12-1971

The Development and Empirical Validation of a Teaching Program

Arlene Chmil

Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/masters_theses

Part of the Educational Psychology Commons

Recommended Citation

https://scholarworks.wmich.edu/masters_theses/2849

This Masters Thesis-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Master's Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact maira.bundza@wmich.edu.
THE DEVELOPMENT AND
EMPIRICAL VALIDATION OF A
TEACHING PROGRAM

by

Arlene Chmil

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Master of Arts

Western Michigan University
Kalamazoo, Michigan
December, 1971
The original purpose of this study was to teach college students to write psychology laboratory reports. A programmed text on how to draw a graph that would meet the publication requirements as specified by the American Psychological Association was written and tested on a small sample of psychology students. Results showed that the rules were not adequate discriminative stimuli for controlling behavior. It was necessary to give the students discrimination training with examples related to those rules. There was a high percent of errors on rules that pertained to the concepts of the independent and dependent variables, and the task of using equal intervals in assigning numerical values on the axes. Two subprograms were written to supplement the main program. Results showed that both subprograms reduced the number of incorrect discriminations made in the main program and on the graph drawings. In general the main program is achieving its objectives.
ACKNOWLEDGEMENT

In writing this thesis, I have benefited from the encouragement, advice, and constructive criticism of Dr. Richard W. Malott. My thanks go to him.
Masters Thesis

CHMIL, Arlene

The Development and Empirical Validation of a Teaching Program.

Western Michigan University, M.A., 1971
Education, psychology

University Microfilms, A Xerox Company, Ann Arbor, Michigan

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
PLEASE NOTE:

Some Pages have indistinct print. Filmed as received.

UNIVERSITY MICROFILMS
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>METHOD</td>
<td>4</td>
</tr>
<tr>
<td>PHASE I: INITIAL PROGRAM ON GRAPH CONSTRUCTION</td>
<td>5</td>
</tr>
<tr>
<td>PHASE II: A SUBPROGRAM ON THE CONCEPTS OF THE INDEPENDENT AND DEPENDENT VARIABLES</td>
<td>9</td>
</tr>
<tr>
<td>PHASE III: EMPIRICAL VALIDATION OF THE INDEPENDENT AND DEPENDENT VARIABLES SUBPROGRAM</td>
<td>13</td>
</tr>
<tr>
<td>PHASE IV: A SUBPROGRAM ON THE CONSTRUCTION OF EQUAL INTERVAL AXES</td>
<td>17</td>
</tr>
<tr>
<td>PHASE V: EMPIRICAL VALIDATION OF THE ENTIRE PROGRAMMED SEQUENCE</td>
<td>21</td>
</tr>
<tr>
<td>APPENDIX 1</td>
<td>29</td>
</tr>
<tr>
<td>APPENDIX 2</td>
<td>32</td>
</tr>
<tr>
<td>APPENDIX 3</td>
<td>34</td>
</tr>
<tr>
<td>APPENDIX 4</td>
<td>36</td>
</tr>
<tr>
<td>APPENDIX 5</td>
<td>38</td>
</tr>
</tbody>
</table>
After reading several hundred college student psychology laboratory reports, it became evident that technical writing was not an easy task for them. Therefore the purpose of this overall project is to teach college students how to write a psychology laboratory report. This particular study is concerned with the development of a programmed text on how to construct a graph that meets the publication requirements as specified by the American Psychological Association. Ten rules were stated. The following is a condensed version of the rules (see Appendix 1): 1-Center graph; 2-Label axes; 3-Print labels parallel to the axes; 4-Grid marks; 5-Scale at equal intervals; 6-Plot data points; 7-Connect data points; 8-Write legends; 9-Use geometric forms; 10-One graph per page.

After testing a small sample of students enrolled in an introductory psychology course at Western Michigan University, it was discovered that these rules did not govern or control their behavior; that is, the students were not able to follow these rules. Rules 2 and 8 were violated often. They pertained to the concepts of independent and dependent variables. Rule 5 was also violated often. It pertained to the task of using equal intervals when assigning numerical values on the axes. It became apparent that the students had to be taught how to master these rules.

Millenson (1967) states that Keller and Schoenfeld define "concept" as discrimination between classes and generalization within classes. The procedure for forming concepts begins with reinforcement in the presence of a single discriminative stimulus.
Discrimination training narrows the class of controlling stimuli. Equivalence training broadens the class of controlling stimuli. Concept training involves both discrimination training and equivalence training. Equivalence training means reinforcement of a response in the presence of more than one stimulus within a class of discriminative stimuli.

One way to apply this procedure is to give students verbal definitions of the concepts. With the definitions in front of them, they might be able to apply the concepts. However, results of Phase I of this study showed that this was not the case. Giving the students verbal definitions was not enough to allow them to master the concepts. It was hypothesized that the students could not properly use all of the words or subconcepts in the definitions. Therefore, the major concepts or rules could not control their behavior appropriately.

Another way to teach concepts is to extend the definitions without giving examples. But it may be that without giving numerous examples, you may get into an endless linguistic regress.

An alternative way to teach concepts is to give the students a large number of examples of the various concepts. This procedure may supplement the stimulus control exerted by the component terms of the verbally stated rules.

Perhaps it would be best to combine procedures: give the students the definitions in writing, and give them experience in applying the definitions. Then, with the definitions at their side, allow them to demonstrate their mastery of the major concepts.

Basically this study is attacking the common sense notion...
prevalent in education, that if you simply give students the terms and definitions, they should be able to apply these terms and definitions to novel situations. Instead it may be that they should not be expected to apply the concepts until they have had considerable training in that application.

For this study subprograms had to be written in order that the students would be able to apply rules 2, 5, and 8 while doing the test frames of the main program, and while drawing graphs. The study was a problem of engineering.

In designing and developing programmed texts, it is necessary to empirically validate these educational materials, to prove that the teaching objectives have been achieved.
METHOD

Two methods were used. The first method, used to develop the programs, consisted of writing a programmed text, testing a small sample of students, and analyzing the following: a) performance in using the program, that is, to test the number of correct and incorrect responses on each frame of the program; and b) the terminal behavior performance or graph drawing. The purpose of analyzing the answers that students made while studying the main program or the subprograms was to provide a basis for future programmed text revisions. The purpose of analyzing the graph drawing behavior was to see if the teaching objectives have been achieved.

The two subprograms and the main program contained sample and test frames, but only errors on the test frames were recorded and analyzed. When there was a low error rate, that is, below 10% on all the test frames of a programmed text, a second method was introduced to validate the programs. It consisted of increasing the number of students tested. Students were randomly assigned to an experimental or control group. A pre and post-test design was used with only the experimental group being exposed to the program. This method was used for the two subprograms and the total program.
PHASE I: INITIAL PROGRAM ON GRAPH CONSTRUCTION

Introduction

It was stated above that college students had difficulty in writing a psychology laboratory report and that the original purpose was to teach this skill to college students.

In developing a programmed text on how to construct a graph that would meet the publication requirements as specified by the American Psychological Association, ten rules were formulated and each rule was followed by test frames and feedback.

Discrimination learning techniques were used in composing the test frames.

Three drafts of this program were tested. (See Appendix 1.)

Subjects

Nine students enrolled in an introductory psychology course at Western Michigan University served as subjects. Three different students were tested for each of the three drafts written.

Procedure

The students were allowed as much time as they needed to study and master the program. Then they were given a list of the ten rules and were asked to draw a graph that would meet the publication requirements as specified by the American Psychological Association.

Before the students were given the program, they were informed that they would receive bonus points for volunteering to serve as subjects, and not for their performance on the test frames or their graph drawings.
**Data Collection**

The error rate for each rule of the program, the error rate and kinds of errors made on the graph drawings, study time (the amount of time to do the program and draw a graph), and student comments were recorded.

**Results**

Table 1 shows the percentage of errors on the test frames and graph drawings for the three drafts of the program. There was a high percent error rate for rules 2, 5, and 8. Since the students complained about unclear instructions and "hard to read" test frames, a second draft was written. This included new instructions. In addition, the test frames with which the students had difficulty involved sample graphs. These graphs were drawn more clearly on grided graph paper. However, this did not reduce the number of incorrect responses on the test frames of rules 2, 5, and 8. A third draft was written which contained additional test frames for these rules but was also unsuccessful in reducing the number of incorrect responses.

In general the results showed two indications of errors for rules 2, 5, and 8. First was the poor performance on the program itself, and second was the violation of these rules in drawing a graph.

**Discussion**

The results clearly show that the program did not achieve its objectives. The most frequent kinds of errors that the students made on the test frames and on the graphs were: a) incorrect discriminations for the concepts of the independent and dependent variables,
**TABLE 1**

Mean Error Rate for Three Drafts of the Main Program

<table>
<thead>
<tr>
<th>Rule Number</th>
<th>Test Frames</th>
<th>Graph Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>77</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>33</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>66</td>
</tr>
<tr>
<td>6</td>
<td>22</td>
<td>59</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>36</td>
<td>55</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>46</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
and b) a failure to use equal intervals in assigning numerical values on the axes.

Why were rules 2, 5, and 8 inadequate discriminative stimuli for controlling behavior? If the students were given the rules, they should have had no difficulty in applying them. But if they were not able to discriminate between the two variables, and did not have a behavioral repertoire to construct numbers on the axes, then they should not have been expected to apply the rules. Perhaps the students did not learn all of the words or the subconcepts in the rules. If we taught the students these subconcepts, they should have no difficulty in applying the major concepts or rules.

This hypothesis led to the development of two subprograms to supplement the main program. (See Appendixes 2 through 5.)
Introduction

A subprogram was developed to teach the concepts of "independent variable" and "dependent variable." Students were given definitions in writing, and were also given experience in applying the definitions to numerous and various situations. In essence students were given conceptual training.

Three different pairs of definitions were presented. The first pair of definitions began with the most common sense notions. The following pairs of definitions were much more technical to facilitate the sharpening of discriminations between the two classes of variables, that is, between the independent and dependent variables. (See Appendix 2.)

Students should memorize the definitions of the independent and dependent variables, or be able to apply the concepts without a list of the definitions at their side. But this study was designed to see whether training of the application of the concepts would facilitate their application even with a list of the definitions available during the test.

Subjects

For each of the two drafts, six students were randomly assigned to an experimental or control group.

Procedure

The experimental group was allowed as much time as needed to
study the subprogram. During this time the control group was instructed to read a text (Whaley and Malott, 1969), which was not directly relevant to the task at hand. Then both groups were given the main program. When they finished using it, they were given a list of the rules and were asked to draw a graph.

Results and Discussion

The experimental group had an average error rate of 26% on the test frames of the independent and dependent variables subprogram. Since knowledge of the concepts of the independent and dependent variables was essential for rules 2 and 8, average error rates on the test frames in the main program and graph drawings for both groups was determined.

Table 2 indicates that the experimental and control groups had similar average error rates. The experimental group did not perform better than the control group. This was indicated as errors on the test frames of the main program and violations of rules 2 and 8 while drawing a graph.

It was stated earlier that the experimental group had an average error rate of 26% on the test frames of the subprogram. After analyzing the number of errors made on each test frame, it was discovered that a high frequency of errors occurred on test frames that used a social situation as an example. An illustration of such a test frame was:

The sergeant says, "Squad halt!" and all the men halt.

In many social situations the behavior of one person is the cause of the behavior of the other person and vice versa. In the above
### TABLE 2

Mean Error Rate on Two Rules of the Main Program as a Function of Two Drafts of the Independent and Dependent Variables Subprogram

<table>
<thead>
<tr>
<th>Group</th>
<th>Rule Number</th>
<th>Test Frames</th>
<th>Graph Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>2</td>
<td>16.5</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>21.5</td>
<td>18.5</td>
</tr>
<tr>
<td>Control</td>
<td>2</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>22.5</td>
<td>19.0</td>
</tr>
</tbody>
</table>
example, if the sergeant is the observer, his words, "Squad halt!" affects the behavior of the men. They halt. But if the men are the observers, their halting behavior affects the subsequent behavior of the sergeant. In order for the students to select the correct answers, they would have to look at the above test frame from the observer's point of view. But the students may not know who is doing the observing. This is different from not knowing or understanding the concepts of the independent and dependent variables.

Draft 2 of the subprogram included instructions to pay attention to the wording of the test frames and to look at the social situations from the observer's point of view. This draft was tested with new students who were randomly assigned to an experimental or control group.

Results showed that the experimental group had an average error rate of 21% on the subprogram. Both groups performed about the same on the test frames of rules 2 and 8 of the main program and on drawing graphs relevant to these rules.

Even if the social situation test frames were deleted from the subprogram, the average error rate for the experimental group was still above 10%. Another reason for this high error rate might be the structure of the test frames. The test frames were designed in an essay form. Perhaps the students could not learn the concepts of the independent and dependent variables because the test frames were ambiguous. It may be that the structure of these test frames did not make it clear what discriminations were to be made.
PHASE III: EMPIRICAL VALIDATION OF THE INDEPENDENT AND DEPENDENT VARIABLES SUBPROGRAM

It was decided to delete social situation test frames and design the test frames in a non-essay form. (See Appendix 3.)

Test frames for this draft were converted into a multiple-choice format. By using a multiple-choice format, it becomes maximally clear what discriminations have to be made.

For the research and developmental purposes of this study, non-multiple-choice formats were ambiguous. It was conceivable that the students made the wrong answers for the right reasons. In general, it was much more difficult to get inter-observer reliability on the correctness or incorrectness in an essay format.

Another reason for using a multiple-choice format in the training program was to facilitate accurate feedback to the students since they were constructing their own answers, and were evaluating their responses by comparing it with model answers. If there was considerable room for variation, it may have been very difficult for the students to be certain whether their answers were correct, and thereby get accurate feedback. With the multiple-choice format, however, there was no doubt as to whether or not the students had the correct answers.

Another virtue of the multiple-choice format is that it does not require an instructor to personally give feedback to the students.

Therefore the purpose of this phase was twofold: a) to rewrite the subprogram in a multiple-choice format, and b) to empirically validate it by using a pre and post-test design.
**Subjects**

Sixty students were randomly assigned to experimental and control groups.

**Procedure**

Both groups were given a pre-test. Then the experimental group was given the subprogram while the control group was asked to read a text (Whaley and Malott, 1969). When the experimental group was finished with the subprogram, both groups were given a post-test.

**Data Collection**

The frequency of errors made on the pre and post-tests, the frequency of errors made on the test frames of this subprogram, study time and student ratings were recorded.

**Results and Discussion**

Twenty students were tested with an essay form pre and post-test. Table 3 shows the average error rate of 76% for the experimental group while the average error rate for the control group was 69%. These are the mean error rates for the pre-test.

The post-test results for the experimental group showed an average error rate of 50% while the control group had an average error rate of 71%. Although the post-test results showed a decrease in the average error rate for the experimental group, it was still high. That is, the experimental group discriminated incorrectly 50% of the time. Therefore it was decided to convert the pre and post-tests into a multiple-choice format for the other forty students.

These forty students were also randomly assigned to an experimental or control group.
### TABLE 3

Mean Error Rate on the Independent and Dependent Variables Subprogram

<table>
<thead>
<tr>
<th>Group</th>
<th>Draft 3 Pre-test</th>
<th>Draft 3 Post-test</th>
<th>Draft 4 Pre-test</th>
<th>Draft 4 Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>76</td>
<td>50</td>
<td>52</td>
<td>11</td>
</tr>
<tr>
<td>Control</td>
<td>69</td>
<td>71</td>
<td>52</td>
<td>54</td>
</tr>
</tbody>
</table>
Table 1 indicates that both groups had an average error rate of 52% on the pre-test.

The experimental group had an average error rate of 11% on the post-test; the control group had an average error rate of 54%.

These results clearly demonstrated that the subprogram did teach the concepts of the independent and dependent variables.

The frequency of errors on the test frames of this subprogram was below 5% for the two samples of experimental groups who studied it.

Most experimental subjects used 30 to 45 minutes to study this subprogram.

Fifteen of the twenty students that served as experimental subjects filled out a scaled commentary sheet. In general most of the students rated the instructions as clear, the program as easy, helpful, and not fun.
Introduction

At the beginning of this report it was mentioned that the students also made a high frequency of errors in rule 5 of the main program. The specific kind of error that was made most often was not assigning numerical values at equal intervals on the axes. Thus a second subprogram was written to reduce the frequency of errors made on the test frames of rule 5 in the main program, and to teach students how to construct axes when they are given numbers that must be represented or easily located on the axes. It was also hoped that this subprogram would reduce the number of times that rule 5 was violated when drawing graphs.

A "yes" or "no" multiple-choice format was used. (See Appendix 4.)

Subjects

Ten students enrolled in an introductory psychology course at Western Michigan University served as subjects for which they earned three bonus points. Bonus points were not based on test or program performance.

Procedure

The students were given the program to study. When they finished using it, they were given graph paper and a terminal behavior problem that was designed to test their ability to construct and assign numerical values on the axes.
Data Collection

The frequency of errors made on the test frames of this subprogram, the frequency and kinds of errors made on the graph drawings, study time, and student comments were recorded.

Results

Although Table 4 shows a high average error rate for most of the test frames for draft 1 of this subprogram, the results indicated that only 20% of the students did not use equal intervals in assigning numerical values on the axes. That is, eight of the ten students constructed their own graphs correctly.

Study time ranged from 45 to 60 minutes.

A majority of the students rated the study and sample section as confusing. Half of the students rated the program as difficult and four of the students rated it as easy. Half of the students rated the program as boring.

Discussion

Since there was a high average error rate on the test frames of draft 1 of this subprogram, and the students had made negative comments about this subprogram, another attempt was made. (See Appendix 4.)

Draft 2 - Introduction

A new draft of this subtext was written. Again a yes-no answer format was used.

Subjects

Eight new students participated and received three bonus points for volunteering.
TABLE 4
Mean Error Rate for Subprogram Number 2

<table>
<thead>
<tr>
<th>Test Frame Number</th>
<th>Draft 1</th>
<th>Draft 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Procedure

Students were allowed as much time as needed to study the program before the terminal behavior test.

Data Collection

The same information was recorded as for draft 1.

Results and Discussion

Table 4 indicates that there were no errors made on eight of the ten test frames. There was an average error rate of 50% on one frame, and another frame had an average error rate of 12%. It was decided to revise these two test frames to reduce the future probability of a high frequency of errors.

The graph drawing results indicated that seven of the eight students constructed their graphs correctly.

All of the students rated the instructions as clear. Six of the students rated the program as fun and two rated it as boring. Seven of the students rated the program as easy.
Introduction

Since a satisfactory subprogram was developed, the next step was to empirically validate it. After a few revisions were made, this was done concurrently with empirically revalidating the first subprogram, and empirically validating the main program.

Procedure

The students had a list of the definitions of independent and dependent variables, a list of the guidelines on how to use equal intervals when assigning numerical values on the axes, and a list of rules on how to construct a graph that would meet the publication requirements of the American Psychological Association when they took the relevant pre and post-tests.

Sixty-three students enrolled in the psychology 160 course at Western Michigan University served as subjects. Students were not informed what the consequences were for taking the three part program. If they inquired about earning a grade or grades, they were given answers such as, "I do not know;" or "You may be right." It was decided later that students would receive three grades, one for each of the post-tests.

On day 1, students were given a pre-test, the subprogram on the concepts of the independent and dependent variables, and a post-test.

On day 2, these same students were given a pre-test, the subprogram on how to use equal intervals when assigning numerical values on the axes, and a post-test.
On days 3 and 4, all these students were given a pre-test, the main program which was designed to teach them to construct a graph that would meet the publication requirements of the American Psychological Association, and a post-test.

Data Collection

The frequency of errors made on the pre-tests, the post-tests, the test frames of the main program, study time, and student ratings were recorded.

Results and Discussion

Table 5 shows that the average error rate on the pre-test for the independent and dependent variables program was 30%.

The average error rate for the post-test for this subtext was 1%.

Although Table 5 does not include the average error rate for the test frames of this subprogram, an analysis showed that every test frame had an error rate below 10%.

Table 5 indicated that for the program on using equal intervals when assigning numerical values on the axes showed that 55% of the students drew incorrect graphs.

The post-test results showed that only 5% of the students drew incorrect graphs.

Two test frames in the program had an average error rate above 10%. These are the same test frames that needed revision before. It appears that closer examination and further revision is necessary.

Table 5 shows that the pre-test for the main program indicated that the average error rates for rules 2 and 8, which required
<table>
<thead>
<tr>
<th>Subprogram 1</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Improvement Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>Subprogram 2</td>
<td>55</td>
<td>5</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rule Number</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Improvement Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67</td>
<td>14</td>
<td>53</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>44</td>
<td>-11</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>6</td>
<td>42</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>19</td>
<td>-3</td>
</tr>
<tr>
<td>9</td>
<td>16</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>
knowledge of the concepts that pertained to independent and dependent variables, was above 10%. For rule 2 however, only 15% of the students actually discriminated incorrectly between the variables. Of the remaining errors, 18% of the students failed to use all capital letters in labeling their graphs and 1% for labeling in legends.

The incorrect discrimination between independent and dependent variables on the pre-test was the fault of the relevant subprogram. The pre-test presented information that students were not taught in the subprogram. Training in the application of the definitions for the independent variable was given with the class of tangible stimuli such as electric shock and food, but no training in the application of the definitions for the independent variable was given to the class of intangible events such as time, number of trials, and number of sessions which are variables an experimenter can also manipulate or vary. When the students were asked to apply the definitions to this new and different class of events, some could not because they did not have the behavioral repertoire to do so. Therefore the subprogram on the concepts of the independent and dependent variables needs the addition of test frames to treat this problem.

This inability to apply the definitions of the independent variable to the class of intangible events also becomes apparent when looking at the average error rate of 44% on rule 2 for the post-test. Rule 8 was also violated on the post-tests more than 10% of the time because the students were unable to identify
intangible class of events as independent variables.

The average error rate on the test frames of the main program for rules 2 and 8 was slightly above 10%.

Since the second subprogram was developed to reduce errors on rule 5, its success can be determined by looking at average error rates on the pre and post-tests, and on the test frames of the main program. In all three instances, average error rates was below 10%.

The results for the other seven rules in the main program indicated that revisions are necessary to reduce the high average error rates on the test frames of rules 1 and 6.

Rule 1 was violated by most of the students on the pre-test. The frequent kind of error made was oversized graph drawings, that is, the graphs filled the area of the page. Rule 1 was also violated more than 10% of the time on the post-test and the test frames of the main program.

The kind of error made 37% of the time on the pre-test for rule 3 was not printing parallel to the axes. This kind of error was reduced to 3% on the post-test after doing the test frames for rule 3 of the main program.

On the pre-test for rule 4, 48% of the students failed to follow this rule. In general most of the students drew grid marks that intersected through the axes. However doing the test frames of rule 4 of the main program reduced the average error rate on the post-test to 6%.

The average error rate on the pre and post-tests for rule 6 was 14%. Perhaps additional test frames in the main program would
train the students to plot more carefully or accurately.

There were no errors made on the pre and post-tests, and the test frames of the main program for rule 7. All students drew straight lines when connecting data points.

The average error rate for rule 9 was slightly above 10% on the pre-test. It was below 10% on the test frames and on the post-test.

The amount of time to take the three pre-tests, do the three programs, and take the three post-tests required four to five hours.

Forty-one of the sixty-three students completed a scaled commentary page. This was distributed for students to rate the three programs as a unit. The ratings indicated that the instructions were clear. 50% of the students considered the programs as boring, while 50% of the students rated it as fun. 90% of the students considered the programs easy to do. 75% of the students said the programs were helpful, while 20% said the programs were not helpful.
CONCLUSIONS

One way of teaching a student how to draw a graph that would meet the publication requirements of the American Psychological Association would be to give him a set of graphs to draw, and then have an instructor personally examine each of the constructed responses. The problem with this method is that it is labor intensive. As you increase the number of students being taught, you proportionately increase the number of instructors needed, and you increase the time required.

The technology that this study used required many hours of research development. But once the educational material was developed and empirically validated, very little time is required on the part of instructors to monitor a student's behavior during the training program. This is the virtue of such a technology. You can increase the number of students in a training program without greatly increasing faculty time and effort.

In general the results of this study have shown that the teaching objectives of both subprograms have been achieved. Most, but not all of the teaching objectives of the main program were achieved. It is likely that there will be slight revisions in both subprograms to better supplement the main program, and undoubtedly, several revisions will be needed in the main program itself. However, it will continue to be a step by step process in developing a satisfactory main program and then empirically validating it.
REFERENCES


APPENDIX 1

Development of the Main Program - Draft 1: "How to Draw a Graph that Meets the Publication Requirements as Specified by the American Psychological Association."

Writing the Program.

Objectives. The terminal behaviors after studying the main program are:

a) discriminate between independent and dependent variables in order to apply rules 2 and 8

b) discriminate between correct and incorrect graphs

c) draw a graph that meets the publication requirements as specified by the American Psychological Association.

List of Rules.

1. Center graph on the page.

2. In all capital letters, label the independent variable on the x-axis, and the dependent variable on the y-axis.

3. When labeling the axes, printing must be clear, parallel to the axes, and centered.

4. Grid marks should be drawn inside the axes and equally distant from each other to represent the given numerical values that must be plotted across the length of the axes. Make sure the grid marks do not intersect through the axes.

5. Assign numerical values to each of the grid marks drawn. Values must represent convenient scales. Numbers should be easy to read; write them clearly.
6. Plot points at appropriate intervals. A point represents a single unit - \((x, y)\).

7. Connect the points sequentially by drawing straight lines.

8. If there are more than one dependent variables, draw a legend (a square) in the upper righthand corner, and whenever possible, within the axes boundaries.

9. When you have more than one dependent variable, assign a distinct geometric form for each of the dependent variables. Connect sequentially all one kind of geometric form. Use straight lines to connect your data points. When you are labeling in your legend, make sure that your geometric form is on the left, and the wording is on the right.

10. There should be no more than one graph drawing on a sheet of graph paper.

Format of the Main Program.

Students read an information and instruction page. A rule is stated and followed by a series of test frames. Students look at a test frame. They are required to write "yes" on an answer sheet if the test frame follows the rule; they write "no" on the answer sheet if the test frame violates the rule. After they have written an answer to a test frame, they remove a 5 inch by 8 inch index card (shield) to learn the correct response which is followed by an explanation.

Draft 2.

A new instruction page was written. In addition, the test frames that were "hard to read" had sample graphs. These graphs were drawn
more clearly on grided graph paper.

Draft 3.

Rules 2 and 8 contained additional test frames.
APPENDIX 2

Development of the Subprogram - Draft 1: "The Concepts of the Independent and Dependent Variables."

Writing the Subprogram.

Objectives. After studying this subprogram, students should be able to:

a) make no errors or incorrect responses on the test frames of rules 2 and 8 that are related to the concepts of the independent and dependent variables

b) follow rules 2 and 8 in their graph drawings

Design of the Subprogram.

Students read an instruction page.

Section 1: Two definitions were presented.

Independent variable means cause.

Dependent variable means effect.

A series of test frames were presented in essay form. The students read a test frame and single-underlined the independent variable, and double-underlined the dependent variable. Then they removed an index card to learn the correct answers. No explanation was given. If the words the students underlined were not the exact words provided as correct discriminations or feedback, the test frame was counted as wrong. No partial credit was given.

Section 2: Two definitions were given to expand the concepts of the two variables.

Independent variable means what the experimenter does.
Dependent variable means what the subject or organism being studied does.
The rest of the design was the same as for Section 1.

Section 3: Two technical definitions of the concepts were presented to sharpen discrimination training.

Independent variable was defined as an aspect of the environment which the experimenter directly controls, manipulates, or varies.

Dependent variable was defined as the behavior of the subject which the experimenter records or observes as a function of the changes in the independent variable.

Only the first two definitions were given for both concepts. Then an example of the behavior of two people in a social situation was presented and analyzed. A sample section followed, before the essay form test frames were presented. Again students were instructed to single-underline the independent variable, and double-underline the dependent variable.
APPENDIX 3

Draft 3 of the subprogram designed to teach the concepts of the independent and dependent variables.

There are three sections. Each section begins with a definition of the two concepts which are followed by two sample frames designed in a multiple-choice format. The students write the small alphabetical letter or letters that represent the variables. After they have written the answers, they remove their index cards to learn the correct responses. There was also an analysis for each of the two sample frames. Then the students were required to do the ten test frames for each section. Each test frame contained feedback or knowledge of the correct discriminations, but analysis as to why these were the correct responses was discontinued.

Social situation test frames were not included in this draft.

The pre and post-tests that accompanied this draft were written in essay form.

Design of the pre and post-tests.

Test frames for the pre and post-tests were not identical. The words or content of the pre and post-tests was different, but the level of difficulty was the same for both tests. This appeared to be true after matching a pre-test frame with a corresponding post-test frame. Some of the students received one form as the pre-test, and the other students received the second form as the pre-test. Error analyses on the pre-test performances showed that the frequency of errors on a test frame was the same or about the same as the
frequency of errors on a matched test frame of the alternate form.

Draft 4 - Revisions.

The definitions were stated in a multiple-choice form.

The pre and post-tests were converted into a multiple-choice format.

Objectives. The students must master rule 5 in the main program and on their graphs.

Writing the Subprogram.

The students read an information and instruction page. Then they began a study section which illustrated that two requirements should be met:

a) easy interpolation
b) accurate representation.

A sample section was presented. When the students were prepared to do the ten test frames, they looked at a test frame and graph. If the graph met both requirements, they wrote "yes" on the answer sheet; if it did not meet both requirements or only one, they wrote "no" on the answer sheet. Then they removed an index card to learn the correct responses and read the explanation.

Draft 2.

Again students read an information and instruction page. A study section was presented which contained two guidelines for constructing numerical values on the axes. They were:

a) values on the axes that are usually assigned are divisible by 10 or 5
b) values that you assign should be equally distant from each other, or have equal intervals.
Several examples using the guidelines were presented before the students began the test section. Again, they would look at a test frame and a graph illustration. They wrote "yes" if the graph followed the two guidelines, and "no" if it did not. Then they removed an index card to learn the correct answer and read the explanation.
APPENDIX 5

Draft 4 of the Main Program designed to teach the students how to draw a graph that meets the publication requirements of the American Psychological Association.

Revisions.

A new instruction page was written.

Several frames in rules 2 and 8 were deleted because they were repetitious. New frames were added to these rules to test the ability of the students to generalize to a wide range of situations after receiving discrimination training on how to apply the definitions of the concepts of the independent and dependent variables.

Most of the test frames in rule 5 were deleted and replaced by frames that tested the ability of the students to generalize after studying the second subprogram.