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Wesley, Beth Eddinger

THE EFFECTS OF COMPUTER-ASSISTED INSTRUCTION AND LOCUS OF CONTROL UPON PRESERVICE ELEMENTARY TEACHERS' ACQUISITION OF COMPUTER LITERACY AND THE INTEGRATED SCIENCE PROCESS SKILLS

Purdue University PH.D. 1983

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THE EFFECTS OF COMPUTER-ASSISTED INSTRUCTION AND LOCUS OF CONTROL UPON PRESERVICE ELEMENTARY TEACHERS' ACQUISITION OF COMPUTER LITERACY AND THE INTEGRATED SCIENCE PROCESS SKILLS

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Beth Eddinger Wesley

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Signed by the final examining committee:

Gerald H. Krockover, chairman

Alfred De Vito

Charles R Hicks

Maribeth A. Cousin

John F. Feldhusen

Approved by the head of school or department:

December 12 19 83 Shelley C. Stone

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Gerald H. Krockover
Professor in charge of the thesis

I gratefully dedicate this thesis to my parents, Richard and Claire Eddinger--for satisfying my deficiency needs and making growth choices attractive so that I could reach out and satisfy my being needs.

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ABSTRACT

Wesley, Beth Eddinger. Ph.D., Purdue University, December 1983. The Effects of Computer-Assisted Instruction and Locus of Control Upon Preservice Elementary Teachers' Acquisition of Computer Literacy and the Integrated Science Process Skills. Major Professor: Gerald H. Krockover.

The purpose of this study was to determine the effects of computer-assisted instruction (CAI) versus a text mode of programmed instruction (PI), and the cognitive style of locus of control, on preservice elementary teachers' achievement of the integrated science process skills and computer literacy. Eighty-one female preservice elementary teachers in six sections of a science methods class were classified as internally or externally controlled. The sections were randomly assigned to receive instruction in the integrated science process skills via a microcomputer or printed text. The study used a pretest-posttest control group design. Before assessing main and interaction effects, analysis of covariance was used to adjust posttest scores using the pretest scores.

Statistical analysis revealed that main effects were not significant. No differences were found between achievement of the integrated science process skills or computer literacy of individuals receiving the CAI and printed PI treatments. Additionally, no differences were found between internally and externally controlled individuals in their achievement of the integrated science process skills or computer literacy. However, a significant ($p < 0.05$) aptitude by treatment interaction was found. Differences in adjusted posttest scores of externally controlled

individuals favored the CAI mode. There were no differences between treatments when internally controlled subjects were considered.

INTRODUCTION

Background

Because of their widespread use in all aspects of our society, computers have assumed a pervasive role in our everyday life. The computer is no longer a tool to be used in industry and research. Making a bank transaction or telephone call, voting, registering for classes, purchasing items at a grocery store and making plane reservations are all activities which normally require the aid of a computer. Masat (1981) stated that as the United States becomes more of an information-oriented society, a computer literate populace is as important as energy and raw materials. Without some form of computer literacy, many individuals will be excluded from present and future job markets. Indeed, Luehrman (1980) insists that, "computing plays such a crucial role in everyday life and in the technological future of this nation that the general public's ignorance of the subject constitutes a national crisis" (p. 98).

Computer literacy has been designated by the Board of Directors of the National Council of Teachers of Mathematics (1978) as "an essential outcome of contemporary education" (p. 468). Since the 1950's the computer has also had the potential to individualize instruction, improve school productivity, and assist in the management of education (Splittgerber, 1979). "Thus, computers are important in education not only as an object of instruction, but also as a medium of instruction." (Battista and Krockover, 1982, p. 14) The dramatic reduction in costs made possible by microtechnology and mass production has resulted in the widespread aquisition of microcomputers in homes and in schools. The availability of microcomputers in a variety of educational settings has made it possible for every learner to acquire computing skill and develop an understanding of the role of computers in society.

The computer literacy curriculum is still in its infancy. Although opinions vary widely concerning what constitutes computer literacy, it implies knowledge of the capabilities, limitations, applications and implications of computers (Lopez, 1981). As a result, the entire education community shares responsibility for incorporating the microcomputer into school programs. However, the effectiveness of any efforts are chiefly dependent on one person--the computer literate classroom teacher (Zalewski, 1982; Moursund, 1980). One of the most critical barriers to the effective and widespread instructional use of computers is the lack of knowledge among educators (Foreman, 1982; Pratscher, 1981; Charp, 1981; Mossman, 1980; Luehrman, 1980). This problem overshadows all other problems, such as availability of hardware, software or courseware, and teacher, administrative, school board or parental support (Moursund, 1980).

Dickerson and Pritchard (1981) warn that, "Educators must face the possibility that they will be major contributors to computer illiteracy if priorities are not given to the implementation and use of this (computer) technology" (p. 8). Furthermore, the authors contend that computer illiterate student educators graduating from higher education represent a major problem contributing to the literacy crisis. Teacher education institutions must prepare preservice elementary school teachers to utilize, develop and experiment with the capabilities of the computer resource. Certainly a course in computer education could address these needs, but this may not be feasible in many preservice elementary teacher programs which lack space for an additional course (Sherwood et al., 1981). Another way to introduce computer instruction to preservice elementary school teachers is to implement its use in existing preservice courses at the college level. Computer-assisted instruction (CAI) used in preservice elementary school teachers' courses would enable them to learn with the computer. At the same time they would be learning about the computer (Battista and Krockover, 1982).

There is no one educational approach which is best for all students. Many independent student-related variables can interact and affect learning through CAI. Because of this, global comparisons between groups receiving CAI and some other form of instruction may be inappropriate. Aptitude-treatment interaction (ATI) studies attempt to determine aptitudes which can predict which one of several learning methods might help different individuals achieve similar educational objectives (Glaser, 1972). Information from these studies should help educators adapt educational environments to accomodate variations in individual learners' characteristics, backgrounds, cognitive processes, and learning styles. Research on locus of control may help educators make specific recommendations for the use of CAI in individualizing educational settings (Dence, 1980).

Locus of control is an affective learner characteristic which may account for differences in learning through CAI when compared with learning through other instructional media. It is defined as a generalized expectancy for internal or external control of reinforcements (Stipek and Weisz, 1981). Internally controlled individuals see a contingency between events in which they are involved and their own behavior or a relatively permanent characteristic such as ability. In contrast, individuals with an external locus of control do not perceive a contingency between their own actions and events in which they are involved. Instead, they believe events are caused by factors beyond their control, such as luck or task difficulty. Because of this, in the area of academics, externally controlled individuals are less likely to delay gratification; i.e., they are less likely to deny themselves immediate reinforcement, such as play, for deferred reinforcement, such as good grades (Stipek and Weisz, 1981). Perhaps external individuals would benefit more than their internal peers from the external control inherent in CAI (i.e., the student must interact with the materials as the programmer intended) than from printed programmed instruction with which it would be possible to by-pass sections of material or look at answers without first forming responses to questions.

This study was designed to determine if CAI via the use of a microcomputer could significantly promote gains of preservice elementary school teachers in the integrated science process skills and computer literacy. In addition, it investigated the possible interactive effect of locus of control and mode of instruction.

Statement of the Problem

This study attempted to answer the following questions:

1) Do preservice elementary teachers receiving CAI in a science education methods course score higher on 1) the Minnesota Computer Literacy and Awareness Assessment (MCLAA), and 2) the Test of Integrated Science Processes (TISP), than preservice elementary teachers receiving printed programmed instruction in a science education methods course?

2) Do preservice elementary teachers' loci of control (internal versus external) interact with mode of instruction (CAI versus text mode) to yield differences in scores on 1) the MCLAA, and 2) the TISP?

Basic Assumptions

The following assumptions were basic to this study:

1) Developing computer literacy skills is desirable for the training of preservice elementary teachers.

2) Mastering the integrated science process skills is desirable for preservice elementary teachers.

Limitations of the Study

This study was limited to preservice elementary teachers enrolled in a science methods course at Purdue University, in West Lafayette, Indiana, during either the Fall, 1982 or Spring, 1983 semester. Subjects learning through CAI spent four, one-half hour sessions utilizing the microcomputer.

Definitions of Terms

The following key words are defined as they were used in this study.

Computer-Assisted Instruction (CAI)

Computer-assisted instruction involves the utilization of the computer and a computer program to assist in the presentation of learning materials. The student engages in a dialogue with a computer program to achieve a well-defined and measurable understanding or skill. Possible forms of instruction would include: tutorial, drill and practice, problem solving, gaming, and simulation (Splittgerber, 1979). In this study the tutorial mode was used. Students were presented with new material using a programmed instructional approach.

Computer Literacy

There is no widely accepted definition of computer literacy. Generally, it implies a knowledge of the capabilities, limitations, applications and implications of computers (Lopez, 1981). For this study, computer literacy was defined by the instrument used to measure it, the Minnesota Computer Literacy and Awareness Assessment (see Appendix A for cognitive and affective test objectives).

Integrated Science Process Skills

The Integrated Science Process Skills are those abilities associated with planning, conducting and interpreting results from investigations. They include: formulating hypotheses, operationally defining, controlling and manipulating variables, planning investigations, and interpreting data (American Association for the Advancement of Science, 1968). For this study, skills were defined and determined by the Test of the Integrated Processes (TISP; Tobin and Capie, 1982a).

Locus of Control

Locus of control is, ". . . the perception of events, whether positive or negative, as being a consequence of one's own actions and thereby potentially under personal control . . ." (Lefcourt, 1976, p. 29). The locus of control construct is described along an internal-external continuum, related to the extent to which an individual perceives his/her destiny as being self-determined. A person has an external locus of control if he/she believes external factors such as luck, chance, fate or powerful others are responsible for the outcome of events. In contrast, a person possesses an internal locus of control if he/she believes that his/her own ability or effort is a controller of events (Cohen, 1982). For this study, locus of control was defined by the instrument used to measure it, the Multidimensional-Multiattributional Causality Scale (MMCS; Lefcourt *et al*., 1979).

Programmed Instruction (PI)

Programmmed instruction involves teaching materials which possess the following characteristics (Fry, 1963):

1. Subject matter is broken up into small units.
2. Active participation is required from the student.
3. The student is provided with immediate feedback reinforcement.
4. The units are arranged in a careful sequence.
5. Programs are aimed at specific goals.
6. Revisions in programs are based on student responses.
7. Students work through programs at their own pace.

REVIEW OF LITERATURE

The major concern of this study was determining the effect of CAI on the computer literacy and integrated science process skills of pre-service elementary teachers. It additionally focused on the effect that locus of control may have on achievement through a computer-assisted versus a printed text mode of instruction.

The review of research and literature related to this study will address the following areas: 1) programmed instruction, 2) computer-assisted instruction, 3) computer literacy, 4) science process skill instruction for teachers, and 5) locus of control. The term computer-based instruction (CBI), which is generally agreed to include computer-assisted instruction and computer-managed instruction, is recently being used more frequently to describe computer instruction. For the purpose of clarity in this review, research labeled in the literature as CBI will be referred to as CAI research, if that is the specific type of computer instruction that is being described.

Programmed Instruction

Programmed instruction (PI) is a teaching technique which has stimulated much research. Cronbach and Snow (1977) reported that studies on the interaction of abilities with variations in instructional programming ". . . represent the most extensive body of cumulative knowledge that exists regarding any one kind of ATI" (p.213). The characteristics of

PI are closely linked with the ideas of B.F. Skinner (1954). He proposed that learning can be fostered by means of a series of carefully structured, small steps, leading to a desired behavior, provided each correct step is reinforced by some kind of favorable experience. Skinner constructed a mechanical device, known as a teaching machine, which presented information in a manner which he felt satisfied many of the conditions necessary for learning.

The key features of Skinnerian type programmed instruction are: 1) a logical sequence of small steps, 2) active participation by the student, 3) immediate feedback, and 4) self-pacing. Recent programs may include more materials in each step, fewer requests for responses, requests for more complicated responses, and sequences which are more complex. Thus, students may be branched into remedial lessons or more advanced units depending on their responses (Kozma, 1978). Use of the Skinnerian teaching machine was adapted to the less expensive printed instruction known as programmed text. Numerous methods of delivery for PI have since been developed, one of the most promising being the computer (Silberman, 1962; Edwards and Tillman, 1982).

Research on the effectiveness and efficiency of programmed instruction has been extensively reviewed. Silberman (1962) examined 80 studies on PI, most of which had been conducted within the previous three years, using adults or college students as subjects. The studies concentrated on three problem areas: 1) comparisons of different response modes; 2) method of eliciting desired responses from the student--step size, sequencing, prompting methods and confirmation methods; and 3) adaptation of programs to individual programs--branching, pacing and repetition.

Silberman concluded,

> "Beyond demonstrating that a carefully written set of materials will teach if a student will spend enough time studying them, we have little unequivocal evidence for principles of programmed instruction . . . The most consistent finding in these studies is that no significant difference is obtained among treatment comparisons. When significant differences are obtained, they seldom agree with findings of other studies on the same problem."

In his summary of 15 field tests which made more global comparisons of programmed and conventional instruction, he concluded that the results of the learning scores generally favored programmed over conventional instruction. Also the PI usually required less training time.

Schramm (1964) reviewed 36 reports comparing PI with conventional classroom instruction. Half of the studies showed no significant difference for students learning from programs. Seventeen studies reported that PI resulted in significantly superior results while one study showed superiority for students in conventional classes. Furthermore, eight of the studies reported that less time was needed for the PI.

In a comprehensive review, Nash *et al*. (1971) examined over one hundred published empirical studies on PI. They were concerned about researchers' obsession with statistically significant findings and obliviousness to whether the findings had practical implications. Therefore, they defined and summarized the results of studies in terms of practical effectiveness, i.e., how many studies found a difference between two methods that were statistically significant at the ten per cent level or higher. Their findings were three-fold: 1) on the average, PI required one-third less training time than conventional methods, 2) 21 out of 113 of the comparisons favored PI for the immediate learning variable, and 3) four of 30 comparisons favored PI when retention was considered. Results also seemed to show that programmed methods applied in industrial settings had slightly more positive results than those in academic situations.

In their review of research evaluating the effectiveness of PI, Jamison et al. (1974) concluded that PI is as effective as traditional instruction and may result in decreasing the amount of time necessary for achievement of specific educational goals. Costin (1972) compared the lecture method with other forms of teaching, including PI. In 12 of the studies, where the comparison was based on a brief segment of class time, he found the differences between the effect of lecture and self-instruction programs on students' aquisition of information to be inconsistent. Summarizing the findings of studies involving comparisons based on complete courses, he reported that guided reading and study which promote active response, such as programmed methods, ". . . possibly may have an advantage over the traditional lecture method of promoting the aquisition of information" (p. 22).

Kulik and Jaska (1977), compared achievement using PI and conventional instruction in nine studies at the college level. In three of the courses, achievement was significantly higher in the PI groups. There was no significant difference in the six remaining classes. Only one study provided data on long-term retention; it reported no significant difference between the two methods. A time savings with PI was reported in two of the three studies that measured that criterion.

Cronbach and Snow (1977) conducted a comprehensive review of literature related to the interaction of abilities with variations in instructional programming. They found that the claim that PI enables low ability students to learn as much as high ability students was thoroughly disproved.

Outcomes from PI were correlated with initial test scores in the majority of the studies. They concluded that in studies of long-term PI, general aptitudes predicted outcomes. More recently, Willett *et al.* (1983) reported on their meta-analysis of dissertations, journal articles and unpublished articles concerning instructional systems applied in science teaching to students in grades kindergarten through 12. A total of 52 effect sizes were obtained for PI. The mean effect size produced was 0.17 with a standard deviation of 0.48, indicating that, on the average, the PI was about one-fifth of a standard deviation better than conventional science teaching.

Based on the reviews summarized here, results obtained from research on PI seem to indicate that it requires less time than conventional instruction. However, when end-of-treatment performance is used as the criterion, evidence favoring PI is generally weak or nonexistent. In their reviews, several researchers commented on the quality of studies they examined and difficulties they had in interpreting studies. Silberman (1962) reported regarding the experiments he reviewed, that ". . . it was not uncommon to find very short programs, administered in one or two hours to small samples of highly motivated students who viewed the program as a test, followed immediately by a hastily improvised quiz" (p. 17). Willet *et al.* (1983) concurred with Silberman that studies comparing PI and conventional instruction seldom described the conditions of the conventional instruction. Nash *et al.* (1971) asserted that ". . . the most evident conclusion about the effectiveness of PI is that the research completed on the topic is methodologically very poor" (p. 408). They maintained that in many instances the number of subjects was small and there were no controls; in others, important variables were not controlled. A greater proportion of unusually high results favoring programmed materials were found in the lowest quality studies, suggesting overall findings in favor of programmed materials may have been exaggerated. Finally, the terms PI and conventional instruction do not define treatment conditions. Variation within each category made generalizations concerning overall results of studies on the methods difficult.

Computer-Assisted Instruction

Overview

Computer-assisted instruction (CAI) involves "the direct use of the computer to assist, replace, or enhance the instructional process. CAI can include software programs described as drill and practice, tutorial, problem-solving, simulations, gaming, and informational " (Johnson, 1983). Before the early 1960's CAI projects were virtually nonexistent. During the 1960's most projects were developed in university research settings. Beginning in the 1970's, school districts started to offer their own CAI courses (Jamison et al., 1974). As the use of CAI has increased, so has the research documenting its effectiveness. This overview will provide a summary of research on the effectiveness of CAI.

Visonhaler and Bass (1972) summarized the findings of ten independent studies on CAI drill and practice in language arts and mathematics at the elementary level. The studies involved more than 20 separate experiments and approximately 10,000 subjects. Their results showed a substantial advantage for traditional instruction supplemented with CAI.

On standardized achievement tests, CAI groups had performance gains of one to eight months over groups receiving only traditional instruction.

In their review of the effectiveness of alternate instructional media, Jamison et al. (1974) examined research on drill and practice CAI programs in elementary mathematics and reading, and also some CAI studies conducted at the college level. They reported that no simple uniform conclusion could be formed about the effectiveness of CAI. At the elementary level, it seemed to be effective as a supplement to regular instruction. For subjects at the secondary and college levels, CAI was about as effective as traditional instruction when it was used as a replacement. They noted that in some cases, CAI resulted in substantial savings of student time.

Edwards et al. (1975) reported their generalizations concerning CAI effectiveness, based on a review of the research. All of the studies examined showed that normal instruction supplemented by CAI was more effective than normal instruction alone. When CAI was substituted for traditional instruction, nine studies showed higher achievement for CAI subjects, eight studies reported no difference, and three studies showed showed mixed results. Nine studies included data comparing time required for learning by each method. Although evaluation of the studies showed CAI does not always result in greater achievement, all nine studies showed that it took less time for students to learn through CAI than through other methods.

Following a review of the research literature on CAI, Rapaport and Savard (1980) concluded that the evidence was not strong enough to support teaching by CAI exclusively; however, they also reported that research findings made it clear that CAI was an effective supplement to traditional instruction.

Gleason (1981) offered the following personal synthesis of research findings following a sabbatical leave during which he observed and discussed CAI research activities at various institutions (p. 16):

> 1. CAI can be used successfully to assist learners in attaining specified instructional objectives.
>
> 2. There appears to be a substantial savings in time (20 to 40 percent) required for learning as compared to "conventional" instruction.
>
> 3. Retention following CAI is at least as good if not superior to retention following conventional instruction.
>
> 4. Students react very positively to good CAI programs: they reject poor programs.

Using meta-analysis methodology, Hartly (1977) synthesized the data of 153 studies concerning the effectiveness of four techniques of mathematics instruction. The four techniques were CAI, cross-age and peer tutoring, individual learning packets, and PI. The efficacy of each technique was evaluated by comparing the achievement of subjects taught by a particular technique with the achievement of students taught by traditional instruction. She found CAI less effective than tutoring but more effective than individual learning packets or PI. In a later review, Burns and Bozeman (1981) also used meta-analysis to examine 40 studies regarding the effectiveness of computer-assisted mathematics instruction at the elementary and secondary level. Their analysis indicated a significant enhancement of mathematics learning in instructional environments supplemented by CAI.

Kulik et al. (1980) used meta-analysis to integrate the findings of 59 independent evaluations of CAI conducted from 1967 to 1978 at the college level. CAI raised student achievement by an average of one-quarter of a standard deviation in 54 studies which addressed that criterion. Eleven of the 59 studies compared student attitudes in the computer-assisted and conventional classes and, in general, showed a small but significant positive effect of CAI on the attitudes of students toward instruction and subject matter they were studying. Eight investigators examined the amount of time required for each method of instruction--on the average, about two-thirds the time required by conventional instruction. The researchers emphasized that there is little doubt that the computer can reduce time spent in instruction. Finally, they found little relationship between experimental outcomes and design features of experiments, settings for the experiments, or manner and date of publication of the experiments.

In a later review, Kulik *et al.* (1983) integrated the findings of 51 independent evaluations of CAI in grades six through twelve. They reported that CAI raised final examination scores by an average of 0.32 standard deviations (i.e., from the 50th to the 63rd percentile). Also, computer-taught students developed positive attitudes toward the computer and the course they were taking. Only two studies reported comparative data on time necessary for instruction. Both showed that the computer substantially reduced the amount of time necessary for learning. Furthermore, the authors reported that the effects of CAI appeared to be much larger for disadvantaged and low aptitude students than for talented students.

By combining information from his own meta-analysis and that of Hartley (1977), Kulik (1981) studied the interaction of mathematics instructional level with method of instruction. He found positive effects for CAI in the elementary level which fell off at the secondary level and were not much more effective than traditional instruction at the college level. He suggested that the stimulation and guidance provided by CAI may be more important at lower levels of instruction and possibly even counter-productive at higher levels.

Recently, Willet _et al_. (1983) reported the results of their meta-analysis of 130 independent studies of a wide variety of instructional systems applied to science teaching. Sources of the studies included dissertations, journal articles and published studies beginning in 1950. In five relevant studies, they found practically no advantage for CAI over traditional science instruction (mean effect size = 0.01, standard deviation = 0.74).

Computer-Assisted Instruction Versus Printed Programmed Instruction

Research literature abounds with reports of studies comparing the results of a highly structured method, such as CAI or programmed text, with results from less structured methods of instruction, such as lectures or conventional texts (Edwards _et al_., 1975; Kulik _et al_., 1983; Kulik _et al_., 1980; Burns and Bozeman, 1981). However, Gleason (1981) described these studies as futile because of the impossibility of controlling the numerous significant variables which interact in most instructional settings. Media effects are often confounded with effects such as individualization, prestructuring, and even curricular content. He reported that few serious researchers are now interested in comparative CAI studies. Current research tended to focus on such problems as determining which CAI strategies are most effective.

Although tutorial CAI and printed PI share many common instructional features, they are different, and each has advantages over the other. For example, one advantage of programmed text is that it is portable and, therefore, may be studied in a variety of places (Masuo and Furuta, 1981). Avner et al. (1980) maintained that, to justify the selection of CAI over other, less costly alternatives, data must be collected which demonstrates a clear learning advantage for CAI over alternative media. For example, programmed texts may be less costly and still provide the same high amount of structure, self-pacing, and time savings that result from learning through CAI.

An often cited advantage of CAI is its ability to supply rapid feedback without the need to turn pages (Dence, 1980). Swenson and Anderson (1982) reported that, ideally, the interval between the response and the reinforcer should be 0.5 seconds. Eisele (1980a) noted that the speed with which computers can process a response and provide feedback is possibly the greatest attribute of this delivery system. However, CAI studies have shown that delay of feedback for 15 seconds or until the end of the session, compared to immediate feedback, did not result in decreased learning of material and could significantly improve retention (Gaynor, 1981; Rankin and Trepper, 1978).

Anderson et al. (1971) cited eight studies of PI which showed that programs teach as well, or in one study better, when feedback after each frame was omitted than when feedback after each frame was included. They reasoned this was because, in short-circuiting the instructional task, students using workbooks or programmed texts could gain access to correct answers before actually composing their own responses. To test their theory, the researchers had 188 students in an introductory psychology class complete a programmed lesson using CAI. They found that subjects who received feedback after they responded learned significantly more than subjects who received no feedback or could look at answers before they responded. A similar study reported the next year (Anderson _et al._, 1972) confirmed that performance was significantly better when feedback had been provided after, rather than before, the response. It appears that feedback facilitates learning only if contingent upon complete responses. Anderson _et al._ (1971) noted that their use of a computer-based instructional system, unlike previous studies which used alternate media such as programmed text for presentation of instruction, supplied an external control which insured that subjects responded before they received knowledge of the correct responses.

When learning through CAI, the student must interact with the material as the programmer intended. Bypassing sections is not possible, as it is with a programmed text. Dean (1977) argued that external discipline is necessary if learning is to occur, and that this is the very ingredient missing from programmed self-study in text form. Based on a review of a limited number of studies of student control in CAI, Steinberg (1977) reported that students given complete control of course flow generally achieved as much as students who did not have that option. However, students who were poor performers in a subject learned least when given total control over course flow due to the inefficient instructional strategies they chose to use.

Studies with other media (e.g., Gropper and Lumsdaine 1960; Gropper and Lumsdaine, 1961) suggest the advantage of active student response in learning. Edwards and Tillman (1982) asserted that computer/student interaction is very difficult to achieve in other media.

Schurdak (1967) evaluated the use of computers in teaching a portion of a college course to 48 graduate and undergraduate students. Students were divided into groups which learned a portion of a FORTRAN course by three treatments--computer in addition to conventional text, programmed text, and conventional text. They concluded that, at least for materials and a student population similar to those in their studies, computers can bring real advantages to the instructional process. Students in the computer group scored significantly higher on an achievement test than the other two groups. Additionally, the CAI treatment was more advantageous for students of lower aptitudes than for students with higher aptitudes. "The differential treatment given to those whose course performance signified the need for additional assistance resulted in a substantial improvement in the performance of students of lesser ability" (p. 72). A weakness of their study was the confounding effect of variations in content included within each treatment.

In a later study, Walter and Lutta (1969) compared the effect of a PI text and a comparable CAI version of the same material upon the learning of mathematics by eighth graders. Criteria used included immediate posttest scores, retention scores, number of errors in the learning program and learning time. In contrast to the findings of Schurdak (1967), they discovered that students using the PI text performed significantly better than those using CAI, and high ability students performed better than low ability students. They attributed the differences to the very poor performance of the low ability students receiving the CAI treatment and suggested that low ability students might need hard copy memory aids to supplement CAI instruction.

Blitz (1972) investigated the ways in which personality characteristics affect performance on CAI and programmed text. Fifty-one dental students in an oral pathology course were divided into two groups. One group took the first half of the course on CAI and the second half on programmed text. The other group took the first half of the course on programmed text and the second half on CAI. Their scores on a final achievement test were keyed to their instruction by both CAI and programmed text and analyzed on the basis of personality characteristics and academic aptitudes. None of the academic aptitudes produced ATI effects. Five of the personality variables did produce ATI effects. Students described as deferent, orderly, nuturant and endurant performed better with the programmed text and those characterized as aggressive performed better with CAI. The author hypothesized that, "Students performed better on that mode of instruction which filled the particular needs of their personality."

Masuo and Furuta (1981) used 34 university students in an economics course to examine the effects of CAI versus a text mode upon achievement. Half the class completed a PI tutorial on "cost of credit" on computer, while the other half completed the same tutorial as a programmed text. The investigators found no main treatment effects. However, an interaction between prior knowledge and instructional mode was reported. Analysis of the interaction indicated that lower aptitude students experienced a greater benefit from the CAI mode than did higher aptitude students.

A study by Boettcher et al. (1981) compared the learning effectiveness of CAI and printed PI specifically in the cognitive categories of knowledge and application. For 83 baccalaureate nursing students divided into two groups, one learning by CAI and the other by printed PI, there was no significant difference in the initial amount learned or the retention at either cognitive level.

Avner et al. (1980) reported their research which was designed to provide unambiguous evidence for a unique advantage of CAI as an instructional medium. They hypothesized that a computer's capability to provide active individualized control over student interaction made it superior to other competing media. Almost 700 chemistry students, over a period of two semesters, were provided with one of two sets of CAI materials designed for laboratory projects. They were identical in every way except one--one set required that the students give responses during the lesson that indicated understanding of the content being presented, and the other set allowed students to work through the material by simply pressing a key. The researchers judged subjects' laboratory performance by tallying the presence or absence of specific types of errors in their laboratory work. Few errors were made in laboratory sessions solely requiring that students follow instructions, and there were no significant differences in errors between students in the two groups. However, in sessions when students were required to make decisions based on an understanding of principles behind the experiment, interactive versions of the materials resulted in significantly better performance by students. Additionally, students who used the interactive CAI materials took less time to complete accompanying laboratories. Based on their results, the researchers asserted the superiority of active learning over passive learning and of CAI as a medium which could uniquely provide this feature.

In previously cited research articles, authors have frequently cautioned against using their data to make broad generalizations about learning through CAI. Masuo and Furuta (1981) suggested that PI and CAI do not define a treatment. Factors such as content, step size, pacing, duration of instruction and teacher enthusiasm can contribute to an infinite variety of conditions. Therefore, PI and CAI are just labels for true treatment conditions. Avner (1978) concurred that CAI is a medium and not a treatment. He added that there is no guarantee that instructional techniques, possible with CAI, which are effective in one situation, will be effective in another situation. Research by Dennis (1979) showed that hardware variables such as display rate (10 and 30 characters-per-second) and memory support (12-line window, 24-line window and unrestricted viewing access to hard copy printout) exerted an influence upon students' interaction with CAI courseware. Rahmlow (1982) maintained that too often computer systems were unfairly compared with other delivery systems such as PI. In spite of the fact that instructional programs between the two varied, comparisons were erroneously made of the media. Boettcher _et al_. (1981) emphasized that it is _how_ CAI is used rather than the fact that it is used that determines learning effectiveness.

Computer Literacy

Because computers have assumed such a pervasive role in everyday life, educators agree that all students should become computer literate. Molnar (1981) stated that we are moving from an industrial to an informational society. He warned that unless individuals are computer literate, they will be unable to take advantage of information and meaningfully participate in actions that affect their lives. In their position statement on basic mathematical skills, the National Council of Supervisors of Mathematics (1978) listed computer literacy as one of the Ten Basic Skill Areas. The Board of Directors of the National Council of Teachers of Mathematics (1978) also designated computer literacy as "an essential outcome of contemporary education" (p. 468).

The definition of computer literacy has been evolving as the use of computers in society is becoming more widespread. Although educators agree about the need for a computer literate population, opinions vary widely about what constitutes computer literacy. Initially, when the National Council of Supervisors of Mathematics (1978) identified computer literacy as one of ten basic mathematics skills, they described it as an understanding of computer uses and limitations. Moursund (1980) asserted that there are several levels of knowledge of computers, and this definition describes a lower level, commonly referred to as computer "awareness." Emphasis is placed on knowing about computers rather than knowing how to work with them.

Under the auspices of the National Science Foundation, Johnson et al. (1980) reviewed curriculum materials, tests and articles dealing with computers. Making no distinction between computer literacy and computer awareness, they developed a list of cognitive and affective objectives for computer literacy. The objectives were grouped under six main categories: hardware; programming and algorithms; software and data processing; applications; impact; and attitudes, values and motivation. Luehrman (1981) agreed that the list defined computer awareness but argued ". . . that fully four-fifths of these empirically discovered objectives should not be used in any significant definition of computer literacy" (p. 682). He maintained that, just as literacy in language means the ability to do something with language and literacy in mathematics means being able to do mathematics, so computer literacy must mean the ability to do computing. Any course in computer literacy must concentrate on performance objectives which will help learners become literate "doers" of computing.

In their reply to Luehrmann, Anderson et al. (1981) asserted that computer literacy ". . . should be thought of as the knowledge and skills the average citizen needs to know (or do) about computers." They argued that a definition of computer literacy which only addresses computer usage is too narrow. They preferred their own, more comprehensive, view that computer literacy is ". . . an understanding of computers that enables one to evaluate computer applications as well as to do things with them" (p. 687). Further, they asserted that most of what the ordinary person needs to know about computers will not be learned through programming. This was verified by Battista and Krockover (1982), who found that preservice elementary teachers given two periods of instruction and two related assignments using remote terminals and programming showed little or no improvement in computer literacy as measured by the Minnesota Computer Literacy and Awareness Assessment (Anderson, et al., 1979). Battista (1981) also found that teaching elementary school students how to program a computer will not necessarily give them a sound knowledge of computer capabilities.

Eisele (1980b) stated that all students should understand computers and computing. In addition, they should have skill in using computers and positive attitudes toward their productive role in society. He suggested that the following learning opportunities be included in a curriculum designed to foster universal computer literacy (p. 84):

> 1. Developing skills to use computer applications which bear on persistent life situations such as communications, transportation, education, governance, consumerism, entertainment and employment.

2. Developing computing proficiency as a skill for everyday use at home and on the job.

3. Developing ethical practices in providing computer services to others.

4. Developing ethical practices of consumption of computer services.

5. Developing positive attitudes toward the pervasive role of computers in contemporary society.

With the advent of microcomputers, Eisele (1981) maintained that it is now possible to help all learners acquire computing skill and develop an understanding of the role of computers in society.

Moursund (1982) classified student knowledge about computers into four levels: 1) novice level--able to use prepared programs, 2) intermediate level--requires more substantial mastery of the machine, 3) advanced level--involves programming skills, and 4) professional level--prepares for employment in the data processing field. He asserted that the degree to which students can be considered computer literate depends on the level of computer knowledge demanded by their academic endeavors. In a later article (1983) he strongly supported teaching students to use applications packages. Rather than teaching students computer languages which will soon be obsolete, he proposed that teachers show them how to utilize the capabilities of a computer and integrate this knowledge into their overall knowledge and performance.

Computers are no longer tools used exclusively by professionals. They are being used as daily tools in almost every aspect of modern life. Although there is no consensus on the precise knowledge, skills or attitudes an individual needs to function in our increasingly computer-oriented society, there is agreement that some form of computer literacy is an important goal for all students. Dickerson and Pritchard (1981) maintained that, "Educators must face the possibility that they will be major contributors to computer illiteracy if priorities are not given to the implementation and use of this technology" (p.8).

Science Process Skill Instruction For Teachers

During the last two decades, curricular emphasis has shifted from teaching science content to helping students develop competence in the science processes. More importance is being placed on helping children acquire the skills scientists use to process knowledge.

In the 1960's the Commission on Science Education of the American Association for the Advancement of Science (AAAS) prepared and evaluated science education materials, published under the title Science--A Process Approach (SAPA), designed to improve children's skills in using the science processes (Livermore, 1964). For the primary grades, the materials focused on eight basic process skills: observing, using time/space relationships, classifying, using numbers, measuring, communicating, predicting and inferring (AAAS, 1968). The basic process skills provide a foundation for the more complex integrated science process skills. The integrated processes are the skills an individual needs to do science experiments or solve problems. Five integrated science process skills are emphasized in the intermediate grades: controlling variables, interpreting data, formulating hypotheses, defining operationally, and experimenting.

In spite of science courses which preservice elementary teachers had taken to fulfill their science requirement, Gabel *et al*. (1977) claimed that prospective teachers had not mastered the science process skills. Jaus' (1975) findings, also, implied that elementary teachers receive minimal integrated science process skill instruction in their science content courses. He stated, "If a major goal of education is to develop science process skill competence in children, a logical first step toward this goal is to produce teachers who are competent in these skills" (p. 445).

Numerous studies have been done to determine the effects of teaching preservice and inservice teachers the science process skills upon their subsequent achievement, attitudes, and teaching practices. Wilson (1967) found that teachers trained in the science process skills encouraged a significantly larger number of science process skill experiences in their classrooms than a matched group of teachers who had not received training in the process skills. The influence of a summer institute in inquiry-centered science education upon the teaching strategies of elementary teachers was investigated by Schmidt (1969). Following the experience of the summer institute, teachers significantly increased the use of process skill experiences in their science classes and also their social studies classes.

Brown (1977) prepared a series of fourteen laboratory exercises, based on the process skills used in SAPA, to be completed by undergraduate preservice elementary teachers enrolled in a science methods class. Their scores on a paper and pencil test of the process skills, developed by the researcher, were significantly higher than those of an equivalent control group which did not complete the exercises.

Bluhn (1979) also found that hands-on activities designed to teach science process skills can be successfully used to improve the science process skill achievement of preservice elementary teachers. His instruction consisted of a series of short (one to two hour), instructor-guided, hands-on instructional activities related to observing, inferring, hypothesizing, interpreting data and experimenting. Using a self-constructed paper and pencil test, Inquiry Skills Inventory-3, he found that the students who received the instruction significantly improved their knowledge of science processes, ability to use science processes, and ability to sequence science processes as used in scientific problem solving.

Riley (1979) studied the effect of hands-on versus nonmanipulative training in process skills for preservice student teachers in an undergraduate methods program. He trained one group of subjects in the process skills, using a hands-on approach, and another with the same content except that all manipulation of materials was done by the instructor. A third control group received no training in the process skills. He found that both the active-inquiry and vicarious-inquiry approaches improved the preservice teachers' competence in selected process skills--classifying and using space/time relationships--as measured by The Science Process Measure for Teachers from SAPA. Neither treatment had a significant effect on the preservice teachers' understanding of science, attitude toward science and science teaching, or attitude toward method of instruction.

Campbell and Okey (1977) investigated the effectiveness of an individualized, self-instructional program on mastery of the basic science process skills. Preservice elementary teachers, enrolled in a program that combined methods instruction with student teaching, completed paper-and-pencil and laboratory activities on measurement, observation, classification, communication, inference and prediction. Compared to an equivalent control group which did not receive the instructional treatment, the preservice teachers in the treatment group 1) scored significantly higher on the Basic Science Process Skill achievement test, 2) chose more process skill objectives for science units, and 3) incorporated more process skill activities in their lesson plans. The group of preservice teachers trained in the basic science process skills did not differ significantly from the control group in their attitudes toward the use of the process skills in school science instruction or the number of process objectives they included in their lesson plans.

In a similar study, Jaus (1975) used self-instructional materials to teach the integrated science process skills to a group of prospective elementary teachers in a science methods class, and gave no instruction on the process skills to a similar control group. Individuals who received training in the integrated process skills significantly improved their integrated science process skill achievement, as measured by a paper-and-pencil test constructed by the researcher; wrote more instructional objectives to teach process skills to children; and designed more process skill activities than the control group. However, he found no differences between the attitudes of the two groups toward the use of the integrated science process skills in the classroom. Jaus also gave written persuasive communication, in the form of a 700-word handout advocating the use of the integrated science process skills, to a third group of prospective teachers along with the process skill instruction. Their scores on the dependent measures in the study did not vary significantly from those of the group which received only the process skill instruction.

Zeitler (1981) examined the type of practice in which preservice elementary teachers engaged during acquisition of science process skills.

Focusing on several of the integrated process skills, he used a microteaching strategy for one group of students while a second group designed but never practiced teaching lessons modeled after the instructor's activities. Both groups showed significant gains between their pretest and posttest scores on a process skills test constructed by the researcher. However, there were no significant differences in skill achievement between the two groups. Although both groups included process skills in their teaching plans, subjects who practiced through microteaching incorporated the skills in their teaching plans more frequently. Zeitler also indicated that students who practiced with microteaching demonstrated more effective classroom instruction of the process skills than those who practiced with modeling.

Gabel _et al_. (1977) reported that teaching the science process skills within the framework of science content had beneficial results. Preservice teachers who attended laboratory sections of their physics course which placed emphasis on the science process skills showed a higher level of proficiency in physics and achieved higher scores on a process skills test than their peers whose laboratories did not emphasize the process skills. No significant differences in attitude toward science or science teaching for the two groups was found.

In a later study, Gabel and Rubba (1980) concluded that the science process skills appeared to be more effectively taught in a physics course than a science methods course. However, the methods class was more successful in improving attitudes toward science teaching than was the physics course. They suggested that teaching science process skills are a vital part of science. In addition, teaching the process skills in a content class would allow more time in a methods class to concentrate on teaching skills necessary for good instruction.

The studies reviewed indicate that the science process skills may be effectively taught to elementary teachers through a variety of strategies in science methods courses, science content courses, or inservice experiences. In addition, the studies show that teachers who receive training in the science process skills achieve proficiency in the science process skills and include the science process skills in their teaching plans.

Locus of Control

Background

The concept of locus of control arose from social learning theory, a theory which attempts to predict human behavior by explaining how individuals make choices from the variety of potential behaviors available to them. According to social learning theory, an individual's behavior is predicted on the basis of his/her values, his/her expectations and the situations he/she is in.

Much of the experimental data about locus of control is derived from Rotter's social learning theory (Lefcourt, 1976). His theory is unique because it puts equal emphasis on value, expectancy of reinforcement and situational specificity. The relationship between these variables as they predict behavior is stated in the following formula:

$$BP_{x,s_1,R_a} = f(E_{x,R_a,s_1} \& RV_{a,s_1}) \qquad (1)$$

The formula reads: "The potential for behavior x to occur, in situation 1 in relation to reinforcement a, is a function of the expectancy of the occurence of reinforcement a, following behavior x in situation 1, and the value of reinforcement a in situation 1 " (Rotter, Chance, and

Phares, 1972, p. 14). As shown by the formula, behavior potential will be high when expectancy and reinforcement value are high. Other learning theories often emphasize the importance of the value variable, but in Rotter's theory, expectancies are not secondary to values.

Formula (1) may be extended to make predictions for a range of potential behaviors, in regard to a number of expectancies and a variety of situations. The more generalized formula for predicting behavior may be simplified and stated as follows:

$$NP = f(FM \& NV) \quad (2)$$

This is read, "The potentiality of occurrence of a set of behaviors that lead to the satisfaction of some need (need potential) is a function of the expectancies that these behaviors will lead to these reinforcements (freedom of movement) and the strength or value of these reinforcements (need value)" (Rotter, 1954, p. 110).

Freedom of movement is a generalized expectancy of success, based on an individual's recollection of a lifetime of specific expectancy behavior-outcome sequences (Lefcourt, 1976). Locus of control is defined as a generalized expectancy for internal versus external control of reinforcement. While freedom of movement concerns the possibility of success, locus of control involves a causal analysis of success and failure. Rotter et al. (1962) state: "Internal control refers to the perception of positive and/or negative events as being a consequence of one's own actions and thereby under personal control . . . external control refers to the perception of positive and/or negative events as being unrelated to one's own behaviors in certain situations and therefore beyond personal control" (p. 499). Internal individuals believe that their own effort and ability are controllers of events. In contrast, external individuals may attribute causality to any number of external forces such as luck, fate, significant others (e.g., teachers and parents), supernatural powers, complex social and political processes, task or situation characteristics, etc.

Expectancies are generalized from a specific situation to a series of situations which are perceived as similar. Locus of control, which is a problem-solving generalized expectancy, is an attitude regarding the causal relationship between one's own behavior and its consequences. Rotter (1966) maintained that the perception of control might affect a variety of behavioral choices across a large number of life situations. He stated (p. 5):

> "In its simplist form, our basic hypothesis is that if a person perceives reinforcement as contingent upon his own behavior then the occurrence of either a positive or negative reinforcement will strengthen or weaken potential for that behavior to recur in the same or similar situation. If he sees the reinforcement as being outside his own control or not contingent, that is depending upon chance, fate, powerful others, or unpredictable, then the preceeding behavior is less likely to be strengthened or is weakened."

The problem-solving expectancy of locus of control is incorporated into the following overall formula for determining expectancies (Rotter, Chance, and Phares, 1972, p. 41):

$$E = \frac{f(E' \ \& \ GE_r \ \& \ GE_{ps_1} \ \& \ GE_{ps_2} \ . \ . \ . \ GE_{ps_n}}{f(N_{s_1})} \qquad (3)$$

This shows that, ". . . an expectancy in situation 1 is determined by the expectancy that a given reinforcement will occur based on previous experience in the same situation (E'), experiences generalized from other related situations (GE_r), and a variety of problem-solving generalized expectancies (GE_{ps_1} . . ., GE_{ps_n}), divided by some function of the number of expectancies the individual has had in the specific situation (N_{s_1})" (Phares, 1976, p. 20). Therefore, when quantified, locus of control can be used along with other social learning theory variables to predict human social behavior.

Measurement of Locus of Control

The first scale devised to assess individual differences in locus of control beliefs was developed by Phares (1955) and later revised by James (1957). Following this, systematic and extensive work by Rotter, Seeman and Liverant (1962) was done to develop a locus of control scale. This resulted in a 29-item scale (including six filler items) known as the Rotter Internal-External Control Scale (I-E Scale) (Rotter, 1966) which is frequently used in locus of control research with adults. It was originally designed to measure control expectancies in several areas--academic recognition, social recognition, love and affection, dominance, social-political events, and general life philosophy. However, the final version does not contain subscales which can be used to predict profiles in several separate areas but rather is taken to yield a general measure of locus of control which describes an individual's "average" locus of control attributes over many situations (Phares, 1976).

Lacking evidence that locus of control beliefs are consistent across all areas of experience, Crandall *et al*. (1965) devised the Intellectual Achievement Responsibility Questionnaire (IAR) to measure locus of control in children solely in intellectual achievement situations. The scale differs from previous instruments in that it restricts itself to one source of external control--those persons who have the most personal contact with a child (parents, teachers and peers). Finally, the

IAR samples an equal number of positive and negative events and contains two separate subscales for measuring a subject's willingness to accept responsibility for success (I+) and failure (I-). The scale consists of 34 forced-choice items and is widely used to measure children's control expectancies.

Lefcourt _et al_. (1979) developed the Multidimensional-Multiattributional Causality Scale which contains scales assessing the locus of control for affiliation and for achievement of university undergraduates. The instrument contains an equal number of items concerning success and failure experiences. In addition, it differentiates between stable and unstable attributions. This is based on the premise that an unstable attribution can lead to a behavior prediction opposing that of a stable attribution, even though both the unstable and stable attributions could be due to an internal cause. For example, Dweck and Reppucci (1973) found that children who believe their failure is a result of their lack of ability (a stable internal characteristic) are less likely to persist in their efforts than those who believe failure is due to lack of motivation (an unstable internal characteristic). Although both causes are internal, one encourages goal-striving behavior and the other does not.

Numerous other instruments have been developed to measure individual differences in locus of control beliefs. These include: Bialer's Locus of Control Questionnaire, Dean's Alienation Scales, Norwicki-Strickland Locus of Control Scale for Children, Reid-Ware Three-Factor I-E Scale, Stanford Preschool I-E Scale, Stevens-Delys Reinforcement Contingency Interview, and The Norwicki-Duke Scale (Lefcourt, 1976; Phares, 1976).

As with other psychological constructs, researchers must be cautious when equating locus of control with its measuring device. Crandal *et al.* (1965) raised three important issues in the assessment of perceived control. Beliefs are not necessarily consistent across all areas of experience. The specification of agents of external control is important. Also, the type of reinforcement involved (positive versus negative) must be considered. Lefcourt (1976) advises that there is enough evidence to encourage researchers to continue using existing scales for measuring locus of control and also to develop newer, more criterion-specific measures.

Locus of Control and Academic Achievement

Much of the impetus for studies investigating the relationship bewteen locus of control and academic achievement came from the publication of the Coleman report. Coleman *et al.* (1966) found that minority children (except Oriental Americans), more often than white children, have far less conviction that they can affect their own environments and futures. In addition, their study showed that for non-white children, the best predictor of academic achievement was a measure of the extent to which they felt they had control over their destiny.

Using the IAR and Test of Logical Thinking with students in grades seven through eleven, Tobin and Capie (1979) determined that there is no significant relationship between locus of control and formal reasoning ability ($r = 0.02$, $p = 0.46$). This finding was confirmed in a later study (Tobin and Capie, 1982b) with middle school students. They argued that locus of control and cognitive development are ideal variables for predicting outcomes in science and examining aptitude-treatment interactions, since they are unlikely to account for common variance.

Tobin and Capie (1982b) observed twelve students in each of thirteen middle school science classes and rated their overt and covert engagement behavior. Using the IAR to measure locus of control, they found that locus of control was significantly related to rates of attending ($r = 0.21$, $p < 0.01$) and total engagement ($r = 0.20$, $p < 0.05$). Research has shown that in task-linked situations, internals tend to use a distinct motivational style (Bar-Tal and Bar-Zohar, 1977). They show more initiative, exert more effort, and persist to a greater extent than externals. In regard to cognitive reactions, internals focus on task-relevant information to a greater extent and utilize it more efficiently than externals.

Differences in cognitive reactions and motivational style between internally and externally oriented individuals might lead one to predict differences in their academic performance. An individual who feels responsible for academic successes and failures should show more conscious effort, persistence dispite difficulties and willingness to sacrifice immediate pleasures for the purpose of attaining more long-term goals, thereby reaching a higher level of achievement. However, studies investigating the relationship between perception of locus of control and academic achievement have not always yielded consistent data (Lefcourt, 1976).

Studies of the relationship between various measures of locus of control and academic achievement often contain inconsistent results. For example, an important, early study by Crandall et al. (1965), using the IAR, showed a correlation between total I scores of third, fourth and fifth graders, and their Iowa Test scores and report card grades. They also found Iowa test scores and report card grades of girls in grades three and four to be highly related to their IAR scores for success events (I+). In contrast, fifth grade boys' I- scores (i.e., responsibility for failure) were significantly related to their Iowa Test scores and report card grades. In grades six, eight, ten, and twelve, there were significant relations between total I scores and report card grades. However, achievement test scores were only occasionally related significantly to IAR scores. Thus, grade level, sex, attribution for success versus failure, and the dependent measure of academic achievement affect the predictive validity of the construct. In his book on locus of control, Lefcourt stated (1976, p. 66),

> "The research . . . fails to support a simplistic, one-to-one relationship between locus of control and achievement. As in most instances when a topic is closely scrutinized, the observed relationships are found to be anything but simple and conclusive."

In a study with reformatory inmates, Seeman (1963) presented inmates with three categories of materials related to correctional matters: 1) the present reformatory setting, 2) long-range prospects for a noncriminal career, and 3) factors related to achieving successful parole. He found no differences in learning the materials in the first two catagories. In contrast, the more internally oriented inmates learned the parole-related information significantly better than the inmates high in externality. Lefcourt (1966), in a review of research on internal versus external control of reinforcement, summarized that, "In investigations concerned with learning and achievement-related variables, the control construct allows some prediction when the materials are relevant to the subjects' goal strivings" (p. 214).

Although the studies do not always provide consistent data, Bar-Tal and Bar-Zohar (1977), in a review of 36 studies on the relationship between perception of locus of control and academic achievement, found a firm trend suggesting that the more internal an individual's orientation, the higher is the individual's achievement. Only one study contained a negative relationship between internal perception and achievement, and four studies found no significant relationship. Thirty-one of the studies reported a positive relationship between internal perception of locus of control and achievement, for at least some of the achievement measures and with at least part of the sample. In their review, Stipek and Weisz (1981) concurred that studies using questionnaire measures of locus of control show a relationship between some aspect of children's perceptions of causality and achievement.

ATI research has been used in an attempt to establish principles which would help educators adapt the educational environment to individual differences in perception of control (Cronbach and Snow, 1977). Most of the studies dealing with locus of control have examined its effect on the learning process in high- and low-structure situations. Generally, research on locus of control predicts that students with an external locus of control will excel in high-structure situations, while internal students will do better in low-structure situations (Horak and Horak, 1982).

Parent *et al*. (1975) studied the interactive effects of teaching strategy and personal locus of control on college students' performance in a two-hour "mini-course" on computer programming. They found that the more internally controlled students performed better under low-discipline conditions, whereas the more externally controlled students performed better under high teacher-discipline condidions ($p < 0.05$). Similarly, Daniels and Stevens (1976) found a very strong interaction between Rotter I-E scale scores and instructional methods in an eight-week introductory psychology class ($p < 0.0001$). Internally oriented college students under a contract-for-grade plan performed at a higher level than those with an external orientation. However, when the class was taught in a more traditional, teacher-controlled method, externally oriented students performed at a higher level than students who were internally oriented. Daniels and Stevens suggest that the reason for inconsistency of results in research related to locus of control and course performance is that the instructional context has not been given enough consideration.

Edwards and Waters (1981) found that I-E scores of 223 college students were unrelated to their grade point average ($r = 0$). Given the variety of courses and instructional methods influencing students' grade point averages, they believed their results were consistent with the findings of Daniels and Stevens (1976).

Horak and Slobodzian (1980) investigated the influence of instructional structure and locus of control on achievement by preservice elementary science teachers. Two alternative instructional programs, one with high- and one with low-structure format, were developed. Both program modules dealt with planning science field trip activities for elementary children and required 315 minutes for completion. Main effects analysis showed that the high-structure condition resulted in the highest achievement as measured by an application test of science processes ($p < 0.01$). However, when analyzing achievement as measured by an application test of science content, they found that internal students achieved most in a low-structured environment and external students achieved most in a high-structured environment ($p < 0.01$).

In their study on the achievement of preservice elementary teachers in an undergraduate biology course, Yeany _et al_. (1980) compared the achievement of students who received performance objectives and remedial assignments following diagnostic measures with the achievement of students who only received performance objectives. They hypothesized that internal students would act more readily on feedback and thereby perform better under the diagnostic-prescriptive procedure. However, they found no interaction between instructional strategy and locus of control ($p = 0.99$). A possible explanation offered is that the Rotter I-E Scale which was used to measure locus of control does not guide university students' behavior.

Schafer (1981) attempted to promote shifts in college students' locus of control by modifying an introductory, "Classic" Audio-Tutorial zoology course. He allowed students in his experimental group to use an Individualized Goal-Setting approach to their optional mini-courses and compared them with a control group receiving a "Classic" Audio-Tutorial approach. As measured by the Rotter I-E Scale ($p = 0.40$) and a self-constructed Academic I-E Scale ($p = 0.87$), Individualized Goal-Setting did not promote shifts to an internal locus of control. Schafer attributed the absence of change in expectancy for control to the limited potency of the treatment, failure of students to utilize the goal-setting opportunity, possible difficulties with the predictive validity of locus of control in many classroom settings, and his small sample size (total $N = 52$).

In their study on locus of control and science achievement of elementary school children, Brooks and Hounshell (1975) found that external students (as determined by the IAR in nongraded schools) scored lower on the Stanford Achievement Test in Science than students with an internal locus of control in the same settings. External students in the nongraded school also scored lower than their counterparts, students with an external locus of control, in graded schools. A finding of their study which they considered even more important was that there were significantly more internally controlled students in the nongraded settings than in the graded schools. They saw this as the logical outcome of a situation where students were permitted and encouraged to make choices and explore within their environment.

Cohen (1982) investigated the relationship between locus of control and development of spatial conceptual abilities of fifth grade students. One class received individualized instruction from the Energy Sources unit of SCIS (Science Curriculum Improvement Study), with emphasis placed on the manipulation of objects. The control class's instruction was teacher-directed in a group manner around a textbook, with demonstrations done for the entire class as a single unit. Locus of control was measured using the Norwicki-Strickland Locus of Control Measure for Children. He reported that internally oriented pupils performed equally well on projective spatial tasks regardless of whether they were in the experimental or control group. In contrast, pupils exhibiting externality and having access to manipulatives demonstrated a higher degree of spatial conceptual ability than external individuals not having access.

Very little research has been done which examines the possible interaction between locus of control and CAI as an instructional method. Smith (1971), in his doctoral dissertation, examined the effect of CAI on locus of control of seventh, eighth, and ninth grade students. Using the Crandall Locus of Control Instrument and Coleman Control Items, he found no differences in the mean locus of control scores of students participating in a CAI math drill-and-practice program and students in the non-CAI control group. However, caution must be taken in interpreting results from this study as subjects were not randomly assigned to the CAI or non-CAI group. Students in the CAI group had been placed there because of the recommendations of their teachers. As a group they had lower pretest math self-concept scores than the non-CAI group. Also, the special nature of the students sampled (two to three years below grade level in arithmetic and 75 percent Mexican-Americans) limits the generalizability of the study's findings.

METHODS AND MATERIALS

Sample

This study involved 81 preservice elementary teachers enrolled in Education 323, Teaching Science in the Elementary School Curriculum, at Purdue University during the Fall, 1982, and Spring, 1983, semesters. Of the 81 subjects, 75 were Seniors and six were Juniors. The population sampled represented those students in the upper or lower third of the total group of 125 students enrolled, based on their scores on the achievement subscale of the Multidimensional-Multiattributional Causality Scale.

Subjects were assigned, by the University computer registration program when they registered, to one of two self-contained, intact classes during the fall semester or to one of four self-contained, intact classes during the spring semester. The intact classes were matched for instructors and then randomly assigned to an experimental group and a control group each semester. The experimental group consisted of 39 subjects who had been assigned to three self-contained, intact classes. They were given CAI in the integrated science process skills. The control group consisted of 42 subjects who had been assigned to three self-contained, intact classes. They received instruction regarding the integrated science process skills via printed PI.

Description of the Study

This study attempted to ascertain whether CAI would result in differences from printed PI in preservice elementary teachers' achievement of the integrated science process skills and computer literacy. In addition, the study investigated whether locus of control interacted with mode of instruction (CAI versus printed PI) to yield differences in preservice elementary teachers' achievement of the integrated science process skills.

Four lessons were designed to develop the subjects' integrated science process skills. Skills taught during the four lessons were: identifying variables, interpreting data, formulating hypotheses and experimenting. The lessons were printed for control subjects (sample lesson in Appendix B) and programmed for use with a TRS-80 Model III microcomputer, using a tutorial approach, for the experimental group (sample program in Appendix C). Following each lesson, both groups took quizzes which gave them feedback about their progress. Students were informed that quiz scores were designed solely to give them feedback and would not be used to determine course grades. CAI learners received immediate feedback from the computer in response to their answers. Subjects using the printed text handed in their quizzes which were scored by the researcher and returned during the following class period.

At the beginning of each semester, subjects were assigned, by the University computer registration program, to a self-contained, intact class section of Education 323. Only those subjects scoring in the upper or lower third on the achievement subscale of the MMCS were included in the study. Subjects who scored in the upper one third (>43) of the total pool of subjects were labeled as having an external locus of control. Similarly, subjects scoring in the lower one-third (<36) were labeled as being internally controlled. Subjects scoring in the middle one-third of the total pool of subjects on the achievement subscale of the MMCS were eliminated from the study. Consideration of only the subjects who scored in the extremes on the internal-external continuum of locus of control should magnify differences between the performances of the two groups.

Two intact classes enrolled during the Fall, 1982, semester and four intact classes enrolled during the Spring, 1983, semester were matched for instructors and then randomly assigned to experimental or control groups. Three class sections (the control group) completed the printed PI. The other three class sections (the experimental group) received their instruction from the CAI lessons. Each lesson was treated as a weekly out-of-class assignment. Students in the experimental group scheduled one-half hour per lesson to work on a microcomputer; those using the printed text received one lesson in class each week which they completed on their own within a week.

Education 323 met for the first eight weeks of each semester. During the first two weeks of the semester, subjects were administered three pretests: the MCLAA, the TISP, and the achievement subscale of the MMCS. During the next four weeks students completed one process skill lesson per week. Two posttests, the MCLAA and the TISP, were administered during the final two weeks of class. In addition, students completed questionnaires, reporting data such as their class status, grade point average, science background and previous experience with computers. This procedure was followed, using two classes in the Fall, 1982. The research experiment was replicated in the Spring, 1983, using four classes and the same procedure.

Instruments Used in the Study

The instruments used in the study are paper and pencil tests. They are:

1. The Minnesota Computer Literacy and Awareness Assessment (MCLAA; Anderson et al., 1979). The MCLAA measures subjects' affective and cognitive knowledge of computers. It is based on the affective and cognitive components considered necessary by the Minnesota Educational Computing Consortium for the development of computer literacy. The test consists of 83 items.

The 30 items of the affective subscale measure subject's attitudes and values related to computers: enjoyment, anxiety, efficacy (confidence), attitude toward computers in schools, social and personal values, and technical values. Students respond on a five-point semantic differential scale (strongly disagree to strongly agree) and a three-point semantic differential scale (unimportant to extremely important).

The 53 items of the cognitive subscale measure knowledge about the technical areas related to computer hardware, software, programming, algorithms, applications and impact on society. The subscale includes 22 true/false questions and 31 multiple choice questions.

Anderson et al. (1979) reported the overall test reliability of the MCLAA to be 0.90 as measured by the Cronbach Alpha. When 1,131 students were retested, the test-retest correlation was 0.75. Reliability was redetermined for the subjects used in this study. For the 81 students who took the MCLAA pretest, the following Spearman-Brown formula split half correlations were determined: affective subscale, 0.93; cognitive subscale, 0.79; total test, 0.88.

2. The Test of the Integrated Processes (TISP; Tobin and Capie, 1982a). The TISP measures students' achievement of the integrated process skills associated with planning and conducting an investigation. The skills were developed by the Commission on Science Education of the American Association for the Advancement of Science (AAAS) in the 1960's when they prepared a science program for Kindergarten through grade six (Livermore, 1964). The process approach to teaching science is based on imitating what a scientist does and the integrated science process skills are the terminal skills necessary to do science experiments and solve problems. They include formulating hypotheses, operationally defining, controlling and manipulating variables, planning investigations, and interpreting data.

The test consists of 24 multiple choice items. There are two items for each of 12 objectives related to autonomously planning and conducting an investigation. The objectives are listed in the flow chart in Figure 1. The test requires approximately 35 minutes to administer. It has acceptable content and construct validity. Tobin and Capie (1982) reported that the reliability of the test for a group of 109 female undergraduates indicated that students (alpha = 0.77) and items (alpha = 0.96) could be dependably differentiated. The reliability of the test was established for subjects used in this study. For the 81 students taking the pretest, the split-half reliability was 0.67.

3. The Multidimensional-Multiattributional Causality Scale (MMCS; Lefcourt, et al., 1979). This test measures two goal-specific loci of control: achievement and affiliation. Only the subscale which assesses locus of control for achievement was used since it measures specific expectancies associated with academic learning.

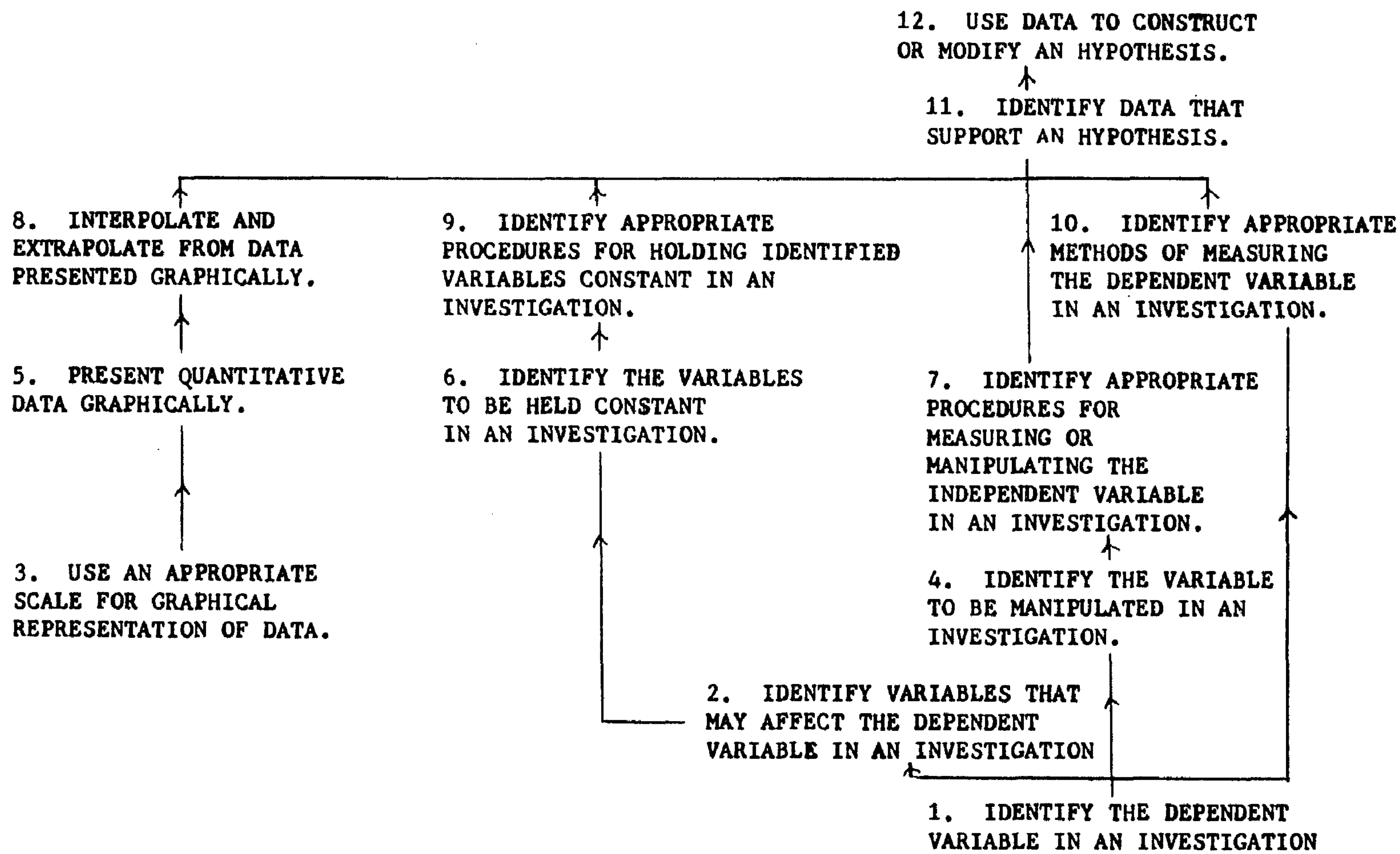


Figure 1. Flowchart for planning and conducting an investigation (from Tobin and Capie, 1982).

The achievement subscale consists of 24-item Likert scales. Twelve items concern success and 12 concern failure. The set of 24 items is also divided equally between four attributions: six stable internal items (relatively unchangeable and beyond immediate control) such as ability or skill, six unstable internal items (relatively changeable and under immediate control) such as effort and motivation, six stable external items such as task difficulty, and six unstable external items such as luck or fate. The possible range of scores is from 0 to 96, with the Likert rating for each item being zero to four (agree to disagree).

The following measures of internal consistency for the achievement subscale when administered to 241 undergraduates have been reported (Lefcourt, et al., 1979): Cronbach alpha, 0.61; Spearman-Brown split half correlation, 0.77. Reliability for the subjects used in this study was established using the Cronbach alpha formula. The reliability of the test for the 81 subjects was 0.80.

Statistical Hypotheses

H_o: 1 There is no difference in the affective computer literacy mean posttest score of the experimental group when compared with the control group as measured by the Affective Computer Literacy Subscale of the MCLAA.

H_o: 2 There is no difference in the affective computer literacy mean posttest score of students classified as internal when compared with students classified as external as measured by the Affective Computer Literacy Subscale of the MCLAA.

H_o: 3 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the affective computer literacy mean posttest score as measured by the Affective Computer Literacy Subscale of the MCLAA.

H_o: 4 There is no difference in the cognitive computer literacy mean posttest score of the experimental group when compared with the control group as measured by the Cognitive Computer Literacy Subscale of the MCLAA.

H_o: 5 There is no difference in the cognitive computer literacy mean posttest score of students classified as internal when compared with students classified as external as measured by the Cognitive Computer Literacy Subscale of the MCLAA.

H_o: 6 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the affective computer literacy mean posttest score as measured by the Affective Computer Literacy Subscale of the MCLAA.

H_o: 7 There is no difference in the composite computer literacy mean posttest score of the experimental group when compared with the control group as measured by the Composite Computer Literacy Score of the MCLAA.

H_o: 8 There is no difference in the composite computer literacy mean posttest score of students classified as internal when compared with students classified as external as measured by the Composite Computer Literacy Score of the MCLAA.

H_o: 9 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the composite computer literacy mean posttest score as measured by the Composite Computer Literacy Score of the MCLAA.

H_o: 10 There is no difference in the integrated science process skills mean posttest score of the experimental group when compared to the control group as measured by the TISP.

H_o: 11 There is no difference in the integrated science process skills mean score of students classified as internal when compared with students classified as external as measured by the TISP.

H_o: 12 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the integrated science process skills mean posttest score as measured by the TISP.

Research Design

The Campbell and Stanley (1963) Pretest-Posttest Control Group Design (#4) was selected for this study because equivalent groups were achieved through randomization.

The research design was:

Experimental Group, G_1	O_1 ----- X_1 ----- O_2
Control Group, G_2	O_1 ----- X_2 ----- O_2

Observations

O_1 -- Pretests

1. MCLAA
2. TISP
3. MMCS (achievement subscale)

O_2 -- Posttests

1. MCLAA
2. TISP

Treatments

X_1 -- CAI for the Integrated Science Process Skills

X_2 -- printed PI for the Integrated Science Process Skills

Statistical Design and Method of Analysis

This study used a two-factor, 2 x 2, factorial experiment. One factor was the two levels of instructional treatment (experimental and control). The second factor was the two levels of locus of control (internal and external). Subjects were nested within each variable. However, the mean score of each group of subjects nested within the independent variables was used as the experimental measurement unit of the dependent measures. The equivalence of both groups was assumed since groups of students were randomly assigned to control and experimental groups.

Pearson correlation coefficients between the pretest and posttest scores on each dependent measure were computed to determine whether a significant relationship existed between the two. The correlation coefficients for each measure were: MCLAA affective subscale, 0.69; MCLAA cognitive subscale, 0.83; MCLAA composite score, 0.71; and TISP, 0.66. Because of the strong correlation between pretests ($X_{i,j,k}$), and posttests ($Y_{i,j,k}$), analysis of covariance was used to adjust the posttest scores with the pretest scores before assessing main and interaction effects.

The model used to test the hypotheses was:

$$Y_{ijk} = \mu + \beta(X_{ijk} - \bar{X}) + G_i + L_j + GL_{ij} + \epsilon_{k(i,j)}$$

G_i = group $i = 1,2$

L_j = locus of control $j = 1,2$

$\epsilon_{k(i,j)}$ = random error within cell i,j $k = 1,2,3$

β = slope between Y and X over all the data

ANALYSIS OF DATA

This study was designed to determine if CAI via the use of a microcomputer could significantly promote gains by preservice elementary school teachers in the integrated science process skills and computer literacy. In addition, it investigated the possible interactive effect of locus of control and mode of instruction. The mean of each group of subjects nested within the independent variables was used as the experimental unit for each of the dependent measures. Random assignment to experimental and control groups assured a lack of initial bias between groups. Therefore, statistical analysis of the groups' pretest scores on the dependent variables for establishing the initial equivalence of the groups was unnecessary.

One-way analysis of variance was used to compare pretest scores of the internally and externally controlled subjects in each group. Table 1 reports the mean pretest scores and corresponding standard deviations of subjects with internal and external loci of control on each of the dependent measures. Results of the analysis of variance for the affective subscale of the MCLAA, cognitive subscale of the MCLAA and composite computer literacy score of the MCLAA are shown on Tables 2, 3 and 4, respectively. While there was no statistically significant difference between pretest scores of internally and externally controlled subjects on the affective subscale of the MCLAA, pretest scores of subjects with internal control were significantly higher than subjects with external

Table 1. Mean pretest scores and standard deviations for internally and externally controlled students on the MCLAA and TISP.

	Locus of Control	
	Internal	External
MCLAA Affective Subscale	$\bar{y}$ = 108.4 s.d. = 4.70 n = 6	$\bar{y}$ = 104.6 s.d. = 4.58 n = 6
MCLAA Cognitive Subscale	$\bar{y}$ = 42.7 s.d. = 2.39 n = 6	$\bar{y}$ = 38.2 s.d. = 2.26 n = 6
MCLAA Composite Score	$\bar{y}$ = 150.9 s.d. = 5.62 n = 6	$\bar{y}$ = 142.7 s.d. = 6.29 n = 6
TISP	$\bar{y}$.= 17.7 s.d. = 1.41 n = 6	$\bar{y}$ = 17.2 s.d. = 0.82 n = 6

Table 2. ANOVA for locus of control on pretest scores of affective computer literacy subscale of MCLAA.

Source	D.F.	SS	MS	F
Treatments	1	44.08	44.08	2.12
Error	10	207.72	22.77	

Table 3. ANOVA for locus of control on pretest scores of cognitive computer literacy subscale of MCLAA.

Source	D.F.	SS	MS	F
Treatments	1	58.96	58.96	10.92**
Error	10	54.00	5.40	

**Significant at p=0.01.

Table 4. ANOVA for locus of control on pretest composite computer literacy scores of MCLAA.

Source	D.F.	SS	MS	F
Treatments	1	202.54	202.54	5.69*
Error	10	355.97	35.60	

*Significant at p=0.05.

control for the cognitive subscale of the MCLAA ($p < 0.01$) and the composite MCLAA computer literacy score ($p < 0.05$). This is consistent with the trend found in the literature suggesting that the more internal an individual's orientation, the higher is the individual's achievement (Bar-Zohar, 1977).

Analysis of variance of the pretest scores on the TISP are reported in Table 5. There was no statistically significant difference between internally and externally controlled subjects at an alpha level of 0.05.

The first three hypotheses were:

H_o: 1 There is no difference in the affective computer literacy posttest score of the experimental group when compared with the control group, as measured by the Affective Computer Literacy Subscale of the MCLAA.

H_o: 2 There is no difference in the affective computer literacy posttest score of the students classified as internal when compared with students classified as external, as measured by the Affective Computer Literacy Subscale of the MCLAA.

H_o: 3 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the affective computer literacy mean posttest score, as measured by the Affective Computer Literacy Subscale of the MCLAA.

Table 6 provides an overview of subjects' scores on the Affective Computer Literacy Subscale of the MCLAA. Table 7 reports the mean scores and standard deviations of the groups on the Affective Subscale. The Pearson correlation coefficient for the pretest and posttest scores of the Affective subscale was 0.69. Therefore, analysis of covariance was used to adjust the posttest scores using the pretest scores, before assessing main and interaction effects.

Table 5. ANOVA for locus of control on pretest scores of TISP.

Source	D.F.	SS	MS	F
Treatments	1	1.02	1.02	0.759
Error	10	13.45	1.35	

Table 6. Pretest and posttest scores on the Affective Computer Literacy Subscale of the MCLAA.

	Groups			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	108.5	107.7	104.6	105.7
	102.3	106.2	109.0	109.8
	115.8	115.2	110.3	122.3
External	102.7	106.6	98.5	100.5
	101.5	111.5	108.0	107.9
	110.2	122.4	106.6	111.8

Table 7. Mean pretest and posttest scores and standard deviations on the Affective Computer Literacy Subscale of the MCLAA.

	Groups			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	$\bar{y}$ = 108.9	$\bar{y}$ = 109.7	$\bar{y}$ = 108.0	$\bar{y}$ = 112.6
	s.d.=6.52	s.d.=4.82	s.d.=2.99	s.d.=8.65
	n = 3	n = 3	n = 3	n = 3
External	$\bar{y}$ = 104.8	$\bar{y}$ = 113.5	$\bar{y}$ = 104.4	$\bar{y}$ = 106.7
	s.d.=4.71	s.d.=8.09	s.d.=5.13	s.d.=5.74
	n = 3	n = 3	n = 3	n = 3

Table 8 shows the results of the analysis of covariance for scores on the affective subscale of the MCLAA. As shown by the table, at an alpha level of 0.05, there is no evidence to support a rejection of any of the first three null hypotheses (H_o: 1, H_o: 2, H_o: 3). Thus, no differences were shown between the experimental and control groups, or between internally and externally controlled students, on the Affective Computer Literacy Subscale of the MCLAA. Additionally, no interaction effects between groups and loci of control were demonstrated.

The next three hypotheses were:

H_o: 4 There is no difference in the cognitive computer literacy mean posttest score of the experimental group when compared with the control group, as measured by the Cognitive Computer Literacy Subscale of the MCLAA.

H_o: 5 There is no difference in the cognitive computer literacy mean posttest score of students classified as internal when compared with students classified as external, as measured by the Cognitive Computer Literacy Subscale of the MCLAA.

H_o: 6 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the cognitive computer literacy mean posttest score as measured by the Cognitive Computer Literacy Subscale of the MCLAA.

Table 9 provides an overview of subjects' scores on the Cognitive Computer Literacy Subscale of the MCLAA. Table 10 reports the mean scores and standard deviations of the groups on the Cognitive Subscale.

The Pearson correlation coefficient for the pretest and posttest scores of the Cognitive subscale of the MCLAA is 0.83. Therefore, analysis of covariance was used to adjust the posttest scores using the

Table 8. Analysis of covariance for the Affective Computer Literacy Subscale of the MCLAA.

Source	D.F.	SS	MS	F Ratio	P
Pretest	1	225.809	225.809	10.909	0.013
Group	1	4.393	4.393	0.212	0.659
Locus of Control	1	23.800	23.800	1.150	0.319
Group x Locus of Control	1	77.636	77.636	3.751	0.094
Error	7	144.889	20.698		

Table 9. Pretest and posttest scores on the Cognitive Computer Literacy Subscale of the MCLAA.

	Groups			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	40.2	40.7	39.7	43.7
	45.0	45.2	44.5	44.3
	44.7	45.2	41.8	44.2
External	38.3	41.3	37.0	37.0
	34.5	40.0	38.9	40.4
	41.0	43.8	39.6	41.2

Table 10. Mean pretest and posttest scores and standard deviations on the Cognitive Computer Literacy Subscale of the MCLAA.

	Groups			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	$\bar{y}$ = 43.3	$\bar{y}$ = 43.7	$\bar{y}$ = 42.0	$\bar{y}$ = 44.1
	s.d.= 2.69	s.d.=2.60	s.d.=2.41	s.d.=0.32
	n = 3	n = 3	n = 3	n = 3
External	$\bar{y}$ = 37.9	$\bar{y}$ = 41.7	$\bar{y}$ = 38.5	$\bar{y}$ = 39.5
	s.d.=3.27	s.d.=1.93	s.d.=1.35	s.d.=2.23
	n = 3	n = 3	n = 3	n = 3

pretest scores, before assessing main and interaction effects. Table 11 shows the results of the analysis of covariance for scores on the cognitive subscale. As shown by the table, at an alpha level of 0.05, there is no evidence to support a rejection of H_o: 4 or H_o: 5. Thus no differences were shown between the main effects of group (experimental or control) or locus of control (internal or external).

However, at an alpha level of 0.05, the null hypothesis of no interaction between groups and loci of control in cognitive computer literacy (H_o: 6) is rejected. This indicates that internal and external subjects each responded differently to the experimental treatment than they did to the control treatment. Figure 2 presents a graph of the interaction which displays the mean posttest scores, adjusted by the pretest scores, for the combination of each factor at each level. The Newman-Keuls range test (Hicks, 1973) was used to determine which means differed. Figure 3 depicts these differences. Scores of the external subjects in the control group were significantly lower than those of the internally controlled subjects in the control group and the externally controlled subjects in the experimental group.

The next three null hypotheses were:

H_o: 7 There is no difference in the composite computer literacy mean posttest score of the experimental group when compared with the control group, as measured by the Composite Computer Literacy Score of the MCLAA.

H_o: 8 There is no difference in the composite computer literacy mean posttest score of students classified as internal when compared with students classified as external as measured by the Composite Computer Literacy Score of the MCLAA.

Table 11. Analysis of covariance for the Cognitive Computer Literacy Subscale of the MCLAA.

Source	D.F.	SS	MS	F Ratio	P
Pretest	1	48.934	48.934	37.415	0.001
Group	1	1.440	1.440	1.101	0.329
Locus of Control	1	0.897	0.897	0.686	0.435
Group x Locus of Control	1	10.077	10.077	7.705	0.027
Error	7	9.155	1.308		

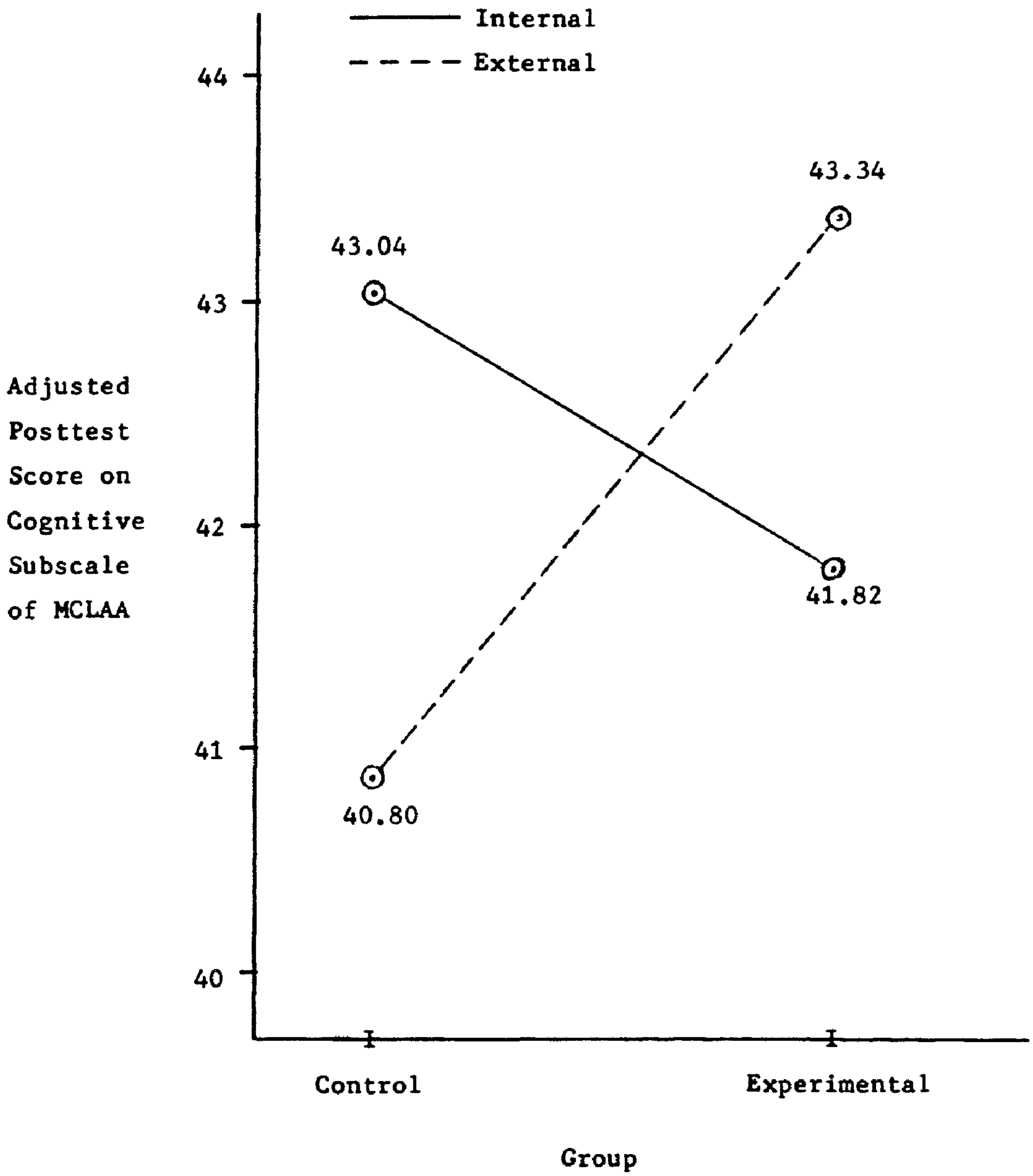
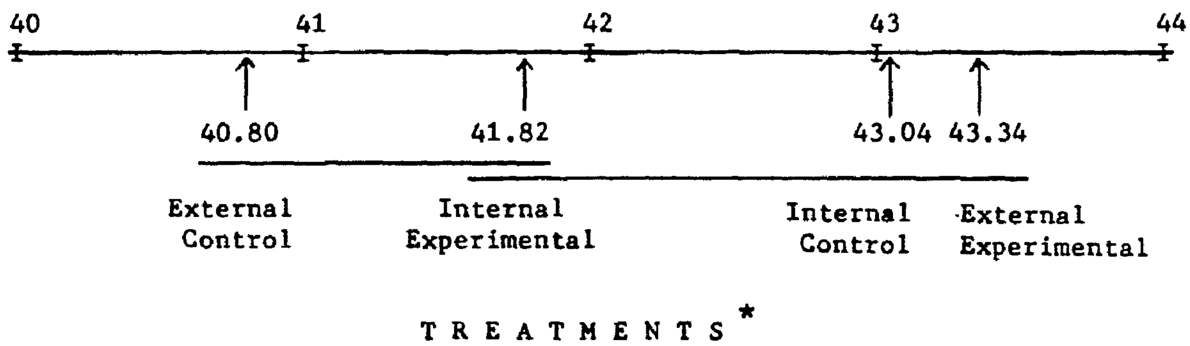


Figure 2. Interaction between group and locus of control for adjusted posttest scores on the Cognitive Subscale of the MCLAA.



*Treatment means not underscored by the same line are significantly different ($p<0.05$), and those underscored by the same line are not significantly different ($p>0.05$).

Figure 3. Significant differences between mean adjusted posttest scores on the Cognitive Computer Literacy Subscale of the MCLAA as determined by the Newman-Keuls range test.

H_o: 9 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the composite computer literacy mean posttest score as measured by the Composite Computer Literacy Score of the MCLAA.

Table 12 provides an overview of subjects' scores on the Composite Computer Literacy Subscale of the MCLAA. Table 13 reports the mean scores and standard deviations of the groups on the composite score of the MCLAA. The Pearson correlation coefficient for the pretest and posttest composite scores of the MCLAA was 0.71. Therefore, analysis of covariance was used to adjust the posttest scores using the pretest scores, before assessing main and interaction effects. Table 14 shows the results of the analysis of covariance for composite computer literacy scores. As shown by the table, at an alpha level of 0.05, there is no evidence to support a rejection of H_o: 7 or H_o: 8. Thus, no differences were shown between the main effects of group (experimental or control) or locus of control (internal or external).

At an alpha level of 0.05, the null hypothesis of no interaction between groups and loci of control in composite computer literacy (H_o: 9) is rejected. This indicates that internal and external subjects each responded differently to the experimental treatment than they did to the control treatment. Figure 4 presents a graph of the interaction which displays the mean posttest scores, adjusted by the pretest scores, for the combination of each factor at each level. Analysis by the Newman-Keuls range test, at an alpha level of 0.05, indicates that no statistically significant differences exist between the adjusted posttest means of the individual treatments. However, analysis by the Duncan Multiple Range Test (Duncan, 1956) at an alpha level of 0.05

Table 12. Pretest and posttest scores on the Composite Computer Literacy Subscale of the MCLAA.

	Group			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	148.7	148.3	144.3	149.3
	147.3	151.3	152.6	153.4
	160.5	160.4	152.2	166.5
External	141.0	147.9	135.5	137.5
	136.0	151.5	146.5	147.8
	151.2	166.2	146.1	153.0

Table 13. Mean pretest and posttest scores and standard deviations on the Composite Computer Literacy Subscale of the MCLAA.

	Groups			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	$\bar{y}$ = 152.2	$\bar{y}$ = 153.3	$\bar{y}$ = 149.7	$\bar{y}$ = 156.4
	s.d. = 7.25	s.d. = 6.30	s.d. = 4.68	s.d. = 8.98
	n = 3	n = 3	n = 3	n = 3
External	$\bar{y}$ = 142.7	$\bar{y}$ = 155.2	$\bar{y}$ = 142.6	$\bar{y}$ = 146.1
	s.d. = 7.75	s.d. = 9.69	s.d. = 6.24	s.d. = 7.89
	n = 3	n = 3	n = 3	n = 3

Table 14. Analysis of covariance for the Composite Computer Literacy Subscale of the MCLAA.

Source	D.F.	SS	MS	F Ratio	P
Pretest	1	373.474	373.474	15.203	0.006
Group	1	39.086	39.086	0.391	0.552
Locus of Control	1	27.051	27.051	1.101	0.392
Group x Locus of Control	1	160.412	160.412	6.530	0.038
Error	7	171.957	24.565		

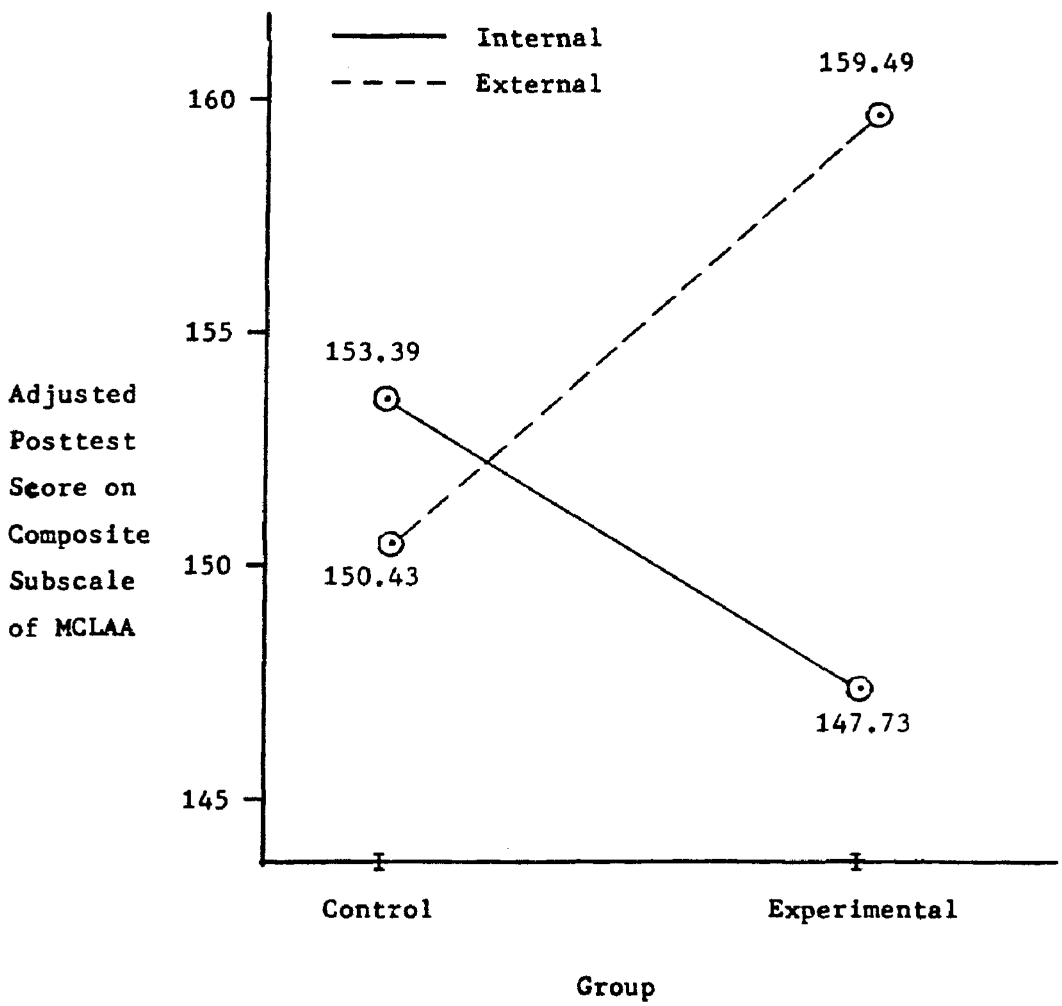
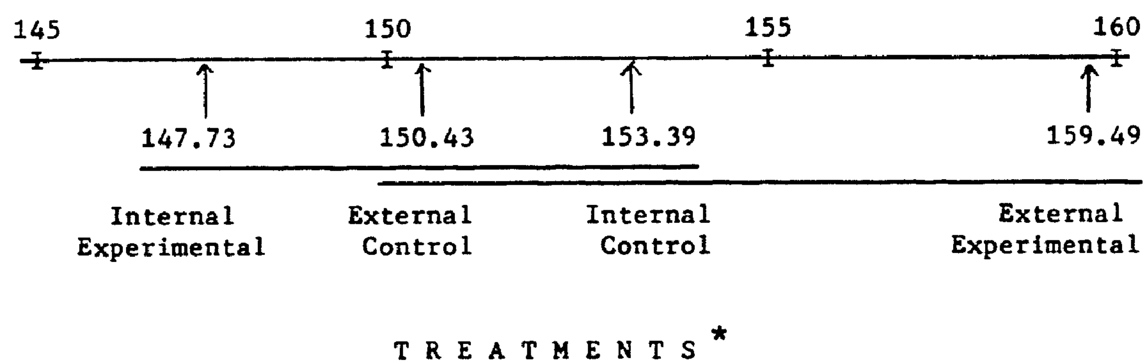


Figure 4. Interaction between group and locus of control for adjusted posttest scores on the Composite Subscale of the MCLAA.



*Treatment means not underscored by the same line are significantly different ($p<0.05$), and those underscored by the same line are not significantly different ($p>0.05$).

Figure 5. Significant differences between mean adjusted posttest scores on the Composite Computer Literacy Subscale of the MCLAA as determined by the Duncan Multiple Range Test.

demonstrates that scores of the external subjects in the experimental group were significantly higher than those of the internal subjects in the experimental group. Figure 5 depicts the results of the Duncan Multiple Range Test.

The remaining three hypotheses are:

H_o: 10 There is no difference on the integrated science process skills mean score of the experimental group when compared to the control group, as measured by the TISP.

H_o: 11 There is no difference on the integrated science process skills mean score of students classified as internal when compared with students classified as external, as measured by the TISP.

H_o: 12 There is no interaction between loci of control (internal and external) and groups (experimental and control) in the integrated science process skills mean posttest score as measured by the TISP.

Table 15 provides an overview of subjects' scores on the TISP. Table 16 reports the mean scores and standard deviations of the groups on the TISP. The Pearson correlation coefficient for the pretest and posttest scores on the TISP was 0.66. Therefore, analysis of covariance was used to adjust the posttest scores using the pretest scores, before assessing main and interaction effects. Table 17 shows the results of the analysis of covariance for the TISP. As shown by the table, at an alpha level of 0.05, there is no evidence to support a rejection of H_o: 10, H_o: 11, or H_o: 12. Thus, no differences were shown between the experimental and control group, or between internally and externally controlled students on the TISP. Furthermore, no interaction effects between groups and loci of control were demonstrated.

Table 15. Pretest and posttest scores on the TISP.

	Groups			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	16.3	17.7	16.0	18.2
	19.3	20.2	19.3	19.5
	17.6	19.7	17.7	20.5
External	16.6	18.6	17.0	20.0
	17.5	20.0	16.3	17.5
	18.6	19.2	16.7	17.3

Table 16. Mean pretest and posttest scores and standard deviations on the TISP.

	Groups			
	Experimental		Control	
Locus of Control	Pretest	Posttest	Pretest	Posttest
Internal	$\bar{y}$ = 17.7	$\bar{y}$ = 19.2	$\bar{y}$ = 17.7	$\bar{y}$ = 19.4
	s.d. = 1.50	s.d. = 1.32	s.d. = 1.65	s.d. = 1.18
	n = 3	n = 3	n = 3	n = 3
External	$\bar{y}$ = 17.6	$\bar{y}$ = 19.3	$\bar{y}$ = 16.7	$\bar{y}$ = 18.3
	s.d. = 1.00	s.d. = 0.70	s.d. = 0.35	s.d. = 1.50
	n = 3	n = 3	n = 3	n = 3

Table 17. Analysis of covariance for the posttest scores on the TISP.

Source	D.F.	SS	MS	F Ratio	P
Pretest	1	6.194	6.194	5.836	0.046
Group	1	0.028	0.028	0.026	0.877
Locus of Control	1	0.080	0.080	0.075	0.792
Group x Locus of Control	1	0.362	0.362	0.341	0.578
Error	7	7.429	1.061		

DISCUSSION

Using the data collected for this study, none of the null hypotheses regarding main effects on attainment of computer literacy were rejected. There was no statistically significant difference between the experimental and control groups on subjects' affective, cognitive or composite computer literacy scores on the MCLAA. This contradicts the expectation that students receiving PI on the computer (CAI) would show greater gains in computer literacy than those receiving PI via a printed text. A possible explanation is that, as a treatment, the CAI simply lacked potency. The majority of the subjects had some prior, limited experience with using a computer. Only nine of the 81 subjects in the study had never used a computer before. However, the preponderance of students' computer experiences were with computer games. Twenty-one percent of the subjects had completed a course about computers or computer programming. Thus, it appears both groups of subjects may have gained exposure, however limited, to computers during and prior to, but independently from, the study.

The approximately two hours (four sessions) of CAI received by the experimental group in this study was possibly not a strong enough treatment to result in a measurable difference in computer literacy between the experimental and control groups. Because they are scheduled to do their student teaching during the second half of the semester, most of the students enrolled in Education 323 are also including other eight-week courses in the first part of their semester. While attending these classes, which require that students complete the same amount of work in one-half the amount of time as those enrolled in three-credit, 16 week classes, the students are effectively carrying course loads of approximately 18 credit hours. It is difficult to require more from them, in terms of outside classwork, considering their already demanding schedules.

There was no statistically significant difference between the internally and externally controlled subjects on the adjusted posttest scores of the affective subscale of the MCLAA, cognitive subscale of the MCLAA, or composite computer literacy score of the MCLAA. The absense of differences in the performance of internally and externally controlled individuals may be due to the small sample size used for this study. Small sample sizes make it more difficult to obtain statistical significance.

There was no interaction between groups (experimental and control) and loci of control (internal and external) in affective computer literacy. However, there was an interaction between the independent variables in cognitive computer literacy and the composite computer literacy score. The external subjects in the experimental group scored significantly higher than the external subjects in the control group on the cognitive subscale of the MCLAA ($p < 0.05$). In addition, the internal subjects in the control group scored higher than the external subjects in the control group on the cognitive subscale. Also, the composite computer literacy scores of the external subjects in the experimental group were significantly higher than those of the internal subjects in the experimental group ($p < 0.05$).

The findings of interaction effects between groups and loci of control indicate the differential value of the experimental treatment for externally controlled subjects and internally controlled subjects. Subjects with an external locus of control benefited more, in terms of scores on the cognitive subscale of the MCLAA and composite computer literacy score of the MCLAA, from the experimental treatment than internally controlled subjects. Research has shown that internally controlled students are more likely to engage in data gathering activities and make greater use of information than externally controlled students (Tobin and Capie, 1982b). Perhaps, externally controlled individuals did not gain as much exposure to or knowledge about computers in situations outside of the study as their internal peers. For example, the questionnaire completed by all participants in the study indicates that 17 individuals had previously enrolled in an elective computer class. Of those 17 subjects, only five were externally controlled and 12 were internally controlled. This would support the assertion that, apart from exposure to the computer required within their course of study, internally controlled preservice elementary teachers are more likely to engage in activities which will give them experience with computers than their externally controlled peers. Thus, computer experiences encorporated into required courses for preservice elementary teachers are even more critically important for the achievement of computer literacy in externally controlled individuals than individuals with an internal locus of control.

In this study, both the experimental and control groups received high-structure instructional treatments. Aside from the software, the main difference between the treatments was external control. Students using the printed text could gain access to correct answers before composing their own responses. However, those subjects learning through CAI were required to respond before they received knowledge of correct responses. Dean (1977) argues that the external discipline, present in CAI but not in printed PI, is necessary for learning to occur. He cites the educational theory which suggests that ". . . learning does not take place unless the learner himself is overtly involved in some interaction with that which he is attempting to learn. A covert interaction which only involves recognizing or assuming that one knows the answer does not result in learning" (p. 2).

Research (e.g., Pines, 1973; Pines and Julian, 1972) indicates that internally controlled individuals are more active information processors and are better able to use previous information in decision making tasks than individuals with an external locus of control. The finding of interaction in this study between loci of control and groups suggests that the external discipline inherent in the CAI differentially benefitted the externally controlled students over their internally controlled peers. It appears that the external control exerted by the CAI, was less critical for the learning process of internal individuals who already posessed a higher level of internalized discipline than their external peers.

None of the three null hypotheses regarding subjects' achievement of the integrated science process skills were rejected. No differences were found between the experimental and control groups. Scores of internally and externally controlled subjects did not differ. Additionally, there was no statistically significant interaction between groups and loci of control. The lack of statistically significant effects may be due to the samll sample size or the instrument used to assess subjects' achievement of the integrated science process skills.

This study used the Test of the Integrated Science Processes to evaluate subjects' achievement of the integrated process skills. The authors of the test administered it as a pretest to a sample of 109 female college students enrolled in undergraduate courses (Tobin and Capie, 1982). They reported a mean performance score on the TISP of 13.38 out of 24 (s.d. = 4.31). The subjects in the present study had a mean performance score of 17.26 out of 24 (s.d. = 3.10) on the pretest.

As the mean score of a test approaches the number of items on a test, the test gets easier and the variability decreases. Thus, the test is less capable of discriminating between subjects and its reliability decreases. This is confirmed by data in this study. Tobin and Capie reported an alpha coefficient of 0.77 for subjects in their study (1982); however, for subjects in this study the split-half reliability was 0.64 and the Kuder-Richardson 20 reliability was 0.67. The lack of any significant main or interaction effects might be explained by a ceiling effect caused by the TISP. Pretest scores on the scale of the TISP were so high that significant improvement on the posttest was unlikely.

Tobin and Capie did not describe the level of the 109 subjects used for their reliability study any further than labeling them as undergraduates. The subjects used in this study were also undergraduates. However, ninety-three percent of the subjects in this study were seniors and the rest were juniors. If the subjects used by Tobin and Capie included underclassmen, this might explain the higher mean performance of the Purdue subjects.

The integrated process skills were chosen as a topic to be taught in this study because they were relevant to the curriculum of Education 323 and not otherwise formally taught. However, several of the students in this study offered unsolicited comments that they had already learned a number of the skills taught in the study, in an earlier requisite course of the Elementary Education program. In complying with the requirements of the Elementary Education program, students enrolled in Education 323 have previously completed six credit hours of Biology, three credit hours of Physics and eight credit hours of Mathematics. Many have also satisfied part or all of the departmental requirement for six additional credit hours of science. Based on the subjects' pretest TISP scores, it appears that many of them had mastered the integrated process skills in other science courses, prior to enrolling in Education 323. This, too, could have contributed to the higher mean performance of the Purdue subjects.

SUMMARY AND CONCLUSIONS

The ubiquitous presence of computers in our society has created the need for a computer literate populace. Furthermore, the availability of microcomputers in educational settings has allowed the use of the computer as a medium of instruction as well as an object of instruction. Successful incorporation of microcomputers into school programs is dependent on the efforts of computer literate classroom teachers. Therefore, teacher education institutions must prepare preservice elementary teachers to use and develop the capabilities of the computer resource.

One way to introduce computer instruction to preservice elementary teachers is to utilize it in existing preservice courses. This study was designed to determine if CAI in the integrated science process skills would result in differences from comparable printed PI in preservice elementary teachers' achievement of computer literacy and the integrated science process skills. In addition, it investigated the possible interactive effect of locus of control and mode of instruction. Research on locus of control may help educators make specific recommendations for the use of CAI in individualizing educational settings.

A randomized pretest-posttest control group design was used to compare the computer literacy and integrated science process skills achievement of internally and externally controlled preservice elementary teachers receiving CAI and printed PI in the integrated science process skills. Main effects were not significant. No differences were found between the integrated science process skill achievement or computer literacy of individuals classified as internally and externally controlled. Additionally, there were no differences between the computer literacy or science process skill achievement of subjects receiving CAI and those receiving printed PI.

However, a significant ($p < 0.05$) aptitude x treatment interaction was found. Differences in posttest computer literacy scores favored the CAI mode when students were externally controlled. Differences between treatments disappeared when individuals were internally controlled. This might be explained by the differential amount of exposure to computers outside of required activities in which internally and externally controlled students engage. It appears that internally controlled preservice elementary teachers are more likely to engage in activities which will give them experience with computers than externally controlled individuals. Thus, deliberate planning for a preservice elementary teachers' curriculum which will ensure computer literacy is even more critical for externally controlled individuals than it is for their internally controlled peers.

Recommendations for Further Research

There are many possibilities for further research related to this study which would help to elucidate its findings. A replication of this study using subjects who have had less previous exposure to the integrated science process skills and which involved instructional treatments of greater length would be desirable. Large variation between content and form of questionnaire measures of locus of control make generalizations from results of individual studies difficult. More, basic research, developing newer and more criterion-specific measures of locus of control, will aid researchers attempting to determine the effects of perceived control on the learning process. Additionally, research focusing on the following problems, as related to locus of control and CAI in science, would be useful:

1. What type of feedback is most effective? How often should feedback be provided? At what point in the program should feedback be provided?

2. What types of learner interaction are most productive?

3. How much learner control should be allowed in the design of CAI?

4. What is the relationship between important behavior variables related to task situations in CAI and locus of control?

5. Can CAI be used to contribute to positive changes in locus of control?

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APPENDICES

APPENDIX A

COGNITIVE AND AFFECTIVE OBJECTIVES FOR THE

MINNESOTA COMPUTER LITERACY AND AWARENESS ASSESSMENT

I. Cognitive

A. Hardware

1. Identify the five major components of a computer: input equipment, memory unit, control unit, arithmetic unit, output equipment.
2. Identify the basic operation of a computer system. Input of data or information - processing of data or information - output of data or information.
3. Distinguish between hardware and software
4. Identify how a person can access a computer.
5. Recognize the rapid growth of computer hardware since the 1940's.
6. Determine that the basic components function as an interconnected system under the control of a stored program developed by a person.
7. Compare computer processing and storage capabilities to the human brain, listing some general similarities and differences.

B. Software and Data Processing

1. Identify the fact that data processing involves the transformation of data by means of a set of pre-defined rules.
2. Recognize that a computer needs instructions to operate.
3. Recognize that a computer gets instructions from a program written in a programming language.
4. Recognize that a computer is capable of storing a program and data.
5. Recognize that computers process data by searching, sorting, deleting, updating, summarizing, moving, etc.
6. Select an appropriate attribute for ordering of data for a particular task.

C. Applications

1. Recognize specific uses of computers in some of the following fields: medicine, law enforcement, education, engineering, business, transportation, military defense systems, weather, prediction, recreation, government, the library, and creative arts.
2. Recognize that the following activities are among the major types of applications of the computer: information storage and retrieval, simulation and modelling, process control - decision making, computation, and data processing.

3. Recognize that computers are generally good at information processing tasks that benefit from: speed, accuracy, and repetitiveness.
4. Recognize that some limiting considerations for using computers are: cost, software availability, and storage capacity.
5. Recognize the basic features of a computerized information system.
6. Determine how computers can assist the consumer.
7. Determine how computers can assist in a decision-making process.

D. Impact

1. Distinguish among the following careers: keypuncher/keyoperator, computer operator, computer programmer, systems analyst, and computer scientist.
2. Recognize that computers are used to commit a wide variety of serious crimes but especially stealing money and stealing information.
3. Recognize that identification codes (numbers) and passwords are a primary means for restricting use of computer systems, of computer programs, and of data files.
4. Identify some advantages or disadvantages of a data base containing personal information on a large number of people.
5. Recognize that most "privacy problems" are characteristic of large information files whether or not they are computerized.
6. Recognize that computerization both increases and decreases employment.
7. Recognize that computerization both personalizes and impersonalizes procedures in fields such as education.
8. Recognize that computerization can lead to both great independence and dependence upon one's tools.
9. Recognize that while computers do not have the mental capacity that humans do, through techniques such as artificial intelligence, computers have been able to modify their own instruction set and do many of the information processing tasks that humans do.
10. Recognize that alleged "computer mistakes" are usually mistakes made by people.
11. Recognize that even though a person does not go near a computer, he or she is affected indirectly because the society is different in many sectors as a consequence of computerization.

E. Programming and Algorithms

1. Follow and give the correct output for a simple algorithm.
2. Given a simple algorithm explain what it accomplishes.
3. Modify a simple algorithm to accomplish a new but related task.

II. Affective

A. Anxiety

1. Does not feel fear, anxiety, or intimidation from computer experiences.

Efficacy

1. Feels confident about his/her ability to use and control computers.

C. Policy Concern

1. Values efficient information processing provided that it does not neglect accuracy, the protection of individual rights, and social needs.
2. Values computerization of routine tasks so long as it frees people to engage in other activities and is not done as an end in itself.
3. Values increased communication and availability of information made possible through computer use provided that it does not violate personal rights to privacy and accuracy of personal data.
4. Values economic benefits of computerization for a society.

D. Enjoyment

1. Enjoys and desires work or play with computers, especially computer assisted learning.

APPENDIX B

SAMPLE PRINTED PROGRAMMED INSTRUCTION LESSON

INTERPRETING DATA

In this module you will learn how to construct and interpret graphs. Graphs are 'pictures' that scientists use to describe relationships between variables.

After you finish this module you should be able to:

1. Construct a graph when provided with a brief description of an experiment and a table of data.

2. Identify a graph that represents some given data.

3. Describe the relationship between variables pictured on a graph.

4. Interpolate and extrapolate from data presented graphically.

Directions:

Questions with multiple choice answers may have more than one choice which is correct.

Answers to the first 20 questions are in the answer key on the last page. Check your answers after you have attempted the questions. The answers are not given for the final quiz questions. These will be handed in, scored, and then returned.

When making a graph, the x-axis (horizontal) is usually reserved for the manipulated variable. You, as the experimenter, choose the values for the manipulated variable.

The y-axis (vertical) is used to record the responding variable. You do not choose the values for the responding variable. They vary in response to changes in the manipulated variable.

For example, an experiment was done to determine the amount of sugar that will dissolve in water at different temperatures. 'Water temperature' is the manipulated variable and belongs on the x-axis (horizontal). 'Amount of sugar dissolved' is the responding variable and belongs on the y-axis (vertical).

AMOUNT OF SUGAR (GRAMS)

In addition to labeling axes with the names of the variables, you should include the units with which the variables were measured. (e.g., grams, ^{o}C)

WATER TEMPERATURE (^{o}C)

1. Suppose you did an experiment to measure the water holding capacity of different brands of paper towels. Which variables belong on which axes? (Remember, manipulated variable--x-axis; responding variable--y-axis)

   A. towel brand--x-axis; water holding capacity--y-axis
   B. water holding capacity--x-axis; towel brand--x-axis

2. Nathan suspects that there is a relationship between the number of candy bars he eats and the amount of weight he gains. He keeps a record of his candy bar intake and weight gain each week. How should he graph his data?

   A. weight gain--x-axis; brand of candy bar--y-axis
   B. brand of candy bar--x-axis; weight gain--y-axis
   C. weight gain--x-axis; number of candy bars--y-axis
   D. number of candy bars--x-axis; weight gain--y-axis

Once you have labeled the axes with the correct variables, you are ready to locate the position of the points on the graph.

Here is a table of data from an experiment. Which variable belongs on the horizontal axis?

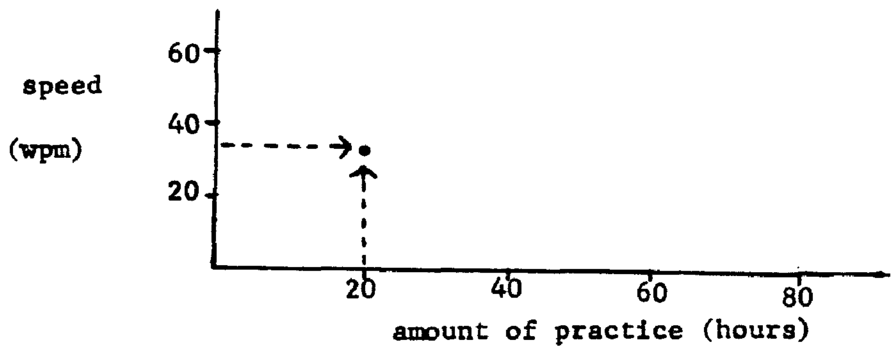
A. typing speed (wpm)
B. amount of practice (hrs)

amount of practice (hrs)	typing speed (wpm)
20	35
40	45
60	55
80	60

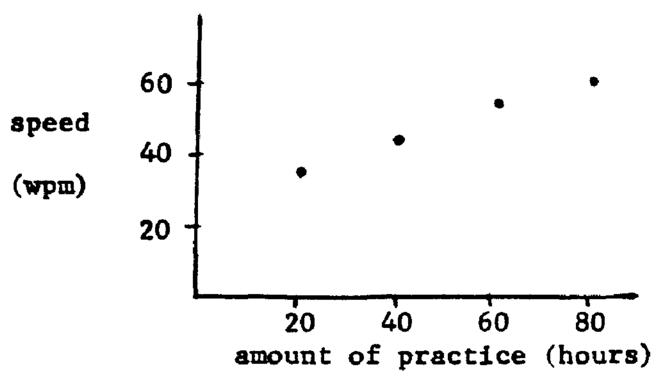
The correct answer is 'B'. 'Amount of practice' is the manipulated variable and belongs on the horizontal axis.

Now the data points must be put on the graph.

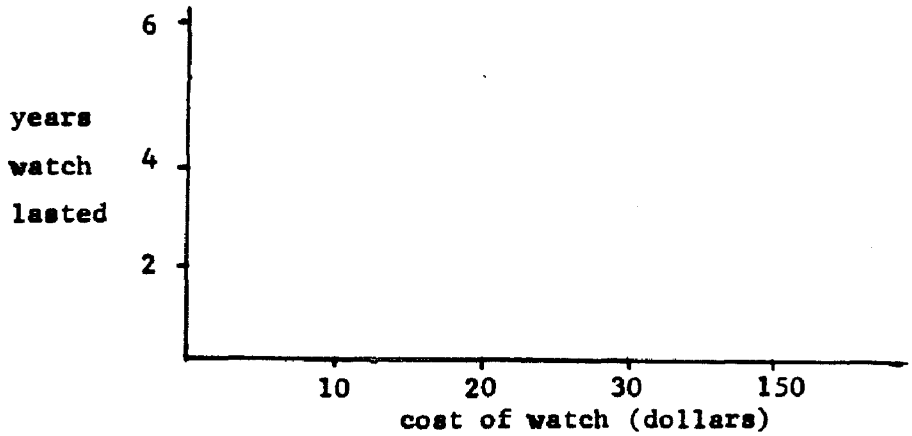
The first pair of numbers is (20,35). To mark their positions, locate 20 on the horizontal axis and 35 on the vertical axis. . . . straight up from the 20 and straight across from the 35. Where the imaginary lines cross is a point. Can you find it?



All four pairs of points have been plotted on this graph. Check and make sure you agree that they have been correctly positioned.

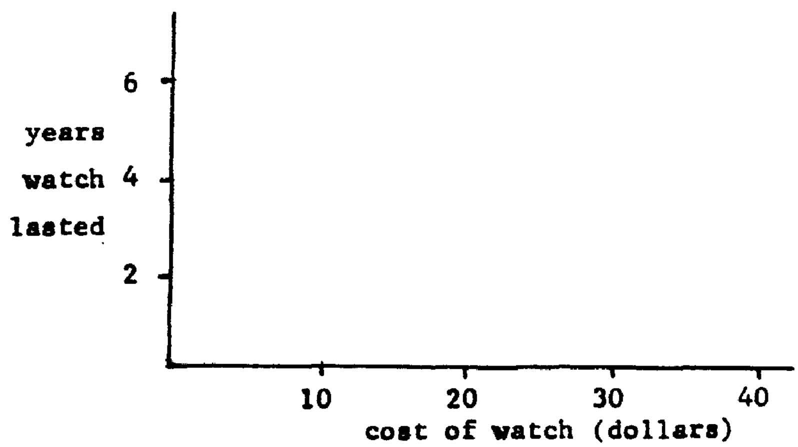


When constructing a graph, you will need to mark its axes with equal length segments that are labeled with numerals.



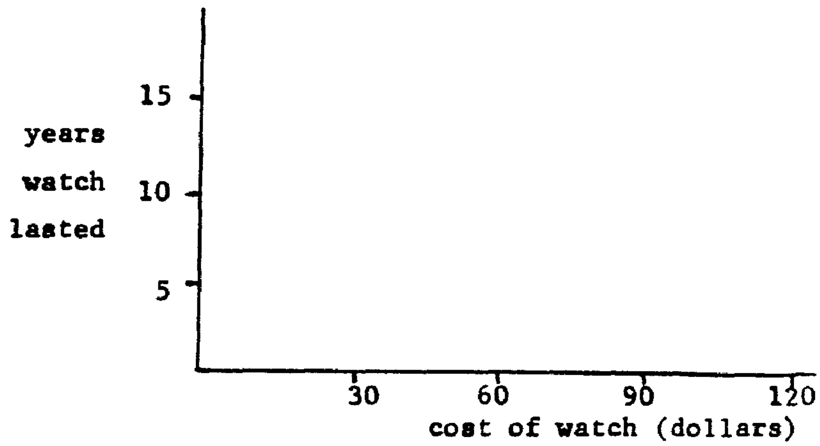
This graph is improperly constructed. The intervals on the vertical axis are not equally spaced. The differences between the numbers on the horizontal axis are not equal.

watch cost (dollars)	years watch lasted
8	2
10	2.5
25	3
120	15



The intervals and numbers on the axes of this graph are improved, but the numbers do not include large enough values for the last watch listed to be plotted on the graph.

watch cost (dollars)	years watch lasted
8	2
10	2.5
25	3
120	15

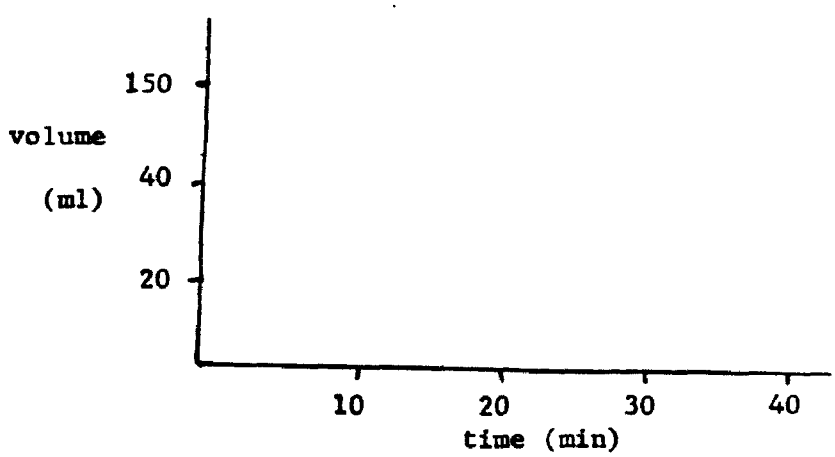


This graph would be satisfactory for graphing the information given in the data table.

3. Marta allowed herself different amounts of time and measured how big she could blow up a balloon. Which of the following best describes the graph constructed for her data?

A. x-axis correct; y-axis correct
B. x-axis incorrect; y-axis correct
C. x-axis correct; y-axis incorrect
D. x-axis incorrect; y-axis incorrect

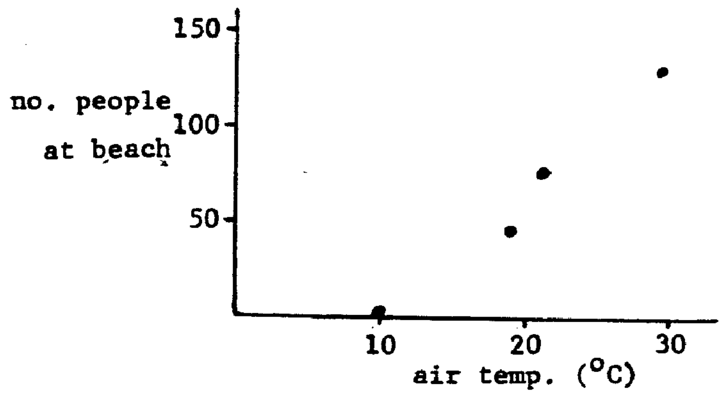
time (min)	volume (ml)
10	50
20	120
30	140
40	145



4. Here is a data table with the graph already made. Which of the points has/have been incorrectly positioned?

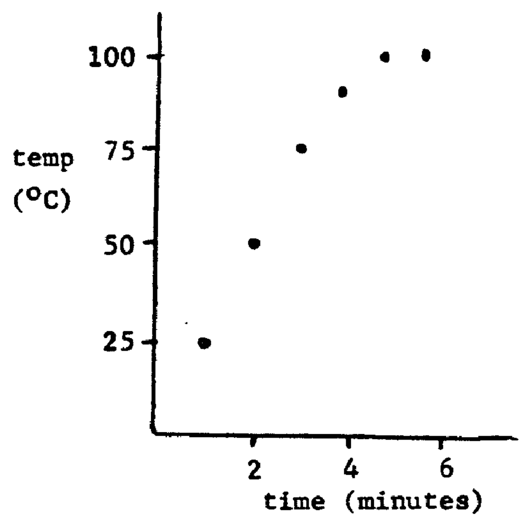
A. 2) and 3)
B. 1)
C. 2)
D. All points are positioned correctly.

	air temp. (°C)	no. people at beach
1)	21	74
2)	15	50
3)	10	2
4)	29	125



Rachel heated a pot of water and measured its temperature after different lengths of time. She graphed her data.

time (min)	temp (°C)
1	25
2	50
3	75
4	100
5	100
6	100



5. Has she put the variables on the correct axes? (yes or no)

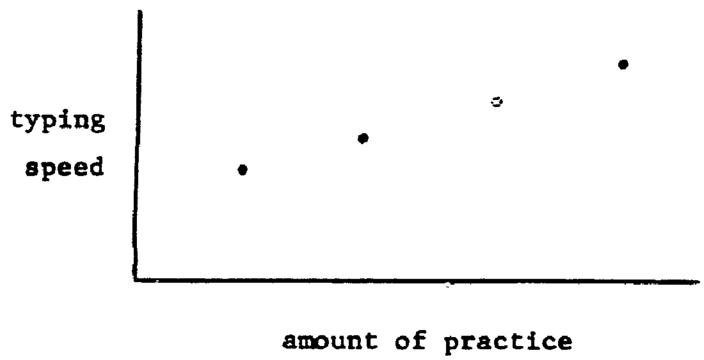
6. Are her number scales drawn correctly? (yes or no)

7. Are all the points in the correct locations? (yes or no)

How would you describe the relationship between two variables on a graph? Here's a rule that may help you and an example.

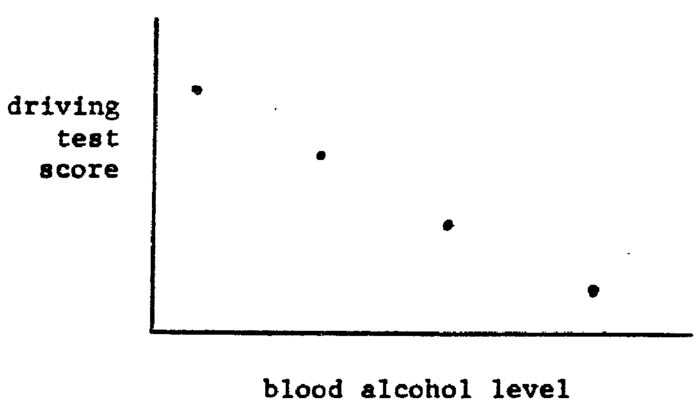
Rule: Tell what happens to the responding variable as the manipulated variable as the manipulated variable changes.

Example: Typing speed increases as the amount of practice increases.



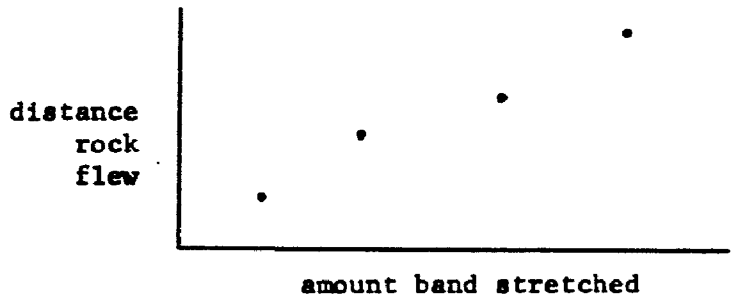
8. How would you describe the relationship between the variables on this graph?

A. The blood alcohol level increases as the driving score decreases.
B. The driving score decreases as the blood alcohol level decreases.
C. The driving score decreases as the blood alcohol level increases.

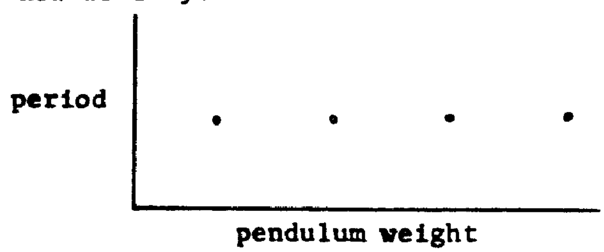


9. Eric measured the distance his rock traveled when he stretched his slingshot band different amounts. How would you describe the results of his experiment shown on the graph below?

A. The distance the rock flew increased as the amount the band was stretched increased.
B. The amount the band was stretched decreased as the distance the rock flew decreased.
C. The distance the rock flew increased as the amount the band was stretched decreased.



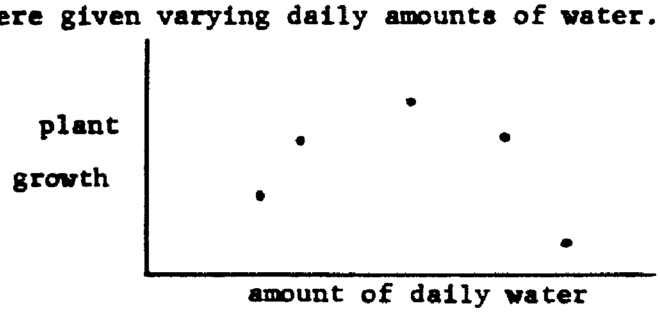
10. An experiment was done to determine how the weight of a pendulum affects its period (the time it takes to swing from one side to the other). How would you describe the relationship?



Answer:

The period of the pendulum remains constant as the pendulum weight increases. The weight of the pendulum has no effect on the period of the pendulum. (Your answer does not have to be in these exact words but the idea should be similar.)

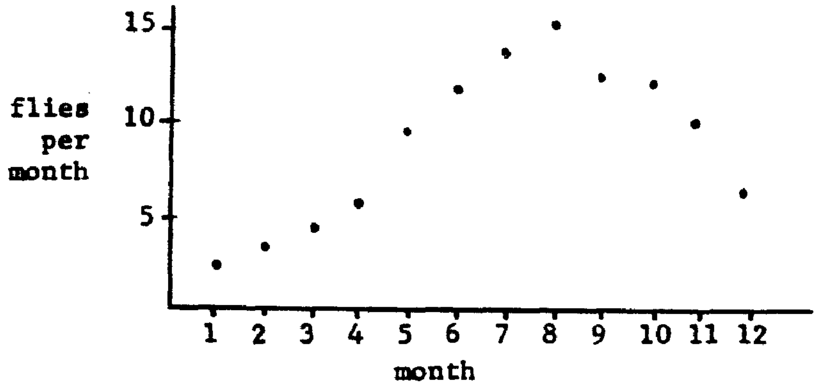
The pattern formed by points on a graph does not always form a straight line. Look at the graph below of an experiment with bean seedlings which were given varying daily amounts of water.



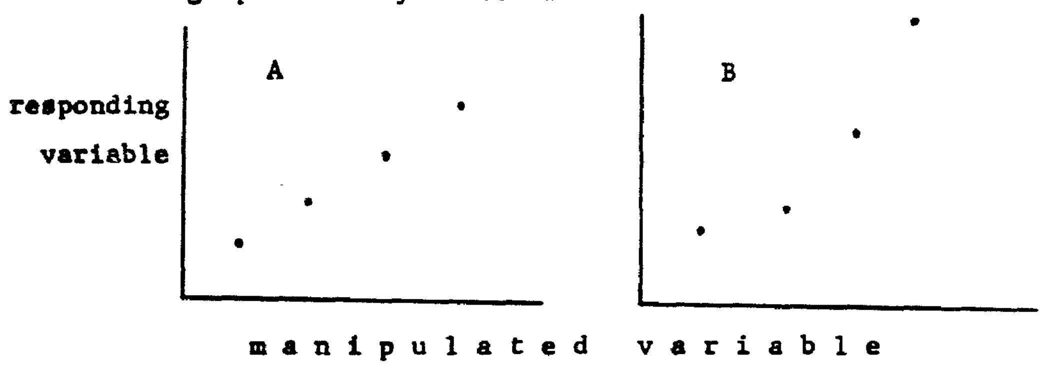
As amount of water increases, plant growth increases to a point and then decreases.

11. Gretta kept track of the number of flies she found in her apartment each month for one year. How would you describe the relationship between the two variables she graphed below??

A. The number of flies increased as the year progressed.
B. Between January and September, the number of flies increased, and then it decreased for the rest of the year.
C. Between January and August, the number of flies increased, and then it decreased for the rest of the year.



In both of the graphs below, the responding variable increases as the manipulated variable increases. However, something looks different between the two graphs. Can you tell what it is?



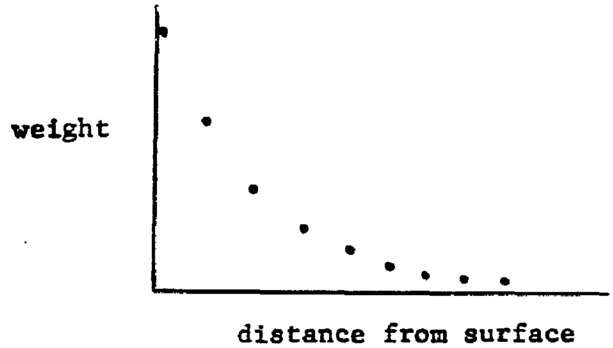
Answer:

In graph 'A', the points form a straight line. To describe the graph in more detail, you could say that the responding variable increases linearly (or steadily) as the manipulated variable increases.

In graph 'B', the points form a line; however, it is curved, not straight. To describe the graph in more detail, you could say that the responding variable increases, nonlinearly, as the manipulated variable increases.

This graph shows the relationship between the weight of an object and its distance from the earth's surface.

Is the relationship linear or nonlinear?



Answer:

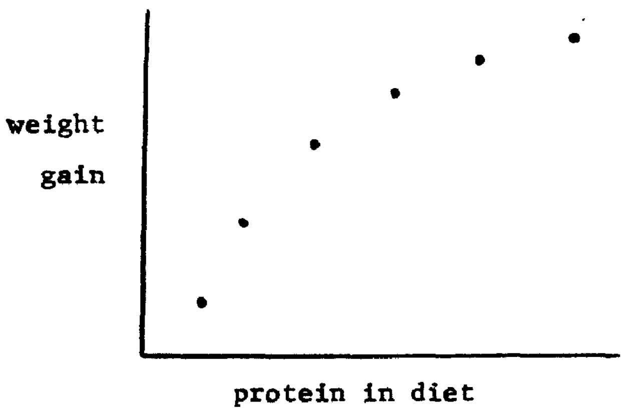
nonlinear

To describe how these variables are related you could say:

The weight of the object decreases nonlinearly as the distance of the object from the earth's surface increases.

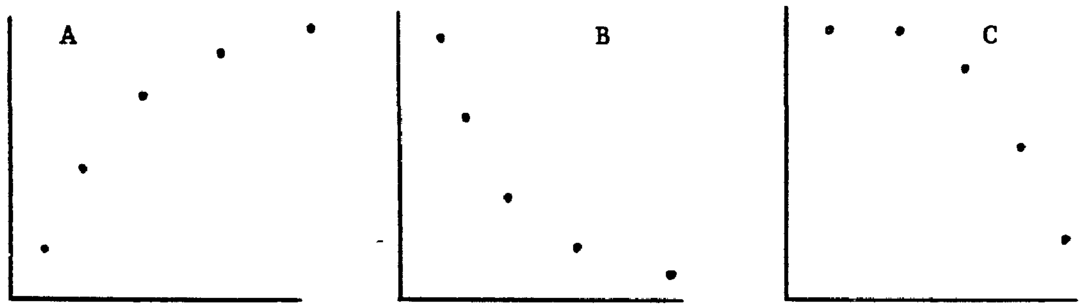
12. Zach did an experiment to see how the amount of protein in the diet of turkeys affected their weight gain. Using the graph of his data, how would you describe the relationship between these variables?

A. Weight gain decreases nonlinearly as protein decreases.
B. Protein increases linearly as weight gain increases.
C. Weight gain increases nonlinearly as protein increases.
D. Weight gain increases to a point and then decreases as protein increases.



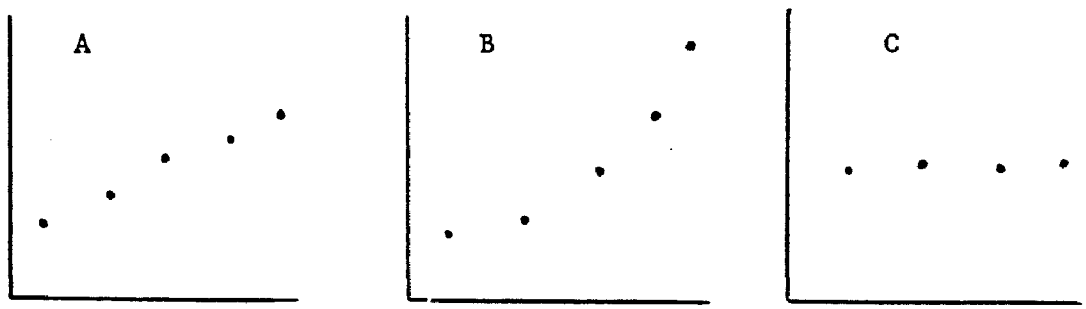
13. Tom set up an experiment to determine if the price of a theater ticket affects how many people attend a movie. He found that the average number of people attending a movie decreased nonlinearly as the price of the ticket increased.

Which graph(s) would match the relationship he found?



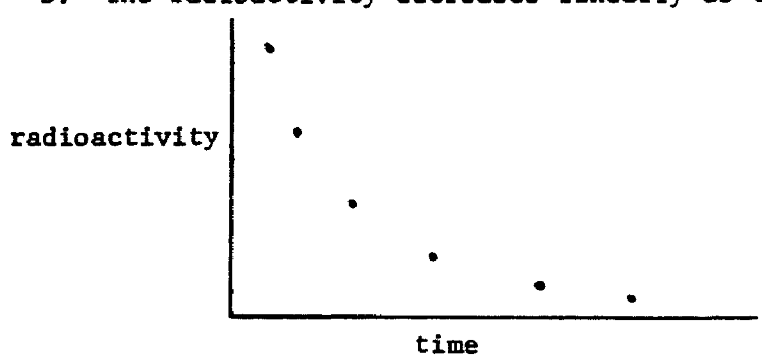
14. Lois went up to the Boundary Waters Canoe Area in Minnesota for a fishing trip. While fishing, she collected some data and found that the average weight of the fish she caught increased linearly as the size of the fish hook she used increased.

Which graph(s) would match with the relationship she found?

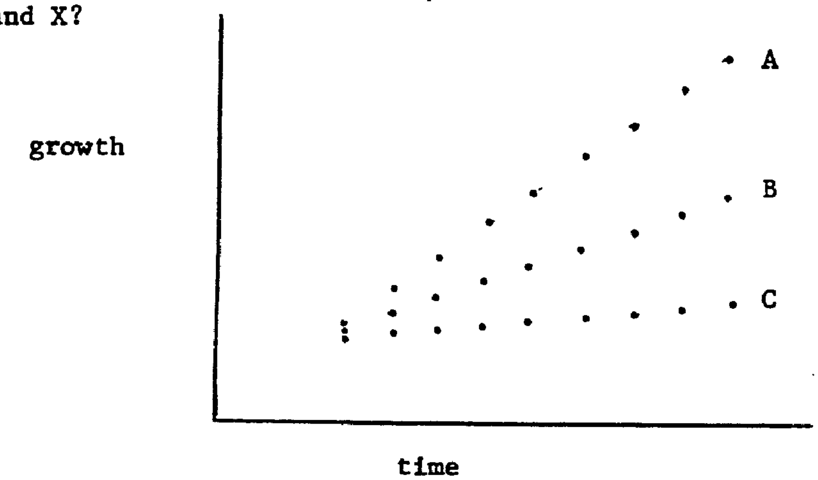


15. Below is data, in graphic form, of the radioactive decay of a piece of uranium. How would you describe the relationship between the two variables graphed?

A. The radioactivity decreases nonlinearly as time increases.
B. The radioactivity decreases nonlinearly as time decreases.
C. The radioactivity decreases linearly as time increases.
D. The radioactivity decreases linearly as time decreases.

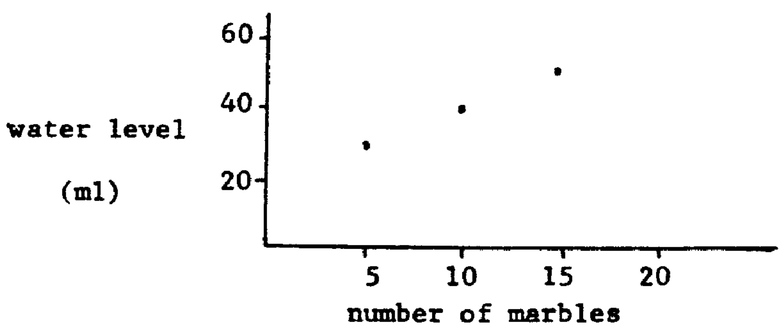


16. Kate used 3 brands of fertilizer (X,Y, and Z) on 3 or her violets. She kept track of their growth (total number of leaves) each day. She graphed her data but forgot to label each set of points. She remembers that she used Brand X fertilizer on the plant that grew the fastest. Can you tell which points form the line which represents Brand X?



You have seen how graphs can be used to picture relationships between variables. Another way you can use graphs is to make predictions. Let's look at an example!

Marbles, all the same size, were dropped in a graduated cylinder which was partially filled with water. The water level was measured after 5, 10, and 15 marbles were dropped in the cylinder. Below is a graph of the data obtained.



Even though the water level wasn't measured when 7 marbles were added, you could use the graph to predict that it would be approximately 34 ml.

Using your graph to make predictions between observed values is called interpolation ('inter-' means between).

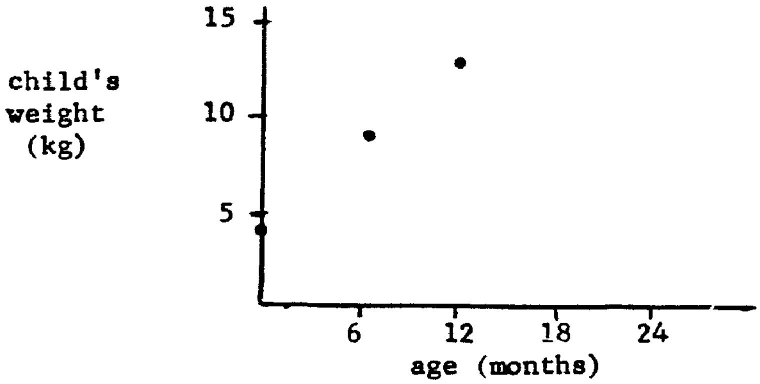
Can you predict what the water level would be if 20 marbles were added to the cylinder? (Use the previous graph.)

Answer:

Your answer should be around 60 ml. This kind of prediction is made from extrapolation of the data.

The process of extending a relationship outside the range of observations is called extrapolation ('extra-' means 'outside' or 'beyond'. Don't you wish you took Latin so you'd already know all this?)

Use the graph below for questions 17-20.



17. Predict the weight of the child at 9 months.

    A. 8 kg
    B. 10 kg
    C. 12 kg
    D. 14 kg

18. What method did you use to make your prediction?

    A. interpolation
    B. extrapolation

19. What would you predict the child's weight will be at 2 years?

    A. 14 kg
    B. 16 kg
    C. 18 kg
    D. 20 kg

20. What method did you use to make your prediction for question #19?

    A. interpolation
    B. extrapolation

Which prediction did you have more confidence in, the one made by interpolation (9 months) or extrapolation (2 years)?

Answer:

Your answer should be interpolation.

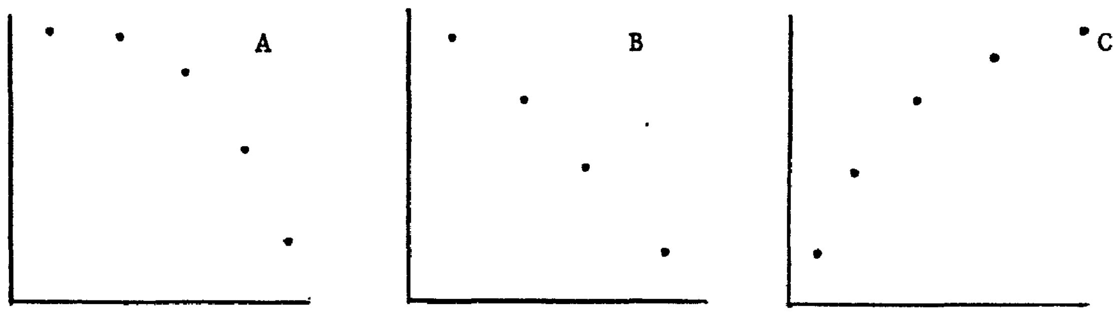
The farther you extrapolate to make your prediction, the less confidence you can have in your prediction. For example, if you used the graph to predict how much the "child" would weigh at 50 years of age your answer would be approximately 400 kg!(That's 880 pounds in case you're still not thinking metric.) This shows the danger of extrapolating a graph too far.

ANSWER KEY

1. A
2. D
3. C
4. C
5. yes
6. yes
7. no
8. C
9. A
10.
11. C
12. C
13. B,C
14. A
15. A
16. A
17. B
18. A
19. D
20. B

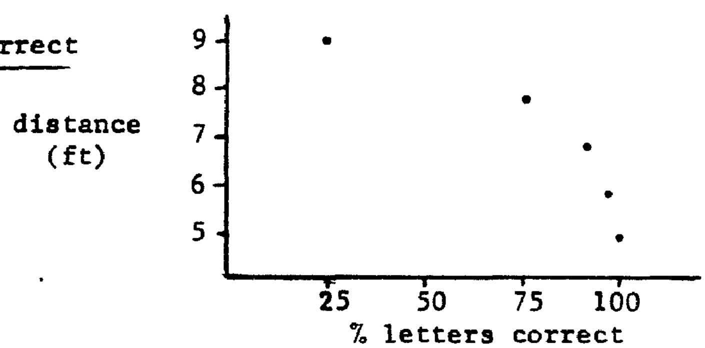
INTERPRETING DATA-QUIZ

1. A food processing company does an experiment to see how long they need to heat their canned beans to insure that they will be safe for consumption. Different sized cans are used and the temperature of the center of the can of beans is measured after 5 minutes in the retort (pressure cooker). They find that the temperature of beans in the center of the can decreases nonlinearly as the volume of the can increases. Which graph(s) will match with the relationship they found?



Rick tested Matt's eyesight by having him try to identify, at different distances, 20 letters printed on a sheet of paper. The graph and table below show the data from his experiment. Use them to answer questions 2 and 3.

distance (ft)	% letters correct
5	100
6	95
7	90
8	75
9	25



2. Is the graph made properly?

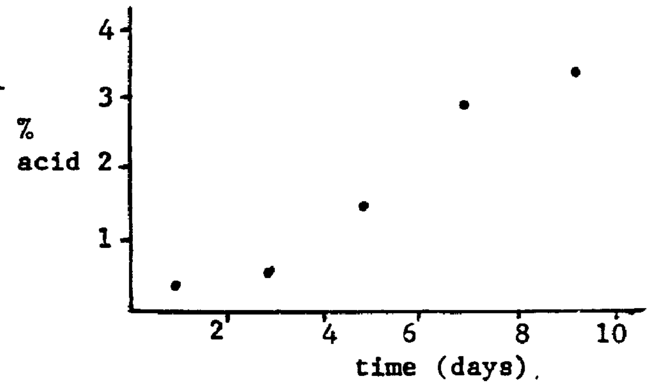
A. Graph O.K.
B. Variables on wrong axis
C. Scales not drawn correctly
D. Points in wrong location

3. How would you describe the relationship between the % letters identified correctly and Matt's distance from the paper?

A. As the distance decreased, the % letters correct decreased nonlinearly.
B. The % letters correct decreased nonlinearly as the distance decreased.
C. The % letters correct increased nonlinearly as the distance decreased.
D. As the distance increased, the % letters correct decreased nonlinearly.

Margaret made some sauerkraut. She shredded her cabbage, added salt, and waited for the microorganisms to start the fermentation. Every other day, she measured the acidity of the sauerkraut. Below is her data table and a graph she made. Use them to answer questions 4 through 6.

time (days)	% acid
1	0.3
3	0.4
5	1.6
7	3.0
9	3.3



4. Is the graph made properly?

   A. Graph O.K.
   B. Variables on wrong axis
   C. Scales not drawn correctly
   D. Points in wrong location

5. How would you describe the relationship between time and acid production?

   A. As time increases, the % acid increases linearly.
   B. As time increases, the % acid decreases linearly.
   C. As time increases, the % acid increases nonlinearly.
   D. The % acid decreases nonlinearly as time increases.

6. How much acid do you predict would have been produced by Day 8?

   A. 2.5% acid
   B. 2.9% acid
   C. 3.2% acid
   D. 3.4% acid

APPENDIX C

SAMPLE PROGRAM FOR COMPUTER-ASSISTED INSTRUCTION LESSON

```
70 LET C=0
71 CLS
72 LET C=C+1
73 OVER=RND(127)
74 DOWN=RND(47)
75 SET(OVER,DOWN)
76 IF C=1000 GOTO 78
77 GOTO 72
78 FOR DOWN=15 TO 29
79 FOR OVER=25 TO 94
80 RESET(OVER,DOWN)
81 NEXT OVER
82 NEXT DOWN
83 PRINT@468,"IDENTIFYING VARIABLES";
84 PRINT@960,"PRESS 'ENTER' KEY TO CONTINUE       ";
85 INPUT I$
100 CLEAR 130
131 CLS
132 PRINT:PRINT
135 PRINT "IN THIS MODULE YOU WILL LEARN TO IDENTIFY VARIABLES,
140 PRINT "AN IMPORTANT SKILL IN EXPERIMENTATION.  IT WILL BE IMPORTANT
145 PRINT "WHEN YOU DO YOUR OWN EXPERIMENTS, AS WELL AS WHEN YOU ARE
150 PRINT "ANALYZING SOMEONE ELSE'S EXPERIMENT."
160 PRINT:PRINT:PRINT:PRINT:PRINT
170 PRINT "PRESS 'ENTER' TO CONTINUE"
180 INPUT " ";A$
188 CLS
190 PRINT "AFTER YOU FINISH THIS MODULE YOU SHOULD BE ABLE TO:
200 PRINT
210 PRINT "   1. IDENTIFY VARIABLES WHICH ARE MANIPULATED, RESPONDING,
220 PRINT "OR CONTROLLED, GIVEN A DESCRIPTION OF AN INVESTIGATION.
230 PRINT
240 PRINT "   2. IDENTIFY VARIABLES WHICH MAY AFFECT THE DEPENDENT
250 PRINT "VARIABLE SPECIFIED, IN A GIVEN PROBLEM."
260 PRINT:PRINT:PRINT:PRINT
270 PRINT "PRESS 'ENTER' TO CONTINUE"
280 INPUT " ";A$
290 CLS
299 PRINT:PRINT
300 PRINT "THE COMPUTER WILL WAIT FOR YOU TO RESPOND TO A QUESTION":PRINT
310 PRINT "BEFORE IT CONTINUES .  IF NO QUESTION HAS BEEN POSED,":PRINT
320 PRINT "YOU WILL NEVERTHELESS NOTICE A QUESTION MARK AT THE":PRINT
325 PRINT "BOTTOM OF THE SCREEN.  SIMPLY PRESS THE 'ENTER' KEY":PRINT
330 PRINT "AND THE PROGRAM WILL CONTINUE.":PRINT:PRINT
340 INPUT "";A$
350 CLS
360 PRINT:PRINT
370 PRINT"QUESTIONS WITH MULTIPLE CHOICE ANSWERS MAY HAVE MORE THAN ONE
380 PRINT"CHOICE WHICH IS CORRECT.
390 PRINT
400 PRINT"IF YOU WANT TO ANSWER WITH MORE THAN ONE CHOICE, PUT A DASH
410 PRINT"BETWEEN YOUR CHOICES AND LIST THEM IN ALPHABETICAL ORDER.
420 PRINT:PRINT
430 PRINT"WOULD YOU LIKE TO TRY A SAMPLE QUESTION?? (YES OR NO)
440 INPUT I$
450 LET A$="YES"
460 IF A$<>I$ GOTO 700
```

```
470 CLS
480 PRINT:PRINT:PRINT
490 PRINT"PURDUE'S SCHOOL COLORS ARE:
500 PRINT
510 PRINT"      A.   BLACK
520 PRINT"      B.   GOLD
530 PRINT"      C.   PINK
540 PRINT:PRINT
550 PRINT"THE ANSWER TO THIS QUESTION IS BOTH CHOICES 'A' AND 'B,,
560 PRINT"SO YOU SHOULD TYPE ON THE KEYBOARD:  A-B
565 PRINT
570 LET A$="A-B"
575 PRINT"TRY TYPING:  A-B
580 INPUT I$
588 IF A$=I$ GOTO 599
590 CLS
591 PRINT"OOPS!!     TRY AGAIN!!!
592 PRINT
593 PRINT"REMEMBER,  IF THE CORRECT ANSWER INCLUDES MORE THAN ONE CHOICE,
594 PRINT"YOU MUST TYPE THE LETTERS IN ALPHABETICAL ORDER.
595 GOTO 490
599 CLS:PRINT:PRINT:PRINT:PRINT
600 PRINT"IF YOU HAD TYPED 'B-A', THE COMPUTER WOULD HAVE SCORED YOUR
601 PRINT"ANSWER AS INCORRECT BECAUSE THE LETTERS ARE NOT LISTED IN
602 PRINT"ALPHABETICAL ORDER.
603 PRINT:PRINT"I THINK YOU'VE GOT IT!!
604 PRINT:PRINT:PRINT:PRINT
605 INPUT I$
608 CLS
609 PRINT:PRINT:PRINT:PRINT
610 INPUT"SHALL WE BEGIN THE QUIZ??    (YES OR NO)";I$
700 CLS
710 PRINT:PRINT:PRINT
720 PRINT "A VARIABLE IS SOMETHING WHICH CAN VARY OR CHANGE
730 PRINT
740 PRINT "IN A SITUATION."
745 PRINT:PRINT:PRINT
750 INPUT " ";I$
760 CLS
800 PRINT "LOOK AT AN EXAMPLE:":PRINT:PRINT
810 PRINT "THE HEIGHT A BALL WILL BOUNCE WHEN DROPPED IS AFFECTED"
820 PRINT"BY THE MATERIAL A BALL IS MADE OF."
830 PRINT
840 PRINT "THE VARIABLES IN THIS STATEMENT ARE:
850 PRINT
860 PRINT "   1. MATERIAL BALL IS CONSTRUCTED FROM
870 PRINT "   2. DISTANCE BALL REBOUNDS
875 PRINT "   3. MANNER OF RELEASE
880 PRINT
890 PRINT "NOTICE, IT IS NOT ENOUGH TO JUST SAY THE VARIABLES ARE
900 PRINT "'MATERIAL' AND 'DISTANCE'.  YOU MUST INCLUDE HOW THEY
910 PRINT "ARE EVALUATED!"
920 INPUT " " :I$
```

```
1200 CLS
1205 LET CANS=0
1210 PRINT
1220 PRINT"SEE IF YOU CAN IDENTIFY THE VARIABLES IN THIS STATEMENT:
1225 PRINT
1230 PRINT"1.  A STUDY WAS DONE TO SEE IF STUDENTS' SCORES ON A TEST
1240 PRINT"DEPENDED ON THE NUMBER OF HOURS THEY STUDIED.
1250 PRINT:PRINT
1260 PRINT"WHAT ARE THE VARIABLES??
1270 PRINT
1280 PRINT"     A.  STUDENTS' TEST SCORES
1290 PRINT"     B.  HOURS
1300 PRINT"     C.  HOURS SPENT STUDYING
1310 PRINT"     D.  SCORES
1320 LET A$="A-C"
1330 PRINT
1340 INPUT I$
1350 GOSUB 2000
1360 IF C$=D$ GOTO 1200
1400 CLS
1405 PRINT"TRY ANOTHER PROBLEM:
1410 PRINT
1415 PRINT"2.  THE AMOUNT OF B-VITAMINS THAT IS LOST WHEN COOKING
1420 PRINT"GREEN BEANS IN BOILING WATER INCREASES AS THE LENGTH OF
1425 PRINT"TIME THE BEANS ARE COOKED INCREASES.
1430 PRINT
1435 PRINT"THE VARIABLES IN THE STATEMENT ARE:
1440 PRINT"     A.  B-VITAMINS
1445 PRINT"     B.  TIME
1450 PRINT"     C.  LENGTH OF TIME BEANS ARE COOKED
1455 PRINT"     D.  AMOUNT OF B-VITAMINS LOST
1460 LET A$="C-D"
1465 INPUT I$
1470 GOSUB 2000
1475 IF C$=D$ GOTO 1415
1600 CLS
1605 PRINT"EXPERIMENTS MAY HAVE MORE THAN TWO VARIABLES INVOLVED.
1610 PRINT"HOW MANY CAN YOU IDENTIFY IN THIS EXPERIMENT?
1615 PRINT:PRINT
1620 PRINT"3.  SARAH BAKED HER AWARD-WINNING BREAD BY LETTING HER
1625 PRINT"MIXTURE OF YEAST, SUGAR, FLOUR, SALT, AND WATER
1630 PRINT"RISE OVERNIGHT AND THEN BAKE FOR 20 MINUTES AT
1635 PRINT"375 DEGREES FAHRENHEIT.
1640 PRINT
1645 PRINT"WHAT ARE SOME OF THE VARIABLES INVOLVED??
1646 PRINT"    (YOU MAY TYPE IN AN ANSWER OF NO MORE THAN 2 LINES)
1650 PRINT
1655 INPUT I$
1660 PRINT
1665 PRINT"YOUR ANSWER COULD HAVE INCLUDED:  BRANDS OF INGREDIENTS,
1670 PRINT"AMOUNTS OF INGREDIENTS, AMOUNT OF TIME BREAD WAS ALLOWED TO
1675 PRINT"RISE, BAKING TEMPERATURE, AND AMOUNT OF TIME BREAD BAKED.
1678 PRINT
1680 PRINT"THERE ARE OTHER VARIABLES, TOO, WHICH WEREN'T MENTIONED
1685 PRINT"SPECIFICALLY IN THIS PASSAGE.
1690 INPUT I$
```

```
1800 CLS
1805 PRINT"TRY ONE MORE PROBLEM TO MAKE SURE YOU HAVE MASTERED THE
1810 PRINT"ART OF IDENTIFYING VARIABLES.
1815 INPUT I$
1818 CLS
1820 PRINT "4.  ALBERT DID AN EXPERIMENT TO SEE IF THE TEMPERATURE OF A
1825 PRINT"BEAKER OF WATER AFFECTED HOW QUICKLY SALT WOULD DISSOLVE IN IT.
1830 PRINT
1835 PRINT"WHAT ARE SOME VARIABLES IN ALBERT'S EXPERIMENT??
1840 PRINT
1845 PRINT"      A.  WATER TEMPERATURE
1850 PRINT"      B.  THE WATCH ALBERT USED TO MEASURE TIME
1855 PRINT"      C.  THE AMOUNT OF TIME IT TOOK THE SALT TO
1856 PRINT"          COMPLETELY DISSOLVE.
1860 PRINT"      D.  TIME
1865 PRINT"      E.  TEMPERATURE
1868 PRINT
1870 LET A$="A-C"
1872 PRINT
1875 PRINT
1880 INPUT I$
1885 GOSUB 2000
1890 IF C$=D$ GOTO 1820
1900 GOTO 2100
2000 IF A$<>I$ GOTO 2060
2005 LET CANS=CANS+1
2010 PRINT"THAT'S RIGHT!!     KEEP GOING!!!"
2015 LET C$="."
2020 INPUT I$
2055 RETURN
2060 PRINT"BAD BREAK!  REMEMBER, WHEN YOU NAME VARIABLES, YOU MUST
2065 PRINT"INCLUDE HOW THEY ARE EVALUATED.
2070 PRINT"WOULD YOU LIKE TO TRY AGAIN??    (YES OR NO)
2074 LET C$="YES"
2075 INPUT D$
2077 CLS
2080 RETURN
2100 IF CANS=3 GOTO 2150
2103 CLS
2104 PRINT:PRINT
2105 PRINT"IN THE PREVIOUS SECTION OF THIS PROGRAM, YOU ANSWERED
2110 PRINT;CANS;" OF THE 3 MULTIPLE CHOICE QUESTIONS CORRECTLY.
2115 PRINT
2120 PRINT"WOULD YOU LIKE TO REVIEW THIS PART OF THE PROGRAM??  (YES OR NO)
2125 LET A$="YES"
2130 INPUT I$
2135 IF A$=I$ GOTO 700
2140 GOTO 2200
2150 PRINT:PRINT
2152 CLS
2155 PRINT"IN THE PREVIOUS SECTION OF THIS PROGRAM, YOU ANSWERED
2160 PRINT"ALL OF THE 3 MULTIPLE CHOICE QUESTIONS CORRECTLY.
2165 PRINT
2170 PRINT"SUPER!!!
2175 PRINT
2180 PRINT"YOU ARE READY TO GO ON TO THE SECOND OF THE FOUR SECTIONS
2185 PRINT"IN THIS PROGRAM.
2190 INPUT I$
```

```
2200 CLS
2204 PRINT:PRINT:PRINT
2205 PRINT"WHICH WOULD YOU PREFER TO DO??
2210 PRINT:PRINT
2215 PRINT"   A.  STOP HERE AND FINISH THE REST OF THE PROGRAM AT A
2220 PRINT"       LATER DATE.
2225 PRINT"   B.  CONTINUE ON TO THE SECOND SECTION.
2230 LET A$="B"
2235 PRINT
2238 PRINT:PRINT:PRINT:PRINT
2240 INPUT I$
2245 IF A$=I$ GOTO 2500
2249 PRINT
2250 INPUT"ARE YOU SURE??";B$
2255 LET C$="YES"
2260 IF B$=C$ GOTO 9999
2265 PRINT"THIS SURELY IS A TOUGH DECISION, BUT YOU'RE GOING TO
2270 PRINT"HAVE TO MAKE UP YOUR MIND!!
2275 GOTO 2205
2500 CLS
2502 LET CANS=0
2505 PRINT:PRINT
2510 PRINT"IF A VARIABLE IS DELIBERATELY CHANGED (OR MANIPULATED),
2515 PRINT"IT IS CALLED A MANIPULATED VARIABLE.
2520 PRINT
2525 PRINT"YOU, AS AN EXPERIMENTER, OFTEN SELECT THE
2530 PRINT"MANIPULATED VARIABLE.
2535 PRINT:PRINT:PRINT
2540 INPUT I$
2545 CLS
2550 PRINT"5.  RECALL THE INVESTIGATION DONE TO DETERMINE THE EFFECT
2555 PRINT"OF STUDY HOURS ON STUDENTS' TEST SCORES.
2560 PRINT
2565 PRINT"WHAT WAS THE MANIPULATED VARIABLE (THAT IS, THE ONE WHICH
2570 PRINT"WAS DELIBERATELY CHANGED)??
2575 PRINT
2580 PRINT"   A.  STUDENTS' TEST SCORES
2585 PRINT"   B.  HOURS SPENT STUDYING
2590 LET A$="B"
2595 PRINT
2600 INPUT I$
2605 GOSUB 3300
2610 IF C$=D$ GOTO 2550
2700 CLS
2705 PRINT"6.  THE TEMPERATURE OF THE WATER IN A LAKE WAS MEASURED
2710 PRINT"AT DIFFERENT DEPTHS.
2715 PRINT
2720 PRINT"WHAT IS THE MANIPULATED VARIABLE IN THIS INVESTIGATION??
2725 PRINT
2730 INPUT I$
2735 PRINT
2740 PRINT"THE MANIPULATED VARIABLE IS 'DISTANCE BELOW THE WATER'S
2745 PRINT"SURFACE.'  YOUR ANSWER DOESN'T HAVE TO BE EXACTLY THESE
2750 PRINT"WORDS, BUT IT SHOULD BE SIMILAR.
```

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2755 PRINT
2760 PRINT"IF YOUR ANSWER WAS ONLY 'DEPTH' OR 'DISTANCE', IT WAS AN
2765 PRINT"INCOMPLETE ANSWER.  THE ANSWER SHOULD DESCRIBE HOW THE
2770 PRINT"VARIABLE WILL BE MEASURED.
2775 PRINT
2780 INPUT I$
2900 CLS
2905 PRINT"7.  EMIL WONDERED IF THE LENGTH OF TIME THAT A CANDLE WOULD
2910 PRINT"BURN IN A CLOSED JAR WAS DETERMINED BY THE VOLUME OF THE JAR.
2915 PRINT
2920 PRINT"WHAT WOULD BE THE MANIPULATED VARIABLE IN EMIL'S EXPERIMENT
2925 PRINT"TO ANSWER HIS QUESTION??
2930 PRINT
2935 PRINT"   A.  TYPE OF CANDLE
2940 PRINT"   B.  LENGTH OF TIME THE CANDLE BURNED
2945 PRINT"   C.  TIME
2950 PRINT"   D.  VOLUME OF THE JAR
2955 LET A$="D"
2960 PRINT
2965 INPUT I$
2970 GOSUB 3300
2975 IF C$=D$ GOTO 2900
3100 CLS
3105 PRINT"8.  THE MORE OFTEN A RAT IS ALLOWED TO RUN THROUGH A MAZE,
3110 PRINT"THE QUICKER HE WILL BE ABLE TO DO IT.
3115 PRINT:PRINT
3120 PRINT"WHAT IS THE MANIPULATED VARIABLE IN THIS SITUATION??
3125 PRINT
3130 PRINT"   A.  TIME
3135 PRINT"   B.  AVERAGE AMOUNT OF TIME IT TOOK THE RAT TO RUN THROUGH
3140 PRINT"       THE MAZE EACH TIME
3145 PRINT"   C.  AMOUNT OF TIME IT TOOK THE RAT TO RUN THROUGH THE MAZE
3150 PRINT"       THE MOST RECENT TIME
3155 PRINT"   D.  NUMBER OF TIMES THE RAT HAS RUN THROUGH THE MAZE
3160 LET A$="D"
3165 PRINT
3170 INPUT I$
3175 GOSUB 3300
3180 IF C$=D$ GOTO 3100
3190 GOTO 3383
3300 IF A$<>I$ GOTO 3360
3305 LET CANS=CANS+1
3310 PRINT"GOOD ANSWER!!     CARRY ON!!!
3315 LET C$="."
3320 INPUT I$
3355 RETURN
3360 PRINT"NOPE!  KEEP IN MIND THAT THE MANIPULATED VARIABLE IS THE
3365 PRINT"ONE WHICH IS DELIBERATELY CHANGED.
3370 PRINT"WOULD YOU LIKE TO TRY AGAIN??   (YES OR NO)
3374 LET C$="YES"
3375 INPUT D$
3377 CLS
3380 RETURN
3383 CLS:PRINT:PRINT
3384 PRINT"UP TO THIS POINT, YOU HAVE FOCUSED YOUR ATTENTION ON
3385 PRINT"MANIPULATED VARIABLES.":PRINT:PRINT
3386 PRINT"ARE THERE ANY OTHER KINDS?":PRINT:PRINT
3387 PRINT"CONTINUE ON AND YOU'LL SEE!":PRINT:PRINT
3388 INPUT I$
```

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3389 CLS:PRINT:PRINT
3390 PRINT"THE MORE CALORIES A PERSON TAKES IN, THE MORE WEIGHT HE WILL":PRINT"G
AIN.":PRINT:PRINT
3391 PRINT"IN THE STATEMENT ABOVE, 'NUMBER OF CALORIES TAKEN IN'
3392 PRINT"IS THE 'MANIPULATED VARIABLE'.":PRINT
3393 PRINT"ANOTHER IMPORTANT VARIABLE IS 'WEIGHT GAINED BY AN INDIVIDUAL'.":PRIN
T"THIS VARIABLE IS CALLED THE 'RESPONDING VARIABLE.'":PRINT
3394 PRINT"THE 'RESPONDING VARIABLE' IS THE VARIABLE THAT CHANGES AS A
3395 PRINT"RESULT OF A CHANGE IN THE MANIPULATED VARIABLE.
3396 PRINT"YOU DO NOT CHOOSE THE VALUES FOR THE RESPONDING VARIABLE.
3397 PRINT"THEY CHANGE IN RESPONSE TO CHANGES IN THE MANIPULATED VARIABLE.
3398 INPUT I$
3399 CLS
3400 PRINT:PRINT:PRINT:PRINT
3405 PRINT"USE THE NEXT 3 PROBLEM SETS TO PRACTICE IDENTIFYING
3410 PRINT"MANIPULATED AND RESPONDING VARIABLES.
3415 INPUT I$
3418 GOSUB 3420
3419 GOTO3475
3420 CLS
3425 PRINT"A STUDY WAS DONE WITH LABORATORY MICE TO SEE IF THE AMOUNT
3430 PRINT"OF CAFFEINE CONSUMED HAD AN EFFECT ON THE % OF OFFSPRING
3435 PRINT"BORN WITH DEFORMITIES.
3440 PRINT
3445 PRINT".  A.  OFFSPRING BORN
3450 PRINT"   B.  % OF OFFSPRING BORN WITH DEFORMITIES
3455 PRINT"   C.  TYPE OF COFFEE USED
3460 PRINT"   D.  AMOUNT OF CAFFEINE CONSUMED
3465 PRINT"   E.  NUMBER OF MICE TESTED
3470 RETURN
3475 PRINT
3480 PRINT"9.  WHAT IS THE MANIPULATED VARIABLE??
3485 LET A$="D"
3490 PRINT
3495 INPUT I$
3500 GOSUB 3700
3505 IF C$=D$ GOTO 3418
3510 CLS
3515 GOSUB 3420
3517 PRINT
3520 PRINT"10.  WHAT IS THE RESPONDING VARIABLE??
3525 LET A$="B"
3530 PRINT
3535 INPUT I$
3540 GOSUB 3600
3545 IF C$=D$ GOTO 3510
3550 GOTO 3800
3600 IF A$<>I$ GOTO 3660
3605 LET CANS=CANS+1
3610 PRINT"CORRECT!!  YOU MAY CONTINUE!!!
3615 LET C$="."
3620 INPUT I$
3625 RETURN
```

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3660 PRINT"CURSES!!  FOILED AGAIN!!!
3665 PRINT"KEEP IN MIND THAT THE RESPONDING VARIABLE CHANGES AS A RESULT
3670 PRINT"OF A CHANGE IN THE MANIPULATED VARIABLE.
3675 PRINT"WOULD YOU LIKE TO TRY AGAIN??   (YES OR NO)
3678 LET C$="YES"
3680 INPUT D$
3682 CLS
3684 RETURN
3700 IF A$<>I$ GOTO 3760
3705 LET CANS=CANS+1
3710 PRINT"CORRECT!!  YOU MAY CONTINUE!!!
3715 LET C$="."
3720 INPUT I$
3725 RETURN
3760 PRINT"CURSES!!  FOILED AGAIN!!!
3765 PRINT"REMEMBER, THE MANIPULATED VARIABLE IS THE ONE THAT IS
3770 PRINT"DELIBERATELY CHANGED.
3775 PRINT"WOULD YOU LIKE TO TRY AGAIN??   (YES OR NO)
3777 LET C$="YES"
3779 INPUT D$
3781 CLS
3785 RETURN
3800 GOSUB 3806
3805 GOTO 3850
3806 CLS
3807 PRINT"INCREASING THE AMOUNT OF YEAST IN A BREAD RECIPE
3810 PRINT"DECREASES THE AMOUNT OF TIME NEEDED FOR THE BREAD
3815 PRINT"TO RISE TO THE CORRECT SIZE.
3820 PRINT
3825 PRINT"    A.  AMOUNT OF YEAST
3830 PRINT"    B.  THE BREAD RECIPE
3835 PRINT"    C.  TIME NEEDED FOR BREAD TO RISE
3840 PRINT"    D.  THE CORRECT SIZE OF A BREAD LOAF
3845 RETURN
3850 PRINT
3855 PRINT"11.  WHAT IS THE MANIPULATED VARIABLE??
3860 LET A$="A"
3865 PRINT
3870 INPUT I$
3875 GOSUB 3700
3880 IF C$=D$ GOTO 3800
3885 CLS
3890 GOSUB 3806
3895 PRINT
3900 PRINT"12.  WHAT IS THE RESPONDING VARIABLE??
3905 LET A$="C"
3910 PRINT
3915 INPUT I$
3920 GOSUB 3600
3925 IF C$=D$ GOTO 3885
3930 GOTO 4000
4000 GOSUB 4010
4005 GOTO 4060
```

```
4010 CLS
4015 PRINT"A STUDENT'S GRADE POINT AVERAGE DEPENDS ON HER GRADES FOR
4020 PRINT"INDIVIDUAL CLASSES SHE HAS COMPLETED.
4025 PRINT
4030 PRINT"   A.  G.P.A.
4035 PRINT"   B.  NUMBER OF CLASSES COMPLETED
4040 PRINT"   C.  FINAL GRADE IN EACH CLASS
4045 PRINT"   D.  CLASS ATTENDANCE
4050 RETURN
4060 PRINT
4065 PRINT"13.  WHAT IS THE MANIPULATED VARIABLE??
4070 LET A$="C"
4075 PRINT
4080 INPUT I$
4085 GOSUB 3700
4090 IF C$=D$ GOTO 4000
4095 CLS
4100 GOSUB 4015
4105 PRINT
4110 PRINT"14.  WHAT IS THE RESPONDING VARIABLE??
4115 LET A$="A"
4120 PRINT
4125 INPUT I$
4130 GOSUB 3600
4135 IF C$=D$ GOTO 4095
4140 GOTO 4200
4200 IF CANS>6 GOTO 4250
4204 CLS
4205 PRINT:PRINT
4210 PRINT"IN THE SECOND SECTION OF THIS PROGRAM, YOU ANSWERED
4215 PRINT:CANS;" OUT OF THE 9 MULTIPLE CHOICE QUESTIONS CORRECTLY.
4220 PRINT
4225 PRINT"WOULD YOU LIKE TO REVIEW THIS PART OF THE PROGRAM??  (YES OR NO)
4230 LET A$="YES"
4233 PRINT:PRINT:PRINT
4235 INPUT I$
4240 IF A$=I$ GOTO 2500
4245 GOTO 4300
4250 PRINT:PRINT
4252 CLS
4255 PRINT"IN THE PREVIOUS SECTION OF THIS PROGRAM, YOU ANSWERED
4260 PRINT:CANS;"OUT OF THE 9 MULTIPLE CHIOCE QUESTIONS CORRECTLY.
4265 PRINT
4270 PRINT"SUPER!!!
4275 PRINT
4280 PRINT"YOU ARE READY TO GO ON TO THE THIRD OF THE FOUR SECTIONS
4285 PRINT"IN THIS PROGRAM.
4290 INPUT I$
4300 CLS
4304 PRINT:PRINT:PRINT
4305 PRINT"WHAT WOULD YOU LIKE TO DO NOW??
4310 PRINT:PRINT
4315 PRINT"   A.  STOP HERE AND FINISH THE REST OF THE PROGRAM
4320 PRINT"       AT A LATER DATE.
4325 PRINT"   B.  CONTINUE ON TO THE THIRD SECTION.
4330 LET A$="B"
4335 PRINT
```

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4338 PRINT:PRINT:PRINT:PRINT
4340 INPUT I$
4345 IF A$=I$ GOTO 5000
4349 PRINT
4350 INPUT"ARE YOU SURE??";B$
4355 LET C$="YES"
4360 IF B$=C$ GOTO 9999
4365 PRINT"THIS IS ANOTHER TOUGH DECISION, BUT YOU MUST GIVE AN ANSWER!!
4370 GOTO 4305
5000 CLS
5005 LET CANS=0
5010 PRINT:PRINT:PRINT
5015 PRINT"SUPPOSE YOU WANTED TO DO AN EXPERIMENT TO SEE HOW THE AMOUNT
5020 PRINT"OF BAKING POWDER IN A CUPCAKE RECIPE AFFECTS THE AMOUNT THAT
5025 PRINT"THE CUPCAKE RISES.
5030 PRINT:PRINT
5035 PRINT"YOU DO AN EXPERIMENT TO FIND OUT.
5040 PRINT:PRINT:PRINT:PRINT
5045 INPUT I$
5050 CLS
5055 PRINT"15.  YOU MIX UP SEVERAL CUPCAKE RECIPES AND ADD DIFFERENT
5060 PRINT"AMOUNTS OF BAKING POWDER TO EACH ONE.
5065 PRINT
5070 PRINT"WHAT IS 'THE AMOUNT OF BAKING POWDER' CALLED??
5075 PRINT:PRINT
5080 PRINT"  A.  MANIPULATED VARIABLE
5085 PRINT"  B.  RESPONDING VARIABLE
5090 LET A$="A"
5095 PRINT
5100 INPUT I$
5105 GOSUB 5200
5110 IF C$=D$ GOTO 5050
5115 CLS
5120 PRINT"16.  YOU THEN BAKE EACH OF THE CUPCAKE RECIPES.  AFTER THEY
5125 PRINT"COME OUT OF THE OVEN, YOU MEASURE THEIR HEIGHTS.
5130 PRINT"WHAT IS THE 'HEIGHT OF CUPCAKE' CALLED??
5135 PRINT:PRINT
5140 PRINT"   A.  MANIPULATED VARIABLE
5145 PRINT"   B.  RESPONDING VARIABLE
5150 LET A$="B"
5155 PRINT
5160 INPUT I$
5165 GOSUB 5200
5166 IF C$=D$ GOTO 5120
5170 GOTO 5299
5200 IF A$<>I$ GOTO 5250
5202 LET CANS=CANS+1
5205 PRINT"BINGO!!    YOU'RE DOING FINE!!!
5210 LET C$="."
5215 INPUT I$
5220 RETURN
5250 PRINT"NO.  THERE IS ONLY ONE OTHER CHOICE.
5255 PRINT"WOULD YOU LIKE TO GO BACK AND GET THIS QUESTION CORRECT?? (YES
5256 PRINT"OR NO)
5260 LET C$="YES"
5265 INPUT D$
5270 CLS
5275 RETURN
```

```
5299 CLS
5300 PRINT:PRINT:PRINT:PRINT:PRINT
5305 PRINT"PERHAPS YOU ARE THINKING THAT THERE ARE OTHER VARIABLES
5310 PRINT"WHICH COULD AFFECT THE HEIGHT OF THE CUPCAKES.
5315 PRINT
5320 PRINT"THIS IS TRUE.
5325 PRINT:PRINT:PRINT
5330 INPUT I$
5335 CLS
5340 PRINT:PRINT:PRINT:PRINT:PRINT
5345 PRINT"USING DIFFERENTLY SHAPED CONTAINERS FOR EACH CUPCAKE RECIPE
5350 PRINT"COULD AFFECT THE HEIGHT OF THE CUPCAKES.
5355 PRINT
5360 PRINT"VARYING THE AMOUNT OF TIME THE CUPCAKES WERE BAKED COULD
5365 PRINT"ALSO AFFECT THEIR HEIGHT.
5370 PRINT:PRINT:PRINT
5375 INPUT I$
5379 CLS
5380 PRINT:PRINT:PRINT
5385 PRINT"YOU WILL GET THE BEST RESULTS FROM YOUR EXPERIMENT IF YOU
5390 PRINT"CHANGE ONE VARIABLE (MANIPULATED VARIABLE) IN A SYSTEMATIC
5395 PRINT"WAY AND MEASURE THE CORRESPONDING CHANGE IN ANOTHER VARIABLE
5400 PRINT"(RESPONDING VARIABLE).
5405 PRINT:PRINT
5410 PRINT"AT THE SAME TIME, IT IS IMPORTANT TO CONTROL ANY OTHER
5415 PRINT"VARIABLES WHICH MAY AFFECT YOUR RESULTS BY HOLDING THEM
5416 PRINT"CONSTANT.  THE VARIABLES WHICH ARE HELD CONSTANT ARE CALLED
5417 PRINT"'CONTROLLED VARIABLES.'
5420 PRINT:PRINT
5425 INPUT I$
5430 PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
5434 CLS
5435 PRINT"CAN YOU NAME A VARIABLE WHICH SHOULD BE CONTROLLED IN THE
5440 PRINT"CUPCAKE EXPERIMENT??  (TYPE IN YOUR ANSWER AND PRESS 'ENTER')
5445 PRINT
5450 INPUT I$
5455 PRINT
5460 PRINT"THERE ARE MANY VARIABLES WHICH SHOULD BE CONTROLLED IN THIS
5465 PRINT"EXPERIMENT.   SOME OF THEM ARE:
5470 PRINT
5475 PRINT"      AMOUNT OF BATTER IN EACH CUPCAKE CONTAINER
5480 INPUT I$
5485 PRINT"      SHAPE OF THE CONTAINER
5490 INPUT I$
5495 PRINT"      AMOUNT OF TIME THE CUPCAKES BAKED
5500 INPUT I$
5505 PRINT"      OVEN TEMPERATURE
5510 INPUT I$
5515 PRINT"      AMOUNT OF EACH INGREDIENT IN THE RECIPE (EXCEPT THE
5520 PRINT"                                                 BAKING POWDER)
5525 INPUT I$
5530 PRINT
5535 PRINT"YOU MAY HAVE THOUGHT OF SOME ADDITIONAL CONTROLLED VARIABLES.
5540 PRINT
5545 INPUT I$
5549 CLS
```

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5550 PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
5555 PRINT"TRY IDENTIFYING THE VARIABLES IN THE FOLLOWING EXPERIMENT.
5560 PRINT:PRINT:PRINT
5565 INPUT I$
5567 GOSUB 5600
5570 GOTO 5677
5600 CLS
5605 PRINT"A MICROBIOLOGIST BELIEVES THAT THE TEMPERATURE OF FOOD AFFECTS
5610 PRINT"HOW QUICKLY SPOILAGE ORGANISMS WILL GROW ON IT.
5615 PRINT"HE PUTS AN EQUAL NUMBER OF STARTING MICROORGANISMS IN IDENTICAL
5620 PRINT"FOOD SAMPLES AND PUTS EACH FOOD SAMPLE IN AN INCUBATOR AT A
5625 PRINT"DIFFERENT TEMPERATURE FOR 1 HOUR.  THEN HE COUNTS HOW MANY
5630 PRINT"MICROORGANISMS ARE ON EACH FOOD SAMPLE.
5655 PRINT"   A.  NUMBER OF STARTING ORGANISMS
5660 PRINT"   B.  NUMBER OF ORGANISMS IN FOOD AFTER INCUBATING 1 HOUR
5665 PRINT"   C.  SIZE OF FOOD SAMPLE
5670 PRINT"   D.  TEMPERATURE AT WHICH THE FOOD WAS INCUBATED
5675 PRINT"   E.  AMOUNT OF TIME THE FOOD WAS HELD IN THE INCUBATOR
5676 RETURN
5677 PRINT
5679 PRINT"17. WHAT WAS THE MANIPULATED VARIABLE IN THIS EXPERIMENT (THAT
5681 PRINT"IS, WHICH VARIABLE DID THE MICROBIOLOGIST DELIBERATELY CHANGE?)?
5685 LET A$="D"
5690 INPUT I$
5695 GOSUB 6000
5700 IF C$=D$ GOTO 5567
5705 CLS
5706 GOSUB 5600
5710 PRINT
5715 PRINT"18.  WHAT WAS THE RESPONDING VARIABLE IN THE MICROBIOLOGIST'S
5720 PRINT"EXPERIMENT? (THAT IS, WHICH VARIABLE CHANGED AS A RESULT
5725 PRINT"OF A CHANGE IN THE MANIPULATED VARIABLE?)?
5730 LET A$="B"
5735 INPUT I$
5740 GOSUB 6000
5750 IF C$=D$ GOTO 5706
5800 GOSUB 5600
5810 PRINT"19.  WHICH OF THE ABOVE WERE CONTROLLED VARIABLES IN THE
5815 PRINT"EXPERIMENT (THAT IS, WHICH VARIABLES WERE KEPT CONSTANT SO THE
5820 PRINT"EXPERIMENTER COULD BE SURE THEY WOULD NOT AFFECT THE
5822 PRINT"RESPONDING VARIABLE?)?
5825 LET A$= "A-C-E"
5830 INPUT I$
5835 GOSUB 6000
5840 IF C$=D$ GOTO 5800
5845 GOTO 6100
6000 IF A$<>I$ GOTO 6050
6005 LET CANS = CANS + 1
6010 PRINT "GREAT!  KEEP UP THE GOOD WORK!!
6015 LET C$="."
6020 INPUT I$
6025 RETURN
6050 PRINT" NO. WOULD YOU LIKE TO TRY AGAIN?   (YES OR NO)
6055 LET C$="YES"
6060 INPUT D$
6065 CLS
6070 RETURN
```

```
6100 CLS
6105 PRINT"SUPPOSE YOU WANTED TO STUDY THE GROWTH RATE OF GUPPIES (FISH).":PRINT
6110 PRINT"WHAT MIGHT BE A VARIABLE WHICH WOULD AFFECT THE GROWTH
6115 PRINT"OF THE FISH?   (TYPE IN YOUR ANSWER AND PRESS 'ENTER')
6120 PRINT:PRINT
6125 INPUT I$
6130 PRINT:PRINT
6135 PRINT"  THERE ARE LOTS OF VARIABLES WHICH YOU MIGHT DECIDE TO STUDY.
6140 PRINT"SOME INCLUDE:  THE AMOUNT OF FOOD THEY ARE GIVEN, THE TYPE
6145 PRINT"OF FOOD THEY ARE GIVEN, THE WATER THEY LIVE IN, OR THE
6150 PRINT"AMOUNT OF LIGHT THEY RECEIVE.":PRINT
6155 INPUT I$
6160 GOSUB 6200
6165 GOTO 6250
6200 CLS
6205 PRINT"SUPPOSE YOU DECIDE TO STUDY HOW THE TEMPERATURE OF
6210 PRINT"THE WATER THE FISH LIVED IN AFFECTED THEIR GROWTH RATE.":PRINT
6220 PRINT"   A.  GROWTH RATE OF THE FISH
6225 PRINT"   B.  AMOUNT OF FOOD FISH ARE GIVEN
6230 PRINT"   C.  TYPE OF FOOD FISH ARE GIVEN
6235 PRINT"   D.  COLOR OF CONTAINER FISH FOOD IS KEPT IN
6240 PRINT"   E.  TEMPERATURE OF WATER FISH LIVE IN
6245 RETURN
6250 PRINT
6255 PRINT"20.  WHAT WOULD BE THE MANIPULATED VARIABLE IN YOUR EXPERIMENT?":PRIN
T
6260 LET A$="E"
6265 INPUT I$
6270 PRINT
6275 GOSUB 6000
6280 IF C$=D$ GOTO 6160
6300 GOSUB 6200
6305 PRINT
6310 PRINT"21.  WHAT WOULD BE THE RESPONDING VARIABLE IN YOUR EXPERIMENT?":PRINT
6315 LET A$="A"
6320 INPUT I$
6325 PRINT
6330 GOSUB 6000
6335 IF C$=D$ GOTO 6300
6400 GOSUB 6200
6405 PRINT
6410 PRINT"22.  WHICH OF THE ABOVE VARIABLES WOULD BE IMPORTANT
6415 PRINT"TO CONTROL BY HOLDING CONSTANT?":PRINT
6420 LET A$="B-C"
6425 INPUT I$
6430 PRINT
6435 GOSUB 6000
6440 IF C$ = D$ GOTO 6400
6500 IF CANS>5 GOTO 6560
6505 CLS
6510 PRINT:PRINT
6515 PRINT"IN THE THIRD SECTION OF THIS PROGRAM, YOU ANSWERED
6520 PRINT;CANS;" OUT OF THE 8 MULTIPLE CHOICE QUESTIONS CORRECTLY.
6525 PRINT
6530 PRINT"WOULD YOU LIKE TO REVIEW THIS PART OF THE PROGRAM??  (YES OR NO)
6535 LET A$= "YES"
6540 PRINT:PRINT:PRINT
```

```
6545 INPUT I$
6550 IF A$=I$ GOTO 5000
6555 GOTO 6700
6560 CLS
6565 PRINT:PRINT
6570 PRINT"IN THE PREVIOUS SECTION OF THIS PROGRAM, YOU ANSWERED
6575 PRINT;CANS;"OUT OF THE 8 MULTIPLE CHOICE QUESTIONS CORRECTLY.
6580 PRINT:PRINT
6585 PRINT"FANTASTIC!!!"
6590 PRINT
6595 PRINT"YOU ARE READY TO GO ON TO THE LAST SECTION IN THIS PROGRAM.
6600 INPUT I$
6700 CLS
6705 PRINT:PRINT:PRINT
6710 PRINT" THE LAST SECTION OF THIS PROGRAM IS A SHORT QUIZ
6715 PRINT" (2 PROBLEM SETS-6 QUESTIONS) TO HELP YOU EVALUATE
6720 PRINT" HOW WELL YOU HAVE MASTERED THE OBJECTIVES OF THIS
6725 PRINT" OF THIS PROGRAM.
6730 PRINT:PRINT
6735 PRINT" WHAT WOULD YOU LIKE TO DO NOW?
6740 PRINT:PRINT
6745 PRINT "    A.  I'M EXHAUSTED!  I'LL STOP HERE AND TAKE THE
6746 PRINT"         SHORT QUIZ AT A LATER DATE.
6747 PRINT"     B.  I'M READY TO TAKE THE SHORT QUIZ NOW!
6750 LET A$="B"
6755 PRINT:PRINT:PRINT
6760 INPUT I$
6765 IF A$= I$ GOTO 7000
6770 PRINT
6775 INPUT "ARE YOU SURE?";B$
6777 CLS
6780 LET C$= "YES"
6785 IF B$= C$ GOTO 9999
6790 PRINT" YOU MUST MAKE UP YOUR MIND!":PRINT
6795 GOTO 6735
7000 CLS
7001 LET CANS=0
7005 GOSUB 7015
7010 GOTO 7100
7015 PRINT"ELIZA MADE 4 ICE CUBES--A CUBE, A SPHERE, A PYRAMID, AND
7016 LET I$="."
7020 PRINT"A CYLINDER.  THEY ALL HAD THE SAME VOLUME AND MASS.
7025 PRINT"SHE PUT EACH ICE CUBE IN AN INDIVIDUAL BEAKER FILLED WITH
7030 PRINT"150 MILLILITERS OF WATER THAT WAS AT 30 DEGREES C.
7035 PRINT"THEN SHE MEASURED HOW LONG IT TOOK EACH ICE CUBE TO MELT.
7040 PRINT
7045 PRINT"  A.  MANIPULATED VARIABLE
7050 PRINT"  B.  RESPONDING VARIABLE
7055 PRINT"  C.  CONTROLLED VARIABLE
7060 RETURN
7100 PRINT
7105 PRINT"23.  WHAT KIND OF VARIABLE IS 'THE AMOUNT OF TIME FOR THE ICE
7110 PRINT"     CUBE TO MELT'??
7115 LET A$="B"
7120 INPUT I$
7125 GOTO 7200
7130 CLS
7132 GOSUB 7015
```

```
7135 PRINT
7140 PRINT"24.  WHAT KIND OF VARIABLE IS 'THE VOLUME OF WATER IN THE
7145 PRINT"     BEAKER INITIALLY'??
7150 LET A$="C"
7155 INPUT I$
7160 GOTO 7300
7165 CLS:PRINT
7167 GOSUB 7015
7170 PRINT"25.  WHAT KIND OF VARIABLE IS 'ICE CUBE SHAPE'??
7175 LET A$="A"
7180 INPUT I$
7185 GOTO 7400
7190 GOTO 7400
7200 IF A$<>I$ GOTO 7250
7205 LET CANS=CANS+1
7210 PRINT"TERRIFIC!!     GO ON!!!
7215 INPUT I$
7220 GOTO 7130
7250 PRINT"NO.  THE CORRECT ANSWER IS B.
7260 PRINT"YOU MAY CONTINUE.
7265 INPUT I$
7270 GOTO 7130
7300 IF A$<>I$ GOTO 7350
7305 LET CANS=CANS+1
7310 PRINT"TERRIFIC!!     GO ON!!!
7315 INPUT I$
7320 GOTO 7165
7350 PRINT"NO.  THE CORRECT ANSWER IS C.
7360 PRINT"YOU MAY CONTINUE.
7365 INPUT I$
7370 GOTO 7165
7400 IF A$<>I$ GOTO 7450
7405 LET CANS=CANS+1
7410 PRINT"TERRIFIC!!     GO ON!!
7415 INPUT I$
7420 GOTO 7500
7450 PRINT"NO.  THE CORRECT ANSWER IS A.
7455 PRINT
7460 PRINT"YOU MAY CONTINUE.
7465 INPUT I$
7470 GOTO 7500
7500 GOSUB 7504
7501 GOTO 7600
7504 CLS
7505 PRINT"BART SUSPECTS THAT THE NUMBER OF MILES THAT HIS CAR TRAVELS
7506 LET I$="."
7510 PRINT"PER GALLON OF GASOLINE DECREASES AS HE INCREASES THE WEIGHT
7515 PRINT"THE CAR CARRIES.  HE DOES AN INVESTIGATION TO FIND OUT IF
7520 PRINT"HIS HYPOTHESIS IS CORRECT.
7525 PRINT
7530 RETURN
7600 GOTO7605
7605 PRINT"26.  WHAT IS THE MANIPULATED VARIABLE IN BART'S INVESTIGATION??
7610 GOSUB 7640
7615 GOTO 7750
```

```
7640 PRINT
7645 PRINT"   A.  NUMBER OF MILES THE CAR TRAVELED PER GALLON OF GASOLINE
7650 PRINT"   B.  WEIGHT OF THE CAR'S CONTENTS
7655 PRINT"   C.  NUMBER OF PEOPLE RIDING IN THE CAR
7660 PRINT"   D.  WEIGHT
7665 RETURN
7750 INPUT I$
7755 LET A$="B"
7760 IF A$<>I$ GOTO 7780
7765 LET CANS=CANS+1
7770 PRINT"TERRIFIC!!     GO ON!!!
7775 INPUT I$
7777 GOTO 7800
7780 PRINT"NO.  THE CORRECT ANSWER IS B.
7785 PRINT"YOU MAY CONTINUE.
7790 INPUT I$
7800 GOSUB 7504
7805 GOTO 7900
7900 GOTO 7905
7905 PRINT"27.  WHAT IS THE RESPONDING VARIABLE??
7910 GOSUB 7640
7915 GOTO 8050
8050 INPUT I$
8055 LET A$="A"
8060 IF A$<>I$ GOTO 8080
8065 LET CANS=CANS+1
8070 PRINT"TERRIFIC!!     GO ON!!!
8075 INPUT I$
8077 GOTO 8100
8080 PRINT"NO.  THE CORRECT ANSWER IS A.
8085 PRINT"YOU MAY CONTINUE.
8090 INPUT I$
8100 GOSUB 7504
8200 GOTO 8205
8205 PRINT"28.  WHICH OF THE FOLLOWING SHOULD BART MAKE SURE ARE
8210 PRINT"CONTROLLED VARIABLES IN HIS EXPERIMENT??
8215 PRINT
8220 PRINT"   A.  SPEED AT WHICH THE CAR TRAVELS
8225 PRINT"   B.  MILES THE CAR TRAVELS PER GALLON OF GASOLINE
8230 PRINT"   C.  TYPE OF GASOLINE
8235 PRINT"   D.  WEIGHT
8240 INPUT I$
8245 LET A$="A-C"
8250 IF A$<>I$ GOTO 8270
8255 LET CANS=CANS+1
8260 PRINT"TERRIFIC!!
8265 INPUT I$
8267 GOTO 9000
8270 PRINT"NO.  THE CORRECT ANSWER IS A-C.
8275 INPUT I$
9000 IF CANS>4 GOTO 9100
9001 CLS
```

```
9005 PRINT:PRINT:PRINT:PRINT
9010 PRINT"IN THE LAST SECTION OF THIS PROGRAM, YOU ANSWERED" ;CANS;"OUT"
9015 PRINT"OF 6 QUESTIONS CORRECTLY.  yOU MAY WISH TO USE THIS PROGRAM
9020 PRINT"AGAIN OR SPEAK TO YOUR INSTRUCTOR ABOUT ANY DIFFICULTIES
9025 PRINT"YOU ARE HAVING IN IDENTIFYING VARIABLES.
9027 PRINT:PRINT:PRINT:PRINT
9028 INPUT I$
9029 GOTO 9135
9030 END
9100 CLS
9101 PRINT:PRINT:PRINT:PRINT
9105 PRINT"IN THIS QUIZ, YOU ANSWERED" ;CANS;"OUT OF 6 QUESTIONS CORRECTLY."
9115 PRINT:PRINT:PRINT:PRINT:PRINT
9116 INPUT I$
9117 LET G=0
9118 CLS:PRINT:PRINT:PRINT:PRINT
9119 PRINT CHR$(23)
9120 PRINT"        WUNDERBAR!!!
9121 T=300:GOSUB 9125
9122 LET G=G+1:CLS
9123 T=100:GOSUB 9125
9124 GOTO 9118
9125 FOR Z=1 TO T:NEXT Z
9126 IF G=5 GOTO 9129
9127 RETURN
9129 PRINT:PRINT:PRINT:PRINT
9130 INPUT I$
9135 CLS:PRINT:PRINT:PRINT:PRINT:PRINT
9138 PRINT CHR$(23)
9140 PRINT"           THE END
9145 PRINT:PRINT:PRINT:PRINT
9150 INPUT I$
9999 END
```

VITA

VITA

Beth Holly Eddinger was born in Bridgeport, Connecticut, on September 16, 1955, the child of R. Emil and Claire Eddinger. At the age of 10, she moved to Monroe, Connecticut, where she graduated from Masuk High School in 1973. She entered Thiel College in Greenville, Pennsylvania in the fall of 1973 and received her B.A. in 1977 with a major in Chemistry and also certified in elementary education.

She came to Purdue in the fall of 1977 to work on her M.S. in Food Science, which she received in December of 1979. Her thesis topic was the characterization of sauerkraut volatiles by high resolution gas chromatography. Following a year's work at the Laboratory of Renewable Resources Engineering at Purdue University, she began work on her Ph.D. in Science Education in 1981 and expects to be granted the degree in December of 1983.

The author was married to Ronald David Wesley on July 5, 1980, in Bridgeport, Connecticut. They have a daughter, Anna Eddinger Wesley, born in Lafayette, Indiana on January 3, 1983.