Research in the Use of State Diagramming as a Communication, Diagnostic, and Descriptive Tool in Applied Educational Programs

Roger S. Coates
Western Michigan University

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RESEARCH IN THE USE OF STATE DIAGRAMMING AS
A COMMUNICATION, DIAGNOSTIC, AND DESCRIPTIVE TOOL
IN APPLIED EDUCATIONAL PROGRAMS

by

Roger S. Coates

A Project Report
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Specialist in Education
Department of Psychology

Western Michigan University
Kalamazoo, Michigan
December 1982
State diagramming is a schematic communication tool used to present experimental designs or educationally-significant conditions in applied settings. In applied situations, public school teachers and students, and college students used state diagramming as an effective communication and diagnostic tool for educational programming. Four of five teachers showed rapid comprehension of classroom programs when the use of diagramming was compared to written narratives. College students described antecedent events present in familiar educational systems at a higher percentage of accuracy and total information presented almost doubled when diagrams were utilized. Training public school students in drawing state diagrams was initially successful. This technique was discussed in terms of ease of application and quality of information communicated.
ACKNOWLEDGEMENTS

This study was done to partially meet the requirements for a Specialist in Education degree under the School Psychology program at Western Michigan University. The author wishes to thank two people who have persisted in their encouragement and help over several years. I thank Howard E. Farris for his continual assistance in developing this project and whose interest in State Diagramming made this study a reality. I also wish to thank William K. Redmon for providing the author with deadlines and objectives to meet in completing this paper. Both have helped by reading drafts and suggesting revisions throughout the writing of this thesis. Lastly, I wish to thank the Schoolcraft School District for allowing the author to conduct research at its facilities. The author is now working for the Van Buren Intermediate School District in Lawrence, Michigan and communications should be directed there.

Roger S. Coates
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Western Michigan University

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INTRODUCTION

Schematic visuals have provided information and directed human behavior from ancient pictographs to flow charting used in computer technology. Educational technology has also made use of such schematic visual aides. In the area of special education, the National Association of State Directors of Special Education, 1976, printed a collection of flowcharts to accompany verbal explanations of the functions of due process committees under Public Law: 94-142. The rationale for this was the ease in which time restrictions and alternative actions could be shown. It allowed a school committee to trace its path through the due process procedure for suspected and identified handicapped students according to the federal law.

More directly related to the technology of education, is the use of visuals by Baker (1978). A curriculum used in teaching was developed using the technique of assigning stages of instruction to columns and specific activities to rows underneath the columns. Arrows connecting these activities specified the inputs that were necessary for the completion of the activity. This method showed when tasks had to be accomplished before a certain activity was started and it allowed planning for resources to meet deadlines when several separate tasks served as inputs. In the teaching of psychology, Reese and Woolfenden (1973) taught behavior analysis skills to college students using a flowchart system. The schematic visual system was a teaching aide and provided students with a

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conceptual framework in which to do a behavioral analysis of specific social conditions. Specific questions in a sequence were answered and the answer given led to different questions. Students could determine what schedule of reinforcement or punishment was in use in a given example by using the system. In each of these three examples, the visual aides directed behavior through a series of steps in an applied situation.

Snapper, Knapp, Kusher, and Kadden (1967) designed a descriptive system that extended flow charting from computer technology to describe the wiring of apparatus used in experimental psychology studies. The analytical-descriptive technique was called "state diagramming." The term "state" applied to the experimental conditions, or stimuli, present at a given time in an experiment. State diagramming was advocated to serve as an aid not only in replicating the experimental procedure, but also to convey the conditions of the actual experiment being conducted. These authors believed that the state diagram could be effectively used in every experimental psychology article as a type of graph to accompany the method section in a journal article. It was characterized as a clearer way of presenting the information as compared to written narrative form. The arranged sequence of steps and the effect of the subject on this sequence could be clearly and concisely described in the visual format.

Farris (1976) was the first to use this state diagramming system to describe the environmental conditions that human subjects operated under in an educational environment. A collection of behavior management systems in public school classrooms was presented in both
a narrative and state-diagram format. The state diagram was included to make the management program better understood while the written narrative provided information to supplement the terminology and labels used on the state diagram. The idea of using state diagramming as a behavior management tool was proposed by Farris and Kiley (1977). It was believed that the clarity of a schematic visual made it easier to recognize possible management problems in a classroom. When combined with training in behavior management techniques, the state diagram information could be used to provide actual prescriptions to make an instructional program more effective in the classroom.

The present study attempted to show state diagramming as an effective system for relaying information about classroom programs in comparison to written narrative descriptions, the ease in which the state diagramming system could be taught and to what degree of reliability, and the effect of state diagramming classroom programs on the quantity and quality of information obtained. In each of the three experiments, the results are discussed in terms of potential benefit and utility to public education.
EXPERIMENT I

A description of teaching procedures in a classroom must convey relevant information to all people that must use the information. Various descriptions can be judged by how effectively they allow people to respond to the information conveyed (Bijou, Peterson, and Ault, 1968). The typical way of describing a teaching activity is by using oral or written language. School personnel can show their comprehension of the information by paraphrasing the contents or by answering questions using the information. State notation is an alternative way of describing teaching routines. To be effective as a communication tool, it must be comprehended as well, or better, than a written description. It also must show utility by conveying information to school personnel untrained in state diagramming and be appropriate as a way of describing a variety of teaching programs. The purpose of Experiment I was to show that state notation could accurately relay information about a variety of teaching procedures to a spectrum of school personnel without explicit training in the state-diagramming format.

Method

Subjects

School personnel were selected to provide a sample of people responsible for making decisions about teaching procedures and for serving different functions in school work. A high school principal,
a guidance counselor, a vocational-education teacher, a high school chemistry teacher, and an elementary principal were asked and agreed to be the subjects for the study. Each subject had little or no experience using the state diagramming technique. Subjects were told that their participation would help the experimenter perfect the technique. The experimenter suggested improvements could be made so that a variety of school staff could comprehend classroom descriptions in state notation.

Setting

A variety of settings were used within the school system; a small, rural, public school with a student enrollment of about 1,000. The settings remained the same for each subject throughout the study but varied between subjects based on the space available during the experimental sessions with each subject. A teacher's lounge, approximately 20 by 35 feet, was used with the guidance counselor and the chemistry and vocational-education teachers. The setting for the two principals was their offices which were approximately 15 by 20 feet. Each setting was well lit and ventilated. The offices were quiet, while there was always some talking present in the teacher's lounge. Each subject participated at the same time and day throughout the study, although the times varied between subjects.

Materials

Six classroom descriptions were developed using a state diagram and written narrative format. A ten question, short answer essay
quiz was developed for the six different classroom descriptions.

Procedure

A written description of a teaching program was obtained for each state diagram of a program. Written descriptions of these programs were obtained by taking the exact labels from the states and transitions of the state diagram. These labels were arranged in correct sequence. Words were added only to make the written description appropriate for English grammar and syntax. Six teaching programs were chosen for their variety. They varied in complexity from seven to twelve different teacher activities. The classes described included several grade levels and both regular and special education classes.

Individual testing sessions lasted with each subject between 15 and 20 minutes and were held each week at approximately the same time for a total of six weeks. The sessions consisted of a brief restatement of the purpose of the study and presentation of a classroom description of a certain format. These descriptions were drawn or typed on standard size white paper. A written test was also presented at this time. It had ten short answer essay questions. The subjects were told to write the minimum required to answer the question. A stop watch was used to measure the time between presentation and completion of the test. Occasionally, a subject asked a question or was interrupted. Time during these incidents was not counted and the watch was stopped. Any question asked by the subjects about the descriptions or test questions were answered by noncommittal statements such as; "Do the best you can," or "The way you interpret that is good information for the study."
Experimental Design

There were two experimental conditions for each subject. These were the two formats used when describing each classroom program: 1) State Diagram (S), and 2) Written Narrative (W). There were also six different classroom descriptions numbered one through six. In all, this made 12 different ways in which classroom designs were presented. Each subject responded to six descriptions, three S and three W format descriptions. The description-presentation order was based on a random selection for two pairs of subjects and for a single subject. Table 1 shows the order of presentations for each subject. For every subject, the description format, W or S, alternated by the weekly sessions so that a subject never received the same format of a description for two consecutive weeks. Subjects 1 and 3, and Subjects 2 and 4 were paired. Each pair of subjects received the same classroom description, but one subject had a S format and the other subject a W format. For instance, if Subject 1 was given a W format description of classroom #1, the paired subject, Subject 3, would receive a S format of the same classroom description. The fifth subject was given the order of classroom description on random assignment regardless of the other subjects.

This experimental design approximates a multielement design (Ulman and Sulzer-Azaroff, 1975), a design where experimental conditions are presented over a relatively short period of time. In this experiment the S and W conditions alternated by week. The possible effects of presentation order was controlled for by pairing subjects and starting them under opposite conditions. In this respect, an
<table>
<thead>
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<th>Format</th>
<th>Subjects</th>
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<tbody>
<tr>
<td>1</td>
<td>1 5 1 5 1</td>
<td>S S W W S</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4 1 4 1 3</td>
<td>W W S S W</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5 3 5 3 6</td>
<td>S S W W S</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3 2 3 2 5</td>
<td>W W S S W</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6 6 6 6 4</td>
<td>S S W W S</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2 4 2 4 2</td>
<td>W W S S W</td>
<td></td>
</tr>
</tbody>
</table>
A-B-A-B-A-B design was matched with a B-A-B-A-B-A design.

Results

All five subjects completed the testing sessions and stated a preference in writing for one of the two descriptive techniques. Performances were judged as a function of the number of correct answers per minute. This allowed consideration for both the speed at which a subject could locate information from the descriptive technique and the degree to which the correct information was obtained. The results of the weekly test session in Figure 1 show the subjects' mean performance on various written narrative and state notation descriptions in the order by session in which they were presented. There appeared to be no significant practice effects over time as the test score means over the first half of the sessions were 1.441 compared to a mean of 1.446 for the second half of the sessions. There appeared to be little difference between subject's performance on the written narrative and state notation descriptions. The mean test score for subjects when using the state diagram style was 1.5 compared to the mean of 1.32 for scores obtained using the written narrative style. In real terms, this difference represents one additional correct answer every five minutes. Table 2 presents the test scores obtained on state diagrammed and written descriptions when these descriptive techniques described the same classroom program. The mean correct answers per minute for classroom descriptions 1, 3, and 4 were slightly higher overall than the other classroom descriptions. These same descriptions had the least number of discrete teacher
Figure 1. Experiment 1—Mean correct responses per minute for the two pairs of subjects (Subjects 1-2 and 3-4) across the experimental sessions (1-6) for the classroom description formats in State Notation or in Written Narrative format.
Figure 1.
Table 2

Mean Number of Correct Answers Per Minute for Classroom Descriptions (1-6) Using State Notation and Written Narrative Styles

<table>
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<th>Description</th>
<th>Notation</th>
<th>Narrative</th>
<th>Components</th>
</tr>
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<tr>
<td>#1</td>
<td>1.91</td>
<td>1.61</td>
<td>8</td>
</tr>
<tr>
<td>#2</td>
<td>1.27</td>
<td>1.05</td>
<td>12</td>
</tr>
<tr>
<td>#3</td>
<td>1.34</td>
<td>1.46</td>
<td>8</td>
</tr>
<tr>
<td>#4</td>
<td>1.68</td>
<td>1.26</td>
<td>7</td>
</tr>
<tr>
<td>#5</td>
<td>1.46</td>
<td>1.33</td>
<td>10</td>
</tr>
<tr>
<td>#6</td>
<td>1.21</td>
<td>1.29</td>
<td>12</td>
</tr>
</tbody>
</table>

activities and were therefore less complex. It appeared subjects had a preference for the state-diagrammed style specifically for classroom descriptions 1, 2, 4, and 5 since subjects scored better than their counterpart pair having the same classroom description but in the written narrative style. These descriptions included classrooms having the most and least number of separate teacher activities and ranged from relatively simple to complex. The written narrative style for classroom descriptions 3 and 6 showed a slightly higher subject performance than subjects receiving the same classroom description but in the state diagrammed notation. The mean of the subject's performances on each classroom description was varied. This was hoped for since classroom routines were chosen to provide a variety of subjects and teaching methods. Subject performance over all of the classroom descriptions revealed a slight preference for the state notation style.
Table 3

Mean Number of Correct Answers Per Minute on Classroom Descriptions for Subjects (1-5) Using State Notation and Written Narrative Styles

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Notation</th>
<th>Narrative</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.06</td>
<td>3.69</td>
</tr>
<tr>
<td>2</td>
<td>3.23</td>
<td>4.36</td>
</tr>
<tr>
<td>3</td>
<td>4.25</td>
<td>4.18</td>
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<tr>
<td>4</td>
<td>5.11</td>
<td>3.44</td>
</tr>
<tr>
<td>5</td>
<td>4.85</td>
<td>4.16</td>
</tr>
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The mean performance scores for Subjects 1, 3, 4, and 5 on state-diagrammed classroom routines were higher than their performance on written narrative style descriptions. Subject 2 showed a mean performance score slightly favoring the written narrative style. The data on performance by subjects was consistent with the subjects' stated preference for one of the description formats. Only Subject 2 reported a preference for the classroom descriptions presented in the written narrative style.

Discussion

The purpose of Experiment I was to determine the extent to which state diagramming could convey information on teaching procedures to relevant school personnel. The results showed no practice effects on subjects' performances over time and no clear distinction between the
complexity of the classroom description and a preference in format style. There was a slight improvement in performance for classroom descriptions that were less complex, but this improvement was shared by both state diagramming and written narration. The mean subject performance favored the state diagramming style to the rate of one additional correct answer per five minute period. Data were reported in terms of a rate of correct answers per minutes as the best measure of communication. In half of the sessions subjects needed more time to answer questions of classroom descriptions presented in the state notation style.

If only a measure of accuracy was taken all but two of the six sessions would show better mean accuracy for the subjects receiving a state-diagrammed description. As the reported results show, all but one subject did better on the mean performance rate measure taken for the state diagrammed presentations. These four subjects that did better overall when shown a state diagram also stated a preference for the state notation format. One subject commented that state diagrams were easier to refer back to for information after reading a test item. Another subject stated a preference for visual diagrams in general and that he used visuals in teaching his classes. The other two subjects said the visual summary of classroom activities made it easier to see when changes occurred in the classroom. The lone subject preferring the written narrative style said that lack of training in state diagramming made the written description style easier to understand. It is interesting that all subjects stated a firm preference even when they had the option of stating no relative preference.
This study appears to validate applied state diagramming as a useful communication tool in a way Snapper, et al., advanced for experimental research studies. The very nature of applied settings make it impossible to use the technique in applied conditions in the same way, but some of the same benefits appear to be present. In experimental conditions the researcher has control over all stimulus conditions, response opportunities, and sometimes the response topography. In the applied state diagrams, possible responses and outcomes had to be included. Perhaps this makes every applied use of diagramming relatively more complex.

It can be argued that state diagramming is a cost-effective procedure as no subject training occurred prior to the experiment. Subjects also did not become trained over the course of the study as their test scores on the first and second half of the experiment were practically the same.

This study limited itself to the question of communication. Other research follows in Experiment II and III to show the degree it is possible to train observers and use the system as a diagnostic tool. But additional research in the area of communication could explore its uses with parents and school-wide systems. The scope of a diagram could possible include school related sequences besides classroom programs. Attendance policies, discipline procedures, and requirements for passing grades might be best explained through a state diagram format. It could be that any educational sequence that can be written using observable behaviors, contingencies, and consequences can also be effectively diagrammed.
EXPERIMENT II

This experiment attempted to determine the extent to which teacher aides, or non-professionals, could be trained in the use of state notation. The use of non-professionals has been reported in a variety of journals and for different training outcomes. It has been studied with high school students learning to teach mentally impaired students (Gladstone and Sherman, 1975), with a paraprofessional trained as a teacher consultant (Moser, 1973), with a mother as a therapist (Zeilberger, 1968), and even with an elementary student trained as a behavioral engineer (Surratt, Ulrich and Hawkins, 1969).

Non-professionals could likely be trained in state diagramming if adequate instruction could be provided, i.e., if the observational system could be readily explained to someone without a history of similar training. If this were the case, several positive features to state diagramming would be added. One feature is the possible economic and implementation value of having aides trained. Another is the assumption that more skilled educators (e.g., teachers) could be trained just as easily as the aides.

Public schools have many non-professionals currently being employed or just "available." Non-professionals as teacher aides or tutors may be salaried workers but high school students are often just given credit or release time. Since they are paid below teacher salaries and more often free, it is a cost effective way to provide educational services needing little training to implement. Aides, or
non-professionals, are less costly and tend to be available in general. Schools may feel that observational data are not worth the expense of a teacher's salary. Aides can be directed or employed by the classroom teacher to have this done.

Classroom observations, diagnostic testing, and also state diagramming are difficult for a teacher solely in charge of a class. It can be expected that classroom teachers would not be willing, have the time, or be required to observe their class and develop a state diagram. Training teacher aides makes it more likely that classroom programs would be state diagrammed. Aide availability was one consideration when the experiment was designed. It can be assumed, however, that a trained educator would perform as well or better under similar conditions.

Method

Subjects

Four high school students were selected as subjects based on their permission and time available to be in the study. Each subject attended the school district which was the setting for Experiment I. All subjects were judged by their teachers as being responsible and competent in academic subjects. They were all 14 years old, one male and three females.

Setting

The study was conducted in a standard classroom with six large tables, approximately 24 chairs, and 30 X 30 feet in size. During the
time the study was conducted, the classroom served as a study area for other high school students. The subjects were all aides that helped to conduct the study sessions in the classroom. The four subjects helped on the average two students each Tuesday and Thursday for an hour in the afternoon when the study service was available. This allowed the subjects of the study at least 15 minutes of open time in which the present experiment was conducted.

Materials

Written materials were developed for the study along with lecture notes to be used by the experimenter. The materials consisted of classroom descriptions in a narrative format for each of the experimental sessions. These were similar to the narratives used in Experiment I. Typing paper, the only other material, was provided for the subjects when drawing state diagrams.

Procedure

A multiple baseline design across subjects (Baer, Wolf and Risley, 1968) was used to show the acquisition of skills for diagramming classroom events with the state notation system. Seven sessions were conducted in total. Additional sessions were scheduled but for various reasons could not be held. Each session was 15 to 30 minutes long. Sessions for the subjects followed an established sequence of four conditions which were staggered across subjects so that no one subject received the same training condition during a session. This allowed a multiple baseline across subjects design.
Each condition existed during one or two sessions for each subject with the exceptions of the initial condition. The Baseline condition was presented a different number of sessions for each subject to establish the separate training conditions. The sequence of conditions started with Baseline and proceeded with Training on State, Training on Vectors, and Training on the Combined Use of Vectors and States.

Under Baseline Condition the subjects were told the purpose of the experiment and that they would learn to describe classroom programs in state notation. Their activities during the Baseline Condition were simply to provide information on their skills prior to training. The subjects drew a state diagram after receiving a written narrative description of a classroom instructional program. The experimenter told the subjects that states were drawn with circles and vectors were drawn as arrows. The first training condition was Training on Vectors, vectors being one of the main components to a state diagram and often the easiest to identify. The experimenter explained the following rules for identifying a vector with both oral examples from high school classes and with written classroom descriptions.

a) drawn as a line with an arrow,
b) drawn to connect two states,
c) drawn to specify what allows a student to move from one state to another,
d) drawn anytime the type of student activity changes,
e) vectors are always the completion of work to some criteria, the passage of time—either fixed or variable, some other
condition in the classroom being met, or a combination of any of the above.

After presenting these rules, the experimenter applied the rules to determine if events taken from the previous session's baseline test could be considered vectors. A series of examples and non-examples of vectors were then given the subject. Always two possibilities were given that differed by only one critical feature for the event to be considered a vector. At the end of the 15-minute training session all the subjects were again given a written description to draw in state notation. The second experimental condition consisted of training on the identification of states. The same training system was used. Subjects were taught the following rules governing states and they demonstrated application of the rules to given examples:

- drawn as numerated circles,
- represent stimuli in the student's environment,
- stimuli are included as states only if they come in contact with the student in ways that are educationally relevant,
- states are often teacher behaviors, but can also be things that the teacher has arranged to occur in order to teach the student.

Examples and non-examples were again given to firm the discrimination being taught. Training started using the previous session's test. The test results were explained to subjects in the experimental conditions and all subjects were given a new classroom description to diagram at the end of the session. The third experimental condition
consisted of a review of the rules governing states and vectors. Examples of a vector and state or state and vector combinations were given the subject in written form. The subject had to then use the description to draw an appropriate state diagram. When the subject had completed several of the two component descriptions correctly, larger descriptions were given. The only additional rules were the following:

a) all states must have at least one vector connected to it but may have additional vectors,

b) all vectors connected to a state must be mutually exclusive.

After the session of training a written classroom description was again given the subject to be drawn in state notation.

The subject's descriptions were coded for three types of information. Coded as states were any circle drawn with a description of a behavior or ongoing activity when this description was actually stated in the given written description to diagram. Vectors were coded when a description of a criteria being met by some means was given over a drawn arrow. Vectors had to be instantaneous events and have had been included in the written description given. The third code, Connections, applied to the number of correct pairs of states and vectors occurring in sequence according to the written description. Pairs of first a state and then a vector counted as one connection. Every possible correctly connected pair in the diagram was coded as a connection.
Results

Written diagrams by the subjects were analyzed for a percentage of the total number of coded instances possible. The data are presented in Figure 2. For Subject 1, the percentage coded correctly increased as the training conditions advanced. Baseline data rose 14% to 52% with training on vectors in the second training session. Subject 1 received this additional training session as the initial training session ended prematurely and time prohibited her from completely coding the written test description. Training on states and combinations of states and vectors showed accuracy of 84% and 83% respectively. Subject 2 showed the following mean percentages by each condition. Baseline resulted in 25% accuracy, vectors showed 96% accuracy, and states resulted in 86% accuracy. Only one training session for states and for vectors were conducted but the subject remained in the Baseline condition for four sessions. Over these sessions the scores ranged from 15% to 31% accuracy. Subject 3 was only able to complete the Baseline and Training on Vector conditions. The results under Baseline showed a range of 7% to 32% accuracy with a mean of 21%. After the single training session on vectors, this accuracy rose to 57%. The fourth subject remained in the Baseline condition throughout the study for a total of four sessions. These baseline scores ranged from 21% to 43% accuracy with a mean of 28%. There was a slight but consistent improvement in the scores over time in spite of not receiving any formal training in the state diagramming system.
Figure 2. Experiment 2—Percentage State Diagram components from the total number of components possible in the six written narratives as presented to the subjects over the six sessions. Baseline data was interrupted for Subjects 3 and 4 due to absences. The open circle for Subject 1 in the third session represents data obtained only on the vector component of the written narrative due to limited time available.
Figure 2.

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Discussion

The results of the experiment showed that high school students could be trained in the state diagramming procedure to correctly interpret a written description into a state diagram. This was shown by various training conditions resulting in improved subject performance. Subject 1 who completed the three training conditions improved from 14% to 83% accuracy. These gains were shown as training occurred on states and vectors. In the last training condition, the subject scored a percentage point lower than the previous session. The subject's raw score of coded instances were the same in each case but the written description to be diagrammed in the last session had three additional code opportunities. This subject was the only one to receive two training sessions under the same experimental condition. The first score obtained after initial training on states was obtained by having the subject diagram the given written description only in terms of states. This was done because of a lack of time remaining in the session. Although the subject was asked to diagram only the states, the percentage of accuracy was taken on the total number of code possibilities. This was the only instance where a subject was asked to diagram less than the total written description given at the end of a session as the assessment test. The percent in accuracy of states alone improved from 23% to 43% after this initial training session. Subject 2 also showed gains after training. There was a near perfect performance after the single training session on states. Subject 3 showed a 25% increase in accuracy. There was only a slight increase
in rate over that shown under previous three baseline conditions. Subject four remained in Baseline throughout the study but showed slight increases in accuracy over this time. The ascending baseline was lower in accuracy and had an apparently level rate in contrast to the performances of the other subjects that received training conditions.

The study would have benefited from additional data obtained through continuing the experimental conditions until Subject 4 had received training in the combined use of states and vectors, the last experimental condition. This would have been done if not for various activities the subjects had to participate in near the end of their public school year.

Future research in training subjects in the use of the state diagram notation could be done in diagramming actual teaching environments in operation. This study has shown a modest development of skills in transcribing written narratives to a state diagram format, but generalization of this training to applied situations was not assessed.

Even though the final product of training in this study resulted in accurate transcribing of printed material into a state diagram format, this was accomplished with a minimum amount of training and with subjects having no previous experience with behavior measurement systems. It seems reasonable to expect a dynamic training program—a program including longer training sessions, more frequent weekly training sessions, and audio-visual equipment—to generalize to accurate state diagrams of observed classroom programs.
EXPERIMENT III

In the previous experiments state diagramming has been studied in terms of a communication tool and a trainable observation system. Still, the usefulness of a classroom teacher in altering or modifying teaching techniques has not been researched. The purpose of this experiment was to show the utility of state diagramming as a diagnostic tool.

Teachers have the most current and often most complete information on the instructional designs used in their classroom. It is often possible that information a teacher has on their teaching routines is sufficient to help trained instructional specialists, classroom management consultants, and other school support personnel to offer educationally significant suggestions. A difficulty arises in obtaining this information however. Teachers may have problems targeting what information is useful. When asked to describe what they do to provide a learning experience it is possible that only sparse information will be provided or that educationally irrelevant information will be given. If a technique could be used to minimize these problems it would be a useful diagnostic tool. It would clarify the information a teacher is able to relate and point out areas in need of additional work or even show possible remedial strategies.

Experiment III attempted to show that subjects trained in the state diagramming technique would provide more and better information than when untrained. It was an attempt at "structuring" their
approach to describing a learning situation and thus, obtaining more relevant information than the subject could previously give.

Method

Setting

A college lecture room approximately 40 X 80 feet having rows of fixed seats gradually rising toward the back of the room was the setting for this experiment. Students sat in alternating seats throughout the room. Lighting was furnished by fluorescent overhead fixtures and in the front of the room blackboards were available on the wall.

Subjects

Twenty-four college graduate students enrolled in a psychology class in learning principles were the subjects that participated in this study. The class met one day a week for a total of three hours. The subjects' educational background varied considerably. Some of the graduate programs they were enrolled in were Flight Technology, Special Education, Teacher Education, and Psychology. The general purpose of the class was to teach learning principles having teneral utility. As a component of the course, class projects were done in which subjects applied class instruction to their particular setting. One of the projects dealt with classroom management and a state diagram description of their class was a graded section of that project.
Materials

The subjects supplied their own pencils, pens, and lined paper. They were given a sheet of blank paper to be used when drawing a state diagram. No other materials were used by the subjects. The blackboard was used by the experimenter when illustrating lectured instruction.

Procedure

After the subjects had entered the classroom having already completed a quiz and taken a break, a lecture was delivered by the experimenter. The subjects were told to describe in detail a learning sequence they had developed, experienced, or witnessed. Subjects described a teaching routine that they were currently using, a time when they gave instructions to their children, or made up a learning sequence. In any case, five discrete learning activities were required as part of the description. They were also asked to describe all the things they did as teachers to have these activities occur as well as any materials or environmental conditions that were necessary for the learning to occur. They wrote these descriptions on notebook paper in the approximate 20 minutes provided. The experimenter, a doctoral student, and the course professor moved around the room to answer any student questions during this time and aided subjects in construction of the five-step learning sequence. The lecture continued with instruction on the vector component of the state notation system. Subjects were told vectors met the following conditions:
a) can be worded as a criteria for moving a student from one instructional condition to another,
b) can be a condition being met by a student or teacher behavior,
c) can be an environmental condition being met,
d) can be the passage of a certain length of time,
e) are drawn as arrows with a descriptive label given,
f) must all be logically possible and mutually exclusive if they occur at the same time in a learning sequence.

A vector was drawn on the blackboard along with the key term: "criteria". States, the other component to a state diagram, were described next. Rules for states were given as:

a) a student, teacher, or environmental condition that could last some time period,

b) an activity usually describing a student or teacher's ongoing behavior,

c) a circle drawn with a descriptive label written inside.

A sample state was drawn on the blackboard with the key word: "activity". Lastly, the experimenter did a sample classroom description on the board showing how to identify criteria and activities inherent in a classroom description. Descriptions were read and the subjects were asked to identify examples of vectors and states. The possibility of several vectors, or exit criteria, from one state was discussed. Also discussed was the way to show several different vectors, or criteria, leading to the same state, or activity. Students were told to number states 1 through X in the order in which
they occurred in the instructional procedure. They were then asked to use their completed written description and do a state diagram of the same five-step learning sequence. They were asked to include all their information about state diagramming and to again include in their description all student and teacher behaviors, and environmental conditions that were necessary for the learning sequence to occur.

Subjects were told that participation in the exercises would allow them to receive feedback on their mastery of the state diagramming system before it was due as a part of their course project. Students were given approximately another twenty minutes to complete the diagram. During this time assistance was provided to students with questions. At the end of the time period, both the state diagram and the written descriptions were collected.

Experimental Design

The experimental question was whether state diagramming would function as a diagnostic tool by identifying instructional features in a teaching or learning sequence. To measure this, both the written narrative and state diagram descriptions were analyzed for six possible components: 1) teacher behaviors, 2) student behaviors, 3) environmental features, 4) teacher behavioral criteria, 5) student behavioral criteria, and 6) environmental criteria. A simple A-B design replicated across various subjects was the design employed. A frequency count of the six possible components were done for the pair of descriptions by each subject.
Results

Reliability checks were made on six classroom descriptions. Reliability was tallied for each of the six description codes possible and was calculated using the number of code occurrence agreements. Written narrative coding reliability ranged from 40 to 100 percent with a mean of 92 percent. State diagram coding reliability ranged from 67 to 100 percent. Its mean was 96 percent.

Pre and post training data are shown as means for all subjects for each of the possible description codes. The results indicate a general increase in the information given by subjects when employing the state diagramming technique. This particularly was shown with an

Table 4

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<th>Frequency Count of Description Code Instances</th>
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<tr>
<td>TB</td>
</tr>
<tr>
<td>Written Description</td>
</tr>
<tr>
<td>State Diagram</td>
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<tr>
<td>Difference</td>
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increase of 117 instances of student behavioral criteria being specified from a written description of eight instances to a total of 125 instances for the diagrammed description. The second highest increase in code instances was for student behaviors. An increase of 27
instances, a 81 to 108 increase, was shown using the diagramming system. All other categories, except teacher behaviors, showed modest increases in the state diagrammed descriptions. Examples of Teacher Behavioral Conditions were specified 10 more times from a total of three written description instances. Environmental Conditions were doubled, but only resulted in a single actual addition to the one instance given in the written description. Environmental criteria tripled in frequency with the seven diagrammed examples as opposed to the two written description examples. The remaining category, Teacher Behavior, decreased from 90 to 75 instances. These 15 examples were lost when the state diagram system was used. The total amount of information included in the state diagrammed descriptions over that in written descriptions was 145 for the 22 sample pairs. This is an average of 6.2 more pieces of information per classroom description. Figure 3 shows pre and post test data by subject for instance of Teacher and Student Behaviors. The mean number of Teacher Behaviors identified per diagram was 4 under the written description and 3.4 under the state description, a decrease of .6. This average drop from written to state descriptions was with a range of -4 to +6 additional pieces of information. When describing Student Behavior there was a mean increase of 1.2 instances from the written to the state descriptions. The mean for states were 4.9 with written descriptions being 3.7. There was a fairly consistent increase with the range of -2 to +9 instances of additional information included on the state description. The most varied results from pre and post data was the frequency of Student Behavior Criteria. There was a mean
Figure 3. Experiment 3—The instances subjects (1-22) included examples of criteria (either teacher, student or environmental) on both the written narrative and the state diagram.
Figure 4.

Written Narrative
- Teacher Behavior
- Student Behavior

State Diagram
- Teacher Behavior
- Student Behavior

Instances of Behaviors Stated

Subjects
Figure 4. Experiment 3--Instances of behaviors stated by the subjects (1-22) for both teacher behaviors and student behaviors on both their written narrative and subsequent state diagram.
Figure 3.

Instances of Criteria Stated

State Diagram
Written Narrative

Subjects
increase of 5.3 pieces of information in favor of state diagramming. New information was included on all but one of the subjects' descriptions.

Discussion

The results of this experiment showed the possibility of the use of state diagramming as a diagnostic tool for rapidly trained graduate students from dissimilar educational backgrounds. This was shown in the overall increase of information provided on the state diagrams and, in particular, the increased information in the criteria stated on the state diagrams. As the introduction related, the results of this increased information were not unexpected. However, the form in which this occurred was informative. There are several ways that clearly could have increased the power of the state diagramming technique through the training procedure. When the results are evaluated, several possible explanations are possible to account for the changes between information provided on the state diagramming and written narratives.

Increased information is shown by the raw number of coded examples from the descriptions provided by the subjects. A total of 185 coded instances were found on the 22 written descriptions compared to a total of 330 instances of state notation. The state diagrams tended to view the teaching procedure from the student's point of view as opposed to the teacher's as there was a greater number of described teacher behaviors with the written descriptions and a considerable increase in the described student behaviors with the state diagrams.
There were four subject description sets that showed a complete shift from the written description to the state description by either having zero student behaviors under the written description or zero teacher behaviors under the state diagram when the counterpart description contained most of the information on behaviors in those categories. It was unforeseen that subjects would alter their perspective of the teaching procedure in this way as a result of a different description technique. Using one of the subject's pair of descriptions it is interesting to look at the wording used when stating behaviors to occur in the teaching procedure. On the written description, the following behaviors were stated: 1) teacher says, "line up at sink;" 2) teacher says, "wash and dry your hands for lunch;" 3) teacher puts lunch bags on the table; and 4) children sit at the table. Compare this to the state diagram description: 1) teacher says, "line up at the sink;" 2) students wash hands and dry; 3) children sit at the table; 4) children take their lunches out of the bag. In the written description there were three teacher behaviors and one student behavior stated. The state diagram stated three student behaviors and one teacher behavior. This sample pair of descriptions show a learning situation from different viewpoints. The tendency to do the state diagram from the student's point of view was found on exactly half of the 22 pairs of classroom descriptions done by the subjects.

Comparing the total number of behaviors stated on the descriptions there were only 13 additional coded instances on the state diagrams over the total found in the written descriptions. The increase in information found on the state diagrams was primarily due to subjects
including descriptions of criteria present in their described teaching program. With only one exception, every state diagram included more criteria. This amounted to a total of 127 new pieces of information. The specification of criteria is an important aspect of an effective instructional program (Becker, Engelmann, and Thomas, 1975). The nature of the state-diagramming description technique requires criteria to be stated in order for the students to move from a learning condition, or state. If subjects failed to state a criteria there would be a blank arrow connecting these states or an incorrectly labeled arrow. The rules governing the form of a descriptive technique are an effective way to obtain types of information (Depert, 1979).

Depert developed a matrix which forced educators to revise their techniques or materials for instructing students based on target population data within the matrix. Flow charting is another such example (Spencer, 1973) as the geometric shapes used to enclose labels have rules governing their use and these rules relate to a future working computer program. It is interesting that subjects failed to state a criteria but drew a blank arrow to connect states only three times. It must not have been difficult for the subjects to recall criteria present in their teaching procedures as a total of 138 were given and the subjects had less than twenty minutes to complete their entire state diagram. To take an actual description: 1) students put materials away and sit quietly when signaled; 2) students get up by row and dress for recess on command; 3) students line up by the door. Corresponding to these three statements a state diagram was done. The letters "s" and "t" respectively stand for a state and a
transition as drawn by the subject and labeled: 1) t, recess bell rings; 2) s, students put materials away and sit quietly; 3) t, materials put away and students are quiet; 4) s, teacher points to a row; 5) t, row is indicated; 6) s, students in row go to the lockers; 7) t, students at locker; 8) s, students dress for recess. This is a fairly typical pair of descriptions. The state diagram presents information in smaller units and tends to present more information. In the example given there is a discrepancy between the two descriptions. It was common for the pair of subject description to be somewhat different in content. In the sample written description above, the students are to wait at the door after their row has been called to recess. The state diagrammed description has the students leaving the room by rows after being chosen for recess because they were quiet. The discrepancies between the written and state descriptions can be accounted for because of the added information given when including more criteria on the state diagrams.

When looking at the criteria specified on the diagrams, there was an overwhelming number of criteria given in terms of student behaviors. Only 15 of the 138 examples from the state diagrams were criteria other than a student behavioral criteria. It is understandable why subjects chose to include more student behaviors to meet a criterion, afterall, a teaching program depends more on what the students do. The teacher's behavior is meaningful to the extent that a desired student behavioral outcome is achieved. The emphasis on student behaviors meeting a criteria might account for the shift in the types of behaviors described from the written to the state descriptions. As
explained earlier, the state descriptions included more student behaviors at the expense of excluding teacher behaviors, while the written descriptions did the opposite.

The training procedure used in this study may not have been the most powerful system. There were only three monitors for the group of 22 plus subjects. Training time was marginal. Explanations were given on the requirements of the written description for 20 minutes. About twenty minutes was again used to teach the state diagramming system. Training was done in a lecture format. Didactic instruction is not as effective as techniques that allow small learning steps, differential feedback, possible remediation and review, and active participation. These techniques would be possible if training took place over a longer period of time or with smaller instructional groups. It is interesting that subjects learned while given only a minimum of instruction. It would be worthwhile to attempt a similar study with additional training as in a school in-service.
DISCUSSION

The three experiments show features of the state diagramming technique for educational purposes and point out some advantages to current practices. It is shown through Experiment I that the technique did not hinder communicating educational information with naive evaluators. In fact, state diagramming facilitated the transfer of information gathered as shown by three of the five subjects in a measure combining speed with accuracy. The second experiment showed that it is possible to train observers to use the state diagramming technique regardless of previous experience in education or data collection. Although Experiment II had to be terminated somewhat prematurely it is possible to see the ease in which the para-professionals were trained. The last experiment showed how a classroom of college students rapidly identified relevant educational conditions with a minimum of training in the state diagramming technique. The identification of significant conditions present in their own classrooms or educational experiences was accomplished only after training in state diagramming. Together, the experiments show the state diagramming tool to be an effective and efficient addition to current educational practices.

The advantages of an observation or descriptive technique is only as good as the ease in application and in the quantity of relevant information obtained. Bijou, et al. (1968), presents four characteristics that make raw data worthwhile in empirical research. This raw
information specifies objectively the setting of the study; defines and records behavioral and environmental events in observable terms; has a high degree of reliability; and provides procedures for collecting, interpreting, and analyzing the data. The authors proposed collecting data by written accounts of the time, the antecedent event, the response, and the consequent event. A chart with these four headings served as a format. Appropriate observer reliability was presented as a function of using codes, operational definitions, observer training, and of calculating reliability by a formula applicable to the situation. The authors proposed that the best manner to prepare data for analysis and interpretation was by using graphs, tables, writing, and statistics. Any system attempting to aide communication would have powerful utility in education to the extent the above conditions are met. State diagramming appears to be a useful tool in terms of the Bijou, et al. (1968) criteria.

In public education, classroom programs are usually described orally or in writing. Raw data, or information, in this written or oral form does not fulfill the criteria of usefulness (Bijou, et al. (1968). It follows no systemic procedure and therefore is likely to be variable in the information provided across settings and between educators. State diagramming may be a better technique to use in presenting raw data. Experiment III supports this notion. Subjects were better able to identify criteria expected by the instructor for the student and teacher behaviors when a state diagram was used.

The state diagram shows a complex stimulus-response chain and acts as a prompt for students while they are acquiring stimulus control.
(Skinner, 1953). State diagramming does more than provide information for retrieval, it can have an active part in changing the probability of a user's behavior if it in fact acts as a prompt. Suitable con-
sequence of student behaviors involved with meeting deadlines would be necessary for the posted diagram to acquire the stimulus control as a prompt.

There are other uses for state diagramming as a communication and management tool. Experiment III demonstrated the system as a diagnostic tool by increasing the amount of information on classroom programs that was relevant to antecedent, behavioral, and consequent conditions. The state diagram would likely facilitate parental understanding of these conditions also. It was easy for subjects to learn the diagramming system and get information from it without training. This use of state diagramming could help parents participate in alternative programming of their child's classroom. In the area of special education a structured communication tool is clearly important. The parents have a right to have the educational programming explained fully to them and to their understanding. They also have the right to participate in the development of their child's school program according to P.A.:94-142; The Rights of Education to the Handicapped. Also in special education instructional procedures often must be documented as appropriate to a student to meet the student's special education needs. The state diagram could be a communication tool to adequately explain these procedures regardless of the target population. State diagrams could be included in reports of individual education plans and be useful in due process hearings for contested special education.
programming. This is in line with the federal government's interpretations of the concepts of least restrictive alternatives, documented alternative attempts, and informed consent.

The possibility of doing a formal reliability on a classroom description is a useful feature. The second experiment showed the degree to which subjects were trained to have reliability with the experimenter. To the extent that reliability of a classroom description must be shown, as in a due process hearing, the state diagram has additional advantages. A high reliability between observers is an indication of "truth" or validity of the classroom description. Because state diagramming follows a structure of observation and coding that can be trained, reliability on a classroom program could be obtained and quantified.

It appears that the data obtained in Experiment III may apply well to teacher training. The analysis the subjects made was possible in a short period of time, approximately one hour. Instead of relying on consultant time which is often difficult to get, teachers may become their own consultants. Time and energy is again saved so that hired consultants could be more sophisticated in the analysis and developments of program modifications.

The practical, actual procedures to follow when diagramming a classroom has not been analyzed or discussed up to now. This analysis rests on the fact that states and vectors reflect pertinent responses and stimuli in an educational program. In state diagramming notation the state component includes ongoing activities such as seatwork, small group instruction, teacher directions, and other aspects of a
class that occur for a given amount of time. Often states identify teacher or student behaviors. As a general rule, a state describes a behavior or class of behavior. However, ongoing activities can be designed prior to classtime so that an important structure in a class exists without an observed behavior during class. Aspects of the environment that are necessary to appropriate behavior are included as states if they last an amount of time and are not transient. Learning centers, workshops, student work folders, and other structuring in the classroom environment could be an ongoing classroom feature pertaining to the instruction being conducted. These would also be considered states. In the state notation format, states are drawn as circles. A descriptive label is written within the state. Often this is elaborated in an accompanying written narrative. Each state is also given a number to aid in identification and location. The other component in state notation is the vector. As previously described, it is drawn as an arrow and connects states while representing the criteria necessary to move from one state to another. In this way the vector closely represents a stimulus condition. The vector is an instantaneous condition though. It is the initial change in the environment that counts as a vector. If this stimulus condition persists, then it would be included as part of a state. Vectors can be the accomplishment of a task at a predetermined level, the passage of time, or some condition being met by the environment. For example, a teacher could stop a lecture if the recess bell rings, a student's hand is raised, or noise is produced by student not attending to the
lecture. These environmental conditions are vectors for leaving the state of lecturing.

Because state diagramming can be analyzed in terms of stimuli and responses it is possible to collect raw data across all settings and subjects, but also on four levels. These levels allow at least three different comparisons to be made. The diagrams used in Experiment I included descriptions of elementary, junior high, and high school classes. Across these settings and students the same rules applied. The descriptions all happened to describe the classroom routines as they affected the entire class. In some cases the diagrams were done through direct observations but teacher verbal reports could also have been used. There seem to be four meaningful levels on which a diagram can be done. It is possible to develop a diagram solely on a verbal report, likely a teacher's report to a state diagramming consultant. Another level would be actual observations of a classroom program with states and vectors pertaining to the entire classroom. This level of diagramming would exclude classroom features and stimuli if they did not pertain to the class as a whole. A finer analysis level may be made by including a select group of students or a target student along with the diagram of the entire class routine. On the base level, an individual student's operation in a classroom can be diagrammed to include all observed behaviors. These four levels suggest three comparisons. The teacher's verbal report can be diagrammed and compared to anyone of the diagrams done by directly observing the class in operation. This comparison shows the degree to which the teacher's instruction design corresponds to what actually happens. It may give
information on the accuracy of the teacher's verbal reports and degree of the teacher's consistency. Another comparison crosses levels. Individual, or student group, diagrams in comparison with a general classroom diagram will show discrepancies. This difference between students and their peers can provide information on the success or need of classroom interventions. With small instructional groups, it could show critical periods of time when the small group needs teacher monitoring. It might allow better planning of instruction time to serve these students separate from the class while maintaining other instructional groups in the classroom. The last clearly separate comparison is made by diagramming from both a teacher and then a student perspective. It may seem curious to view teacher behaviors under the control of students, but it is useful in classroom management. This could be a less threatening way to present information to teachers. The goal would be for appropriate student behaviors evoking more teacher behaviors than inappropriate student behavior. It could also show a teacher to be under the control of stimuli other than the ones generated by students, e.g., the passage of time.

Before starting a state diagram, a decision must be made on the setting, subjects, perspective, and level of analysis. It would be important to specify classes of behaviors prior to any direct observations. For instance, what behaviors could in the behavioral class of "seatwork." Would sharpening a pencil be considered in this class of behaviors? As the level of the diagram becomes more basic it becomes more important to clarify behavioral definitions. A useful approach is to initially diagram a class based on teacher reports. Definitions
and clarifications in the observational system can then be made prior to actual observations in the classroom. It could be possible to establish a set of behaviors and stimuli and diagram an instructional program in only those respects.

In order to specify the advantages of state diagramming, a comparison between diagramming and other pictural representations of data is necessary. State diagramming is similar to other descriptive techniques such as flow charting (Spencer, 1973) and PERT charting (Cook, 1966). They all are a symbolic format based on rules; a pictoral sequential arrangement of events; and show the interrelatedness between these events. Even if these ways of presenting raw data are better than a written or oral description, state diagramming seems to be a more effective tool for educational use.

There are two basic components in state notation to show an instructional design. These are the state, a descriptor of ongoing subject behavior, and the vector, a descriptor of environmental conditions that must be met to move the subject out of a state. The connections of states and vectors show the sequence of activities and relevant stimuli that comprise the instructional design. In contrast, there are eight basic codes in flow charting. The "process" symbol typically indicates the use of a formula or some other process of data used in a program. In an educational sense this could represent materials used or a classroom routine. It does not relate clearly to the specification of behaviors necessary to participate in or arrange for the activity as the state diagram does with its vectors and states. A "decision" symbol is used when a yes or no question
needs to be asked. Each decision symbol requires this yes or no answer. In comparison, a state diagram vector states a criteria that must be met before exit from a state is possible. In education, often there are many possible conditions that allow a student's activity to change. In flow charting this type of presentation is not clear. Each possible option in a class would be charted using separate decision points. This is even misleading as options can exist at the same time in a classroom but these options must be charted as a series of decision points. Using a state diagram, the options are drawn as vectors exiting from a single state. For example, a student may leave an on-going activity (state) of seatwork if the teacher calls him to a reading group, if the recess bell rings, if a 10-minute work period has elapsed, or if the student completes the assignment. These possible exit criteria would all be drawn as vectors for leaving the state of seatwork. Notice that these vectors must only be mutually exclusive to be possible exits from the same state. As Bijou (1968) has pointed out, raw data should include all relevant behaviors and environmental conditions as they exist so in all cases the flow charting system would need alterations in the "decision" and "process" symbol rules. The other flow charting symbols are technically related to apparatus in computer use. A "flow symbol" is an unlabeled arrow that connects two, and only two other symbols to show the sequential order in the flowchart. The "terminal" indicates the beginning or end of a program. The "paper tag" and "document" symbols indicate the use of particular materials. The "connector" aids in showing the directions of a flow across other flow lines. The last basic symbol, "annotation", presents
an area for written clarification of a flow chart feature. These symbols and their use offer little or no advantage in comparison to state diagramming. State notation benefits from its simplicity, a factor likely making it possible to be as well understood as written classroom descriptions as found in Experiment I.

The Bijou, et al. (1968) article presents reliability and analysis of data as two other aspects for judging the usefulness of raw data. It is difficult to compare state diagramming with flow charting in these respects because no research has been done in this area. Experiment II shows the reliability obtained when training paraprofessionals in the state diagramming system. It was shown in Experiment III that state diagramming made subjects analyze their instructional programs as a function of converting their written information into the state diagram format. Research needs to be done in order to show that flow charting has the same usefulness as state diagramming in these respects.

PERT (Program Evaluation and Review Technique) charting is another common systemic visual system that could present raw data. On the surface, PERT appears very much like state diagramming. This is simply, and only, because they use the same format of circles and arrows. The differences can be shown by comparing both to the criteria proposed by Bijou in judging the usefulness of raw data.

A PERT chart specifies an activity and stresses the need to include all information needed to define the task, expected outcomes, and resources used. In this way a PERT chart specifies objectively the setting of the study. A state diagram could combine a class of behaviors by a single task, as in PERT, but stimuli that are needed to evoke and consequate behaviors within the class would be excluded.
In comparison to state diagramming, PERT may not include relevant information about environmental conditions within an activity.

In terms of objectivity, PERT charting is done by estimating the amount of time needed to complete a series of tasks. The system allows for an optimistic, pessimistic, and most likely analysis of this time variable. The two ways in which estimates are established are by deterministic calculations, calculations based on past history with the task, and probability calculations, a best guess approach. PERT can be used in observation of behaviors and environmental events. These can be described in writing and given a number. The number corresponds to a circle on the PERT chart. The other visual component is an arrow. This arrow is labeled with the estimated amount of time that will elapse between the tasks. In comparison with state diagramming, the arrow, or vector, specifies the stimulus condition needed to move from task to task and in many cases would be more than the passage of time. While PERT can be used to describe behavioral and environmental events objectively, the system provides less control over what information would be included. A state diagram must include the relevant transition information as a vector. A PERT chart may fail to clarify this aspect when describing the task. A simple estimate of time between tasks has more limited value than state diagramming transitions.

The reliability in PERT charting has been disputed with no conclusion to be made (Cook, 1966). It would seem difficult to be reliable about time estimates, but comparison of reliability between PERT and state diagramming need to be determined through further research.
There are major differences in the common uses of PERT, flowcharting, and state diagramming. PERT is used to analyze time and resource management problems. A flowchart is typically used to organize computer programs. State diagramming is used to describe complex communication networks and in this paper, classroom procedures. PERT and flowcharts are seldom used as observational tools and appear less useful than state diagramming after the data are in.

In practice, state diagramming is a communication tool that can quickly tell a teacher, student, parent, or other educator the teacher's expectations of student behavior, the consequences and results of that student's behavior, and the overall classroom routine. Instead of a course description, a state diagram could include all pertinent information such as test, lecture, and assignment dates; the student behaviors required at each of these events under course policy; and how these behaviors lead to consequences resulting in the final course grade. A grade school curriculum having students working at their own pace, as in Keller's PSI teaching technology, would find the state diagram helpful in prompting students through the sequence of school tasks, avoiding frequent oral teacher explanations. Put to this use, state diagramming could avoid student interruptions of teachers and save student activity time.

Whenever there are options in a classroom, a general explanation to students would be less adequate and might encourage inappropriate student behavior for teacher attention (Becker, 1975). Often public school teachers will present all the tasks for the morning, and afternoon, and sometimes the entire day at one time. This requires students
to have a good memory in order to complete the assignments correctly. A state diagram could be used to solve this problem. In the public school setting for Experiment I, a chemistry teacher had posted a state diagram showing how the class operated. It aided the students in pacing themselves through experiments and course readings in order to finish by the end of the period.

Research in the uses of state diagramming can be done in areas of training observers, of developing formal observation procedures and codes to increase reliability and in the use of state diagramming as a management and diagnostic tool. The last aspect seems to be the most exciting. I believe a professional trained in classroom management techniques would find the state diagram focuses an entire classroom design on relevant aspects. This would tend to make deficiencies in an instructional design clearer. It would hopefully show how to incorporate corrective changes in the existing education design. The author suggests case studies of classroom intervention using state diagramming alone and as part of an intervention strategy.
APPENDIX A

EXPERIMENT I
Experiment #1 Material
Condition B₁

As the student enters the room, he looks at the day's lecture topic on the blackboard. If he is currently working on the assignment associated with the lecture, he will sit in the lecture group. If he is ahead or behind of the assignment associated with the lecture, he will work on his assignment at his seat without the teacher for 10 minutes. When the teacher completes the 10-minute lecture, all students work at their seats with the teacher. If the student asks a question, the teacher will give assistance. After the question has been answered, the student will continue to work at his seat. When a student completes an assignment he turns it in to the teacher. The teacher checks the assignment. If it is not acceptable, it is returned to the student for more individual seatwork with the teacher. When a student turns in an assignment and it is acceptable with at least 10 minutes remaining in the class, the teacher hands out an individual quiz. When the student completes the quiz it is corrected. If it meets criteria, the teacher records the points on the student's point sheet. The student then has optional time until the teacher says the class is dismissed. If the student fails to meet the criteria, he returns to his seat to work on the assignment with the teacher's help.
Experiment #1 Material
Condition A2
As the student enters the room, he turns in his report card to the teacher at her desk. Students that have checksheets receive points from the teacher. When the students receive these points, they go to their chart and record the amount of points earned. If a student does not have a home checksheet, he can go immediately to an optional activity. When the buzzer sounds, all students take their seat. When all the students are in their seat, individual assignments are given by the teacher. Whenever a student requires help, the student will work with the teacher or aide. If students are competent to work on the assignment, they do individual seatwork. If any student needs help over the assignment once it has been started, he can work with the teacher or aide until their help has been completed. As soon as a student finishes an assignment and turns it in, he may engage in optional activities while the teacher or aide corrects the assignment. If there is 100% accuracy, the teacher grades the student's report card and the student charts his grade. After the student has completed the charting, he may engage in optional activities or art work. If the student's assignment is less than 100% correct, the student continues to work individually at his seat. When the buzzer sounds, all students get in or remain in their seat. Once all the students are in their seat a new subject begins.
APPENDIX B

EXPERIMENT III
EXPERIMENT III

Code Definitions

Teacher Behavior:

- whenever a teacher direction is stated
- whenever a teacher behavior is stated
- whenever an activity that has to be arranged by the teacher is stated
- If a teacher and student behavior occur at the same time, assume that the teacher behavior is a direction for the student behavior and should be coded as a teacher behavior.
- Some unclear descriptions require judging by previous information. For example, "answers questions" could be a teacher or student behavior depending on what information previously was given. If a teacher asked for student questions, "answers questions" would be a teacher behavior. If a teacher said there is an oral quiz, then "answers questions" would be a student behavior.

Student Behavior:

- any label or description stating a student behavior or an activity independent from a teacher
- Examples include a student taking (to complete) a test, students work at seat, and students listen to directions.
- When students enter room, or just "enter," code as a student behavior.
Environmental Conditions:

- an arranged occurrence in the living space, materials, or other environmental engineering that is not dependent on a student or teacher behavior during the class session.

- Examples include "classroom," materials in desk, or blackboard.

Student Behavior Criteria:

- some condition that can be met only with a described student response.

- Examples include "all words read to 100% accuracy" and "books read." Often it is easy to determine whose behavior has to meet the criteria by reading the preceding label and description. On state diagrams refer to the previous state.

Teacher Behavior Criteria:

- some condition that be met only with a described teacher response.

- when both a teacher behavior criteria and student behavior criteria are stated and the student's criteria is met through the teacher meeting a criteria. For instance, "(has) teacher checked for 90% and the student's test" would be coded as a teacher behavior criteria.

- It helps to read the preceding activity that has been described or labeled. On state diagrams look at the state that is connected to the arrow having the stated criteria.
Environmental Condition Criteria:

- some condition being met as the function of arranged events that occur without regard to a teacher or student behavior.

- Examples include the passage of time, the end of class-time, and the fact that a bell has rung.

Coding Written Descriptions

The written descriptions are more difficult to code since there is no format that dictates if a criteria or an activity is meant to be described. On state diagrams this is clear as the states should be considered a type of activity and the arrows a type of criteria. The following example shows an interpretation of a written description.

"Teacher leaves and aide comes in. Children take out lunch and eat it."

If it was worded as one sentence, it would not be clear if there was both a student and a teacher behavior and should be coded as a single teacher behavior as there is an implied direction by the teacher. As it is worded, the description includes both a teacher and a student behavior.
BIBLIOGRAPHY


