The Effects of Metacognitive Advice and Control of Sequence on Student Achievement and Attitude Toward Computer-Assisted Instruction and Content.

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THE EFFECTS OF METACOGNITIVE ADVICE AND CONTROL OF SEQUENCE ON STUDENT ACHIEVEMENT AND ATTITUDE TOWARD COMPUTER-ASSISTED INSTRUCTION AND CONTENT

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for degree of Doctor of Philosophy in The School of Vocational Education

by Andrew Mark Holden
B.Sc., University of Waterloo, 1990
May 1995
ACKNOWLEDGMENTS

I would like to thank Dr. J. W. Trott and Dr. M. F. Burnett for guiding me with my research project. Special thanks goes to Dr. S. K. MacGregor for help with the design of the instructional program. I would also like to thank the other members of my committee, Dr. J. G. McMurry, Dr. J. K. Kotrlik, and Dr. K. Koonce, for their assistance.

In the School of Vocational Education, I would like to thank Sandra Cash and Sharon Hutchison for helping with registration and other administrative necessities to graduate from LSU. In the Department of Administration and Foundational Services, I would like to thank Sundar Vedantham and Deborah Humbles for their outstanding assistance in helping me overcome administrative obstacles. Special thanks goes to Aravind Somanchi for help with the file transfers while I completed my dissertation from Montréal.

I would like to thank my colleagues Skip Twitchell, Geetanjali Soni, and Cathy Hamilton for their suggestions with my study, for our discussions, and for our comradeship during my studies at LSU.

Finally, I would like to thank my family for their support, especially my father who, during the last week of his life, told me he was proud of me. I would not have been able to complete this process without the love, help, and support from my wife Dr. Mamta Rawat. She was there for me when I needed encouragement to continue and she never stopped believing in my ability to finish the degree.
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ABSTRACT

The purpose of the study was to investigate the effects of the CAI design features - metacognitive advice and control of instructional sequence upon student achievement and attitude toward the instructional program and content. The topic of the CAI was designing comparative research to control threats to internal validity. Four versions of the CAI were created based upon the combinations of the bi-level independent variables - metacognitive advice and control of instructional sequence.

The participants of the study were graduate students from four departments at Louisiana State University. The independent variables were metacognitive advice, control of instructional sequence, and the participant's self-directed learning readiness level. The dependent variables were posttest achievement and attitude toward the instructional program and content.

The study had four objectives and five hypotheses. The treatment variables metacognitive advice and control of instructional sequence had no effect upon posttest achievement. However, the researcher found that the participants' self-directed learning readiness was important. First, when the participants had control of the instructional sequence, the higher self-directed learning readiness participants had higher achievement than the lower level participants. Second, for the lower level self-directed learning readiness participants, the participants with program control of instructional sequence had higher achievement than the participants with learner control of instructional sequence. Regarding the attitude toward the
instructional program and content, there were no differences in attitude among the participants who used the four different version of the CAI.

The participant’s problem solving ability and prior knowledge of content were used as covariates and were significant in the analyses. This, along with the finding that self-directed learning readiness is important with achievement in learner control of instruction, indicates that personal characteristics are important factor in having control of CAI.
CHAPTER 1

INTRODUCTION

Computers have been used as instructional delivery methods since 1959 and has come to be known as computer-assisted instruction (CAI). There are two different philosophies regarding how the computer should deliver instruction. Advocates of the first philosophical position, program control of instruction, believe that the computer should present the necessary instruction and the learner should have no control over his or her learning. In contrast with this philosophy is the idea that the learner should be allowed to have control of his or her learning, called learner control of instruction. Supporters of this philosophical position feel that program control of instruction is not beneficial to the learner since real world learning is not always adaptive to individual learner needs. The supporters of learner control of instruction presumed that students would be more motivated, have higher achievement, lower frustration and anxiety because they would be able to choose the information they needed (Steinberg, 1989). However those that support program control of instruction feel that the student cannot make effective decisions regarding his or her learning. The computer could assess student's performance and, based upon the student's performance, could provide more practice, review examples, or move the student to more advanced material as needed.
Statement of the problem

Researchers have studied giving students control of sequence, review items, practice items, pace, text density, and feedback. The results have not been conclusive as to which dimensions the learner can effectively control (Tennyson & Buttrey, 1980; Higginbotham-Wheat, 1990; Tennyson, 1980). Some studies have included advice to help the students make effective choices regarding instruction. Advice is information given to the student from the CAI. This advice can include information regarding sequence of instruction, problem solving modelling, or learning needs regarding mastery level.

Metacognitive skills are very important for the success of students working independently on CAI (Haynes & Malouf, 1986). Metacognition is what learners know of their own cognition and their ability to control those cognitions (Meichenbaum, 1980). Gagne (1985) described metacognition as having four steps: awareness of task goals, knowledge of applicable learning strategies, selection of appropriate learning strategy, and self-monitoring. While some studies have given students advice regarding parts of the metacognitive process, no studies have given advice regarding all four steps in the metacognitive process.

Learner control of instruction allows for more individualized instruction on a given topic. Allowing learners to choose the sequence for their instruction would allow them to learn in ways more meaningful for themselves. However, not all students have the metacognitive ability to learn efficiently. Thus, a metacognitive advisement strategy may be helpful to those learners who are lacking in such skills.
Most studies regarding learner control of instruction have included college age students or younger as subjects in the study. However, this study included older adults as subjects. One important issue with independent learning with adults is their self-directed learning ability. Adults are competent when they engage in self-directed learning activities in day to day life (Tough, 1979 in Knowles, 1990) but may not be in a formal learning situation (Knowles & Associates, 1984 in Knowles, 1990). Therefore, if an adult is allowed more control of their learning in a CAI format, his or her level of self-directedness may impact their achievement.

No previous research has examined the relationship between a student's self-directed learning readiness and their achievement with learner controlled CAI. One possible reason is self-directed learning readiness is less of an issue for the younger subjects in previous learner control research since they are less likely to be self-directed (Knowles, 1980).

Purpose

The purpose of this study was to examine the effect of metacognitive advisement and control of sequence upon achievement in an educational research design CAI program for two levels of student self-directed learning readiness. There have been numerous advances in computer technology to improve the delivery of instruction using microcomputers. The capability of microcomputers to utilize sound, graphics, still photographs, and video has lead to an increased availability of software for educational purposes. Some of these CAI programs will provide opportunities for autonomous learning. This study provided some
additional information to key areas of learner control regarding what should be controlled and by whom. The metacognitive advice feature and the self-directed learning readiness characteristic of the participants provided this information.

In this study, there were three independent variables, each with two levels. The first, metacognitive advisement had the levels of students receiving metacognitive advice and students receiving no advice. Second, learner control of instructional sequence, had levels of learner control of instructional sequence and program control of instructional sequence. Finally, the self-directed learning readiness of the participants was classified as higher or lower based upon the median of the participant's scores on the Self-Directed Learning Readiness Scale (SDLRS).

Four versions of the CAI program were created to place the subjects into groups having program control of sequence with and without metacognitive advisement and learner control of sequence with and without metacognitive advisement. The advisement strategies were metacognitive in nature to assist learners in successful completion of the learning objectives. The students were blocked on their self-directed learning readiness level before being assigned to the four treatment levels.

The dependent variables used were the participant's posttest achievement, attitude toward CAI, and attitude toward the CAI content. Also, there were two extraneous variables. First, the participant's prior knowledge of content was
measured by the pretest. Second, the participant’s problem solving ability was measured by the student’s GRE analytical score.

Objectives

Four objectives and five hypotheses were formulated to guide the researcher in this study. The four objectives were:

1. To describe the sample of graduate students on the following characteristics: college department, gender, age, level of study, education status, SDLRS score, GRE quantitative, verbal, and analytical scores, pretest and posttest achievement scores, and the participants’ attitudes toward the instructional program and the instructional content;

2. To compare the attitude toward the instructional program by categories of each of the three treatment variables: Self-directed learning readiness, metacognitive advice, and control of instructional sequence;

3. To compare the attitude toward instructional content by categories of each of the three treatment effects: Self-directed learning readiness, metacognitive advice, and control of instructional sequence; and

4. To determine if a significant relationship exists between the subject’s SDLRS score and their attitude toward the instructional program by each of the four treatment groups; learner control with metacognitive advice, learner control without metacognitive advice, program control with metacognitive advice, and program control without metacognitive advice.
Hypotheses

The five hypotheses were:

1. The posttest scores of those who received metacognitive advice were higher than those who had not received the metacognitive advice controlling for the participant’s prior knowledge of content and problem solving ability;

2. For those with learner control of sequence, the posttest scores of those who received metacognitive advice would have higher scores than who had not received the metacognitive advice controlling for the participant’s prior knowledge of content and problem solving ability;

3. For those without metacognitive advice, the posttest scores of those with program control of instructional sequence were higher than those with learner control of instructional sequence controlling for the participant’s prior knowledge of content and problem solving ability;

4. For those with learner control of instructional sequence, the posttest scores of those with higher self-directed learning readiness would be higher than those with lower self-directed learning readiness controlling for the participant’s prior knowledge of content and problem solving ability; and

5. For those with lower self-directed learning readiness, the posttest scores of those with program control of sequence were higher than those with learner control of sequence controlling for the participant’s prior knowledge of content and problem solving ability.
Significance of the study

CAI researchers have found that students are not always able to make effective learning choices when using learner control CAI. Some researchers have given students ongoing advice (Lee 1990, 1991) modelling suggestions (Armstrong, 1989) and advice regarding learning needs compared to a specific mastery level (Johansen & Tennyson, 1983). However, no research has determined the effectiveness of giving students metacognitive advice for all components that comprise metacognition. In addition, while CAI has been suggested as a method to develop self-directed learning skills, no research has examined the relationship between subject self-directed learning ability and achievement using CAI when the subject has the opportunity for self-directed study through the control of instruction.

Limitations

The research was conducted on a purposive sample of education graduate students at Louisiana State University, Baton Rouge campus. The participants were volunteers from the School of Vocational Education, the School of Human Ecology, Administrative and Foundational Services, and Curriculum and Instruction departments. Thus, the reader should be cautioned when generalizing these findings to the general population of education graduate students, since volunteers for the study may not have been representative of the accessible population of education graduate students. However, the graduate students were
described based upon certain descriptive characteristics to enable readers to obtain an idea of the characteristics of the sample studied.
CHAPTER 2
REVIEW OF LITERATURE

Introduction

This chapter provides an overview of research literature related to learner control of CAI. The first section discusses the history of CAI and some of the factors that have lead to the widespread use of CAI. The second section describes existing CAI for the subject matter of statistics and research methodology. Metacognition and its components were described in the third section. Finally, the last section describes past research on learner control of instruction, in general, and the characteristics of learners and previous variables of investigation in more detail.

Computer-assisted instruction history

Instructional designers have developed automated systems of instruction since 1959 (Merrill, et al., 1992). The first project of significance was PLATO. This system was initially funded by the University of Illinois and the Department of Defense. Features included in the system were an authoring system language called TUTOR and specially designed computer terminals connected to minicomputers. TUTOR has greatly facilitated the development of CAI programs. PLATO guided the user through the instruction and the student had no control over the sequence, speed, and content. Basically, the program made the decisions about review and sequence depending on the needs of the student.
The basic premise of instruction developed on systems such as PLATO was that the CAI should adapt to the learning style and characteristics of each student. The CAI could then present information in the most appropriate manner for each student. However, others felt that this would make the student dependent upon the computer and subsequent learning would be difficult since most learning is not adaptive to the learner’s needs (Milheim, et al. 1992). Subsequently, the combined efforts of engineers from MITRE Corporation, in McLean, Virginia, educators at the CAI laboratory, at the University of Texas, and the Institute for Computer Uses in Education at Brigham Young University developed a CAI system (TICCIT) that would allow students to become more independent. TICCIT was also developed for minicomputers.

TICCIT, developed in 1971, differed from other CAI in its instructional strategies since it was the first program to allow learners to control their own instruction. Basically, the TICCIT system differed from previous CAI by having instructional methods built into the system, not the software, and instruction that taught concept classification instead of drill and practice. Furthermore, the CAI allowed learners this control by indicating their choices for sequence and type of display, and whether it was the rule, example, or practice for a concept (Merrill, et al., 1992).

The cost of these minicomputers and CAI systems was high compared to the microcomputers that were available in the 1970’s, and most public schools could only afford to obtain the less powerful microcomputers. The earliest CAI
programs developed for these microcomputers mimicked printed programmed instruction by presenting information in a linear fashion with learners understanding one concept before moving on to the next (Nix, 1990). These programs were typically drill and practice or tutorial CAI. However, all information does not have a unidirectional, linear relationship among concepts. Any one piece of knowledge is usually connected to many different ideas and this knowledge can be represented by different cognitive psychology memory models (Solso, 1991). One reason for the unavailability of nonlinear CAI was the lack of computing power available at the time.

In the 1980's, microcomputers became more powerful and could be used for more creative CAI. The availability of more powerful computers lead to the development of programs that can access information in a nonlinear fashion. These programs use a concept called hypermedia. Hypermedia allows for intelligent non-linear connections of information. It allows a user to branch from one information section to the next using a navigational system. Furthermore, these logical links can show how one piece of information relates to others in a similar subject area to allow understanding of the knowledge structure for that subject content.

The widespread use of computers in the education system has the potential to provide more personalized instruction. Computers can provide individualized instruction to students with different learning styles and cognitive processes (Wesley, Krockover, & Hicks, 1985). Allowing the learner to control aspects of
the instructional program allows for a more personalized educational setting. Learner control of instruction provides the opportunity for the student to make choices regarding his or her learning situation. These learner control strategies are based upon the premise that the independent learner will make intelligent choices regarding his or her learning and thus will be able to increase achievement.

Statistics and research methodology computer-assisted instruction

In a literature review of existing Statistics and Research methodology CAI, nine instructional programs were mentioned. Almost all the CAI is concerning statistical instruction. In addition, the CAI was used on Macintosh, IBM, and minicomputer platforms and targeted for college-level courses. The length of the instruction varied from a few hours for the CAI used in experiments to a one semester CAI course.

The statistics and research CAI can be classified in two ways: development of software or topic and instructional format. First, the classification system includes whether the author discussed previously developed software or the CAI was developed by the author. For the second classification method, the topics of instruction consisted of a general introduction to statistics, which is similar to an introductory college level course on statistics that includes descriptive and inferential statistics, or only a few statistics topics. The instructional format is the type of CAI which could be tutorial, drill and practice or a combination of the different content delivery methods.
First, concerning the CAI that the author did not develop, two programs, Statmaster (Davis & Knaupp, 1984) and Bootstrap Statistics (Simon, 1988) were reviewed for their instructional value. Also, Reynolds and Dansereau (1990) discuss how Macstat was used as the CAI for their experiment regarding the effectiveness of using hypertext versus hypermaps on college students' learning.

The other development classification for statistics and research CAI is the CAI was developed by the researcher. The first use was for instruction of statistical concept (Layne & Wells, 1990; Hunka, 1991; Barnes, Swehosky, & Laguna-Castillo, 1988). The other use for the statistics CAI was in an experiment using statistics as a content area for the subjects to study (Ross, Morrison, & O'Dell, 1989; Evans, 1982).

The second method of classifying the statistics and research CAI is by topic and instructional format. Most of the CAI described included content to cover the basic descriptive and inferential concepts included in a typical college level introductory statistics course. In this group of CAI, two programs consisted of tutorial format (Ross, Morrison, & O'Dell, 1989; Barnes, Swehosky, & Laguna-Castillo, 1988; Evans, 1982). The others consisted of tutorial and at least one other CAI type of instruction, such as drill and practice or problem solving. Shelley and Knaupp (1984) described CAI that allows the user to enter data for examples of statistical concepts, while Layne and Wells (1990) use drill and practice along with tutorial instruction. The final CAI described in this section utilizes diagnosis and remediation, drill, review, problem solving, simulation, and
testing (Hunka, 1991). The CAI described by Hunka was the only system that replaced the traditional method of classroom instruction instead of supplementing it.

The instruction for one CAI system contained only the t-test and z-test for content in a tutorial delivery method (Reynolds & Dansereau, 1990). Finally, one CAI program described did not indicate the extent of the content for the drill and practice and tutorial (Simon, 1988).

Metacognition

Metacognition is what learners know of their own cognition and their ability to control those cognitions (Meichenbaum, 1980). This process is made up of several components. Gagne (1985) defined four metacognitive strategies that are important for success in any learning task. These are: awareness of task goals, knowledge of applicable learning strategies, selection of appropriate learning strategies, and self-monitoring. Regarding learning strategies, Milkulecky and Adams (1986) reviewed the literature to find writing notes, focus, questioning, use of prior experience, mental imagery, reaction and arousal to be the characteristics of metacognitive behavior for learning strategy.

Learners who have developed metacognitive skills can be more efficient in their learning. People with good metacognitive skills predicted their performance better (Flavell, Freidrick, & Hoyt, 1970), differentiated between relevant and irrelevant information (Markham, 1977), and identified tasks that required specific types of strategies (Kreutzer, 1975). In addition, less skilled learners and those
who encounter new subject matter tend not to detect their failure to understand new material (August, Flavell, & Clift, 1984; Baker, 1979; Flavell, 1979; Garner, 1981; Garner & Anderson, 1982; Grabe & Mann, 1984; Markham, 1977; Robinson & Robinson, 1984; Whimbey, 1976).

Self-directed learning

One of the main tenets of andragogy is that the natural maturation process of people is to move from dependency to increasing levels of self-directedness (Knowles, 1980). Knowles (1990) describes the self-directed learner as having several competencies relating to:

- understanding of instructor directed and self-directed and when each is appropriate;
- desire and ability to maintain curiosity toward learning;
- objective self perception and acceptance of feedback nondefensively;
- self diagnosis of realistic learning needs and seeking help when needed;
- ability to translate learning needs into measurable objectives;
- resource identification for learning objective;
- strategy planning for effective use of resources;
- ability to carry out plan for learning;
- self assessment ability when objectives are met;
- collaboration with peers for sharing learning resources; and
ability to take initiative in using instructors and other experts for resource needs.

Liberman and Linn (1991) indicate that students who are learning to be self-directed can learn from external instruction, but they must eventually practice their self-directed skills independently. CAI can be a tool for students to practice their self-directed learning skills. In addition, Tennyson and Rasch (1988) suggest that computer software programs that are domain-specific and provide for self-directed learning offer beneficial opportunities for developing higher level thinking strategies.

The University of Georgia is using CAI for such a purpose. Mills and DeJoy (1988) observed self-directed adult learning and adult use of technology for learning at the University of Georgia Learning Lab. From their observations, they identified 12 design elements that are important to self-directed adult learners. These are:

- clear behavioral objectives;
- opportunities for practice;
- appropriate feedback;
- adjustable levels of difficulty;
- adjustable speed of presentation;
- opportunities for backup and review;
- adjustable sequencing of information;
- opportunities to correct entries;
o exiting at any time;
o exiting and reentering program at same place;
o opportunities to move around program without repetition;
o confidential storage of entries; and
o cross referencing of CAI and support materials.

Liberman and Linn (1991) describe the self-directed learning process to include metacognition. While there has been research conducted on the relationship of the student’s metacognition and learner control, there has not been any research to examine the student’s self-directed learning ability related to learner control of CAI.

**Learner control of instruction**

This section describes previous research on learner control of instruction. First, the reasoning behind learner control of instruction is given. Then, the variables examined in previous research were described. Finally, the variables relevant to this study were discussed in greater detail.

The debate between whether or not learners should be given control of their learning has two basic arguments. The basis for the first argument is that instructional designers know what is best for students and can design CAI to ensure that the student would proceed through the required material and that this would allow the student to achieve the objective. The opposing viewpoint of the debate concerns giving the learner control of their learning. One premise in this argument is that the learners know what they need to achieve the given objective, and thus
should be given control of their own learning. Students should control their own learning and not be dependent upon the computer to succeed.

Learner control in computer aided instruction is not one construct but a collection of strategies that function in different ways depending on what is being controlled and by whom (Ross & Morrison, 1989). The learner may have control over lesson pace, sequence, content, feedback, number of practice items, advisement, or a combination of these CAI features. Intuitively, learners should be given control of their learning.

Providing opportunities for control is based upon the argument that students would have higher motivation if allowed to control their own learning (Steinberg, 1989). Steinberg also believed that this control would reduce boredom, frustration, and anxiety from working with CAI since students would be able to choose selectively the information. This also allows the student to avoid materials he or she is not prepared to study or to exclude sections he or she had previously learned. In addition, Steinberg indicated that learner control of instruction "will maintain attention longer, involve students more deeply, and perhaps give students greater insights" (1989, p. 117).

While giving the learner more control of his or her learning is a noble goal, doing so can present some problems for the learner. A student who does not know how to make intelligent decisions for learning may not use learner control of instruction effectively. This is the "too-much-rope" syndrome (Borsook, 1991)
characterized by the students having freedom to make decisions and thus have enough rope to hang themselves.

There has been much research on various aspects of learner control, but the studies have not confirmed the anticipated benefits of greater individual achievement and motivation. One possible reason for the lack of advantage in using learner control of instruction is that research studies did not examine the psychological processes and individual differences in learning skills and strategies (Steinberg, 1989). Examples of these are: lack of clearly defined objectives (Romiszowski, 1981), naive or erroneous learning strategies (Steinberg, 1977), lack of metacognitive skills (Rigney, 1978; Allen & Merrill, 1985), or lack of feedback information for the learner to make meaningful decisions (Tennyson & Rothen, 1979). The metacognitive skills are the control process of thinking which relates new knowledge to existing knowledge, selecting thinking strategies, and planning, monitoring, and evaluating the thinking process (Dirkes, 1985).

Learner control researchers have given students control of various aspects of the instructional system in an attempt to determine the instructional conditions in which students would learn more efficiently. Unfortunately, the results have not been consistent enough to give a clear indication of what aspects of the instruction the learner should be allowed to control. This does not mean however, that the student should not have control of his or her learning. The learner control research has shown that learner control of instruction can be more efficient than program control. Therefore, the mission for researchers is to determine when the
student should have control of his or her learning. This includes the aspects of the CAI that the student might be able to control as well as which students should be able to control their instruction.

**Variables of investigation**

This section describes previous learner control of instruction research regarding the variables that the researchers have examined. Several variables of investigation have been researched with learner control. They can be broken down into three categories of variables: characteristics of the learner, components of computer assisted instruction, and learning.

First, the variables associated with the characteristics of the learner include locus of control orientation, personality styles, and cognitive ability. Second, variables investigated with components of the CAI program include control of content path, pace (Hannafin, 1984), level of difficulty, amount of practice, completion time, (Steinberg, 1977) and text density (Morrison, Ross, & O’Dell, 1988; Ross & Morrison, 1989; Ross & Rakow, 1982; Tennyson, 1980; Tullis, 1981, 1983). The research variables typically included control of content, sequence, and pacing. Finally, regarding the instructional features of the CAI Hannafin (1984) examined contingencies of instruction, and Steinberg (1977) described instructional strategies that were studied. In addition, Lee (1990, 1991) investigated giving students advice for effective learning.
Variables in this study

The variables of metacognitive advice and learner control of sequence were selected for this study based upon the need for further research into CAI design features that may compensate for a student's inability to make effective decisions during learner control of instruction. One guidance method is that of giving advice to the learner regarding where to proceed in the instruction. Advice has been shown to be beneficial for learners who do not have sufficient capabilities for independent learning (Tennyson, 1980; Johansen & Tennyson, 1983). Regarding the CAI feature for student control, learner control of sequence of instruction is one of the primary ways that learners can have more active learning.

Learners should be able to control the sequence of the instruction to relate the information in a personal manner to assist in their understanding of the material. This sequence of instruction can occur at two levels. The macro control allows students to select "chapters" while the micro control would allow students to sequence certain "pages" within the chapters.

In this section a more detailed literature review provides information regarding the variables considered in this research. This study looked at the effects of metacognitive advisement, with learner control of sequence instruction, with students grouped by self-directed learning readiness levels. Also, metacognitive advice is one type of advice that students could receive during learner control of instruction. Thus, the literature reviewed includes the importance of advice in general and metacognitive advice in particular. In
addition, the prior knowledge of content is examined because of its influence upon student achievement in learner-control CAI. Finally, the attitude of students is measured because of its importance for learning.

**Sequence**

The learner control of sequence is a common method for students to have more active participation in their learning. Some learner control studies have used learner control of sequence as a feature of the CAI in examining other variables of interest. For example, Johansen and Tennyson (1983) found that learner control of sequence is a useful strategy if advice is given to the student regarding where to proceed. Also, Milheim (1989) found that student’s attitude toward learning was greater when the students had control of sequence.

There have been studies to examine the effectiveness of giving students control of the sequence of instruction. Gray (1988) showed that allowing for this control has a positive effect on comprehension, but no effect upon retention. Also, sequence control of instruction is more effective when provided at different points in the lesson (Gray, 1987).

However, other studies have found no posttest achievement differences between learner control of sequence and program control of sequence (Strickland & Wilcox, 1978; Arnone & Grabowski, 1991). In addition, Strickland and Wilcox found no differences between treatment groups for time on rule, time on example, time of practice, or the numbers of rules, examples or practice items.
Milheim and Martin (1991) describe situations based upon motivation, attribution, or information processing theory bases where giving the student control of learning would be appropriate. They recommend learner control of sequence when students are familiar with a topic and are able to make appropriate relevant choices, and when lengthy programs have content with no prerequisite order. Also, learners should have control when there is a high probability of success regardless of the chosen sequence, and when students perceive through feedback that success is under their personal control. Furthermore, they recommended that when students have previous knowledge of content, or are of higher ability, or when the type of learning includes cognitive strategies or higher-order problem solving, the learner should have control. Finally, they recommend that learner control of sequencing should not be allowed when the material needs to be in a certain order.

Advisement

One of the problems in relinquishing control of instruction is that the learner may not make appropriate decisions for their instruction. Bunderson (1976) found that students make poor choices when left with no instruction for the next decision. Students must make two complex decisions during learner control--how to answer a question, and where to proceed after answering the question (Gray, 1987). Gray also reported that giving the students too much control may distract the students.
Where instructional decisions need to be made, better learning is likely to occur with the provision of external coaching or advisement regarding what resources to select (Tennyson, 1980). Because it is not easily practical to develop adaptive systems, an alternative is to assist the learner by advising as to which decisions should be made next. Hannafin (1984) indicates that learner control would work well when coaching or when advisement is provided to assist learners in making decisions and in using strategies known to be effective. Furthermore, students make use of instructional suggestions and like being given advice on what to do next for sequence and strategy (Laurillard, 1984).

Additional research has shown that learner control with advisement is beneficial, since those students demonstrate greater achievement following instruction than the non-advisement groups (Arnone & Grabowski, 1991; Hannafin, Garhart, Reiber, & Phillips, 1985; Johansen & Tennyson, 1983; Tennyson, 1981; Lee, 1991). Furthermore, Johansen and Tennyson (1983) showed that learner control can be a powerful management strategy for learning when the learner has sufficient advisement of specific learning needs compared to a definite mastery level. Arnone and Grabowski (1992) found that advisement concerning what to study next and curiosity advice resulted in greater achievement and more curiosity for content exploration than did learner control without advice. In a literature review regarding learner control, with advice, Milheim and Azbell (1988) reported that groups with advisement had higher posttest means, had more students reach
mastery, had longer time on task, needed less instructional time, and needed fewer instructional instances.

When comparing levels of advisement and locus of control orientation of the learner, those with adaptive advisement had higher achievement, more advisement was being followed and a greater amount of practice was performed as compared with those who had evaluative feedback, or a combination of the two (Santiago & Okey, 1990).

While most of the research, concerning advisement with learner control of instruction, found advice to be helpful, some studies showed no additional increase in achievement from advice during instruction. Goetzfried and Hannafin (1985) did not find advice to be helpful during learner control for low achieving students in their accuracy of math rule and application learning. For both groups their achievement was poor. Thus, the effectiveness of advice during learner control of instruction may only occur when learners have a minimum level of cognitive ability. In another study, Coorough (1991) also found no difference in posttest achievement or reduction in anxiety between advisement and non-advisement groups.

**Metacognition**

Metacognitive skills are very important for the success of students working independently on CAI (Haynes & Malouf, 1986). Learner control researchers know that good metacognitive skills are a critical component when giving a learner control of his or her learning (Garhart & Hannafin, 1986).
Self monitoring is one critical step in metacognition, and providing such metacognitive assistance for the student's learning with CAI may allow the student to use his or her control more efficiently. One problem that a student may have from controlling the instruction is that he or she may not accurately assess their understanding of lesson information. Garhart and Hannafin (1986) found that there was a low correlation between student's self reported understanding and their achievement.

Another factor related to metacognition is perception of learning needs. Perception is a cognitive function that includes references to previously coded information and comprehension of present and future learning needs (Johansen & Tennyson, 1983). Using learner control in CAI requires higher level complex learning tasks, and learners, without information on learning performance and need, cannot make use of perception (Johansen & Tennyson, 1983). Informing a learner of their initial assessment compared to a mastery criterion and subsequently updating the assessment can give the learner an improved perception of what is required for learning (Johansen & Tennyson, 1983). Furthermore, advisement helps learners in the perception of learning needs, need intensity, and effort required to learn (Johansen & Tennyson, 1983).

Some research has shown a link between achievement and learner control of instruction. Lee (1991) found students had more utilization and correctness of metacognitive monitoring and knowledge acquisition and application for the learner control group compared to a program control group. Also, where the program
control groups emphasized the product of learning, the learner control groups emphasized the process as well as the product of learning. In addition, Quinto and Weener (1983) found a significant correlation between the student's metacognitive ability and achievement on CAI. Furthermore, Quinto and Weener found that college students' self-assessment of their own general ability on problem solving was a good indication of their ability to accurately predict their performance on specific problem-solving tasks.

If the student is weak in his or her metacognitive ability, the CAI can include features to assist the learner. For example, Armstrong (1989) found that presenting a model of how to solve problems helped student's self-monitoring skills. In addition, when supportive factors such as provision of clearly labeled options, basic requirements, and presentation of feedback and advice concerning on-going progress were integrated into the design of the learner control study, it seemed to foster student's metacognition as well as cognitive knowledge and skills in a more effective way than program control (Lee, 1990, 1991).

There is some indication in the literature that the lack of student achievement with learner control in a CAI environment may not be from the lack of control in the environment, but from the lack of the student's metacognitive ability to assess his or her own learning needs. Furthermore, since some studies have shown that higher ability students achieve more with learner control, this might be an indication that those students have the metacognition necessary to
succeed and that success is related to these skills and not the learner control of the program (Higginbotham-Wheat, 1990).

Self-directed learning

Liberman and Linn (1991) describe the self-directed learning process to include metacognition. While there has been research conducted on the relationship of the student’s metacognition and learner control, there has not been any research to examine the student’s self-directed learning ability related to learner control of CAI.

Ability

Previous research on learner control has determined two factors that influence achievement on learner control CAI. The first is prior knowledge of content and the second is the ability of student. Student’s with high ability can use learner control of instruction effectively (Santiago & Okey, 1990b).

One learner characteristic investigated is the ability or aptitude of the students. Most research has shown that those with higher ability have more success when given control of instructional decisions. Many students, especially low achievers, lack the knowledge and motivation to make appropriate decisions regarding such conditions as pacing (Gay, 1986; Reiser, 1984) sequencing of content (Judd, Bunderson, & Bessent, 1970; Seidel, 1975; Seidel & Wagner, 1978) and amount of practice (Ross, Rakow, & Bush, 1980; Ross & Rakow, 1981; Tennyson, 1980). Also, studies have shown that learner control can be effective
when used by high aptitude students (Fry, 1972; Ross & Rakow, 1981; Hannafin, 1984).

The performance of the learner on CAI is affected by the ability of the learner. Researchers have shown that high achieving learners can benefit from a high degree of learner control (Borsook, 1991b; Gay 1986; Santiago & Okey, 1990b). In addition, Carrier, Davidson, and Williamson (1985) found that higher ability students selected more options during CAI and had higher achievement. However, Milheim (1988) found high and low ability students had no difference in achievement with learner control of instruction. Regarding lower ability students, Goetzfried and Hannafin (1985) found no achievement difference for learners, with control of instruction, who were of below average or low ability. Since higher ability learners may benefit from learner control and lower ability students do not, this suggests that learners may need a minimum level of learning competence before being able to benefit from learner control of instruction.

**Prior knowledge of content**

Another factor affecting achievement in learner control CAI is the learner’s prior knowledge of the subject area. Researchers reported that prior knowledge in content area improves achievement with learner control of instruction (Borsook, 1991b; Lee & Lee, 1991; Lee, 1990; Santiago & Okey, 1990b; Gay 1986; Hannafin and Colamaio, 1987). Also, Santiago and Okey (1990a) found that students with prior knowledge of content area can use learner control of instruction
effectively. However, there is also some evidence to suggest that amount of prior knowledge does not make a difference (Lee, 1991).

**Attitude**

Another important aspect of learning is the attitude of the learner concerning the delivery of instruction and the content of instruction. Bloom (1976) indicates that the student's affective level is a factor that accounts for variation in student's learning.

The early research on student's attitude toward student control of learning has produced mixed results regarding the expected outcome of students having a more positive attitude with more control of their own learning. Regarding the research showing more favorable attitudes toward learner control, Lahey, Hurlock, and McCann (1973) found 80% of the students preferred learner control in a naval base electronics course. In addition, other researchers (Fernald, Chiasori, & Lawson 1975; Fry, 1972; Newkirk, 1973) found more favorable attitudes toward learner control of instruction.

Not all research has shown learner control of instruction to improve the attitude of students. Judd, Bunderson, and Bessent (1970) found a lack of improvement of attitude with student control of learning. In addition, Reiser and Sullivan (1977) found student attitudes, regarding taking quizzes at their own pace, to be equal to those with no control of quiz pace. In a review of the learner control literature, Judd (1972) found few studies supporting learner control of instruction to improve attitudes toward learning. A subsequent review of the
literature (Merrill, 1979) also found no consistent increase in attitude toward learning for groups with learner control.

In recent learner controlled instruction CAI research, there has been little work done on attitude toward learning using CAI. However, the recent research still does not give a clear indication that attitude toward learning using CAI would improve if learners have more control of their instruction. Researchers have found learner attitudes more favorable in CAI for learner control of context (Ross, Morrison, & O'Dell, 1990), for higher text density (Ross, Morrison, & O'Dell, 1988), and levels of feedback (Pridemore & Klein, 1992). In addition, Milheim (1989) examined the attitudinal effects of learner control pacing and sequence, but found no differences between attitudes. However, attitudes for all the groups were high for using CAI with an interactive video system.

However, all research on the learner's attitude has not been supportive of learner control. Ross and Morrison (1989) found no difference in attitude when learners had control of text density. Also, Anastasio and Wilder (1984) found less favorable attitudes with learner control in mathematics instruction. In addition, they found that the attitude of learners with learner control of instruction in English was more favorable when the CAI was combined with considerable amount of instructor support.

Summary

This chapter provided an overview of research about the history of CAI, statistics and research methods CAI, characteristics of the learner, and CAI and
learner variables that were in this study. CAI has existed since the late 1950's and
the categories of program and learner control of instruction provide a major
distinction between CAI types. Furthermore, computer technological
developments, such as multimedia software programs, have allowed developers to
design more sophisticated instruction in a manner more meaningful to learners.
Thus, more sophisticated learner control CAI can be designed.

Two factors that might affect how well a learner might use the control of
instruction are metacognition and self-directed learning. Also, the research
described indicated that allowing the learner to control may not result in improved
achievement, however, increased achievement can result from external advice.
Another factor related to achievement with control of instruction is characteristics
of the learner. Prior content knowledge and ability of the learner having control of
CAI was described as being important. Finally, the researched described did not
indicate a consistent improvement in attitude with learners having control of their
instruction.
CHAPTER 3
METHODOLOGY

The purpose of this study was to examine the effect of metacognitive advisement and control of sequence upon achievement in an educational research design CAI program for two levels of student self-directed learning readiness. Since the subject’s prior knowledge of content and cognitive ability can affect achievement in CAI (Lee & Lee, 1991; Santiago & Okey, 1990b), these variables were controlled as covariates in the analysis.

Population and subjects

The target population of this study was education graduate students. The accessible population for this study were the graduate students in the School of Vocational Education, School of Human Ecology, Department of Administrative and Foundational Services, and the Department of Curriculum and Instruction at Louisiana State University, Baton Rouge. The students in the School of Human Ecology were included in the study to obtain the required number of participants. While these students are not classified as education students, there were only nine from this department, thus most of the sample was comprised of education graduate students.

Hinkle, Wiersma and Jurs describe four factors that affect sample size: the effect size, the population variance and the alpha and beta levels for type I and type II errors. The effect size is the size of the difference to be detected. In this study, the effect was the difference in posttest scores between treatment groups of
subjects. The posttest measurement was a 20 item multiple choice test, with each item having a value of one point. For purposes of the study a true difference was considered to exist between posttest means when there was a difference of more than one point between any two groups in the study. The population variance estimate was taken from the final exam scores of two recent VED 7905 Advanced Research Design classes. The content of this course included instruction on the threats to internal and external validity. Since some of the subjects in the study were from the School of Vocational Education, the final exam grades of previous students represented a reasonable estimate of the population variance in this study. The scores from the final exam were converted to a 20 point scale. The variance of the final exam scores was 3. The alpha level for type one errors was set at 0.05. The final component was the power of the test. McNemar (1960) in Hinkle, Wiersma, and Jurs (1988) recommend an alpha to beta ratio of one to four for behavioral science studies. Thus, the established alpha of .05 would yield a beta of 0.20, which would give a power of 0.80 for the statistical test. The sample size for each treatment group depends upon the objective that divides the entire sample into the greatest number of groups. Four of the hypotheses required four groups, from the eight possible treatment groups. Thus, the number of subjects needed, as determined from the sample size formula, was divided in half. The sample size formula for the number of subjects in each treatment group is \( n = \frac{2\sigma(z_\alpha + z_\beta)^2}{ES^2} \). The \( z_\alpha \) for an \( \alpha \) value of 0.05 is 1.65 while the \( z_\beta \) for a \( \beta \) value
of 0.20 is 0.84. These values and the population variance $\sigma^2$ and effect size (ES) were put into the formula $n = \frac{2 \times 3 \times (1.65 + 0.84)^2}{1^2} = 37$.

Since the 37 subjects were split into two groups, another subject was added to make the number of subjects evenly divisible by two. Thus, 19 people were needed for each treatment group, with a total of 152 subjects for the entire study.

Regarding participation in this study, the subjects who agreed to participate signed a participant agreement form to allow the researcher to obtain the GRE analytical score and other demographic information. The researcher had an accessible population of 491 students in the four departments/schools at Louisiana State University. This list was provided by the Records and Registration department at the university. Subsequently, the students on the list were randomly ordered for the researcher to contact. Then, the researcher attempted to contact each student to see if he or she would agree to participate in the study. The researcher attempted to call each person three times over one week at different times during the day. If there was no response from the student after the third phone call, the researcher considered him or her to be unavailable and selected the next person on the list. The researcher could not contact some students because of inaccuracies in the list provided by the Records and Registration department. Once the phone calls were completed, the researcher had obtained 153 people who agreed to participate in the study. Once an individual agreed to participate, the researcher sent the participation agreement form. The participation agreement form briefly described the requirements of participation in the study, collected the
demographic information, the self-directed learning readiness score, and the participant’s approval to release his or her GRE scores. All of this was collected under the provision of confidentiality of the information by the researcher.

If the researcher had not received the participation agreement form after one week, a phone call was made to the participant to request that the form be returned. Some of the participants then sent in the forms, while others withdrew from the study. A final total of 126 participation agreement forms were returned.

The students who agreed to participate in the study were divided into two groups: higher and lower self-directed learning readiness based upon the median of the SDLRS score for all participants. The median SDLRS score for the participants was 240.5. Those with scores above 240.5 were classified as higher self-directed learning readiness participants, and those with scores below 240.5 were classified as lower self-directed learning readiness participants. Thus, each level of the self-directed learning readiness variable contained 63 participants. These people were then randomly assigned to four treatment groups of program control of instructional sequence with and without metacognitive advice and learner control of instructional sequence with and without metacognitive advice. The number of participants assigned to each group is presented in Table 3.1.

After the participants were assigned to their treatment group, the researcher called each participant to schedule time to use the instructional program. Of the 126 people who returned the participation agreement form, nine withdrew from the study, one person’s data was thrown out after the researcher determined the
Table 3.1

**Number of Participants Assigned to Treatment Groups**

<table>
<thead>
<tr>
<th>Self-directed learning readiness</th>
<th>Sequence Control</th>
<th>Advice</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner</td>
<td>No</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Lower Program</td>
<td>No</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>Yes</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Lower Program Yes</td>
<td>Yes</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>No</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Higher Program No</td>
<td>No</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Higher Learner Yes</td>
<td>Yes</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>Yes</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>
participant used the instructional program in an unintended manner, and one person
could not complete the study because of a visual impairment. This left the
researcher with 115 useable responses. The number of useable responses by
treatment group is presented in Table 3.2.

The final 115 data points were less than the number required from the
sample formula to achieve the desired beta level. However, the researcher had
exhausted the accessible population, thus no other participants were available to
replace those who withdrew from the study.

Instrumentation

In this study, six instruments were used. These instruments were used to
collect information regarding demographic information, dependent, independent,
and extraneous variables.

Descriptive information

Selected demographic characteristics of the students were collected, using
the participation agreement form except for each participant's GRE scores, which
were collected, from the participant's student file, using a recording form. The
characteristics selected to describe this population were department/school in which
enrolled, gender, age, level of study, education status, self-directed learning
readiness, and GRE quantitative, verbal, and analytical scores. Also, the
participants were described by their pretest and posttest achievement scores as well
as their attitudes toward the instructional program and instructional content.
Table 3.2

Number of Useable Responses by Treatment Group

<table>
<thead>
<tr>
<th>Self-directed learning readiness</th>
<th>Sequence Control</th>
<th>Advice</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>Learner</td>
<td>No</td>
<td>14</td>
</tr>
<tr>
<td>Lower</td>
<td>Program</td>
<td>No</td>
<td>15</td>
</tr>
<tr>
<td>Lower</td>
<td>Learner</td>
<td>Yes</td>
<td>15</td>
</tr>
<tr>
<td>Lower</td>
<td>Program</td>
<td>Yes</td>
<td>13</td>
</tr>
<tr>
<td>Higher</td>
<td>Learner</td>
<td>No</td>
<td>14</td>
</tr>
<tr>
<td>Higher</td>
<td>Program</td>
<td>No</td>
<td>15</td>
</tr>
<tr>
<td>Higher</td>
<td>Learner</td>
<td>Yes</td>
<td>14</td>
</tr>
<tr>
<td>Higher</td>
<td>Program</td>
<td>Yes</td>
<td>15</td>
</tr>
</tbody>
</table>
Independent variables

The three independent variables in the study were control of instructional sequence, metacognitive advice and the self-directed learning readiness level of the student. The first two variables were design features of the instructional program. The control of sequence had the levels of program and learner control. The program control of sequence feature determined how the participant moved through the information. The participant examined the introduction, the six individual threats, and the case studies. The individual threat sections included information regarding each threat. This included definition, contributing factors and controls, examples, identify threat practice and control threat practice. The participants with program control of sequence saw the information in the order listed above. For the learner control of sequence, each participant had the ability to examine the introduction, individual threats, and cases studies sections as well as the individual threat subsections in the order he or she wanted. A participant had the ability to look at as much or as little information as needed. Also, the participant made decisions about how much to practice.

The metacognitive advice treatment variable had the levels of with and without advice. The advice was designed to assist the participant by getting him or her to think more of their metacognition, and, thus, help his or her achievement. The metacognitive advice given depended upon which screen the learner was viewing at any given moment. Based upon the Gagne (1985) model for metacognition, there are four strategies and each of these strategies had a
corresponding type of advice during the instruction. First, the awareness of task goals advice asked the student if he or she needed to take notes regarding the objective for the section before continuing with the instruction. Next is the knowledge of applicable learning strategies and selection of learning strategies. The learning strategies selected were taking notes and making drawings to help the student understand concepts. The student could have taken notes about any information, or drawn images to create a mental map to help with understanding the material. Regarding the advice, the instructional program monitored student use of note taking and image representation. If the student used the note taking and drawing features of the instructional program, no advice was given. However, if the student did not use those features, the instructional program asked if he or she needed to use the features to help with their understanding and learning of the information. The instruction for each threat included definition, contributing factors and controls, examples, and practice identifying and controlling the threat. Therefore, to help with participant’s understanding, he or she was asked if he or she needed to review a particular section before completing the practice. The final step in metacognitive process is self-monitoring. The self-monitoring advice was given after each practice, where the participant received information regarding the number of practice attempts, the number answered correctly on the first and second try, and the number answered incorrectly. A point system was devised to give the students a score along with the number answered correctly. An answer was worth 5 points for a correct response on the first try, 3 points for a correct response on
the second try, and 0 points for an incorrect response. After the participant saw this information, he or she was asked how well he or she was learning the information. In addition, when the participant had a practice rate less than the mastery level of 85%, the instructional program asked if the participant thought he or she needed to review the instruction for that section before continuing with further practice.

The combination of the control of instructional sequence and metacognitive advice variables resulted in four treatments: Learner control of instructional sequence with and without metacognitive advice and program control of instructional sequence with and without metacognitive advice. Each of the four versions of the instructional programs consisted of about three hours of instruction about the topic (Designing Comparative Research to Control for Threats to Internal Validity). The design of the instruction is described in Appendix A.

The content of the instruction was based upon the work of Cook and Campbell (1979). Cook and Campbell describe thirteen threats to internal validity. Since the participants were expected to use the instructional program for about three hours, the researcher selected six of the thirteen threats for the instruction. The six threats chosen were history, testing, instrumentation, mortality, differential selection, and maturation.

The instructional program was developed using Hypercard and Hypergasp. Hypercard is an authoring system that runs on the Macintosh computers. It is a hypermedia program, which allows one to develop intelligent links between
information that the user can access in a non-linear way. The instructional content was divided into three main sections: introduction, individual threats, and case studies.

The introduction section described threats to internal validity in general and explained common research design symbols. The individual threats section was comprised of the six threats chosen for the instruction. Each individual threat had the following sections: definition, contributing factors and controls, examples, identify threats practice, and control threats practice. The definition information described the threat. For the contributing factors and controls, information was presented when the threat would exist and methods to control the threat. The examples section provided three examples for each threat. These included situations when the threat existed and when it did not exist. For the practice, the participant had a choice of identifying or controlling each threat. He or she read a case study and then identified whether the threat existed or chose how to control the threat. Finally, for the case study information, the participant examined brief research reports for the example, identify, and control cases. The example case presented whether or not all of the threats existed and the identify case allowed the participant to identify whether or not all of the threats existed. The control case allowed the participant to design part of a research study to control as many threats as possible.

The third independent variable was the participant's self-directed learning readiness level. The participant's student self-directed learning readiness was
measured by the SDLRS (Appendix C). Guglielmino (1977 in Guglielmino, Long, & McCune, 1989) developed the SDLRS from a delphi study regarding "the characteristics of the self-directed learner which appear to be most closely related to his self-directed learning" (p. 92). The SDLRS instrument contains 58 items that reflect the desirable characteristics for self-directed learning. The instrument requires people to respond to statements that describe their learning. The 5-point Likert-type items have responses of "Almost always true, "Usually true," "Sometimes true," Usually not true," and "Almost never true."

The SDLRS is a valid and reliable instrument. Guglielmino et al. (1989) indicated the instrument is reliable as determined from the 17 studies conducted to examine the reliability of the instrument. In a recent study, Guglielmino (1988 in Guglielmino, et al., 1989) found the SDLRS had a Pearson split-half reliability estimate of 0.94. In support of the construct validity, Firestone (1984, in Guglielmino, et al., 1989) found instructor and observer ratings of student's self-directedness and the student's SDLRS score were significantly correlated. In addition, Brockett (1985) found the SDLRS to have a Cronbach's alpha reliability of 0.87 for older adults in a study of self-directed learning and life satisfaction.

The students were blocked into two groups, higher and lower self-directed learning readiness groups, based upon the median student SDLRS score (240.5). Therefore, the students who scored above the SDLRS median were classified as having higher self-directed learning readiness and the students who scored below the median were classified as having lower self-directed learning readiness.
The researcher examined the reliability of the SDLRS in this study. The SDLRS had a Cronbach's alpha of $\alpha = .92$.

**Dependent variables**

There were three dependent variables of interest in this study. These were (1) student achievement of the content; (2) student attitude toward the method of delivery of the instruction; and (3) the content of the instruction. Student achievement was determined from the posttest (Appendix D), a 20-item multiple-choice instrument, with each item having four choices. The instrument was designed by the researcher to measure the level of student learning of the content regarding designing comparative research to control for threats to internal validity. The researcher selected a range of questions regarding the definitions, contributing factors, methods to control the threats to internal validity. The researcher used Bloom's (1956) taxonomy of educational objectives for the cognitive domain as a guide to provide different levels of difficulty for the test. There were nine questions that were designed to test knowledge (2, 3, 4, 5, 8, 12, 13, 14, and 15). There were two questions designed to test comprehension (1 and 7). Also, four questions were designed to test application (6, 18, 19, and 20). One question was designed to test analysis (9). Finally, four questions were designed to test evaluation (10, 11, 16, and 17).

The posttest was validated by a research methods expert. The instrument was revised based upon the advice of the expert. After approximately one-quarter of the students had completed the instructional program, the researcher was told by
a participant that one of the questions had two correct possibilities. The researcher reviewed the posttest instrument and found that two of the questions had errors. These were corrected for subsequent participants. The researcher used only the 18 correct items in the data analysis. Regarding the reliability of the posttest, the researcher found a Spearman-Brown split-half reliability of .52.

The Robustness Semantic Differential (RSD) was used to measure the student attitudes. Licata and Willower (1978) developed the construct of environmental robustness as a school climate variable based upon the work of Goffman (1967). Environmental robustness is based upon social situations being understood using theatrical analogies which identify actors, plot, setting, and audience (Licata & Wildes, 1980). The instrument was designed to obtain the student's feeling on ten bipolar adjectives regarding a statement. The two statements in this study, which were used with the RSD, were "The instructional program is" (Appendix E) and "The internal validity threats' content is" (Appendix F). Licata and Willower scored the instrument from 1 to 7 for each bipolar pair of objectives with the more positive adjective receiving the high score. Thus, for the 10 items, the range of possible scores was from 10 to 70, with 70 being the most favorable attitude.

Several researchers have found the RSD to be a reliable measure of attitudes. Licata and Willower found a test-retest reliability of 0.77 (Pearson) for the total instrument. In addition, Ortiz and MacGregor (1991) reported a Cronbach's alpha reliability ranging from 0.83 to 0.92 for six RSD scales relating
to mathematics instruction. Finally, Morris (1986) had six RSD scales concerning middle-school teacher's perceptions of student robustness and student achievement with Cronbach's alpha reliability ranging from 0.84 to 0.92.

The researcher measured the reliability of the RSD for both attitude measures. The RSD for the attitude toward the instructional program had a Cronbach's alpha reliability of $\alpha = .86$, while the RSD for the attitude toward the instructional content had a Cronbach's alpha reliability of $\alpha = .87$.

**Extraneous variables**

The extraneous variables, prior knowledge of content and student problem solving ability, were measured by the pretest (Appendix D) and the student's GRE analytical ability score, respectively. The pretest was the same as the posttest. The researcher found the pretest to have a Spearman-Brown split-half reliability of .08.

The other extraneous variable was student problem solving ability. A measure of this was obtained from the student's GRE analytical score. The GRE analytical score is made up of two analytical abilities: analytic reasoning and logical reasoning. The analytic reasoning is a measure of general analytic reasoning for the "student ability to understand a given structure of arbitrary relationship among fictitious persons, plans, things, or events and to deduce new information from the relationships" (ETS p. 9, 1989 in Ratcliff, et al., 1991). The logical reasoning is a measure of "student ability to understand, analyze, and evaluate positions and contentions" (ETS p. 9, 1989 in Ratcliff, et al., 1991).
Data collection

The demographic information was gathered on a recording form for each student from his or her student file. The other variables were collected during the treatment period in the computer room in the College of Education computer laboratories. Before using the instructional program, each participant was instructed that he or she was testing the computer instructional unit and to behave as if it were a research methods lesson. The variables of investigation for the study were not mentioned to the student. The first measurement made was regarding prior knowledge of content. Each student completed the pretest, which was administered by the computer. Next, the student proceeded through the instruction. Once the student had completed the instruction, the posttest, student attitude toward the instructional program and student attitude toward instructional content instruments were administered by the computer program.

Data analysis

The alpha level of 0.05 was selected as the criteria for statistical significance in all statistical tests performed in this study.

Objective 1

The demographic information was collected from the participation agreement form, the recording form, and the instructional program. The appropriate statistical description for the college department, gender, education level, and education status is the frequency and percentage of group by each treatment group for each variable and level of treatment variables. For the age,
GRE quantitative, verbal, and analytical scores, SDLRS score, pretest and posttest achievement scores, and the attitudes toward the instructional program and instructional content, the appropriate statistical description is the mean, standard deviation, and number for each treatment group and level of treatment variables.

To interpret the SDLRS score, the researcher used Guglielmino and Guglielmino’s (1991) interpretation scale for the instrument. The scale has five levels: high (252-290), above average (227-251), average (202-226), below average (155-201), and low (58-176).

**Objective 2**

The instructional program measured the attitude toward CAI for each subject. Next, the scores of all subjects were sorted by the level of the treatment variables. Three attitude comparisons were made between: program control of sequence and learner control of sequence; presence of metacognitive advice and absence of metacognitive advice; and higher and lower self-directed learning readiness. The appropriate statistical test for this objective was a t-test of attitude toward the instructional program by each treatment effect.

**Objective 3**

The instructional program measured the attitude toward the instructional content for each subject. Next, the scores of all subjects were sorted by the level of the treatment variables. Three attitude comparisons were made between: program control of sequence and learner control of sequence; presence of metacognitive advice and absence of metacognitive advice; and higher and lower
self-directed learning readiness. The appropriate statistical test for this objective is a t-test of attitude toward the instructional content by each treatment effect.

Objective 4

The subjects were divided into four groups: learner control with metacognitive advice, learner control without metacognitive advice, program control with metacognitive advice, and program control without metacognitive advice. For each group, a Pearson product moment correlation was calculated to determine if a relationship existed between the student SDLRS scores and their attitude toward the instructional program.

Hypothesis 1

The posttest scores of the subjects were sorted into two groups: those who had metacognitive advice and those who did not. The appropriate statistical analysis for this hypothesis was an ancova of posttest scores by metacognitive advice or not treatment with pretest and GRE analytical scores used as covariates. The researcher adjusted the alpha level for all ANCOVA analyses to .10 from .05 and the direction of the difference was examined. This was done since the F-test from the ANCOVA is two tailed and the hypotheses are all directional, which requires a one-tail test. Adjusting the alpha value and examining the direction of the difference is an appropriate method to obtain a one-tail F-test (J. Geaghan, personal communication, March 15, 1995). Thus, the desired tail of the test will have the required .05 probability for rejecting the null hypothesis.
Hypothesis 2

The scores of the subjects with learner control of sequence were sorted into two groups: with and without metacognitive advice. The appropriate statistical analysis was an ancova of posttest scores by metacognitive advice or not with pretest and GRE analytical scores used as covariates. The alpha level for this test was set to .10 and the direction of the difference was examined.

Hypothesis 3

The scores of the subjects without metacognitive advice were sorted into two groups: program control of sequence and learner control of sequence. The appropriate statistical analysis was an ancova of posttest scores by metacognitive advice or not with pretest and GRE analytical scores used as covariates. The alpha level was set to .10 and the direction of the difference was examined.

Hypothesis 4

The scores of the subjects with learner control of sequence were sorted into two groups: higher and lower self-directed learning readiness. The appropriate statistical analysis was an ancova of posttest scores by metacognitive advice or not with pretest and GRE analytical scores used as covariates. The alpha level was set to .10 and the direction of the difference was examined.

Hypothesis 5

The scores of the subjects with lower self-directed learning readiness were sorted into two groups: program and learner control of sequence. The appropriate statistical analysis was an ancova of posttest achievement by metacognitive advice
or not with pretest and GRE analytical scores used as covariates. The alpha level was set to .10 and the direction of the difference was examined.
Objective 1

The first objective was to describe the sample of graduate students on the following characteristics: college department, gender, age, level of study, education status, SDLRS score, GRE quantitative, verbal, and analytical scores, pretest and posttest achievement scores, and the participant's attitudes toward the instructional program and instructional content.

The participants in each of the Administration and Foundational Services and Vocational Education departments represented about one third of the sample. About one quarter of the sample was from the Curriculum and Instruction department. The number of participants from each treatment group by department/school are presented in Table 4.1. Regarding the self-directed learning readiness treatment levels, the higher level had 28.6% of the participants from the Administration and Foundational Services department and 30.2% of the participants from the Curriculum and Instruction department. The lower level self-directed learning readiness participants had 36.5% of the participants from the Administration and Foundational Services department and 22.2% from the Curriculum and Instruction department. The number of participants by department/school and treatment variable level are presented in Table 4.2.

Regarding the gender of the participants, approximately 70% of the sample was female. The lowest proportion of female participants was 62.5% for two
Table 4.1

Number and Percent of Participants by Department/School by Treatment Group

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seq b</th>
<th>Adv c</th>
<th>EDAF d</th>
<th>EDCI e</th>
<th>HUEC f</th>
<th>VED g</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n</td>
</tr>
<tr>
<td>Lower Learner</td>
<td>No</td>
<td>3 (18.8)</td>
<td>4 (25.0)</td>
<td>1 (6.3)</td>
<td>8 (50.0)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Lower Program</td>
<td>No</td>
<td>9 (56.6)</td>
<td>3 (18.8)</td>
<td>2 (12.5)</td>
<td>2 (12.5)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Lower Learner</td>
<td>Yes</td>
<td>5 (33.3)</td>
<td>3 (20.0)</td>
<td>2 (13.3)</td>
<td>5 (33.3)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Lower Program</td>
<td>Yes</td>
<td>6 (37.5)</td>
<td>4 (25.0)</td>
<td>1 (6.3)</td>
<td>5 (31.3)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Higher Learner</td>
<td>No</td>
<td>5 (31.3)</td>
<td>5 (31.3)</td>
<td>2 (12.5)</td>
<td>4 (25.0)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Higher Program</td>
<td>No</td>
<td>3 (18.8)</td>
<td>6 (37.5)</td>
<td>0 (0.0)</td>
<td>7 (43.8)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Higher Learner</td>
<td>Yes</td>
<td>5 (33.3)</td>
<td>4 (26.7)</td>
<td>1 (6.7)</td>
<td>5 (33.3)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Higher Program</td>
<td>Yes</td>
<td>5 (31.3)</td>
<td>4 (25.0)</td>
<td>0 (0.0)</td>
<td>7 (43.8)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>41 (32.5)</td>
<td>33 (26.2)</td>
<td>9 (7.1)</td>
<td>43 (34.1)</td>
<td>126</td>
<td></td>
</tr>
</tbody>
</table>

*Self-directed learning readiness. bType of instructional sequence control.

cMetacognitive advice. dAdministration and Foundational Services. eCurriculum and Instruction. fHuman Ecology. gVocational Education.
Table 4.2

Number and Percent of Participants by Department/School by Treatment Level

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>EDAF*</th>
<th>EDCIb</th>
<th>HUECc</th>
<th>VEDd</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL*e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>18 (28.6)</td>
<td>19 (30.2)</td>
<td>3 (4.8)</td>
<td>23 (36.5)</td>
<td>63</td>
</tr>
<tr>
<td>Lower</td>
<td>23 (36.5)</td>
<td>14 (22.2)</td>
<td>6 (9.5)</td>
<td>20 (37.5)</td>
<td>63</td>
</tr>
<tr>
<td>Sequencef</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>18 (29.0)</td>
<td>16 (25.8)</td>
<td>6 (9.7)</td>
<td>22 (35.5)</td>
<td>62</td>
</tr>
<tr>
<td>Program</td>
<td>23 (35.9)</td>
<td>17 (26.6)</td>
<td>3 (4.7)</td>
<td>21 (32.8)</td>
<td>64</td>
</tr>
<tr>
<td>Adviceg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>21 (33.9)</td>
<td>15 (24.2)</td>
<td>4 (6.5)</td>
<td>22 (35.5)</td>
<td>62</td>
</tr>
<tr>
<td>No</td>
<td>20 (31.3)</td>
<td>18 (28.1)</td>
<td>5 (7.8)</td>
<td>21 (32.8)</td>
<td>64</td>
</tr>
</tbody>
</table>

*Administration and Foundational Services. bCurriculum and Instruction. cHuman Ecology. dVocational Education. eSelf-directed learning readiness. fType of instructional sequence control. gMetacognitive advice.
groups: the lower self-directed learning readiness learners who had program control of sequence with metacognitive advice and the higher self-directed learning readiness learners who had learner control of sequence without metacognitive advice. The highest proportion of female participants was 81.3% for the higher self-directed learning readiness learners who had program control of sequence with metacognitive advice. The number of participants from each treatment group by gender are presented in Table 4.3. Also, the number of participants by gender and treatment variable level are presented in Table 4.4.

The mean age of all participants was 36.5 ($SD = 9.4$). The mean ages of participants from each treatment group are presented in Table 4.5. Regarding the self-directed learning readiness treatment levels, the higher self-directed learning readiness participants had a mean age of 39.3 ($SD = 9.7$, $n = 62$) and the lower self-directed learning readiness participants had a mean age of 33.6 ($SD = 8.6$, $n = 63$). The mean ages of participants by treatment variable level are presented in Table 4.6.

Participants were described on the variable education level as either master’s or doctoral students. A little less than one half were doctoral students. The number of participants from each treatment group by education level are presented in Table 4.7. Concerning the metacognitive advice treatment variable, nearly two-thirds of those without metacognitive advice were in the master’s program and for those with metacognitive advice, less than half were in the
Table 4.3

Number and Percent of Participants by Gender by Treatment Group

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seqb</th>
<th>Advc</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n</td>
</tr>
<tr>
<td>Lower</td>
<td>Learner</td>
<td>No</td>
<td>11 (68.8)</td>
<td>5 (31.3)</td>
<td>16</td>
</tr>
<tr>
<td>Lower</td>
<td>Program</td>
<td>No</td>
<td>12 (75.0)</td>
<td>4 (25.0)</td>
<td>16</td>
</tr>
<tr>
<td>Lower</td>
<td>Learner</td>
<td>Yes</td>
<td>10 (66.7)</td>
<td>5 (33.3)</td>
<td>15</td>
</tr>
<tr>
<td>Lower</td>
<td>Program</td>
<td>Yes</td>
<td>10 (62.5)</td>
<td>6 (37.5)</td>
<td>16</td>
</tr>
<tr>
<td>Higher</td>
<td>Learner</td>
<td>No</td>
<td>10 (62.5)</td>
<td>6 (37.5)</td>
<td>16</td>
</tr>
<tr>
<td>Higher</td>
<td>Program</td>
<td>No</td>
<td>12 (75.0)</td>
<td>4 (25.0)</td>
<td>16</td>
</tr>
<tr>
<td>Higher</td>
<td>Learner</td>
<td>Yes</td>
<td>10 (66.7)</td>
<td>5 (33.3)</td>
<td>15</td>
</tr>
<tr>
<td>Higher</td>
<td>Program</td>
<td>Yes</td>
<td>13 (81.3)</td>
<td>3 (18.8)</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>88 (69.8)</td>
<td>38 (30.2)</td>
<td>126</td>
</tr>
</tbody>
</table>

*Self-directed learning readiness.  bType of instructional sequence control.

cMetacognitive advice.
Table 4.4

Number and Percent of Participants by Gender by Treatment Level

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Gender</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>SDL</td>
<td>45 (71.4)</td>
<td>18 (28.6)</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>43 (68.3)</td>
<td>20 (31.7)</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Sequence</td>
<td>41 (66.1)</td>
<td>21 (33.9)</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>47 (73.4)</td>
<td>17 (26.6)</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Advice</td>
<td>43 (69.4)</td>
<td>19 (30.6)</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45 (70.3)</td>
<td>19 (27.9)</td>
<td>64</td>
<td></td>
</tr>
</tbody>
</table>

*Self-directed learning readiness. †Type of instructional sequence control.

ensemcognitive advice.
Table 4.5

Mean Age of Participants by Treatment Group

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seqb</th>
<th>Adv°</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>Learner</td>
<td>No</td>
<td>36.0</td>
<td>9.4</td>
<td>16</td>
</tr>
<tr>
<td>Lower</td>
<td>Program</td>
<td>No</td>
<td>32.3</td>
<td>7.9</td>
<td>16</td>
</tr>
<tr>
<td>Lower</td>
<td>Learner</td>
<td>Yes</td>
<td>32.5</td>
<td>7.9</td>
<td>15</td>
</tr>
<tr>
<td>Lower</td>
<td>Program</td>
<td>Yes</td>
<td>33.7</td>
<td>7.8</td>
<td>16</td>
</tr>
<tr>
<td>Higher</td>
<td>Learner</td>
<td>No</td>
<td>35.9</td>
<td>8.7</td>
<td>16</td>
</tr>
<tr>
<td>Higher</td>
<td>Program</td>
<td>No</td>
<td>39.3</td>
<td>7.8</td>
<td>16</td>
</tr>
<tr>
<td>Higher</td>
<td>Learner</td>
<td>Yes</td>
<td>40.3</td>
<td>10.4</td>
<td>15</td>
</tr>
<tr>
<td>Higher</td>
<td>Program</td>
<td>Yes</td>
<td>42.8</td>
<td>10.6</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>36.5</td>
<td>9.4</td>
<td>125d</td>
</tr>
</tbody>
</table>

*aSelf-directed learning readiness. *bType of instructional sequence control.

*cMetacognitive advice. *d1 (0.8%) Missing [No score]
Table 4.6

Mean Age of Participants by Treatment Level

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>39.3</td>
<td>9.7</td>
<td>62</td>
</tr>
<tr>
<td>Lower</td>
<td>33.6</td>
<td>8.2</td>
<td>63</td>
</tr>
<tr>
<td>Sequenceb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>36.2</td>
<td>9.3</td>
<td>62</td>
</tr>
<tr>
<td>Program</td>
<td>36.7</td>
<td>9.6</td>
<td>63</td>
</tr>
<tr>
<td>Advicec</td>
<td></td>
<td></td>
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<tr>
<td>Yes</td>
<td>35.6</td>
<td>8.7</td>
<td>62</td>
</tr>
<tr>
<td>No</td>
<td>37.4</td>
<td>10.1</td>
<td>63</td>
</tr>
</tbody>
</table>

*Self-directed learning readiness. *Type of instructional sequence control.

Metacognitive advice.
### Table 4.7

**Number and Percent of Participants by Education Level by Treatment Group**

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seqb</th>
<th>Advc</th>
<th>Doctoral</th>
<th>Masters</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n</td>
</tr>
<tr>
<td>Lower Learner No</td>
<td>7 (43.8)</td>
<td>9 (56.3)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program No</td>
<td>3 (18.8)</td>
<td>13 (81.3)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>8 (53.3)</td>
<td>7 (46.7)</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program Yes</td>
<td>10 (62.5)</td>
<td>6 (37.5)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>6 (37.5)</td>
<td>10 (62.5)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program No</td>
<td>6 (37.5)</td>
<td>10 (62.5)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner Yes</td>
<td>8 (53.3)</td>
<td>7 (46.7)</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>9 (56.3)</td>
<td>7 (43.8)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>57 (45.2)</td>
<td>69 (54.8)</td>
<td>126</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Self-directed learning readiness. †Type of instructional sequence control. 
*Metacognitive advice.
master’s program. The number of participants by education level and treatment variable level are presented in Table 4.8.

Participants were described on their education status in the program as either full-time or part-time. Full-time students were considered to be enrolled in nine semester hours of graduate coursework. Any student enrolled in less than nine hours was considered to be part-time. The number of full-time students in the sample was a little more than 40%. The number of participants from each treatment group by education status is presented in Table 4.9. Also, about 37% of the sample were full-time students for the metacognitive advice treatment level and about 47% of the sample were full-time students for the no advice treatment level. The number of participants by education status and treatment variable level are presented in Table 4.10.

The mean GRE quantitative score for the sample was 511 (SD = 103). The means for the treatment groups ranged from 486 (SD = 87) for the lower self-directed learning readiness level participants with program control of instructional sequence without metacognitive advice to 549 (SD = 94) for the higher self-directed learning readiness level participants with learner control of instructional sequence without metacognitive advice. The mean GRE quantitative scores of participants from each treatment group are presented in Table 4.11. Also, the mean GRE quantitative scores by treatment variable level are presented in Table 4.12.
Table 4.8

**Number and Percent of Participants by Education Level by Treatment Level**

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Education Level</th>
<th>Doctoral</th>
<th>Master's</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n</td>
</tr>
<tr>
<td><strong>SDL^a</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>29 (46.0)</td>
<td>34 (54.0)</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>28 (44.4)</td>
<td>35 (55.6)</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td><strong>Sequence^b</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>29 (46.8)</td>
<td>33 (53.2)</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Program</td>
<td>28 (43.8)</td>
<td>36 (56.3)</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td><strong>Advice^c</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>35 (56.5)</td>
<td>27 (43.5)</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>22 (34.4)</td>
<td>42 (65.6)</td>
<td>64</td>
<td></td>
</tr>
</tbody>
</table>

^aSelf-directed learning readiness. ^bType of instructional sequence control.

^cMetacognitive advice.
Table 4.9

**Number and Percent of Participants by Education Status by Treatment Group**

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seqb</th>
<th>Advc</th>
<th>Full-time</th>
<th>Part-time</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner No</td>
<td>9 (56.3)</td>
<td>7 (46.8)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program No</td>
<td>6 (37.5)</td>
<td>10 (62.5)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>5 (33.3)</td>
<td>10 (66.7)</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program Yes</td>
<td>8 (50.0)</td>
<td>8 (50.0)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>7 (43.8)</td>
<td>9 (56.3)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program No</td>
<td>8 (50.0)</td>
<td>8 (50.0)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner Yes</td>
<td>4 (26.7)</td>
<td>11 (73.3)</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>6 (37.5)</td>
<td>10 (62.5)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>53 (42.1)</strong></td>
<td><strong>73 (57.9)</strong></td>
<td><strong>126</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Self-directed learning readiness. Type of instructional sequence control.

^Metacognitive advice.
### Table 4.10

**Number and Percent of Participants by Education Status by Treatment Level**

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Education Status</th>
<th>Full-time</th>
<th>Part-time</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Higher</td>
<td>35 (39.7)</td>
<td>38 (60.3)</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>28 (44.4)</td>
<td>35 (55.6)</td>
<td>63</td>
</tr>
<tr>
<td>Sequence&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Learner</td>
<td>25 (40.3)</td>
<td>37 (59.7)</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Program</td>
<td>28 (43.8)</td>
<td>36 (56.3)</td>
<td>64</td>
</tr>
<tr>
<td>Advice&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Yes</td>
<td>23 (37.1)</td>
<td>39 (62.9)</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>30 (46.9)</td>
<td>34 (53.1)</td>
<td>64</td>
</tr>
</tbody>
</table>

<sup>a</sup>Self-directed learning readiness. <sup>b</sup>Type of instructional sequence control.<br><sup>c</sup>Metacognitive advice.
Table 4.11

**Mean GRE Quantitative and GRE Verbal Scores of Participants by Treatment Group**

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seqb</th>
<th>Advc</th>
<th>Mean Qd</th>
<th>SD</th>
<th>Mean Vc</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner No</td>
<td>504</td>
<td>117</td>
<td>510</td>
<td>89</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program No</td>
<td>486</td>
<td>87</td>
<td>502</td>
<td>85</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>513</td>
<td>126</td>
<td>458</td>
<td>122</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program Yes</td>
<td>511</td>
<td>88</td>
<td>479</td>
<td>127</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>549</td>
<td>94</td>
<td>516</td>
<td>114</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program No</td>
<td>514</td>
<td>122</td>
<td>529</td>
<td>94</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner Yes</td>
<td>487</td>
<td>85</td>
<td>511</td>
<td>106</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>526</td>
<td>109</td>
<td>529</td>
<td>153</td>
<td>14</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>511</td>
<td>103</td>
<td>504</td>
<td>112</td>
<td>119f</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Minimum score = 200 and maximum score = 800.*

*aSelf-directed learning readiness. bType of instructional sequence control.

*cMetacognitive advice. dMean GRE quantitative score. cMean GRE verbal score. f7 (5.5%) missing [7 (5.5%) no score].
Table 4.12

Mean GRE Quantitative and GRE Verbal Scores of Participants by Treatment Level

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Mean Q&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SD</th>
<th>Mean V&lt;sup&gt;b&lt;/sup&gt;</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL&lt;sup&gt;c&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>504</td>
<td>104</td>
<td>488</td>
<td>106</td>
<td>59</td>
</tr>
<tr>
<td>Lower</td>
<td>519</td>
<td>103</td>
<td>521</td>
<td>116</td>
<td>60</td>
</tr>
<tr>
<td>Sequence&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>509</td>
<td>100</td>
<td>510</td>
<td>116</td>
<td>61</td>
</tr>
<tr>
<td>Program</td>
<td>514</td>
<td>107</td>
<td>500</td>
<td>108</td>
<td>58</td>
</tr>
<tr>
<td>Advice&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>514</td>
<td>105</td>
<td>514</td>
<td>95</td>
<td>58</td>
</tr>
<tr>
<td>No</td>
<td>509</td>
<td>102</td>
<td>494</td>
<td>127</td>
<td>61</td>
</tr>
</tbody>
</table>

Note. Minimum score = 200 and maximum score = 800.

<sup>a</sup>Mean GRE quantitative score. <sup>b</sup>Mean GRE verbal score. <sup>c</sup>Self-directed learning readiness. <sup>d</sup>Type of instructional sequence control. <sup>e</sup>Metacognitive advice.
The mean GRE verbal score for the sample was 504 (SD = 112). The means had a range from 458 (SD = 122) for the lower self-directed learning readiness level participants with program control of instructional sequence without metacognitive advice to 529 for the higher self-directed learning readiness level participants with program control of instructional sequence with metacognitive advice (SD = 153) and the higher self-directed learning readiness level participants with program control of instructional sequence without metacognitive advice (SD = 94). The mean GRE verbal scores of participants from each treatment group are presented in Table 4.11. Also, the mean GRE verbal scores by treatment variable level are presented in Table 4.12.

The mean GRE analytical score for the sample was 514 (SD = 117). The mean scores ranged from 489 (SD = 104) for the higher self-directed learning readiness participants with program control of instructional sequence with metacognitive advice to 578 (SD = 120) for the higher self-directed learning readiness participants with learner control of sequence without metacognitive advice. The mean GRE analytical scores of participants from each treatment group are presented in Table 4.13. Those with metacognitive advice had a mean score of 492 (SD = 108), while those without metacognitive advice had a mean score of 533 (SD = 123). The mean GRE analytical score by treatment variable level is presented in Table 4.14.

Concerning the participant’s SDLRS score, the entire sample had a mean of 239 (SD = 19.6). According to the interpretation chart for the self-directed
Table 4.13

Mean GRE Analytical Score of Participants by Treatment Group

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seq b</th>
<th>Adv c</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner No</td>
<td>510</td>
<td>108</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program No</td>
<td>512</td>
<td>122</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>490</td>
<td>107</td>
<td>15</td>
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</tr>
<tr>
<td>Lower Program Yes</td>
<td>492</td>
<td>118</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>578</td>
<td>120</td>
<td>14</td>
<td></td>
<td></td>
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<tr>
<td>Higher Program No</td>
<td>539</td>
<td>145</td>
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</tr>
<tr>
<td>Higher Learner Yes</td>
<td>500</td>
<td>115</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>489</td>
<td>104</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>514</td>
<td>117</td>
<td>107d</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Minimum score = 200 and maximum score = 800.

*Self-directed learning readiness. bType of instructional sequence control.

cMetacognitive advice. d19 (15.1%) missing [19 (15.1%) no score].
Table 4.14

**Mean GRE Analytical Score by Participants by Treatment Level**

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>502</td>
<td>111</td>
<td>49</td>
</tr>
<tr>
<td>Lower</td>
<td>529</td>
<td>123</td>
<td>58</td>
</tr>
<tr>
<td>Sequence</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>508</td>
<td>121</td>
<td>52</td>
</tr>
<tr>
<td>Program</td>
<td>520</td>
<td>115</td>
<td>55</td>
</tr>
<tr>
<td>Advice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>533</td>
<td>123</td>
<td>57</td>
</tr>
<tr>
<td>No</td>
<td>492</td>
<td>107</td>
<td>50</td>
</tr>
</tbody>
</table>

**Note.** Minimum score = 200 and maximum score = 800.

*Self-directed learning readiness. †Type of instructional sequence control.

*Metacognitive advice.*
learning readiness scale (Guglielmino & Guglielmino, 1991), the sample had an above average level of self-directed learning readiness. The mean self-directed learning readiness scores of participants from each treatment group are presented in Table 4.15. The median SDLRS score of 240.5 was used to divide the sample into higher and lower self-directed learning readiness groups. The higher self-directed learning readiness participants had a mean score of 255 ($SD = 8.9$, $n = 63$), while the lower self-directed learning readiness participants had a mean score of 222 ($SD = 12.3$, $n = 63$). According to the interpretation chart for the self-directed learning readiness scale (Guglielmino & Guglielmino, 1991) the higher level participants had a high level of self-directed learning readiness, while the lower level participants had an average level of self-directed learning readiness. The mean SDLRS score for each treatment variable level is presented in Table 4.16.

The mean pretest score for the sample was 6.3 ($SD = 1.9$). The lowest pretest mean score was 5.9 and was shared by two groups, the lower self-directed learning readiness level participants ($SD = 2.0$) and the higher self-directed learning readiness participants who had program control of instructional sequence without metacognitive advice ($SD = 1.5$). The highest was 6.9 ($SD = 1.6$) for the lower self-directed learning readiness participants who had learner control of instructional sequence without metacognitive advice. The mean pretest score for each of the treatment groups is presented in Table 4.17. Concerning the control of sequence treatment variable, the learner control level participants had a mean of
Table 4.15

**Mean Self-Directed Learning Readiness Score of Participants by Treatment Group**

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seqb</th>
<th>Advc</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner No</td>
<td>227</td>
<td>12.8</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program No</td>
<td>222</td>
<td>11.9</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>221</td>
<td>12.9</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program Yes</td>
<td>219</td>
<td>11.1</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>257</td>
<td>8.8</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program No</td>
<td>253</td>
<td>8.0</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner Yes</td>
<td>255</td>
<td>9.2</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>256</td>
<td>10.0</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>239</td>
<td>19.6</td>
<td>126</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Minimum score = 58 and maximum score = 290.

*Self-directed learning readiness.  bType of instructional sequence control.

cMetacognitive advice.
Table 4.16

Mean Self-Directed Learning Readiness Score of Participants by Treatment Level

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Mean</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>255</td>
<td>8.9</td>
<td>63</td>
</tr>
<tr>
<td>Lower</td>
<td>222</td>
<td>12.3</td>
<td>63</td>
</tr>
<tr>
<td>Sequenceb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>240</td>
<td>19.3</td>
<td>62</td>
</tr>
<tr>
<td>Program</td>
<td>237</td>
<td>20.0</td>
<td>64</td>
</tr>
<tr>
<td>Advicec</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>237</td>
<td>20.7</td>
<td>62</td>
</tr>
<tr>
<td>No</td>
<td>240</td>
<td>18.5</td>
<td>64</td>
</tr>
</tbody>
</table>

Note. Minimum score = 58 and maximum score = 290.

*Self-directed learning readiness. bType of instructional sequence control.

cMetacognitive advice.
Table 4.17

Mean Pretest and Posttest Scores of Participants by Treatment Group

<table>
<thead>
<tr>
<th>SDL</th>
<th>Seq</th>
<th>Adv</th>
<th>Mean Pr</th>
<th>SD</th>
<th>Mean Po</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner</td>
<td>No</td>
<td>6.9</td>
<td>1.6</td>
<td>9.1</td>
<td>2.3</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Lower Program</td>
<td>No</td>
<td>5.9</td>
<td>2.0</td>
<td>10.0</td>
<td>2.2</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Lower Learner</td>
<td>Yes</td>
<td>6.3</td>
<td>2.2</td>
<td>8.7</td>
<td>2.7</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Lower Program</td>
<td>Yes</td>
<td>6.3</td>
<td>1.8</td>
<td>9.8</td>
<td>2.7</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Higher Learner</td>
<td>No</td>
<td>6.6</td>
<td>2.0</td>
<td>11.0</td>
<td>2.1</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Higher Program</td>
<td>No</td>
<td>5.9</td>
<td>1.5</td>
<td>10.5</td>
<td>2.3</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Higher Learner</td>
<td>Yes</td>
<td>6.6</td>
<td>2.4</td>
<td>10.4</td>
<td>2.3</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Higher Program</td>
<td>Yes</td>
<td>6.3</td>
<td>1.6</td>
<td>10.1</td>
<td>2.4</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>6.3</td>
<td>1.9</td>
<td>9.9</td>
<td>2.4</td>
<td>115</td>
<td></td>
</tr>
</tbody>
</table>

Note. Maximum score = 18

*Self-directed learning readiness. bType of instructional sequence control.

cMetacognitive advice. dMean pretest score. eMean posttest score.
6.6 (SD = 2.0) while the program control level participants had a mean of 6.1 (SD = 1.7). The pretest means by treatment variable level are presented in Table 4.18.

Presented in Table 4.18 are the posttest means for the treatment groups. Regarding the participants' posttest scores, the mean for the sample was 9.9 (SD = 2.4). The posttest means ranged from 9.1 (SD = 2.3) for the lower self-directed learning readiness level participants who had learner control of instructional sequence without metacognitive advice to 11.0 (SD = 2.1) for the higher self-directed learning readiness level participants who had learner control of instructional sequence without metacognitive advice. The posttest means for each level of the treatment variables are presented in Table 4.18. Concerning the self-directed learning readiness treatment variable, the higher level participants had a mean posttest score of 10.5 (SD = 2.3) while the lower level participants had a mean posttest score of 9.4 (SD = 2.5).

The participants' attitudes toward the instructional program for the sample was 52.0 (SD = 9.0). The attitude scores ranged from 49.8 (SD = 9.0) for the lower self-directed learning readiness level participants who had learner control of instructional sequence without metacognitive advice to 54.3 (SD = 8.2) for the higher self-directed learning readiness participants who had learner control of instructional sequence with metacognitive advice. The mean attitude toward the instructional program for each treatment group is presented in Table 4.19. Also,
Table 4.18

Mean Pretest and Posttest Scores of Participants by Treatment Level

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Mean Pr(^a)</th>
<th>SD</th>
<th>Mean Po(^b)</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDLC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>6.3</td>
<td>1.9</td>
<td>10.5</td>
<td>2.3</td>
<td>58</td>
</tr>
<tr>
<td>Lower</td>
<td>6.3</td>
<td>1.9</td>
<td>9.4</td>
<td>2.5</td>
<td>57</td>
</tr>
<tr>
<td>Sequence(^d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>6.6</td>
<td>2.0</td>
<td>9.8</td>
<td>2.5</td>
<td>57</td>
</tr>
<tr>
<td>Program</td>
<td>6.1</td>
<td>1.7</td>
<td>10.1</td>
<td>2.3</td>
<td>58</td>
</tr>
<tr>
<td>Advice(^e)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>6.4</td>
<td>2.0</td>
<td>9.8</td>
<td>2.5</td>
<td>57</td>
</tr>
<tr>
<td>No</td>
<td>6.3</td>
<td>1.8</td>
<td>10.1</td>
<td>2.3</td>
<td>58</td>
</tr>
</tbody>
</table>

Note. Maximum score = 18

\(^a\)Mean pretest score. \(^b\)Mean posttest score. \(^c\)Self-directed learning readiness. \(^d\)Type of instructional sequence control. \(^e\)Metacognitive advice.
Table 4.19

Mean Attitude toward Instructional Program and Instructional Content of Participants by Treatment Group

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seqb</th>
<th>Adv°</th>
<th>Mean Pd</th>
<th>SD</th>
<th>Mean C°</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner No</td>
<td>49.8</td>
<td>9.0</td>
<td>47.4</td>
<td>7.5</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program No</td>
<td>53.8</td>
<td>8.5</td>
<td>51.5</td>
<td>8.1</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>50.5</td>
<td>8.5</td>
<td>48.7</td>
<td>9.5</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program Yes</td>
<td>50.9</td>
<td>8.5</td>
<td>47.9</td>
<td>8.6</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>50.1</td>
<td>7.4</td>
<td>49.4</td>
<td>8.4</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program No</td>
<td>53.9</td>
<td>8.0</td>
<td>51.8</td>
<td>10.4</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner Yes</td>
<td>54.3</td>
<td>8.2</td>
<td>53.9</td>
<td>8.2</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>52.8</td>
<td>13.1</td>
<td>51.9</td>
<td>13.8</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>52.0</td>
<td>9.0</td>
<td>50.3</td>
<td>9.5</td>
<td>115f</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Minimum score = 10 and maximum score = 70.

*aSelf-directed learning readiness. *bType of instructional sequence control.
*CMetacognitive advice. *dMean attitude toward instructional program. *eMean attitude toward instructional content. *f11 (8.7%) missing [11 (8.7%) mortality].
the mean attitude toward the instructional program for each treatment variable level is presented in Table 4.20.

Regarding the participants’ attitudes toward the instructional content, the sample mean was 50.3 (SD = 9.5). The lowest attitude score was 47.4 (SD = 7.5) for the lower self-directed learning readiness level participants who had learner control of instructional sequence without metacognitive advice. The higher self-directed learning readiness level participants who had learner control of instructional sequence with metacognitive advice had the highest mean attitude score (M = 53.9, SD = 8.2). The mean attitude scores for each treatment group are presented in Table 4.19. In addition, the mean attitude toward the instructional content by treatment variables level is presented in Table 4.20.

Objective 2

The second objective was to compare the attitude toward the instructional program by categories of each of the three treatment variables: Self-directed learning readiness, presence or absence of metacognitive advice, and control of instruction.

There was no difference in attitude toward the instructional program ($t(113) = 0.90, p = .37$) between the higher (M = 52.8) and lower (M = 51.3) self-directed learning readiness participants. Furthermore, there was no significant difference ($t(113) = 0.09, p = .93$) between those who received metacognitive advice (M = 52.1) and those who did not receive the metacognitive advice (M = 51.9). Finally, the participants who had control of instructional sequence (M =
Table 4.20

Mean Attitude toward Instructional Program and Instructional Content of Participants by Treatment Level

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Mean P&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SD</th>
<th>Mean C&lt;sup&gt;b&lt;/sup&gt;</th>
<th>SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>52.8</td>
<td>9.4</td>
<td>51.7</td>
<td>10.4</td>
<td>58</td>
</tr>
<tr>
<td>Lower</td>
<td>51.3</td>
<td>8.5</td>
<td>48.9</td>
<td>8.4</td>
<td>57</td>
</tr>
<tr>
<td>Sequence&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>51.1</td>
<td>8.3</td>
<td>49.8</td>
<td>8.6</td>
<td>57</td>
</tr>
<tr>
<td>Program</td>
<td>53.0</td>
<td>9.6</td>
<td>50.9</td>
<td>10.4</td>
<td>58</td>
</tr>
<tr>
<td>Advice&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>52.1</td>
<td>9.7</td>
<td>50.6</td>
<td>8.7</td>
<td>57</td>
</tr>
<tr>
<td>No</td>
<td>51.9</td>
<td>8.3</td>
<td>50.1</td>
<td>8.7</td>
<td>58</td>
</tr>
</tbody>
</table>

Note. Minimum score = 10 and maximum score = 70.

<sup>a</sup>Mean attitude toward instructional program. <sup>b</sup>Mean attitude toward instructional content. <sup>c</sup>Self-directed learning readiness. <sup>d</sup>Type of instructional sequence control. <sup>e</sup>Metacognitive advice.
51.1) did not have a significantly different attitude toward the instructional program than did those with program control of instructional sequence (M = 52.9), (t(113) = -1.05, p < .30).

**Objective 3**

The third objective was to compare the attitude toward instructional content by categories of each of the three treatment effects: Self-directed learning readiness, metacognitive advice, and control of instructional sequence.

There was no difference in attitude toward the instructional content (t(113) = 1.59, p < .11) between the higher (M = 51.7) and lower (M = 48.9) self-directed learning readiness participants. Also, those who received metacognitive advice (M = 50.6) did not have a significantly different attitude than those who did not receive the metacognitive advice (M = 50.0), (t(113) = 0.33, p < .74). Finally, the participants who had control of instructional sequence (M = 49.8) did not have a significantly different attitude toward the instructional program than did those with program control of instructional sequence (M = 50.9), (t(113) = 0.58, p < .56).

**Objective 4**

The fourth objective was to determine if a significant relationship existed between the participant’s SDLRS score and his or her attitude toward the instructional program by each of the four treatment groups; learner control of instructional sequence with metacognitive advice, learner control of instructional sequence without metacognitive advice, program control of instructional sequence
with metacognitive advice, and program control of instructional sequence without metacognitive advice.

To assist the researcher interpret the Pearson product moment correlation, the researcher used the interpretation of Hinkle, Wiersma, and Jurs (1988). Using the magnitude of the correlation, Hinkle, Wiersma, and Jurs (1988) describe the correlation coefficient from .00 to .30 as having little if any correlation, from .30 to .50 as having low correlation, from .50 to .70 as having moderate correlation, from .70 to .90 as having high correlation, and from .90 to 1.00 as having very high correlation.

The Pearson product moment correlations for the treatment groups were learner control of instructional sequence with metacognitive advice (.23), learner control of instructional sequence without metacognitive advice (.13), program control of instructional sequence with metacognitive advice (-.09), and program control of instructional sequence without metacognitive advice (.02). None of the correlations were significant at the .05 alpha level. Since the correlations ranged from -.09 and .23, there was little correlation (Hinkle, Wiersma, & Jurs, 1988) between the participants SDLRS score and his or her attitude toward the instructional program.

Hypothesis 1

The first hypothesis was that the posttest scores of those who received metacognitive advice were higher than those who did not receive the metacognitive
advice controlling for the participant’s prior knowledge of content and problem solving ability.

Contrary to the predicted result, those who received metacognitive advice ($M = 9.54$) did not perform significantly better than those who did not ($M = 10.21$), controlling for the participant’s prior knowledge of the content and their problem solving ability ($F(1,94) = 0.41, p = .53$). The GRE analytical score was a significant covariate, while the pretest score was not. The results of the ancova are presented in Table 4.21.

**Hypothesis 2**

The second hypothesis was that for those with learner control of sequence, the posttest scores of those who received metacognitive advice were higher than for those who had not received the metacognitive advice, controlling for the participant’s prior knowledge of content and problem solving ability.

Contrary to the predicted result for the participants with learner control of sequence, those who received metacognitive advice ($M = 9.16$) did not perform significantly better than those who did not ($M = 10.28$) controlling for the participants prior knowledge of the content and their problem solving ability ($F(1,49) = 0.84, p = .36$). Neither the GRE analytical score nor the pretest score were significant covariates. The results of the ancova are presented in Table 4.22.

**Hypothesis 3**

The third hypothesis was that for those without metacognitive advice, the posttest scores of those with program control of instructional sequence were higher
### Table 4.21

Ancova of Posttest Score by Metacognitive Advice with Pretest and GRE Analytical Score

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>111.28</td>
<td>2</td>
<td>55.64</td>
<td>11.38</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Pretest</td>
<td>11.09</td>
<td>1</td>
<td>11.09</td>
<td>2.27</td>
<td>.14</td>
</tr>
<tr>
<td>GRE analytical</td>
<td>96.00</td>
<td>1</td>
<td>96.00</td>
<td>19.63</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metacognitive advice</td>
<td>1.99</td>
<td>1</td>
<td>1.99</td>
<td>0.41</td>
<td>.53</td>
</tr>
<tr>
<td>Residual</td>
<td>459.71</td>
<td>94</td>
<td>4.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>572.98</td>
<td>97</td>
<td>5.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. n=98, 28 (22.2%) missing [17 (13.5%) no GRE analytical score, 11 (8.7%) mortality].*
Table 4.22

Ancova of Posttest Score by Metacognitive Advice with Pretest and GRE Analytical Score for Participants with Learner Control of Sequence

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>35.87</td>
<td>2</td>
<td>17.94</td>
<td>3.18</td>
<td>.05</td>
</tr>
<tr>
<td>Pretest</td>
<td>13.55</td>
<td>1</td>
<td>13.55</td>
<td>2.40</td>
<td>.13</td>
</tr>
<tr>
<td>GRE analytical</td>
<td>19.14</td>
<td>1</td>
<td>19.14</td>
<td>3.39</td>
<td>.07</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metacognitive advice</td>
<td>4.75</td>
<td>1</td>
<td>4.75</td>
<td>0.84</td>
<td>.36</td>
</tr>
<tr>
<td>Residual</td>
<td>259.45</td>
<td>46</td>
<td>5.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>300.07</td>
<td>49</td>
<td>6.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. n=50, 12 (19.4%) missing [7 (11.3%) no GRE analytical score, 5 (8.1%) mortality].
than those with learner control of instructional sequence, controlling for the
participant’s prior knowledge of content and problem solving ability.

Contrary to the predicted result for the participants who received
metacognitive advice, those with learner control of sequence \( (M = 10.28) \) did not
perform significantly better than those with program control of sequence \( (M =
10.15) \), controlling for the participants prior knowledge of the content and their
problem solving ability \( (F(1,48) = 0.20, p = .59) \). The GRE analytical score was
a significant covariate, while the pretest score was not. The results of the ancova
are presented in Table 4.23.

**Hypothesis 4**

The fourth hypothesis was that for those with learner control of
instructional sequence, the posttest scores of those with higher self-directed
learning readiness were higher than those with lower self-directed learning
readiness, controlling for the participant’s prior knowledge of content and problem
solving ability.

As predicted for the participants with learner control of sequence, the
posttest score for the higher self-directed learning readiness participants
\( (M = 10.64) \) was significantly higher than the posttest score for the lower self-
directed learning readiness participants \( (M = 10.15) \), controlling for the
participant’s prior knowledge of the content and their problem solving ability
\( (F(1,46) = 9.35, p = .02) \). Neither the GRE analytical score nor the pretest score
were significant covariates. The results of the ancova are presented in Table 4.24.
Table 4.23

Ancova of Posttest Score by Control of Sequence with Pretest and GRE Analytical Score for Participants without Metacognitive Advice

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>103.10</td>
<td>2</td>
<td>51.55</td>
<td>10.54</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Pretest</td>
<td>3.75</td>
<td>1</td>
<td>3.75</td>
<td>0.77</td>
<td>.29</td>
</tr>
<tr>
<td>GRE analytical</td>
<td>91.30</td>
<td>1</td>
<td>91.30</td>
<td>18.67</td>
<td>.00</td>
</tr>
<tr>
<td>Control of instructional sequence</td>
<td>0.98</td>
<td>1</td>
<td>0.98</td>
<td>0.20</td>
<td>.59</td>
</tr>
<tr>
<td>Residual</td>
<td>158.60</td>
<td>48</td>
<td>3.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>262.68</td>
<td>51</td>
<td>5.15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. n=52, 12 (18.8%) missing [6 (9.4%) no GRE analytical score, 6 (9.4%) mortality].
Table 4.24

**Ancova of Posttest Score by Self-Directed Learning Readiness with Pretest and GRE Analytical Score for Participants with Learner Control of Sequence**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>35.87</td>
<td>2</td>
<td>17.94</td>
<td>5.44</td>
<td>.04</td>
</tr>
<tr>
<td>Pretest</td>
<td>13.55</td>
<td>1</td>
<td>13.55</td>
<td>4.11</td>
<td>.11</td>
</tr>
<tr>
<td>GRE analytical</td>
<td>19.14</td>
<td>1</td>
<td>19.14</td>
<td>5.80</td>
<td>.06</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-directed learning readiness</td>
<td>30.86</td>
<td>1</td>
<td>30.86</td>
<td>9.35</td>
<td>.02</td>
</tr>
<tr>
<td>Residual</td>
<td>233.35</td>
<td>46</td>
<td>5.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>300.08</td>
<td>49</td>
<td>6.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. n=50, 12 (19.4%) missing [6 (9.7%) no GRE analytical score, 6 (9.7%) mortality].
Hypothesis 5

The fifth hypothesis was that for those with lower self-directed learning readiness, the posttest scores of those with program control of sequence were higher than those with learner control of sequence, controlling for the participant's prior knowledge of content and problem solving ability.

As predicted for the lower self-directed learning readiness participants, those who had program control of sequence (M = 9.76) performed significantly better (F(1,48) = 13.99, p = .06) than those with learner control of sequence (M = 9.00). This is significant since the alpha level for the directional hypothesis was set to .10 for the ancova. Both the GRE analytical score and the pretest score were significant covariates. The results of the ancova are presented in Table 4.25.

Supplementary results

The researcher developed two other objectives after the data collection had begun. While the researcher was uploading the data to the mainframe computer, he noticed some similarity between the attitude toward the instructional program and attitude toward the instructional content scores. Thus, the researcher decided to determine if there was a significant relationship between these two attitude measures. The other objective was suggested by his doctoral committee. The second objective was to determine if there was an effect of control of instruction, metacognitive advice, or an interaction between the two, while controlling for the effects of the participant's self-directed learning readiness, problem solving ability, and prior knowledge of content.
Table 4.25

Ancova of Posttest Score by Control of Sequence with Pretest and GRE Analytical Score for Lower Self-Directed Learning Readiness Level Participants

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>92.96</td>
<td>2</td>
<td>46.48</td>
<td>14.08</td>
<td>.00</td>
</tr>
<tr>
<td>Pretest</td>
<td>31.05</td>
<td>1</td>
<td>31.05</td>
<td>9.41</td>
<td>.01</td>
</tr>
<tr>
<td>GRE analytical</td>
<td>61.64</td>
<td>1</td>
<td>61.64</td>
<td>18.68</td>
<td>.00</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control of instructional sequence</td>
<td>13.99</td>
<td>1</td>
<td>13.99</td>
<td>4.24</td>
<td>.06</td>
</tr>
<tr>
<td>Residual</td>
<td>185.24</td>
<td>48</td>
<td>3.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>292.19</td>
<td>51</td>
<td>5.73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. n=53, 10 (15.9%) missing [4 (6.3%) no GRE analytical score, 6 (9.5%) mortality].
For the first objective, the Pearson product moment correlations for seven of the treatment groups were between .76 and .88. This means that there was a high correlation (Hinkle, Wiersma, & Jurs, 1988) between the two attitude scores. One treatment group, higher self-directed learning readiness participants with learner control of instructional sequence with metacognitive advice, had a Pearson product moment correlation of .93, which is a very high correlation (Hinkle, Wiersma, & Jurs, 1988). Presented in Table 4.26 are the correlations between the attitude toward instructional content and attitude toward the instructional program for each group and the correlation for the entire sample.

For the second supplementary objective, there was no posttest difference for either the control of sequence or metacognitive advice treatments, nor was there an interaction effect between the two. However, the three covariates in the analysis, self-directed learning readiness and problem solving ability were significant. The prior knowledge of content covariate was not significant. The results of the ancova table are presented in Table 4.27.
Table 4.26

Relationship between Attitude toward Instructional Program and Attitude toward Instructional Content by Treatment Group

<table>
<thead>
<tr>
<th>SDL*</th>
<th>Seq^b</th>
<th>Adv^c</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Learner No</td>
<td>.84</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program No</td>
<td>.81</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Learner Yes</td>
<td>.78</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Program Yes</td>
<td>.87</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner No</td>
<td>.77</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program No</td>
<td>.76</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Learner Yes</td>
<td>.93</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Program Yes</td>
<td>.88</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Self-directed learning readiness. ^Type of instructional sequence control.

^Metacognitive advice.
Table 4.27

**Ancova of Posttest Score by Control of Sequence and Metacognitive Advice with Pretest and GRE Analytical Score for Lower Self-Directed Learning Readiness**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>130.46</td>
<td>3</td>
<td>43.486</td>
<td>9.139</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Self-directed learning readiness</td>
<td>19.18</td>
<td>1</td>
<td>19.18</td>
<td>4.03</td>
<td>.05</td>
</tr>
<tr>
<td>Pretest</td>
<td>15.45</td>
<td>1</td>
<td>15.45</td>
<td>3.25</td>
<td>.08</td>
</tr>
<tr>
<td>GRE analytical score</td>
<td>82.20</td>
<td>1</td>
<td>82.20</td>
<td>17.28</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Treatments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control of instructional sequence</td>
<td>7.75</td>
<td>1</td>
<td>7.75</td>
<td>1.63</td>
<td>.21</td>
</tr>
<tr>
<td>Metacognitive advice</td>
<td>.84</td>
<td>1</td>
<td>.84</td>
<td>.18</td>
<td>.68</td>
</tr>
<tr>
<td>Two-way interaction</td>
<td>.46</td>
<td>1</td>
<td>.46</td>
<td>.10</td>
<td>.76</td>
</tr>
<tr>
<td>Residual</td>
<td>433.00</td>
<td>91</td>
<td>4.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>572.98</td>
<td>97</td>
<td>5.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** n=53, 10 (15.9%) missing [4 (6.3%) no GRE analytical score, 6 (9.5%) mortality].
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

There were four objectives and five hypotheses to guide the researcher. The first objective was to describe the participants based upon selected descriptive characteristics, which included college department, gender, age, level of study, education status, SDLRS score, GRE quantitative, verbal, and analytical scores, pretest and posttest achievement scores, and the participant’s attitudes toward the instructional program and the instructional content. The second objective examined whether or not there were differences in the participants’ attitude toward the instructional program by levels of each of the three treatment variables. The third objective examined if there were differences in the participants’ attitude toward the instructional content by levels of each of the three treatment variables. The fourth objective was to determine if there was a significant relationship between the participant’s SDLRS score and his or her attitude toward the instructional program.

The target population of the study consisted of graduate students in selected departments. The accessible population for the researcher were the graduate students in the School of Vocational Education, School of Human Ecology, Administrative and Foundational Services, and Curriculum and Instruction departments at the Louisiana State University, Baton Rouge.

The researcher determined that the required number of participants for the study was 152, based upon calculations from the sample size formula described by Hinkle, Wiersma, and Jurs (1988). The accessible population of the four
departments was 491 graduate students. A list of graduate students was obtained and all graduate students were randomly ordered within each department. The researcher contacted these students to determine who would be willing to participate in the study. Anyone who agreed to participate was sent a participation agreement form to complete and return to the researcher. If a person could not be contacted by the third attempt in a week, the researcher considered that student to be unavailable, and selected the next potential participant from the list of students. A list of 153 participants was obtained by the researcher.

Each person who agreed to participate in the study was requested to complete a participation agreement form and return it to the researcher. The participation agreement form provided a brief description of what was expected from each participant, collected demographic information, and included the SDLRS. The researcher contacted the people who agreed to participate if they had not returned the participation agreement form within one week. From the sample of 153, 126 participation agreement forms were returned to the researcher, leaving the researcher with a mortality rate of 27 at this stage in the study. Unfortunately, the researcher had exhausted the accessible population and no replacements were available.

The SDLRS scores were calculated for all participants and they were divided into two groups based upon the median score. The participants were defined as having higher and lower self-directed learning readiness levels. These two groups were then assigned to four treatment groups based upon the two other
treatment variables, control of instructional sequence and metacognitive advice. The four program versions were learner control of instructional sequence with and without metacognitive advice and program control of instructional sequence with and without metacognitive advice.

The researcher then proceeded to schedule the participants to complete the instructional program. Of the 126 people, nine withdrew from the study, one data point was eliminated because the individual used the program in an unintended manner, and one person could not complete the study because he had visual disability. Thus, there were 115 useable responses.

The demographic information was collected using the participation agreement form, a recording form, and the instructional program. Concerning the treatment variables, the SDLRS was included with the participation agreement form and the participants were assigned to levels of metacognitive advice and control of instructional sequence. The pretest achievement, posttest achievement, attitude toward the instructional program, and attitude toward the instructional content were measured using the instructional program.

The first objective was to describe the sample based upon the demographic information collected. Regarding the college department, about one third of the participants were from the Curriculum and Instruction Department. The School of Vocational Education and the Administration and Foundation Service department each comprised approximately one-third of the sample. Concerning the gender of
participants, approximately 70% were female. The mean age of the participants was about 37 years.

A little less than one-half of the sample was enrolled at the doctoral level, while the others were enrolled at the master's level. Pertaining to the participants' education status, a little less than 60% were enrolled part-time and the others were enrolled full-time at the university.

The participants were also described by their GRE scores. The mean GRE quantitative score for the treatment groups ranged from 486 to 549. The range of mean GRE verbal scores was from 458 to 529. Finally, for the GRE analytical score, the treatment groups' means ranged from 489 to 578.

Regarding the SDLRS scores of the participants, the mean self-directed learning readiness level was 239. The median score of 240.5 was used to divide the sample into higher and lower self-directed learning readiness levels. The higher level had a mean SDLRS score of 255, while the lower level had a mean SDLRS score of 222.

The pretest scores of the treatment groups ranged from 5.9 to 6.9 with a mean of 6.3 for the entire sample. For the posttest, the mean scores ranged from 8.7 to 11.0 with a mean of 9.9 for the entire sample. Also, the participants were described as to their attitude toward the instructional program and the instructional content. For the entire sample, the mean attitude toward the instructional content was 52, while the mean attitude toward the instructional content was approximately 50.
The second objective was to compare the attitude toward the instructional content by both levels of the three treatment variables self-directed learning readiness, control of instructional sequence, and metacognitive advice. The third objective was to compare the attitude toward the instructional content by both levels of the three treatment variables. For both objectives, there were no differences between levels of the three treatment variables.

The final objective was to determine, for the four treatment groups, if there was a relationship between the participant's SDLRS score and his or her attitude toward the instructional program. The four treatment groups were obtained from the combination of the control of instructional sequence and metacognitive advice treatment variables. The researcher found that there was little correlation between the participant's SDLRS score and their attitude toward the instructional program for all four groups.

The researcher also had five hypotheses in the study. For the first hypothesis, contrary to the predicted results, those who received metacognitive advice did not have a higher posttest score than those who did not receive metacognitive advice, controlling for the participants' prior knowledge of the subject and their problem solving ability. Related to the first hypothesis, the second hypothesis predicted that for the learners with control of instructional sequence, those receiving metacognitive advice would have higher posttest score than those who did not receive metacognitive advice. Contrary to the predicted
results, those receiving metacognitive advice did not have higher posttest score than those who did not receive the advice.

The third hypothesis examined the posttest score between the learner and program control of instructional sequence for those participants who did not receive metacognitive advice. Contrary to the predicted result, those with program control of instructional sequence did not have higher posttest scores than those participants with learner control of instructional sequence.

As predicted in the fourth hypothesis, for the participants with learner control of instructional sequence, those with a higher level of self-directed learning readiness had higher posttest scores than those who had a lower level of self-directed learning readiness.

Finally, as predicted in hypothesis five, the lower self-directed learning readiness participants who had program control of instructional sequence had higher posttest scores than those participants with lower level of self-directed learning readiness who had learner control of instructional sequence.

Conclusions

Objectives 2 and 3

The participants, by all treatment effects, did not have different attitudes toward the instructional program or the instructional content. For this sample, the treatments did not have an effect on the participant's attitude toward the program or content. Previous research has included studies with more positive attitudes from participants having control of instruction (Lahey, Hurlock, & McCann, 1973;
Fry, 1972; Newkirk, 1973). However, there have also been studies where there has been no improvement in attitude from having control of instruction (Judd, Bunderson, & Bessent, 1970; Milheim, 1989). This study adds to the lack of improvement side of the research on improvement in attitude.

The attitude scores had a possible range of 10 to 70, with 70 being the most positive attitude and 10 being the most negative. The mean attitudes toward the instructional program and instructional content with all the treatment variables was about 50. This means the attitude toward the instructional program and content was slightly favorable, but not much above the neutral score of 40.

There are probably three potential factors that could have affected the attitude outcome. First, all of the participants were volunteers. Since they had agreed to participate in a study during which they would learn by using a computer, they may have had a similar disposition toward learning with computers. Thus, a difference in attitude toward learning with computers may appear during a classroom setting and not an experimental setting. Second, the features of the instruction, metacognitive advice and control of instructional sequence, may not have been dramatically different to cause an improvement in attitude. For example, the students who had control of sequence may have taken the same path as those who did not have control of sequence. Therefore, the researcher would not expect to find a difference in attitude between the variable control of instructional sequence. The last potential factor is the participants' experience with instructional programs. Many of the students probably have not had experience...
with any other instructional program and subsequently they would have no basis of comparison for their attitude toward the instructional features.

Concerning the reliability of the attitude measures, the instruments had Cronbach alpha reliability of .86 and .87 for the attitude toward instructional program and the attitude toward the instructional content, respectively. Ary, Jacobs, and Razavieh (1990) indicate that for research purposes that reliability in the range of .30 to .50 might be acceptable for research purposes. Therefore, in this study, the attitude instruments were reliable.

Objective 4

There was no relationship between the participant's SDLRS score and their attitude toward the instructional program. The researcher wanted to determine whether those who had control of sequence would have a relationship between their self-directed learning readiness and their attitude toward the instructional program. This was based upon the premise that those people who were higher self-directed learners would have a more positive attitude toward the instructional program when they had control of the program. While the learner control participants had a higher correlation than the program control participants, all correlations were negligible since r was less than .30 for all treatment combinations. A potential explanation for a low correlation is that the higher self-directed learning readiness participants, with program control of sequence, may have been satisfied with the sequence of the instruction and having control would not change their attitude toward the program that much.
The Cronbach’s alpha reliability for the SDLRS instrument was .92. This is an acceptable level of reliability for the instrument (Ary, Jacobs, & Razavieh, 1990).

**Hypotheses 1 and 2**

There was no posttest difference between those who received metacognitive advice and those who did not. Similarly, for only those participants with learner control of sequence, those with metacognitive advice did not have higher posttest scores than those with metacognitive advice.

Most of the research with advice and learner control of instruction has shown that advice is helpful (Tennyson, 1980; Hannafin, 1984; Johansen & Tennyson, 1983; Milheim & Azbell, 1988). However, some studies found that advice with learner control of instruction did not help posttest achievement (Goetzfried & Hannafin, 1985; Coorough, 1991). In this study the researcher found that metacognitive advice was not helpful in increasing posttest achievement. There are two possible explanations for this. First, the type of advice may not have been very helpful. The metacognitive advice was constructed to assist the student to think about their learning to make better choices with the instruction. Other research on advice has included advice on what the participant should do next not to get him or her to think about what they should do next. The participant may have thought about the metacognitive advice to help them make a better decision.
Another potential explanation for why the metacognitive advice did not help was because of the nature of the learning environment. The students participated voluntarily for about two to three hours in a study where they would have no academic credit for success. Since the students were using the instruction for such a short period of time, they may not have approached the lesson in the same manner as they would a college course. The metacognitive advice may not have been useful in this setting.

The researcher found that the pretest had a split-half reliability of .08 and the posttest had a split-half reliability of .52. The pretest reliability would not be acceptable according to Ary, Jacobs, and Razavieh (1990). However, they describe the reliability measure as being a function of the heterogeneity of the group. Since the standard deviation for the pretest instrument (SD = 1.9) was smaller than the standard deviation for the posttest (SD = 2.4) instrument, the research should expect the reliability for the pretest instrument to be lower. Another factor that might have affected the reliability was the amount of guessing by the participants. The mean pretest score for the group was 6.3, which would be close to the mean score of 4.5, if a group of people had guessed all answers on the 18 item test. Since the pretest and the posttest are the same instrument, the reliability coefficients should not be drastically different. The researcher believes the dramatically lower reliability level for the pretest may be from the low variation in the pretest scores and from the guessing of the participants.
Hypothesis 3

The participants with program control of instructional sequence without metacognitive advice did not have higher achievement than those with learner control of instructional sequence without metacognitive advice. The researcher expected the program control of sequence participants to have higher achievement than the learner control of sequence without metacognitive advice. This would be consistent with some research that learner control of sequence without advice does not lead to higher posttest achievement than program control of sequence (Bunderson, 1976; Strickland & Wilcox, 1978; Arnone & Grabowski, 1991). In this study there was no difference in the posttest scores of those with learner or program control of sequence without advice. These results might have been expected since the participants in the study were graduate students and would be expected to make appropriate decisions regarding their learning given control of instruction.

Hypothesis 4

For the participants with learner control of instructional sequence, the higher self-directed learning readiness participants had a higher posttest achievement than the lower self-directed learning readiness participants. Self-directed learning readiness participants have the ability to identify resources for learning objectives, carry out plans for learning, and assess one’s ability when objectives were met. These results break new ground in the area of computer assisted instruction. The researcher could not find any previous research that
investigated the participants self-directed learning ability as a variable of investigation. This is possible since most of the research with computer-assisted instruction has been with college age students and younger. Since self-directed learning ability is an aspect typically found in literature concerning adult learners, the researchers using children and youths as subjects may not have had a reason to investigate this characteristic. This result in the study is consistent with the theory that those with more self-directed learning ability performed better given control of their learning. Furthermore, an individual’s self-directed learning ability may be a key characteristic when considering whether he or she should have control of their instruction.

**Hypothesis 5**

In this study the lower self-directed learning readiness participants with program control of sequence had higher achievement than the lower self-directed learning readiness participants with learner control of instruction. This was the expected result since the lower self-directed learning readiness participants should do better in a more instructor controlled environment. This is consistent with the results in hypothesis 4, which gives further credibility to the importance of the individual’s self-directed learning readiness. The results indicate that even at an average level of self-directed learning readiness, adults should not have control of the sequence of their instruction in a computer environment.
Supplementary results

There was a relationship between the participant’s attitude toward the instructional program and his or her attitude toward the instructional content. For the eight treatment groups, there was a high or very high correlation between the two attitude scores. From this result, the researcher believes the participants did not separate the content from the program when they indicated their attitudes toward the program and content.

Regarding the second supplementary result, there was no posttest difference between levels of the control of instructional sequence or metacognitive advice, or an interaction between the two. Therefore, metacognitive advice was not helpful to the participants to increase their achievement with the CAI when they had control of instructional sequence.

Covariates

In general, the participant prior knowledge of instruction was not a significant covariate concerning posttest achievement. This covariate was significant with one of the five hypotheses in this study. In this study, the student’s prior knowledge did not significantly contribute to participant achievement. However, since the duration of the experiment was short, the prior knowledge may not have been an important factor. The other covariate, the participants problem solving ability, as measured by their GRE analytical score, was a highly significant covariate with three of the five hypotheses and the other
two were less than .10. Therefore, the participant's problem solving ability is an important indicator of success with this type of instruction.

In addition, the participant's problem solving ability and self-directed learning readiness were significant covariates with the supplementary two-way ancova analysis. This is similar to the results of the other hypotheses and, thus, indicates that problem solving ability and self-directed learning readiness are more important than prior knowledge of content with success with learner control of instructional sequence.

Recommendations for future research

Based upon the results of this study, the researcher believes that further research should be conducted in several areas. First, the self-directed learning characteristic of individuals who use CAI with control of instruction should be investigated to determine if this characteristic is an important criteria for determining who should have control of their instruction. Since this was the first study examining this characteristic, the results need to be confirmed. In addition, this characteristic should be examined regardless of the age of the participants in the study. Younger participant's self-directed learning ability should be examined to determine if it contributes to achievement success with CAI.

The second area of research to be investigated involves the advice given to participants. Studies should be done to investigate the types of advice that improve achievement with control of instruction. Researchers should determine if participants should be given advice regarding where to go next in the sequence or
whether they should be given advice to help them make more effective decisions themselves.

Another study that should be done is to replicate the treatment in a research methodology course. This study was done on a voluntary basis during a short treatment time. The results may be different if the students are in a research methods class and the study is longer in duration. During an entire course, the metacognitive advice may have a different effect than during the short experiment.

Finally, the researcher has two recommendations for studying the attitude toward CAI. First, if a researcher is going to examine the participant's attitude toward the CAI, he or she should examine the participant's attitude toward specific features and not the program in general. The researcher should do this to find out the features that are related to improved attitudes with using CAI. The last recommendation for research is regarding a qualitative study of attitude toward CAI. The researcher believes that a qualitative investigation is required to determine if there is a difference in attitude toward the CAI when participants have control of instruction.

Recommendations for practice

The researcher has two recommendations for practice in the development of CAI. First, the characteristics of the user need to be considered when deciding whether to give control of instruction to the user. If the users will have high problems solving ability, high self-directed learning readiness, or prior knowledge
of the content, the researcher would recommend the user be given control of the instructional sequence.

Second, metacognitive advice may not be helpful in increasing achievement with control of instructional sequence. The advice did not have an effect in increasing the achievement in this study. The researcher does not know if the metacognitive advice increased the student's metacognition, but only that it did not help in increasing the student's achievement in this study.
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Ratcliff, J. L., & The effect of coursework patterns and course selection on the development of general learned abilities among college graduates. (ERIC Document Reproduction Service No. ED 334 927)


APPENDIX A

DESIGN OF INSTRUCTION

The model for the design of the instruction was the systematic design of instruction (Dick and Carey, 1990). This model has eleven steps. These are: identifying an instructional goal, conducting a goal analysis, conducting a subordinate skills analysis, identifying entry behaviors and characteristics, writing performance objectives, developing criterion-referenced test items, developing and instructional strategy, developing instructional materials, designing and conducting formative evaluations, revising instructional materials, and summative evaluation. In addition, the instructional activities contained design elements that are specific to CAI. The design guidelines described by Schwier and Misanchuk (1993) assisted the researcher in designing effective instructional materials.

Topic

The topic for the CAI was "Designing comparative research to control for threats to internal validity."

Audience

The target audience of this instruction was education graduate students. The researcher included examples, practice, and testing cases from many different aspects of education at different educational levels. This variety was included to provide examples that different students might find interesting or have knowledge about the content areas.
Problem and rationale for software

Controlling for threats to internal validity is an important concern when designing comparative research. Frequently, social science graduate students do not have much experience in designing research and will end up in a career conducting research or at least reading research reports. Therefore, these graduate students should be able to effectively design and evaluate research design for threats to internal validity.

Typically, the concept of internal validity is covered in an introductory research methods course. However, many other topics are also discussed and thus graduate students may not receive sufficient practice in designing experiments to control for the threat to internal validity.

Instruction

The instruction consisted of a three hour unit using a Hypercard program. The students read instructional material, practiced designing research, and were evaluated on their progress. Once the instruction was completed, the students should have understood, comprehended and had the ability to apply the knowledge to design research to control for threats to internal validity.

The students were required to control for the six of the thirteen threats to internal validity identified by Cook and Campbell (1979). Six threats were chosen because of the time constraints of designing instruction the student could complete in three hours. The six threats chosen were: History, Testing, Instrumentation, Mortality, Differential Selection, and Maturation. These were chosen of the
thirteen because they are the most common threats to internal validity. The student received instruction regarding the following:

- definitions of the threats to internal validity
- contributing factors and controls for the threat
- examples of the threats
- identification of the threats in an example
- identification of all validity threats in a case
- control measures of individual validity threats in an example
- control measures of all validity threats in a case
- designs of comparative research to control for threats to internal and external validity

Flowchart

The flowchart for the learner control of sequence without metacognitive advice is presented in Appendix B. Some parts of the flowchart were omitted since the sections are duplications and the framework can be seen in the flowchart for the similar sections. Each individual threat had the same structure as the shown in section A. There were three case studies which examined all six threats at the same time, as opposed to one individual threat. The example case allowed a user to view whether the six threats existed. The identify case allowed the participant to identify whether the six threats existed. Finally, the control case allowed the participant to select design aspects to control the six threats. An
assessment of student understanding was made at the score stage during sections F, G, H, and I, as well as during the identify and control threat case studies.

Formative evaluation of instructional program

The instructional program was evaluated by a panel of content experts. This panel included an instructional design expert, a content expert, and two graduate students who were familiar with the research content and instructional design. Revisions to the programs were made based upon the recommendations of the panel. The instruction was evaluated for content accuracy, clarity, and operation. In addition, the researcher asked the first five participants for each of the four versions of the instructional program to provide comments about the program. Minor revisions were made after these comments were gathered.
Designing comparative research to control threats to internal validity
Flowchart for Instructional Program
(Learner Control of Sequence without Metacognitive Advice)

* All individual threats have a similar structure.
APPENDIX C

SELF-DIRECTED LEARNING READINESS SCALE

AAT - Almost Always True
UT - Usually true (more than half the time)
ST - Sometimes True (about half the time)
UNT - Usually Not True (less than half the time)
ANT - Almost Never True

1. I’m looking forward to learning as long as I’m living. AAT UT ST UNT ANT

2. I know what I want to learn. AAT UT ST UNT ANT

3. When I see something that I don’t understand, I stay away from it. AAT UT ST UNT ANT

4. If there is something I want to learn, I can figure out a way to learn it. AAT UT ST UNT ANT

5. I love to learn. AAT UT ST UNT ANT

6. It takes me a while to get started on new projects. AAT UT ST UNT ANT

7. In a classroom situation, I expect the instructor to tell all class members exactly what to do at all times. AAT UT ST UNT ANT

8. I believe that thinking about who you are, where you are, and where you should be going should be a major part of every person’s education. AAT UT ST UNT ANT

9. I don’t work very well on my own. AAT UT ST UNT ANT

10. If I discover a need for information that I don’t have, I know where to go to get it. AAT UT ST UNT ANT

11. I can learn things on my own better than most people. AAT UT ST UNT ANT
12. Even if I had a great idea, I can’t seem to develop a plan for making it work.

13. In a learning experience, I prefer to take part in deciding what will be learned and how.

14. Difficult study doesn’t bother me if I’m interested in something.

15. No one but me is truly responsible for what I learn.

16. I can tell whether I’m learning something well or not.

17. There are so many things I want to learn that I wish that there were more hours in a day.

18. If there is something I have decided to learn, I can find time for it, no matter how busy I am.

19. Understanding what I read is a problem for me.

20. If I don’t learn, it’s not my fault.

21. I know when I need to learn more about something.

22. If I can understand something well enough to get by, it doesn’t bother me if I still have questions about it.

23. I think libraries are boring places.

24. The people I admire most are always learning new things.

25. I can think of many different ways to learn about a new topic.
26. I try to relate what I am learning to my long-term goals. AAT UT ST UNT ANT
27. I am capable of learning for myself almost anything I need to know. AAT UT ST UNT ANT
28. I really enjoy tracking down the answer to a question. AAT UT ST UNT ANT
29. I don’t like dealing with questions where there is not one right answer. AAT UT ST UNT ANT
30. I have a lot of curiosity about things. AAT UT ST UNT ANT
31. I’ll be glad when I’m finished learning. AAT UT ST UNT ANT
32. I’m not as interested in learning as other people seem to be. AAT UT ST UNT ANT
33. I don’t have any problem with basic study skills. AAT UT ST UNT ANT
34. I like to try new things even if I’m not sure how they will turn out. AAT UT ST UNT ANT
35. I don’t like it when people who really know what they’re doing point out mistakes that I am making. AAT UT ST UNT ANT
36. I’m good at thinking of unusual ways to do things. AAT UT ST UNT ANT
37. I like to think about the future. AAT UT ST UNT ANT
38. I’m better than most people are at trying to find out the things I need to know. AAT UT ST UNT ANT
39. I think of problems as challenges, not stop signs. AAT UT ST UNT ANT
40. I can make myself do what I think I should. AAT UT ST UNT ANT
41. I’m happy with the way I investigate problems.

42. I become a leader in group learning situations.

43. I enjoy discussing ideas.

44. I don’t like challenging learning situations.

45. I have a strong desire to learn new things.

46. The more I learn, the more exciting the world becomes.

47. Learning is fun.

48. It’s better to stick with the learning methods that we know will work instead of always trying new ones.

49. I want to learn more so that I can keep growing as a person.

50. I am responsible for my learning - no one else is.

51. Learning how to learn is important to me.

52. I will never be too old to learn new things.

53. Constant learning is a bore.

54. Learning is a tool for life.

55. I learn several new things on my own each year.
56. Learning doesn’t make any difference in my real life.

57. I am an effective learner in a classroom situation and on my own.

58. Learners are leaders.
APPENDIX D

PRETEST AND POSTTEST

1. Which of the following statements provides an accurate description of internal validity.
   a. The instruments used in the study can reliably measure the dependent variables.
   b. The results from the study are from the treatment and not from another influence.
   c. The results of the study can be from the treatment or from another source.
   d. The instruments in the study can accurately measure the dependent variables.

2. Which of the following is not a contributing factor for the testing threat to internal validity.
   a. The time between the pretest and the posttest.
   b. The reactivity of the pretest.
   c. The novelty or motivating effects of the pretest.
   d. The subjectivity of the pretest.

3. Which design accurately represents a pretest-posttest study with two groups?
   a. X O O
      X O O
   b. O X O
      O X O
   c. X O X
      X O X
   d. O X X
      O X X

4. Random assignment does not control which of the following threats to internal validity: (Choose one)
   a. History
   b. Mortality
   c. Testing
   d. Selection
5. Which of the following is a contributing factor for the instrumentation threat to internal validity.
   a. The reactivity of the pretest.
   b. The time between the pretest and the posttest.
   c. The subjectivity of the pretest.
   d. The number of items in the instrument.

6. A history teacher wants to find the impact of a film developed to improve the attitudes toward World War II Holocaust survivors. One group of students will see the film, while the other group of students will see a film about the history of food production in the United States. The teacher has randomly selected sixty tenth grade students to participate in the study. If a pretest will be used to measure the initial students’ attitude, it will be a similar, but not the same instrument. Choose the design of the study that controls the most threats to internal validity.
   a. R X1 O
      R X2 O
   b. R O X1 O
      R O X2 O
   c. O X1 O
      O X2 O
   d. X1 O
      X2 O

7. Which of the following statements best describes the mortality threat to internal validity.
   a. The results of the study are confounded because of the death of the researcher conducting the study.
   b. The study results are confounded by the loss of similar subjects from both treatment groups.
   c. The study results are confounded because the researcher removed subject scores from both groups because the answers were ineligible.
   d. The results if the study are confounded because of the loss of more subjects from one treatment group than the other group.

8. Which of the following is not a factor that may contribute to the maturation threat to internal validity.
   a. Duration of the experiment.
   b. Characteristics of the subjects.
   c. Whether the subjects were randomly selected for the experiment.
   d. Whether the subjects were randomly assigned to treatment groups.
9. A home economics teacher wishes to determine the effects of providing video information regarding safe food handling procedures to seventh grade students. The teacher randomly assigned the group of sixty students to two treatment groups. Both groups are pretested to determine their existing knowledge of safe food handling procedures. One group receives print and verbal instruction on safe food handling procedures and the other group received video instruction in addition to the print and verbal instruction. The home economist teacher knows that randomly assigning the students to the two treatment groups controls for the ______ threat to internal validity.
   a. Testing
   b. Instrumentation
   c. Intrasession History
   d. Maturation

10. A researcher was interested in determining which two sets of curriculum materials is more effective for teaching safety procedures in a welding shop. The participants are sixty ninth grade welding students randomly selected from the school district to participate in the three hour instructional session. The students were assigned to groups based upon the order in which they arrived to the research classroom. The students received a safety awareness pretest, completed the instruction, and then took the posttest. In this study, the least important threat to internal validity is:
   a. Testing
   b. Selection
   c. Mortality
   d. Maturation

11. A researcher was interested in determining which two sets of curriculum materials is more effective for teaching safety procedures in a welding shop. The participants are sixty ninth grade welding students randomly selected from the school district to participate in the three hour instructional session. The students were assigned to groups based upon the order in which they arrived to the research classroom. The students received a safety awareness pretest, completed the instruction, and then took the posttest. In this study, the most important threat to internal validity is:
   a. Testing
   b. Selection
   c. Mortality
   d. Maturation
12. Selection is a threat to internal validity. Choose the control method that will control this threat.
   a. Random assignment of subjects to treatments.
   b. Choosing the duration of the experiment.
   c. Experimental isolation of participants.
   d. Control for changes in the instrument.

13. Random assignment controls which of the following threats to internal validity: (Choose one)
   a. Mortality
   b. Instrumentation
   c. Intrasession History
   d. Maturation

14. A researcher is interested in choosing between two sets of geography curriculum materials. The participants will be sixty eleventh grade students from the same high school. Choose a method that will control for the selection threat to internal validity.
   a. Allow the students to choose their group membership.
   b. Allow the researcher to determine group membership.
   c. Randomly select the students from the eleventh grade classes.
   d. Random assignment of students to treatment groups.

15. Which of the following will control a potential mortality threat to internal validity.
   a. Using randomly assigned matched pairs of participants.
   b. Randomly assigning participants to treatment groups.
   c. Randomly selecting participants for the study.
   d. Using healthy participants.

16. A researcher was interested in determining which of two sets of mathematics curriculum materials was better. The participants in the study were two first grade classes in the same school. The researcher measured the students' initial mathematics knowledge, using an objective instrument, at the beginning of the study. The students participated in the study for four months. At the end of the year, the researcher measured the students' mathematics achievement, using the same pretest instrument, to determine which curriculum materials should be used in the future. Which of the following is the least important threat to internal validity for the study:
   a. History
   b. Testing
   c. Maturation
   d. Mortality
17. A researcher was interested in determining which of two sets of mathematics curriculum materials was better. The participants in the study were two first grade classes in the same school. The researcher measured the students' initial mathematics knowledge, using an objective instrument, at the beginning of the study. The students participated in the study for four months. At the end of the year, the researcher measured the students' mathematics achievement, using the same pretest instrument, to determine which curriculum materials should be used in the future. Which of the following is the most important threat to internal validity for the study:
   a. History
   b. Testing
   c. Maturation
   d. Mortality

18. A researcher is interested if students' attitude toward science is affected by their participation in experiments during class time. The researcher thinks that if students are allowed to get 'hands on' experience in the classroom, they will have a better attitude toward science. The principal of the school has agreed to allow the researcher to experiment on one or two ninth grade agricultural science classes, providing the experiment takes place with the existing classes and during regular class time. The experiment is one week long. The next three questions relate to this study.
   This choice is regarding the measurement of the dependent variable (student attitude toward science). Choose one of the following, remembering your goal is to minimize threats to internal validity.
   a. A twenty item, five point, Lykert-type scale instrument.
   b. A five question short answer instrument.
   c. An outside observer to ask specific questions regarding student attitude toward science.
   d. Two outside observers to ask specific questions regarding student attitude toward science.
19. A researcher is interested if students' attitude toward science is affected by their participation in experiments during class time. The researcher thinks that if students are allowed to get 'hands on' experience in the classroom, they will have a better attitude toward science. The principal of the school has agreed to allow the researcher to experiment on one or two ninth grade agricultural science classes, providing the experiment takes place with the existing classes and during regular class time. The experiment is one week long. The next three questions relate to this study.

Choose a design to control the most threats to internal validity.

a. X1 O
b. O X1 O
c. O X1 O
   -------
   O X2 O
d. X1 O
   -------
   X2 O

20. A researcher is interested if students' attitude toward science is affected by their participation in experiments during class time. The researcher thinks that if students are allowed to get 'hands on' experience in the classroom, they will have a better attitude toward science. The principal of the school has agreed to allow the researcher to experiment on one or two ninth grade agricultural science classes, providing the experiment takes place with the existing classes and during regular class time. The experiment is one week long. The next three questions relate to this study.

Which factor does not affect the history threat to internal validity.

a. The duration of the study.
b. Whether the subjects are randomly assigned to treatment groups.
c. Whether the subjects are isolated from external influences.
d. Whether the subjects are randomly selected from the target population.
APPENDIX E
ROBUSTNESS SEMANTIC DIFFERENTIAL FOR ATTITUDE TOWARD THE
INSTRUCTIONAL PROGRAM

The instructional program is:

<table>
<thead>
<tr>
<th>Word</th>
<th>Quantity</th>
</tr>
</thead>
</table>


APPENDIX F
ROBUSTNESS SEMANTIC DIFFERENTIAL FOR ATTITUDE TOWARD THE INSTRUCTIONAL CONTENT

The "Internal validity threats’ content" is:

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<th>boring</th>
<th>fresh</th>
<th>meaningless</th>
<th>important</th>
<th>usual</th>
<th>powerful</th>
<th>passive</th>
<th>thrilling</th>
<th>uneventful</th>
<th>challenging</th>
</tr>
</thead>
<tbody>
<tr>
<td>interesting</td>
<td></td>
<td>stale</td>
<td>meaningful</td>
<td>unimportant</td>
<td>unusual</td>
<td>weak</td>
<td>active</td>
<td>quieting</td>
<td>action-packed</td>
<td>dull</td>
</tr>
</tbody>
</table>
VITA

Andrew Holden was born in St. Catharines, Ontario on June 1, 1964. He pursued undergraduate studies at the University of Waterloo in Waterloo, Ontario. While finishing his studies at Waterloo, by correspondence, he worked for the Government of Ontario as a receptionist, payroll clerk, and computer technician. He graduated with a Bachelor of Science degree in the spring of 1990.

Andrew then attended graduate school at Louisiana State University. His dissertation research dealt with the effect of metacognitive advice and control of sequence on student achievement and attitude toward computer assisted instruction and content. He received his doctor of philosophy in Vocational Education with a minor in Educational Technology in May, 1995.
DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Andrew Mark Holden

Major Field: Vocational Education

Title of Dissertation: The Effects of Metacognitive Advice and Control of Sequence on Student Achievement and Attitude toward Computer-Assisted Instruction and Content

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Suean McKmacgrae

Joe Katalite

Kenneth J. Toomey

Date of Examination: March 14, 1995