased financial support for educational research. The 88th Congress expressed its concern in the Declaration of Purpose of the Vocational Education Act of 1963 by stating that

> Persons of all ages in all communities of the state . . . will have ready access to vocational training or retraining which is of high quality, which is realistic in light of actual or anticipated opportunities for gainful employment, and which is suited to their needs, interests, and ability to benefit from such training.[1]

Financial support for research is clearly indicated by section 4(c) of the Act which states

> Ten per centum of all the sums appropriated . . . for each fiscal year shall be used . . . to pay part of the cost of research and training programs and of experimental, developmental, or pilot programs. . . .

Statement of the Problem

Although there has been a large volume of programed instruction research, nearly all the programs used have involved subject matter which could be categorized in accordance with the Taxonomy of Educational Objectives[2] as being primarily of the cognitive domain.

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1. Public Law 88-210, 88th Congress, H.R. 4955, December 18, 1963.

2. Benjamin Bloom, ed., Taxonomy of Educational Objectives, Handbook I: Cognitive Domain, pp. 7-9.

A search through Schramm's[3] research bibliography reveals the subjects commonly programed and used include the humanities, physical sciences, biological sciences, and the social sciences. Teaching these academic subjects primarily involves changing the cognitive domain of students. Noticeably absent in research reports on programed instruction are programs dealing with vocational subjects where change in the psychomotor domain is also necessary.

Do educators feel that training in the psychomotor domain is important? Klausmeier states:

> It is easy to underestimate the importance of psychomotor abilities in the overall development of mankind. There is a tendency to think of the great literature, the great advances in architecture, medicine, and the like, almost exclusively in terms of cognitive abilities. Nevertheless, the musical composer, the painter, the author use many psychomotor abilities in developing their products. The great advances recently made in surgery of the brain and heart also require the highest level of psychomotor abilities - manipulation of instruments with speed, precision, coordination, and flexibility.
>
> The success of mankind in gaining control over his environment has been heavily dependent upon channeling his motor abilities into rather highly specialized skills. At some point along the way in man's history, the invention and development of tools and instruments required a specialized use of psychomotor abilities.[4]

Dailey recognized the importance of motor skills as a result of the 1960 Project Talent study in which he reported "that many of the youth from deprived backgrounds lack the basic skills and aptitudes necessary for many of our more highly skilled jobs which are most in demand due to the increasing pace of automation."[5]

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3. Wilbur Schramm, The Research on Programed Instruction: An Annotated Bibliography, pp. 17-107.

4. Herbert J. Klausmeier, Learning and Human Abilities: Educational Psychology, p. 10 and p. 226.

5. John T. Dailey, "Counseling the Disadvantaged," Mimeo, p. 3.

Thus, the importance of the psychomotor domain of behavior in our modern technical society seems obvious; and yet the lack of programed instruction research and study in this area is apparent from a review of the literature.

This leads us to the first basic concern of this study, "Can programs effectively teach certain psychomotor skills?" The answer appears to be a resounding "Yes!" Such programs are being written and reportedly being used successfully with adults. For example, DuPont, who has already developed over 90 programed courses to train its own employees in basic industrial skills, is now offering these programs at a nominal cost to schools for use in vocational training. A newsletter states that, "With increased national attention being given to problems of training, retraining, and upgrading of skills, the company feels it can make a real contribution to business and industry by making these proved training courses available to others."[6] At least one commerical publisher is offering for sale programs designed to teach various motor skills in the automotive and industrial arts areas.[7]

Some programs on psychomotor skills have already been published, and undoubtedly many more will be if one but reflects on the resounding success programs have had in the cognitive domain. In the area of the psychomotor domain, the successful experience of the DuPont Company in training adults for industrial skills is reflected in their statement that

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6. "DuPont Offers Programmed Instruction Courses," DuPont Agricultural News Letter, vol. 33, no. 1 (Spring 1966), p. 3.

7. Programed Learning Courses, '66, Resources Development Corporation, East Lansing, Michigan.

> Experience with more than 10,000 employees, who have taken a total of more than 30,000 courses, has shown that programed courses train more effectively, at lower cost, and in less time than other training methods.[8]

Other companies have reported similar success in their investigations of programed materials used to teach certain skills. There seems to be danger, however, in this success in that it may lead to the publishing and using of many programs on psychomotor topics before much is known about how they should be used.

Perhaps a major reason for the success of the studies and experiences reported above is the fact that the clientele sampled consisted only of adults. These adults we can assume were probably highly motivated and quite serious about improving their skills. It is fair to ask, "Will the same results be obtained when programed instruction is used in high school vocational classes where student attitudes and the degree of motivation span a wide latitude?"

The literature on psychomotor learning showed that little is known about how much of motor learning is physical and how much is mental. There appears to be considerable disagreement about the relative importance of each among the few who have researched this area. The author finds considerable logic in the opinions of those who feel that the learning of many psychomotor tasks requires primarily the learning of additional cognitive knowledge in order to properly utilize motor skills the learner already possesses.

To explore further the relationship between motor aptitude and achievement after training, this study also asked the question, "What

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8. DuPont, p. 3. (Underlining added.)

is the relationship between individual dexterity (motor aptitude) and ability to learn a skill effectively (achievement) from programed materials?"

Finally, one other question of concern appeared to have considerable merit. The search of the literature revealed that few had explored the possibility of supplementing programs with any other media and/or method of instruction. The few studies that had researched this area dealtonly with programs designed to teach cognitive material. It is true that most program authors feel their product can do the job alone.

It seems reasonable to the writer, however, that in the event a program itself did not do an effective job, that perhaps some type of supplement would aid it in doing so. This reasoning gave rise to the third question asked by this study, "Can programed materials be supplemented with another method and/or medium to increase their effectiveness?"

Therefore, the problems of concern investigated by this study may be summarized as:

1. Can programs alone effectively teach certain psychomotor skills to high school vocational students?

2. What is the relationship between student dexterity and ability to learn a skill effectively from programed materials?

3. Can programed materials be supplemented with another method and/or medium to increase their effectiveness?

Review of Related Research

Although the volume of research on programed instruction is extensive, there has been very little research carried out where the behavioral change sought in students was of the psychomotor domain. In fact, there has been relatively little research of any kind carried out in this important area. Speaking of the psychomotor domain in 1956, Bloom states

> Although we recognize the existence of this domain, we find so little done about it in secondary schools or colleges, that we do not believe the development of a classification of these objectives would be very useful at present.[9]

In 1966 Baldwin, who was attempting to develop a conceptual framework for psychomotor behaviors, reported that

> A literature search was initiated, but proved to be rather discouraging. Very little previous work had been done in the psychomotor achievement area, while much work had been done in the aptitude area.[10]

Nevertheless, a search of the literature revealed the following studies which were deemed relevant to this experiment.

Wilbur Twining[11] found in 1949 that "there is little in the literature to indicate just how much of motor learning is physical and how much is mental." He reports on a study by Vandell, Davis, and Clugaton in which the authors concluded that in a basketball free throw experiment "mental practice was about as effective as physical practice." In Twining's ring-toss experiment he concluded "that both mental and physical practice under the conditions of this experiment are effective in facilitating the learning of a simple motor skill."

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9. Bloom, p. 8.

10. Thomas S. Baldwin, "The Development of Achievement Measures for Trade and Technical Education," Progress Report Number One, p. 1.

11. W. E. Twining, "Mental Practice and Physical Practice in Learning a Motor Skill," Research Quarterly, vol. 20 (1949), pp. 432-435.

Waterland[12] in 1956 verified the idea that a learner can be given verbal instructions for mental practice of a skill with effective results. In a bowling experiment, he found that verbal instructions and mental practice increased efficiency in bowling by about one-third over the original method of instruction without mental practice.

Cantor and Brown[13] compared the Navy's traditional method of training in electronics using mock-ups of actual equipment with the same material conveyed either by a punchboard tutor, or be a trainer-tester. "The latter two groups of naval trainees proved to be superior in certain intellectual aspects, while the traditionally taught group in some cases proved superior in laboratory work."

Fleishman, Guilford, and Klausmeier[14] agree that

> Factors not directly motor . . . are required in complex psychomotor skills. The same is true in the many school activities in which the individual must perceive some form of stimulus to initiate and guide his subsequent motor responses.

Fitts reports the results of two surveys of instructor opinions regarding the problem of skill training.

> Respondents in both studies gave greatest emphasis to the following four aspects of skill tasks:
>
> a. Cognitive Aspects of Skill Learning - most instructors believe that an important aspect of skill learning is the development of an understanding of the nature of the task. This factor is most important early in training. . . . At

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12. J. C. Waterland, "The Effect of Mental Practice Combined with Kinesthetic Perception Where the Practice Precedes Each Overt Performance With a Motor Skill."

13. J. H. Cantor and J. S. Brown, An Evaluation of the Trainer-Tester and Punchboard Tutor as Electronics Troubleshooting Training, 1956 as reported by Schramm, p. 31.

14. Klausmeier, p. 228.

> more advanced levels of skill, cognitive aspects involve strategy, judgment, decision making, and planning.
>
> b. Perceptual Aspects of Skill Learning - most instructors emphasize the importance of perceptual factors in skill learning. The student must learn what to look for, how to identify important cues, how to make critical discriminations . . .
>
> c. Coordination - practically all instructors refer to the development of coordination. . . . Timing of successive movement patterns, timing of body movements in relation to movement of external objects, and the development of rhythm are . . . emphasized.
>
> d. Tension - Relaxation - . . . by far the most frequent comment of instructors about this aspect of student behavior concerns the degree of tenseness-relaxation which can be observed in their movements. Beginners exhibit overall tension in many muscle groups and appear to be doing an excessive amount of work; as they become more proficient they seem to relax, movements seem to require less effort, and they appear to have all the time they need for the task at hand.[15]

Thompson, et al.[16] state that the "demonstration is the basic form of instruction" when it comes to teaching motor skills, while "verbal instruction, except as a means of increasing vocabulary in the area, is the least effective."

Paul M. Fitts[17] apparently disagrees with Thompson, et al. saying

> First, the theoretical framework within which skilled performance is now being viewed by most students of this topic is such that sharp distinctions between verbal and motor processes, or between cognitive and motor processes serve no useful purpose. Second, since the processes which underlie skilled perceptual-motor performance are very similar to those which are involved in problem solving, and concept formation, we should expect to find that the laws of learning are also similar, and that no advantage would result from treating motor and verbal learning as separate topics.

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15. Paul M. Fitts, "Factors in Complex Skill Training" in Training Research and Education, ed. by Robert Glaser, pp. 184-186.

16. George G. Thompson, Eric F. Gardner, and Francis J. DiVesta, Educational Psychology, p. 369.

17. Fitts, p. 243.

Baldwin in his study of psychomotor behavior reports:

> After discussing this situation at length we felt that there had to be a link between the aptitude and achievement ends. This link we felt existed in the belief that the psychomotor responses measured before training (aptitude) were quite similar to those measured at the end of training (achievement). The change from unskilled to skilled was, then, accomplished primarily by a rearrangement and integration of different memory feedback systems. Since we are working in the area of psychomotor skills we felt that the development of the kinesthetic sense was of utmost importance.
>
> Discussions were held with psychologists and master tradesmen about the term "feel" one often encounters in discussing any given skill. What is meant by the word feel, and why is it so many people say that it cannot be taught? Although we have not yet investigated this question it is our belief that "feel" refers to and is a product of the rearrangement of tactile-kinesthetic memory feedback to a very fine degree. In fact, to such a degree as to make it well nigh impossible for it to be verbalized. This emphasis on perceptual rearrangement in skill development has been reinforced in discussion with people in the military as well as with people in psychology and education.[18]

While considering the question, what occurs during training that makes a man proficient in a skill and distinguishes him from the untrained individual, Baldwin asserts:

> We feel that the behavioral changes which occur, and quite obviously there are many which occur as a function of training, are on the input side rather than the output side. That is to say, what a person learns during training is to respond to different stimuli. A good driver, in other words, makes the same responses after training as he would have made before training, but he makes it (sic) to different stimuli.[19]

Theoretical Framework and Rationale

The rationale supporting the theory presented below evolves from the educational principles of apperception and transfer as well as from

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18. Baldwin, pp. 1-2.

19. *Ibid.*, p. 4.

extensive research which has shown programed instruction to be a highly effective method of teaching cognitive material.

A basic principle of learning, the principle of apperception, is explained by Ryans as "Previous learning always sets the stage for subsequent learning."[20] Similarly, the fact that one perceives new in terms of old is expressed by Hilgard in the following manner: "Man responds to a new situation as he would to some situation like it, or he responds to some element in the new situation to which he has a response in his repertory."[21]

The other principle supporting this study is the well known principle of transfer which Hilgard defines as the "application of a perceived relationship to another situation in which it is applicable."[22] A person learns something new through transfer to the extent that the abilities acquired in one situation help in another.

The writer feels these principles lend support to the theory presented, namely that "programed instruction can satisfactorily teach those psychomotor tasks which primarily require the learning of cognitive knowledge in order to properly utilize motor skills the learner already possesses." Most individuals possess numerous psychomotor abilities which are required in the performance of various tasks. Furthermore, it is speculated that learning of additional psychomotor tasks requires mainly the acquisition of new cognitive material and merely the transfer of previously acquired motor abilities to the new situation.

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20. Ryans, The Psychology of Learning, p. 313.

21. E. R. Hilgard, Theories of Learning, p. 27.

22. Ibid., p. 27.

Fitts supports this rationale as follows:

> An adult, or even a child of a few years of age, never begins the acquisition of a new form of skilled behavior except from the background of many already existing, highly developed, both general and specific skills. Thus the initial stage of our model is not that of a random network, but an already highly organized system possessing language skills, concepts, and many efficient subroutines such as those employed in maintaining posture, walking, and manipulating.[23]

DuPont's reasoning for using programed instruction with their adult trainees is also supportive of the above theory. O'Donnell, a maintenance engineering consultant for DuPont, had the following reply to a question about their use of a programed unit on oxyacetylene welding:

> I would also like to briefly comment on your recognition of the fact that this programmed unit is used to teach what is essentially a combination psycho-motor-cognitive learning task. This particular course was designed with the intention of finding out if this could be done. We started with the thought that a student, under certain conditions and in certain situations, could learn to monitor his own productions. We assumed that the student would possess the muscular strength and coordination to perform the task. With that muscular ability, and with very strong and detailed mental knowledge of the task elements acquired by means of the programmed unit, we felt that the student would be able to monitor his actions as he performed the task. Through extensive use of this programmed instruction course we found that a programmed unit can be used in this context with complete confidence.[24]

Baldwin's research lends strong support to the theory. Expressing his conception of the change that occurs in psychomotor behaviors as a result of training, he states

> We don't feel that individuals undergoing training in programs with which we are dealing acquire new responses.

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23. Fitts, pp. 259-260.

24. Letter from L. H. O'Donnell to the author, May 13, 1966.

> Perhaps they put together certain responses that are already in their repertoire but in new combinations. We do not feel that essentially new responses are learned during this training.[25]

In essence, Baldwin speculates exactly what is implied by the author's theory, that in the learning of a new psychomotor skill, previously learned motor responses are put together in combinations different from any used before.

Purpose of the Study

The main purpose of the study was to experimentally test the following theory which was derived from the learning principles and previous research cited.

Programed instruction can satisfactorily teach those psychomotor tasks which primarily require the learning of cognitive knowledge in order to properly utilize motor skills the learner already possesses.

Eight hypotheses were derived from the theory and the questions raised in the statement of the problem. Specifically, then, these were the hypotheses tested by this study:

Hypothesis 1: Performance Measure

The mean score of students who complete the program only treatment will be as high or higher than a previously established minimum satisfactory score.

Hypothesis 2: Treatment Effects

Students who complete the program plus 15 minutes of self-instructional practice treatment will score better than those who complete the program only treatment.

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25. Baldwin, p. 3.

Hypothesis 3: Self-Instructional Practice Effect (Time Constant)

Students who complete the program plus 15 minutes of self-instructional practice treatment will score better on a performance test than students who complete the program plus 15 minutes of performance testing will score on a retest.

Hypothesis 4: Dexterity Effects

Students of high dexterity will perform better than those of low dexterity.

Hypothesis 5: Interaction - Treatment X Level

The program plus 15 minutes of self-instructional practice treatment as compared to the program only treatment will be more effective for students of low dexterity than for those of high dexterity.

Hypothesis 6: Treatment Effect on Dexterity Level

At each dexterity level, the mean score of students who completed the program plus 15 minutes of self-instructional practice treatment will be better than the mean score of students who completed the program only treatment.

Hypothesis 7 a and b: Dexterity Level Effect on Each Treatment

(a) In the control treatment, students with high dexterity will perform better than those with low dexterity.

(b) In the experimental treatment, students with high dexterity will perform better than those with low dexterity.

Hypothesis 8: Interaction-Dexterity Level X Testing Time

In the control group, after a period of practice, students of high dexterity will show greater improvement than those of low dexterity.

Importance of the Study

The rapid pace of technological advancements in our society which in turn necessitates extensive and costly training and retraining of our labor force speak for the importance of this type of study. Authorities in the U. S. Labor Department have predicted that in the very near future the average man will have to be trained and retrained for as many as three or four different jobs in one lifetime. Furthermore, countless numbers of persons are continually seeking to upgrade themselves in the skills needed in their present occupation.

When one realizes the tremendous task facing educators today and in the future, there should be little doubt about the need for new and more efficient methods and media of instruction. One of the most promising of these media, especially when it comes to considering the goal of individualizing instruction, is programed instruction. Any new breakthrough in technology, however, requires extensive try-out and experimentation to determine its worth and to improve it. This study was concerned with both of these objectives.

First, in an effort to determine their worth in a relatively new area for programed instruction, the psychomotor domain, an attempt was made to determine whether programed materials alone can effectively teach a psychomotor skill to high school vocational students.

Second, in an effort to improve their worth, the study explored one possibility for supplementing the programed materials in an attempt to increase their effectiveness when teaching a psychomotor skill.

Specifically, this experiment provides evidence for acceptance or rejection of the stated hypotheses and the theory from which they have been derived. Perhaps the most important contribution to education is the practical information provided on how programs may be effectively used in our vocational schools to teach subjects which are of the psychomotor domain.

The use of an experiment for educational research is highly recommended by Campbell and Stanley.[26] They speak of experimentation in education:

> As the only means for settling disputes regarding educational practice, as the only way of verifying educational improvements, and as the only way of establishing a cumulative tradition in which improvements can be introduced without the danger of a faddish discard of old wisdom in favor of inferior novelties.

Finally, the findings of this experiment contribute in a cumulative way to the sparse body of knowledge now existing on the use of programed instruction to teach subject matter categorized as in the psychomotor domain, an area of behavior important to all vocational training programs.

Design of the Experiment

The design of this experiment is similar to what Campbell and Stanley call the "Posttest-Only Control Group Design."[27] The basic elements of this model which they classify as a true experimental design are: (1) randomization, (2) treatment, and (3) posttest. A paradigm of their design is presented in Figure I.

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26. Donald T. Campbell and Julian C. Stanley, "Experimental and Quasi-Experimental Designs for Research on Teaching," Handbook of Research in Teaching, N. L. Gage, ed., p. 172.

27. Ibid., p. 195.

FIGURE I

PARADIGM OF POSTTEST-ONLY CONTROL GROUP DESIGN

	Treatment Group	Received Treatment	Posttest
Randomization	Control	No	Yes
	Experimental	Yes	Yes

In order to adapt the above design to the needs of this experiment three changes were necessary. These were: (1) the addition of a measure on a covariable, (2) the division of each treatment group into three levels of dexterity, and (3) the addition of a retest for the control treatment. The modified design for this experiment is depicted in Figure II.

The two treatment groups were: (a) programed instruction only (control) and (b) programed instruction plus fifteen minutes of self-instructional practice (experimental). Each treatment group was divided into three dexterity levels of approximately equal size according to students' scores on the Tool and Bolt Dexterity Test.[28]

The control variable used in the experiment was reading ability as measured by the Nelson-Denny Reading Test.[29] That is, reading scores were used to equate statistically scores on the criterion variable so as to assure comparability of the experimental and control groups involved in the experiment. Other control procedures utilized in the experiment included: (1) randomizing class assignment to treatment, (2) standardizing

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28. The Tool and Bolt Dexterity Test was specially devised for purposes of this experiment by the researcher.

29. M. J. Nelson and E. C. Denny, The Nelson-Denny Reading Test, Revised ed., Form A.

FIGURE II

TEMPORAL MODEL OF THE EXPERIMENTAL DESIGN USED IN THIS STUDY

Covariate Measure	Dexterity Measure	Randomization To Treatment	Treatment Group		Treatment	Criterion	
Scores on Nelson-Denny Reading Test	Scores on Tool and Bolt Dexterity Test	Classes Paired According to the Number of Students in Respective Skill Levels and Randomly Assigned to Treatment	A Control	High Dexterity	Program Only	15 Minute Perform-ance Test	15 Minute Perform-ance Retest
				Medium Dexterity			
				Low Dexterity			
			B Experi-mental	High Dexterity	Program Plus 15 Minutes of Self-instruc-tional Practice	15 Minute Perform-ance Test	
				Medium Dexterity			
				Low Dexterity			

instructional practice through use of specific written procedures, (3) standardizing the procedures for administration of the performance test through use of specific written instructions and supervision by the researcher, and (4) reducing individual teacher influence by minimizing their role to that of an overseer.

The two independent variables involved were the students' dexterity level and the treatment administered. The dependent or criterion variables were drill rating scores obtained on a fifteen-minute performance test and on a fifteen-minute retest (control group only).

The assumptions upon which this study was based are: (a) that the program selected can adequately teach the cognitive knowledge needed in order to perform the task, (b) that the psychomotor task selected to be taught required of the student only the learning of new cognitive knowledge, (c) that the task selected required only the utilization of motor skills the learner already possessed, and (d) that once the student can pass minimum performance standards and knows the appropriate related cognitive material, his performance will improve through additional practice.

CHAPTER II

METHODOLOGY

The experiment involved the completion of twelve rather distinct steps from beginning to end. The procedures followed in carrying out each step are detailed below.

Step 1 - Selecting the Program

The program was selected on the basis of the following criteria: (a) appropriate subject matter and difficulty, (b) quality of program, (c) length, and (d) availability.

The program used was linear in format and titled "Drills - Part I - Selection, Checking, and Inspection" and "Part II - Regrinding and Modification," 1st ed. 1963, by J. T. Nied. Only Chapter A of Part II, "Regrinding the Drill" was used in order to help improve the appropriateness of the program for the students involved. Except for a few modifications made by the researcher, the program was used as published by E. I. DuPont De Nemours and Company of Wilmington, Delaware. The changes incorporated primarily involved the removal of two sections which pertained to letter and number size drills. Removal of these sections improved the appropriateness of the program for use with vocational agriculture students who are rarely, if ever, called upon to use letter and number size drills.

As the name implies, the selected program involved teaching a relatively complex psychomotor task, namely the regrinding of worn steel drills. In Klausmeier's classification of "Motor and Perceptual Components of Skills,"[30] this task would be ranked as having a high perceptual component and medium motor component. It was speculated that as the motor or manipulative skill requirement increases programed instruction would be less able to do a satisfactory teaching job by itself. It was this anticipation that gave rise to the experimental treatment used in this experiment.

Two unique features of the programed unit selected are that it incorporated the use of both panel books and a panel kit. The panel books, one for each part, contained a series of well executed illustrations and photographs. The panel kit consisted of two drill gauges and five drills of varying sizes. Each panel of the panel books and each item in the panel kit was labelled. Reference to these materials via their label was incorporated throughout the programed booklets.

The mean time required for the students to complete the program was just over three hours. The extremes in the range of time required was a high of just over six hours to a low of just under two hours.

Step 2: Developing a Dexterity Measure

In order to explore the relationship between student dexterity and ability to learn a skill effectively from programed materials it was necessary either to select a dexterity measure already available or to develop one. A thorough search for and review of the psychomotor aptitude tests available was conducted.

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30. Klausmeier, p. 240.

The search revealed that numerous tests were commercially available which had the following characteristics: (a) they required individual administration, (b) they were designed for measuring performance of single elementary motions or limited combinations of these, and (c) they were costly. Since a test was needed that could be group administered, that could measure the specific motor abilities required to perform the task of regrinding a drill, and that would not be prohibitive in cost, the commercially available tests were declared unsuitable for the job.

While searching the literature on psychomotor testing, attention was drawn to the extensive work done in this area by Edwin A. Fleishman mostly as an outgrowth of World War II studies on pilot proficiency. Speaking of Fleishman's work on factors which may account for much of the psychomotor domain Cronback states, "It seems fair to say that Fleishman has brought psychomotor testing to about the point that intellectual testing reached in 1940, following Thurstone's first report on the 'primary abilities.'"[31]

Fleishman's many factorial studies of motor performance have shown that human motor performance cannot be accounted for by a single ability factor. Baldwin in referring to these studies expresses his agreement when he says, "It is clear that several orthogonal dimensions of psychomotor performance have pretty well been identified. These factors have been replicated in numerous studies and seem to be sufficient to define a performance of untrained subjects."[32]

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31. Lee J. Cronbach. Essentials of Psychological Testing, p. 307.

32. Baldwin, "Working Paper Number One," p. 3.

A 1956 study by Fleishman[33] describes the Air Force psychomotor tests and provides a summary of research on eleven factors underlying them. Close scrutiny of the description of these factors, while at the same time keeping in mind the motor abilities that appeared to be involved in regrinding a drill, allowed for the elimination of all but three factors. These factors, listed below, served as the starting point from which the dexterity test was developed.

1. Finger dexterity - described as skillful, controlled finger movement.
2. Manual dexterity - described as controlled movements in manipulating larger objects with whole hand.
3. Arm-hand steadiness - described as precision and steadiness in positioning movements, speed and strength irrelevant.

Drewes concluded that "the predictive utility of psychomotor tests may be substantially increased by developing tests which will more closely approximate actual motion patterns used on the job."[34] With Fleishman's factors and Drewes' advice in mind the researcher set out to develop a dexterity test that would measure by simulation the degree to which each student possessed the motor abilities required in the regrinding of drills. As before mentioned, the factors of cost and convenience of administration to large groups (10-18) also had to be considered.

The final outcome of this development effort, the "Bolt and Tool Dexterity Test" is illustrated in Figures III and IV. Instructions for administering it are located in Appendix F.

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33. Edwin A. Fleishman, "Psychomotor Selection Tests: Research and Applications in the United States Air Force," Personnel Psychology, vol. 9 (1956), p. 455-468.

34. Donald W. Drewes, "Development and Validation of Synthetic Dexterity Tests Based on Elemental Motion Analysis," Journal of Applied Psychology, vol. 45, no. 3, p. 184.

FIGURE III

VIEW (RIGHT SIDE) OF TOOL AND BOLT DEXTERITY TEST

FIGURE IV

VIEW (LEFT SIDE) OF TOOL AND BOLT DEXTERITY TEST

The following materials were used in constructing and assembling each kit of the Tool and Bolt Dexterity Test.

Number	Item	Dimensions or Size
1	hardwood block (birch)	2" x 8" x 10"
15	machine bolts	3/8" x 2 1/4"
15	hex nuts	3/8"
3	containers	2" x 6" x 7"
2	open end wrenches	9/6" x 1/2"
1	cardboard mat	12" x 18"

Fifteen 7/16 inch holes, in three rows of five each, were drilled in each test board. Use of a slightly oversized hole permitted easy insertion and removal of the bolts. After drilling and sanding, the boards were given a coat of varnish. The three containers labelled nuts, washers, and bolts which accompanied each test kit were used to hold the disassembled parts.

The validity of the test was of considerable concern. Speaking on validity, Drewes states, "Since validity cannot be adequately generalized from one situation to another, the test developer is forced to tailor-make a testing program for each situation with little but an educated guess as to what tests will meet the local requirements."[35] Although an attempt was made to construct a test which would possess validity, there is no evidence or assurance other than the writer's best judgment that it actually measures the three desired factors reported above. The writer believes the test has good "face validity," which has been defined by Freeman as "a term that is used to characterize test materials which *appear* to measure that which the test author desired to measure."[36]

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35. *Ibid.*, p. 179.

36. Frank S. Freeman, *Theory and Practice of Psychological Testing*, p. 31.

The other factor of primary concern to any test author is that of reliability. Data on the reliability of the dexterity test was obtained by using the split-halves method. This method yields what is commonly referred to as a coefficient of equivalence. Basically, the procedure involves dividing the test into halves and computing a correlation between them. Since this reliability holds for only half of the whole test, an adjustment is made to determine the reliability of the whole test. See Cronbach[37] for mathematical procedures.

The dexterity test used in this experiment was a two-part test consisting of a disassembly task and an assembly task. The mean score on the disassembly task was 46.34 (n=200) and on the assembly task 49.05. Correlating scores on the disassembly half of the test with scores on the assembly half produced a coefficient of equivalence of .530. Computing the reliability of the whole test resulted in a correlation of .652.

Step 3: Devising the Self-Instructional Practice

One of the basic questions asked by this study was "Can programed materials be supplemented with another method and/or medium to increase their effectiveness?" Many alternative methods and media were considered as possible supplements to the program. Time, cost, and other limitations prohibited the use of more than one type of supplement in this experiment.

The rationale used in deciding upon the written procedures for self-instructional practice was based upon four important characteristics believed desirable for the supplemental method. First, since programed instruction itself is designed for individual self-teaching use, it was reasoned that the supplement should be similar in nature. Secondly, the

37. Cronbach, p. 141.

writer believed the supplement should concentrate on the motor phase of the task, as programed instruction has many times shown itself capable of teaching the cognitive material. Thirdly, the supplement must be suited to easy individual use since students would not all finish their programed booklets at the same time. And fourth, the length of time required to complete the programed booklet dictated that any supplement could be allotted only a very limited amount of time.

Using the rationale outlined the writer devised the written instructions titled "Regrinding Drills - Self-Instructional Practice" which are reproduced below. These instructions were given the student as soon as possible after he had completed the programed booklet. They spell out step-by-step the specific motions recommended by the programed booklet for regrinding drills. No new information of any type was provided by the instructions. Using the instructions, each student was allotted a maximum of fifteen minutes to practice regrinding a drill. He was told to emphasize learning the correct procedures as the drill itself would not be graded.

Regrinding Drills - Self-Instructional Practice

This phase of self-instructional training is designed to help you learn specific recommended procedures for regrinding drills. Please follow the instructions carefully step-by-step. You are allotted a maximum of 15 minutes to practice regrinding a defective drill to a standard 8° lip clearance angle and a 118° point angle. Although your time is limited you should emphasize learning the correct procedures as the drill itself will not be graded.

During this practice period you are to work without assistance from anyone.

Take these instructions and your panel kit to the shop with you so they will be available for easy reference as you practice. Now ask your teacher for a defective drill, then go to the shop, and proceed step-by-step as explained below.

Step 1 - Check the following parts of the drill and indicate (yes or no) the presence of any defects:

a. lip lengths _____
b. lip angles _____
c. lip clearance angles _____
d. cutting lips _____
e. margins _____
f. chisel edge _____

Step 2 - Regrind the drill to restore it to good condition. Grasp the drill near the point between the forefinger and thumb of your left hand.* Grasp the shank between the forefinger and thumb of your right hand.

Step 3 - Steady your left hand by resting it on the tool rest of the grinder. With your right hand, swing the shank to your left to obtain the proper lip angle.

Step 4 - Slide the drill slowly through the fingers of your left hand until the cutting lip touches the face of the wheel.

Step 5 - Push down slowly on the shank end of the drill when it comes in contact with the grinding wheel. Move the drill shank downward, pivoting the point between the fingers of your left hand, until the point clears the wheel.

Step 6 - Repeat the above steps grinding alternately on one cutting lip, then the other, until the worn or damaged portion is removed. As you grind stop from time to time to check the point with the drill gauge to see if you are getting correct lip angles and equal lip lengths.

<u>CAUTION</u>: Be careful to avoid overheating the drill point. Reduce grinding pressure if overheating occurs.

Step 7 - Inspect the drill point visually to see if you are getting adequate lip clearance.

Step 8 - Make a final check to see that the drill has (a) equal lip lengths, (b) proper lip angles, (c) proper lip clearances, (d) sharp cutting lips, (e) sharp margins, and (f) a sharp chisel edge.

When the drill appears to be sharpened <u>correctly</u>, or when time runs out, give the drill back to your teacher.

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*Note: Instructions are written for right handers.

Step 4: Developing the Drill Rating Scale

Written tests are usually not considered valid for measuring achievement in motor skills learning. Thus, a performance rating scale used for evaluating the drills reground by the students served as the criterion measure of the dependent variable. A review of existing performance rating scales was made to gain insight on scale items and construction procedures.

Micheels and Karnes in their discussion of manipulative-performance tests note the following as "important elements of skill which should be considered in evaluating a student's ability to perform a given operation or series of related operations:

> 1. Speed - the student's rate of work as compared with a predetermined standard.
>
> 2. Quality - the precision with which the student works and the extent to which the completed job conforms to prescribed dimensions and specifications.
>
> 3. Procedure - the extent to which the student follows the detailed steps of the accepted method for completing the prescribed job. . . ."[38]

Although ideally, a performance test for most skills would provide for measurement of all three elements, in this experiment the task of evaluating procedure seemed impossible because of the large numbers of students and the corresponding need for observers. Speed or time was standardized by allotting all students a maximum of fifteen minutes to perform the task. The rating scale developed, then, placed major emphasis on the quality of the completed job.

The drill rating scale was developed with the help of graduate students and faculty members who were familiar with the drill task.

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38. William J. Micheels, and M. Ray Karnes, Measuring Educational Achievement, p. 329.

Provision was made on the scale for checking all the important measurable and observable aspects of effective performance. With respect to items in which students normally vary in quality of work, provision was made for giving appropriate credit for the various discernible degrees of quality.

Use of the procedures outlined provide sufficient basis for concluding that the drill rating scale was so constructed as to have reasonable content validity. In the words of Freeman,

> Content validity is very largely a matter of expert judgment. That is, in this instance, the question to be answered is: Does the test, in the judgment of specialists, appear to measure the stated educational objectives of instruction in a given field of study?[39]

The consulting procedures used in developing the scale allow an affirmative answer to the question.

Another essential characteristic of any sound test is reliability. Reliability refers to the extent to which an instrument yields consistent results on testing and retesting. In this experiment a measure of the reliability of the criterion test was obtained by means of the test-retest method. One recommended technique for using this method involves administering a single form of the test twice and correlating the two sets of scores. Employing this technique for the control group in this experiment produced a quite satisfactory .679 coefficient of stability.

A copy of the "Drill Rating Scale for Students" in in Appendix J.

Step 5: Selecting the Sample

The students chosen for this experiment were tenth grade vocational agriculture students in New York State. This choice was consistent with

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39. Freeman, p. 399.

the New York State Bureau of Agricultural Education's suggested core course of study for farm production and management which lists the teaching of several tool fitting skills in the sophomore year.

For reasons of time efficiency and cost economy, the cluster sampling technique was employed. Three cluster areas were selected, two in Western New York and one in Central New York, each of which included a region defined by a circle with a twenty-five mile radius. A letter of solicitation was sent to the thirty-one teachers of agriculture whose departments were within the cluster areas. A copy of the letter is in Appendix A.

Twenty-one teachers with a total of approximately 200 students responded affirmatively. Some teachers replied that while most of their second-year students were sophomores, a few ninth and eleventh graders were also enrolled. These students were allowed to participate and scores from thirty-one of them were used in the analysis.

The previous experience in sharpening drills of all students in the sample was inventoried at the time they were given the Bolt and Tool Dexterity Test. See Appendix L. The scores of all students who reported they had previously reground more than two drills were discarded, as were scores of students from whom complete data were not collected. Finally, seven sets of scores were randomly discarded in order to provide acceptable cell numbers for the statistical analysis. Thus, the resultant sample was composed of 146 individuals.

Step 6: Obtaining Scores on the Covariate

Students were tested for their reading ability by means of the Nelson-Denny Reading Test, Form A. This test yields both a reading comprehension and a vocabulary score. It can be group administered in approximately thirty minutes.

Soon after the teachers indicated their willingness to cooperate, an appropriate number of testing materials and a set of standardized instructions (Appendix I) were mailed along with a cover letter (Appendix B) to them. The tests were administered by the cooperating teachers well in advance of the treatment and returned to the investigator for scoring. The total score, vocabulary score plus comprehension score, was used as the covariate.

Step 7: Obtaining Scores on the Dexterity Test

Before any classes could be randomly assigned to a treatment, scores had to be collected on the student's dexterity. These were obtained using the dexterity measure developed in Step 2. See Appendix F for a copy of the instructions used in administering the test.

Because of the bulkiness and weight of the testing materials, it was considered impractical to mail them. After making an appointment with the teacher the materials were personally delivered to each school and the test administered to the students by the experimenter. An added benefit of this procedure was increased standardization of the administration of these tests. Scores for the disassembly part of the test were added to scores for the assembly part to obtain the total score. A copy of the data collection sheet used is in Appendix L.

Step 8: Assigning Classes to Treatment

The first operation in assigning classes to treatment involved the computation of a correlation between the dexterity test scores and the reading test scores. In the event that the scores had correlated

.5 or higher, the reading covariate would not have been used, since its use would also have partialled out much of the variance due to dexterity differences. Under such circumstances, plans called for pairing classes in so far as possible according to both the number of students in the respective skill levels and mean reading ability before randomly assigning them to treatments.

The actual Pearson product-moment correlation between reading and dexterity scores was -.022. This correlation was judged to be sufficiently low as to permit the use of reading ability as a covariate. Thus, classes were paired as near as possible only according to the number of students in the respective skill levels. For instance, if school A had four students with high dexterity scores, three with medium scores and five with low scores, it was paired with another school having the same or a similar number of students in each of the dexterity levels. Paired classes were then assigned at random to the treatments. This procedure insured fairly equal size cells as well as random assignment.

Step 9: Administering the Treatments

The programed materials and instructions for administering the treatments (Appendix G and H) were delivered to the participating schools by the experimenter. While visiting the schools to administer the dexterity test, teachers were questioned about school vacation periods and preferred dates for administering the treatments. With these data in hand, a schedule that allowed approximately two weeks for each school was planned.

A limited supply of programed materials necessitated administering the treatment to one-third of the sample at a time. Since the programed booklets had to be used three times, the students were instructed to write their responses on specially prepared answer sheets rather than in the programed booklets.

Teachers were sent a letter (Appendix C) stating which treatment their school had been assigned to and estimating the date that the materials would be delivered to their school. As soon as the exact date of delivery was known the teachers were phoned and so informed. Their cooperation was requested in that they were asked to administer the treatment as soon as possible after the materials were delivered.

Step 10: Administering the Performance Test

Close communication was maintained with the teachers once they had started to administer the treatment so that the experimenter knew exactly what day the first students would be ready for the performance test. The teachers did not administer the performance test. By maintaining a rather hectic schedule, the experimenter was able to administer and supervise the performance testing of all students. His doing so permitted standardizing the administration of the performance test beyond what would have otherwise been possible. The experimenter helped speed up the evaluation phase by carrying three portable grinders with him. Use of these grinders by most of the students not only speeded up the evaluation process but also contributed to standardizing the equipment used in testing.

When a student indicated he had finished his programed booklet, his answer sheets were collected and checked to insure completeness. Finding everything completed and enough time remaining, the student was provided with a damaged 3/8 inch drill and asked to regrind it in accordance with the instructions outlined in Appendices G and H. All drills provided the students for regrinding were damaged in the same manner. Both cutting lips were blunted approximately 1/16 inch. The chisel edge was blunted in a similar fashion.

Drills which were reground by the students were labelled and later carefully evaluated by the experimenter using the Drill Rating Scale for Students (Appendix J). The scale permitted a maximum possible score of 44 points. Tools used in the evaluation of the drills included two types of drill gauges and a specially constructed protractor. The gauges were used to measure lip lengths, check lip angles, and measure lip clearance angles. Whenever the angles were not identical with those on the drill point gauge, the specially designed protractor was used to check them.

After the drills had been scored they were reground to obtain a correct point. They were then purposely damaged, in the standard manner described above, to prepare them for use by other students.

Step 11: Determining the Minimum Satisfactory Score

Hypothesis 1 states, "The mean score of students who complete the program only treatment will be as high or higher than a previously established minimum satisfactory score." Hence, the problem arose as to how the minimum satisfactory score should be established.

After considering several alternative methods, the use of a panel of experts was decided upon. It was felt that the collective judgment of the cooperating teachers, most of whom have taught the drill regrinding skill numerous times, would provide the most acceptable basis for establishing the minimum score.

Letters were sent to each of the twenty-one cooperating teachers asking for their help. A slightly revised version of the drill rating scale for students was enclosed with the letter. A copy of the letter and a copy of the modified drill rating scale are located in Appendices D and K respectively.

The teachers were instructed to use their good judgment to establish "the minimum satisfactory score that you would expect before considering a drill acceptable." The mean score, 27.33, of all the ratings (n-15) returned by the deadline date became the minimum satisfactory score used for comparison purposes in Hypothesis 1.

Step 12: Analyzing the Data

Reading tests were scored as received during February and March, 1967. Scores on the dexterity test were obtained during February at the time the test was administered. Drills which were reground by students during the performance tests were evaluated and scored by the experimenter in April and May.

Scores on the four variables of interest, namely, reading ability, dexterity, performance test, and performance retest were punched on IBM cards to facilitate data processing.

The major analyses used on the data consisted of two two-way analysis of covariance run to test differences between the control and experimental treatments, and differences among the three dexterity levels. The covariance procedure allows for the statistical equalization of control and experimental groups on a measure which is considered to be relevant to the criterion variable.

The first two-way analysis of covariance was on performance test scores adjusted for variations in reading score. The second analysis was run on performance retest scores (control group) and performance test scores (experimental group) adjusted for variations in reading score. The covariance analyses provided F values which were compared with tabled values of F (Edwards, 1964)[40] to determine significance.

The F value is computed by dividing the mean square (or the variance) between groups by the mean square within groups. When the F value is as large or larger than the tabled value of F, for a predetermined level of probability, then a significant difference exists between the groups. In this experiment, these differences would be attributed to either treatment effects, dexterity effects, or interaction effect depending on the comparison being made.

In cases where comparisons were planned between means, a multiple t-test on adjusted mean scores was computed to locate significant differences. The multiple t-test of adjusted means yields an LSD (Least Significant Difference) value which takes the place of the regular tabled values of t used in the normal t-test. All differences of means are compared with their respective LSD value, and if any difference is equal to or greater than the LSD value, then a significant difference exists between those adjusted means. Use of the LSD test is considered appropriate only where the comparisons are planned before conducting the experiment. Since the comparisons used in this experiment were planned before the data was analyzed, the above condition was met. The mathematics of this procedure can be found in Federer.[41]

A comparison of means and their confidence intervals was used to determine whether Hypothesis 1 should be accepted. A factorial analysis

40. Allen L. Edwards, Experimental Design in Psychological Research, pp. 364-367.

41. Walter T. Federer, Experimental Design, pp. 20-21.

of variance was computed on test and retest scores for the control treatment to determine whether an interaction existed between testing time and dexterity level.

Correlation coefficients were computed among the following variables: dexterity and reading scores, performance test and performance retest scores, disassembly and assembly scores. A correlation between dexterity and reading scores was needed in order to determine whether the use of reading as a covariate in the analysis of variance would partial out variance due to dexterity. A correlation between the performance test scores and performance retest scores was needed in order to determine the coefficient of stability for the drill rating scale. Similarly, a correlation was computed between the disassembly and assembly scores in order to obtain a coefficient of equivalence for the dexterity test.

In all the analyses conducted for this experiment, the .05 level of probability was used to determine if significant differences existed. Use of the .05 level of probability means that if a significant difference is found, there is a 95 percent likelihood that these differences are due to something other than chance. Or to put it another way, the differences could have happened by chance no more than five times in 100.

The two-way analyses of covariance were calculated at the computing center of the State University of New York at Buffalo using a Fortran IV source program called NYBANV. All other analyses were calculated with a Central Data 1604 computer at Cornell University using the Custat source programs called CORMA, ONVAR, and FANOV.

CHAPTER III

FINDINGS

Three general problems of concern investigated by this study may be summarized as follows:

1. Can programs alone effectively teach certain psychomotor skills to high school vocational students?

2. What is the relationship between student dexterity and ability to learn a skill effectively from programed materials?

3. Can programed materials be supplemented with another method and/or medium to increase their effectiveness?

The main purpose of the study was to experimentally test the following theory which was derived from the learning principles and previous research cited.

<u>Programed instruction can satisfactorily teach those psychomotor tasks which primarily require the learning of cognitive knowledge in order to properly utilize motor skills the learner already possesses</u>.

Eight hypotheses were derived from the theory and the questions of concern summarized above. The hypotheses and related findings are presented in the same order as they were in the statement of purpose. Differences between total experimental and control groups are reported as well as are differences between experimental and control students stratified into three dexterity levels.

While reviewing the hypotheses and findings, the reader may find it helpful to refer to Figure V, which illustrates the statistical design used and Figure VI, which depicts symbolically the individual hypotheses. Reference to the symbols used in Figures V and VI will aid the reader in understanding what comparisons are being made with each hypothesis.

FIGURE V

MODEL OF THE STATISTICAL DESIGN USED: TWO-WAY ANALYSIS OF COVARIANCE WITH FIXED EFFECTS

		Dexterity Level			
		High	Medium	Low	
Treatment	Control	a_1	b_1	c_1	D_1
		a_2	b_2	c_2	D_2
	Experimental	d	e	f	E
		A	B	C	

1 - Denotes test scores
2 - Denotes retest scores

FIGURE VI

SYMBOLIC REPRESENTATION OF HYPOTHESES

Hypothesis 1	$D_1 >$ minimum score
Hypothesis 2	$E > D_1$
Hypothesis 3	$E > D_2$
Hypothesis 4	$A > C$
Hypothesis 5	$f-c_1 > d-a_1$
Hypothesis 6	$d > a_1$
	$e > b_1$
	$f > c_1$
Hypothesis 7 (a)	$a_1 > c_1$
(b)	$d > f$
Hypothesis 8	$a_2-a_1 > c_2-c_1$

Hypothesis 1: Performance Measure

> The mean score of students who complete the program only treatment will be as high or higher than a previously established minimum satisfactory score.

Table 1 shows that the mean test score of all students in the program only treatment was 15.88. The minimum satisfactory score, 27.33, was obtained by taking the mean of all the minimum acceptable scores established by the panel of experts. By assuming that the standard error of the mean for the populations was approximately equal, it was possible to determine whether the 95% confidence interval for the treatment mean overlapped with the 95% confidence interval for the minimum satisfactory score. As can be seen from Table 1, the upper limit of the confidence interval for the treatment mean, 18.02, did not overlap with 25.19, the lower limit for the minimum satisfactory score interval. Since the intervals did not overlap, Hypothesis 1 was not accepted.

TABLE 1

COMPARISON OF MEANS AND THEIR CONFIDENCE INTERVALS FOR THE CONTROL TREATMENT AND THE MINIMUM SATISFACTORY SCORE

Criterion	Mean	95% Confidence Interval
Control Treatment Test, n=73	15.88	13.74 - 18.02
Minimum Satisfactory Score	27.33	25.19 - 29.47

Hypothesis 2: Treatment Effects

> Students who complete the program plus 15 minutes of self-instructional practice treatment will score better than those who complete the program only treatment.

A two-way analysis of covariance was computed on performance test scores. This analysis resulted in a non-significant F value of 2.75 for treatments as compared to the 3.92 value needed at the .05 level of probability, meaning that there was as much variation within groups as between groups. Thus, on the basis of this finding, Hypothesis 2 was not accepted. The results of this analysis are presented below in Table 2. The unadjusted and adjusted means for both treatments are presented in Table 3.

TABLE 2

ANALYSIS OF COVARIANCE ON PERFORMANCE TEST SCORES FOR CONTROL AND EXPERIMENTAL TREATMENTS AT THREE DEXTERITY LEVELS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Treatment	1	208.8	208.8	2.75
Dexterity level	2	643.6	321.8	4.23*
Interaction	2	73.6	36.8	.48
Within	139	10,567.3	76.0	

P.05=3.92 (with 1 and 139 d.f.)
P.05=3.07 (with 2 and 139 d.f.)

*Significant beyond the .05 level.

TABLE 3

UNADJUSTED AND ADJUSTED PERFORMANCE TEST MEANS FOR THE CONTROL AND EXPERIMENTAL TREATMENTS

Treatment	N	Unadjusted Mean	Adjusted Mean
Control (test)	73	15.95	15.88
Experimental	73	18.21	18.27

Hypothesis 3: Self-Instructional Practice (Time Constant)

> Students who complete the program plus 15 minutes of self-instructional practice treatment will score better on a performance test than students who complete the program plus 15 minutes of performance testing will score on a retest.

The second two-way analysis of covariance was computed on test scores for the experimental group and on retest scores for the control group. This procedure served to equalize the amount of time between completion of the programed materials and the criterion measure for each treatment. This allowed, then, a comparison between the treatment effect of the 15 minutes of self-instructional practice (experimental group) and the 15 minutes of performance testing (control group).

The results of this comparison are illustrated by Table 4. A non-significant F value for the treatment effects means that again there was as much variation within groups as between groups. The treatment value of .66 was considerably below the F value of 3.92 which was required for significance at the .05 level. Therefore, Hypothesis 3 was not accepted. The unadjusted and adjusted means for both treatments are presented in Table 5.

TABLE 4

ANALYSIS OF COVARIANCE ON PERFORMANCE TEST SCORES FOR THE EXPERIMENTAL GROUP AND ON PERFORMANCE RETEST SCORES FOR THE CONTROL TREATMENT AT THREE DEXTERITY LEVELS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Treatment	1	51.0	51.0	.66
Dexterity level	2	1,007.6	503.8	6.57*
Interaction	2	119.3	59.7	.78
Within	139	10,657.3	76.7	

P.05=3.92 (with 1 and 139 d.f.)
P.05=3.07 (with 2 and 139 d.f.)

*Significant beyond the .05 level.

TABLE 5

UNADJUSTED AND ADJUSTED PERFORMANCE RETEST MEANS FOR THE CONTROL TREATMENT AND PERFORMANCE TEST MEANS FOR THE EXPERIMENTAL TREATMENT

Treatment	N	Unadjusted Mean	Adjusted Mean
Control (retest)	73	17.21	17.11
Experimental	73	18.21	18.30

Hypothesis 4: Dexterity Effects

> Students of high dexterity will perform better than those of low dexterity.

Findings on this hypothesis are located in Table 2. A glance at Table 2 shows an overall F value of 4.23 for dexterity effects. Since this F value is larger than the 3.07 value needed it is significant beyond the .05 level.

Although the analysis of covariance yielded a significant F value, it did not show between which of the three dexterity levels the significant differences were attributable. For this purpose, a multiple t-test was run between all possible pairs of the three adjusted group means in order to locate the one or more pairs of means which were significantly different from each other. Table 6 shows the results of the multiple t-test on performance test scores (across treatments) for the three levels.

TABLE 6

MULTIPLE T-TEST (ACROSS TREATMENTS) FOR DIFFERENCES BETWEEN ADJUSTED MEANS ON PERFORMANCE TEST SCORES FOR THREE DEXTERITY LEVELS

Level	Adjusted Means	Differences Between Means	5% Least Significant Difference
High dexterity, n=46	19.66	$\bar{X}_1-\bar{X}_2=2.32$	3.53
Medium dexterity, n=48	17.34	$\bar{X}_2-\bar{X}_3=2.80$	3.41
Low dexterity, n=52	14.54	$X_1-X_3=5.12$*	3.40

*Significant beyond the .05 level.

Examination of Table 6 shows that there was no significant difference between the means of the high and medium levels or between the means of the medium and low levels. A significant difference did exist, however, between the high dexterity level and the low dexterity level, with the adjusted mean for the high level, 19.66, being significantly higher than that for the low level, 14.54. This is indicated by the difference between means value of 5.12 being greater than the Least Significant Difference value of 3.40. Due to the significant difference between the high and low dexterity levels, Hypothesis 4 was accepted.

Hypothesis 5: Interaction - Treatment X Dexterity Level

> The program plus 15 minutes of self-instructional practice treatment as compared to the program only treatment will be more effective for students of low dexterity than for those of high dexterity.

Findings on this hypothesis are located in Table 2. The F value for interaction was a low .48, which indicated a lack of any significant interaction between treatment and level. On the basis of this analysis, Hypothesis 5 was not accepted.

Hypothesis 6: Treatment Effect on Dexterity Level

> At each dexterity level, the mean score of students who completed the program plus 15 minutes self-instructional practice treatment will be better than the mean score of students who completed the program only treatment.

Failure to find a significant F value on overall treatment effects is reported in the findings on Hypothesis 2 and illustrated in Table 2. That finding, however, did not indicate whether there were significant treatment differences between the adjusted means at each dexterity level as had been hypothesized. For that purpose, a multiple t-test was computed on the three pairs of means. Comparison of the difference between each pair of means with its respective Least Significant Difference value, as shown in Table 7, indicates a lack of significant differences in treatment effect upon any of the dexterity levels. Because all the differences between means were lower than their respective LSD value, Hypothesis 6 was not accepted.

TABLE 7

ADJUSTED MEAN SCORES ON PERFORMANCE TEST FOR THE CONTROL AND EXPERIMENTAL TREATMENTS AT THREE DEXTERITY LEVELS

Dexterity Level	Experimental Treatment	Control Treatment	Differences Between Means	5% Least Significant Difference
High, n=23	21.26	18.07	3.19	5.10
Medium, n=24	19.21	15.48	3.75	5.07
Low, n=26	14.78	14.30	.48	4.82

Hypothesis 7 a and b: Dexterity Level Effect on Each Treatment

(a) In the control treatment, students with high dexterity will perform better than those with low dexterity.

In order to determine the dexterity level effect on each treatment, another multiple t-test was computed on the high and low dexterity means for each treatment. Comparison of the difference between the high and low dexterity means for the control treatment with its Least Significant Difference value, shown in Table 8, indicated a lack of significant difference between the high and low dexterity levels for the control treatment. The lack of a significant difference is represented by the fact that the difference between means of 3.77 is lower than its LSD value of 4.82. As a result of this finding, Hypothesis 7(a) was not accepted.

(b) In the experimental treatment, the students with high dexterity will perform better than those with low dexterity.

Table 8 shows that a significant difference did exist between the high and low dexterity means for the experimental treatment, meaning that the difference of 6.48 is greater than the LSD value of 4.79. Thus, on the basis of this finding, Hypothesis 7(b) was accepted.

TABLE 8

MULTIPLE T-TEST FOR DIFFERENCES BETWEEN ADJUSTED MEANS ON THE PERFORMANCE TEST FOR THE HIGH AND LOW DEXTERITY LEVELS, BOTH TREATMENTS

Treatment	High Dexterity Mean	Low Dexterity Mean	Differences Between Means	5% Least Significant Difference
Control	18.07	14.30	3.77	4.82
Experimental	21.26	14.78	6.48*	4.79

*Significant beyond the .05 level.

Hypothesis 8: Interaction-Dexterity Level X Testing Time

> In the control group, after a period of practice, students of high dexterity will show greater improvement than those of low dexterity.

A factorial analysis of variance was computed on test and retest scores for the control treatment to determine whether an interaction existed between testing time and dexterity. Use of unadjusted mean scores seemed justifiable since the reading covariate was making only very minor changes in the raw means. Table 9 shows the output of this analysis.

TABLE 9

FACTORIAL ANALYSIS OF VARIANCE ON CONTROL TREATMENT TEST AND RETEST SCORES AT THREE DEXTERITY LEVELS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Dexterity level	2	640.22	320.11	2.23
Error I(1)	66	9,496.00	143.88	
Testing Time	1	47.54	47.54	1.69
Testing Time X Dexterity Interaction	2	72.56	36.28	1.29
Error II(2)	66	1,847.39	27.99	

P.05=3.14 (with 2 and 66 d.f.)

(1) = Subject within dexterity level.

(2) = Test X Subject (within dexterity level) interaction.

As can be seen from Table 9, the F value for the interaction between testing time and dexterity level, 1.29, falls considerably short of significance. Therefore, on the basis of this finding Hypothesis 8 was not accepted. The unadjusted means for the control treatment on both the performance _test_ and the performance _retest_ are presented in Table 10.

TABLE 10

UNADJUSTED MEANS FOR THE CONTROL TREATMENT ON PERFORMANCE _TEST_ AND _RETEST_ SCORES AT THREE DEXTERITY LEVELS

Dexterity Level	Performance _Test_	Performance _Retest_
High	18.17	21.39
Medium	15.88	16.00
Low	14.04	14.62

The remainder of this chapter deals with other findings that the author believes are relevant to the analyses and measures used in this study.

Correlations: Correlations were computed between several of the measures employed in the study. The correlation between dexterity and reading scores, -.022, indicated a lack of any significant relationship. Thus, the use of reading as a covariate in the analysis of variance presented no problem in terms of partialling out variance due to dexterity.

The correlation between test and retest scores, .679, when compared to zero indicated that a highly significant coefficient of stability or reliability exists for the drill rating scale.

A correlation was also computed between the disassembly scores and the assembly scores obtained on the dexterity test. Known as the split-halves method of determining test reliability, the computation yielded a .530 coefficient of equivalence. Adjusting the score for the length of test factor resulted in a whole test reliability coefficient of .652.

Reading as a Covariate: In most programed instruction research reading has correlated fairly high with the criterion measure. Such was not the situation in this experiment. The analysis of covariance output showed that reading correlated only .093 with 146 test scores and only .173 with 73 retest scores.

Table 11 shows the relatively minor adjustment in means that resulted from using reading as a covariate.

TABLE 11

MEANS OF CONTROL AND EXPERIMENTAL STUDENTS ON READING AND UNADJUSTED AND ADJUSTED PERFORMANCE TEST MEANS, CLASSIFIED BY DEXTERITY

Group	N	Covariate	Performance Test	
		Reading Mean	Unadjusted Means	Adjusted Means
Control				
High	23	45.7	18.17	18.07
Medium	24	51.1	15.88	15.48
Low	26	39.0	14.04	14.30
Experimental				
High	23	42.3	21.17	21.26
Medium	24	40.0	19.00	19.21
Low	26	45.1	14.85	14.78

CHAPTER IV

CONCLUSIONS, INTERPRETATIONS, RECOMMENDATIONS, AND SUMMARY

In Chapter III, the findings of this study were presented in terms of the eight hypotheses posed. In this chapter, the researcher has extracted from these findings concise and logical conclusions based upon the data collected for this experiment. The conclusions drawn should be interpreted within the framework of the assumptions made and in recognition of the conditions under which the experiment was conducted. The latter portion of this chapter includes interpretations, recommendations for further research, and a summary of the entire experiment.

Conclusions

The specific conclusions are presented in the same order as the hypotheses cited in Chapter III.

Conclusion 1: Programed instructional materials alone do not satisfactorily teach psychomotor skills.

Conclusion 2: Supplementing programed materials is no more effective than programed materials alone when teaching psychomotor skills.

Conclusion 3: The self-instructional practice designed by the researcher to supplement the programed materials is ineffective in helping to develop psychomotor skills.

Conclusion 4: Programed instructional materials can more effectively teach pyschomotor skills to persons of high dexterity than to those of low dexterity.

Conclusion 5: There is no overall interaction between dexterity levels and the programed instructional techniques used to teach psychomotor skills.

Conclusion 6: The programed instructional techniques used affected each dexterity level to approximately the same degree.

Conclusion 7a: Persons with high dexterity do not learn psychomotor skills more effectively from programed instructional materials used alone, than do persons with low dexterity.

Conclusion 7b: Persons with high dexterity learn psychomotor skills more effectively from programed instructional materials that are supplemented, than do persons with low dexterity.

Conclusion 8: Dexterity levels and testing time do not interact.

General Conclusions: Recognizing the results of this experiment and the assumptions made in carrying it out, the researcher concludes that the data collected fails to support his theory that "programed instruction can satisfactorily teach those psychomotor tasks which primarily require the learning of cognitive knowledge in order to properly utilize motor skills the learner already possesses."

This experiment clearly indicates that a positive relationship exists between student dexterity and ability to learn psychomotor skills effectively from programed materials.

The method used to supplement the programed instructional materials in this study, the self-instructional practice, fails to produce any beneficial effect over use of the program alone.

Interpretations

Due to the researcher's close involvement with the study and the desirability of explaining certain outcomes, the following interpretations are offered.

Although the confidence limits for the mean score of the control treatment did not overlap or exceed the confidence limits for the minimum satisfactory score, several students did obtain a score as high or higher than the minimum satisfactory score. Data on individual achievement reveal that six students in the high dexterity level (n=23), three in the medium dexterity level (n=24), and three in the low dexterity level (n=26) reached the minimum level. Thus, out of seventy-three students, twelve or 16.4 percent did achieve at a satisfactory level.

A logical question arises, then, as to why twelve students were able to achieve satisfactorily while the others did not. The explanation may well be that one of the basic assumptions made in conducting the study, that the task selected required only the utilization of motor skills the learner already possessed, was an invalid one. In other words, a few of the students possessed the necessary motor abilities while the large majority did not. This explanation seems to be supported by the finding that a significant relationship existed between dexterity and ability to perform.

Another question that merits discussion is "How did the findings of this study differ from others and why did they differ?" The only other information available for comparison is that reported by the DuPont Company. The failure of students to reach a minimum satisfactory level in this research as contrasted with the successful achievement experienced by the DuPont Company may be explained by the fact that different criterion measures were used. The DuPont Company utilized a paper and pencil type objective test as a measure of the trainee's attainment, while the experimenter utilized a performance test, the actual regrinding of a drill.

Another plausible explanation as to why so many students failed to achieve satisfactorily is the possibility that the minimum satisfactory score, which was arbitrarily established by the panel of experts, was unrealistically high.

Recommendations

With the experiences gained in conducting this study and a review of the literature on psychomotor skills and programed instruction as a background, the experimenter makes the following recommendations for further research in these areas.

Experiments along the lines of this study should be conducted to test the effectiveness of other programed materials designed to teach the same and/or similar vocational skills. The writer is convinced that the theory used in this study was soundly based on well-established principles of learning and previous research. It is this soundness and the successes experienced by industry with adult trainees which influences the writer in believing that it merits further testing.

Perhaps the most significant outcome of this experiment was discovering that a definite relationship exists between student dexterity and ability to learn the skill of regrinding drills from programed materials. Further research should be conducted to learn if this relationship will hold true for other types of vocational skills.

In addition, pursuit of the relationships that exist between human psychomotor abilities and skilled performance should lead to a better understanding of this very important behavioral area. The fact of individual differences should be used to probe into the training requirements of tasks to be learned. Speaking of this approach to an understanding of skilled performance, Fleishman states, "interest has been traditionally centered on variations in training treatments, with individual differences regarded as troublesome error variance. Yet, one has to be impressed with the large differences in learning due to individual differences when these are compared with the effects usually obtained from different treatments and methods."[42]

Original and creative research is badly needed to develop and test new measures of psychomotor abilities. The lack of adequate standardized tests may well be a factor contributing to the dearth of research in the psychomotor domain. Two types of tests are needed, those that will measure specific motor abilities as well as those that will provide a measure of various combinations of these abilities. Before such tests can be widely used, they must also be adaptable to group administration and be reasonable in cost.

Another fertile field for research includes experimenting with other media and/or methods of supplementing programs designed to teach

42. Edwin A. Fleishman, "The Description and Prediction of Perceptual-Motor Skill Learning," Training Research and Education, Robert Glaser, ed., p. 137.

psychomotor skills. The writer feels testing the effect of supplementing programs with a short filmed demonstration is an especially desirable approach because students seem to experience their greatest difficulty in skill learning when trying to interpret and convert written instructions pertaining to even elementary motions into overt movements. Numerous other media and methods, however, could also be used as a supplement.

Research aimed at determining the relationship between cognitive knowledge and psychomotor performance seems highly desirable. Do those who learn the cognitive aspects of a psychomotor task to a high degree actually perform better than those whose cognitive achievement is low?

Two other questions also merit researching. What is the minimum cognitive knowledge essential for learning a particular skill and what procedures can be employed to identify that cognitive material?

Study of the amount of psychomotor practice necessary for the attainment of a minimum satisfactory level of performance is worthy of investigation. For example, students in this study may have reached a satisfactory performance level had they been given more time to practice the motions involved before they were administered the performance test.

Because of his own experiences in conducting this experiment, the writer strongly recommends that researchers employing any type of performance testing make provision for close supervision of the testing phase by a member of the research team. Many factors such as type of equipment used, adjustment of the equipment, lighting of the work area, distractions, and others could drastically affect the results of such testing.

A final recommendation is that someone closely replicate this study. Certain variations could of course be made to suit the wishes of the researcher. Replication with another sample seems to be especially worthwhile to verify the significant findings of this study with regard to dexterity and performance as well as to further test the theory upon which the study was based.

Summary

Research in this study involved an experiment titled "Using Programed Instruction With and Without Self-Instructional Practice to Teach Psychomotor Skills." Although there has been a large volume of programed instruction research on topics in the cognitive domain, none was found that dealt with the use of programed instruction to teach subjects of the psychomotor domain.

The importance of the psychomotor domain of behavior in our modern technical society seemed obvious, and yet the lack of programed instruction research in this area was apparent from a review of the literature. Reports from companies claiming much success in using programed instruction to teach basic industrial skills to adult trainees helped give impetus to this study.

Three general problems of concern which were investigated by this study may be summarized as:

1. Can programs alone effectively teach certain psychomotor skills to high school vocational students?

2. What is the relationship between student dexterity and ability to learn a skill effectively from programed materials?

3. Can programed materials be supplemented with another method and/or medium to increase their effectiveness?

The main purpose of the study was to experimentally test the following theory which was derived from the learning principles of apperception and transfer, previous research on programed instruction, and research on learning in the psychomotor domain.

Programed instruction can satisfactorily teach those psychomotor tasks which primarily require the learning of cognitive knowledge in order to properly utilize motor skills the learner already possesses.

From the theory and general problems of concern, eight hypotheses were generated for testing. The programed unit selected was designed to teach a relatively complex psychomotor task, the regrinding of worn steel drills.

In order to explore the relationship between student dexterity and ability to learn a skill effectively from programed materials, a specially devised dexterity test was developed and administered to all subjects.

Similarly, to investigate the possibility of supplementing programed instruction with another method in hopes of increasing its effectiveness, a specially devised set of written instructions for self-instructional practice was developed. They consisted primarily of spelling out step-by-step the specific motions recommended by the programed booklet for regrinding drills.

Students chosen for the experiment were tenth grade vocational agriculture students from twenty-one New York schools, selected on the cluster sampling basis. The students were first tested for reading ability. Next they were tested for dexterity and classified into three arbitrary levels--high, medium, and low according to their scores. Intact classes were then paired according to the number of students in the respective skill levels and randomly assigned to treatment.

The two treatments were: A - Control (programed instruction only) and B - Experimental (programed instruction plus fifteen minutes of self-instructional practice). At the end of the instructional period, all students were given a fifteen minute performance test. To equalize total time used for treatment and practice by the experimental group, the control group was given a fifteen minute performance retest.

Complete sets of data which included a reading test score, a dexterity test score, a performance test score, and in the case of the control group, a performance retest score, were collected from 146 students. Of this total, thirty-one were ninth and eleventh graders.

The major analyses used on the data consisted of two two-way analysis of covariance with control on reading. They were computed to test differences between the control and experimental treatments, differences among the three dexterity levels, and to check for possible interactions.

The data collected in this experiment failed to support the theory that "programed instruction can teach satisfactorily those psychomotor tasks which primarily require the learning of cognitive knowledge in order to properly utilize motor skills the learner already possesses." Likewise the method used to supplement the programed instructional materials in this study, the self-instructional practice, did not produce any significant benefit over use of the program alone. However, the findings of this experiment clearly indicated that a significant relationship existed between student dexterity and ability to learn psychomotor skills effectively through use of programed materials.

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APPENDICES

The appendices and photographs of the Tool and Bolt Dexterity Test have been omitted for purposes of this final report. If it is desired to view the photographs and/or the appendices, the reader is referred to the complete thesis available at the Cornell University Mann Library, Ithaca, New York and through University Microfilms, Inc., Ann Arbor, Michigan.