UNIVERSITY OF ALBERTA

COMPUTER ASSISTED INSTRUCTION:

ADVISEMENT AND INTERACTIONS WITH SELECTED LEARNER CHARACTERISTICS IN LEARNING 10TH GRADE MATHEMATICS

BY

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ABSTRACT

An experimental study tested the effect of advisement on achievement in mathematics 10, and advisement's interactions with strength in mathematics and gender of subject, in a computer assisted instruction environment. Subjects were 22 academic challenge (higher ability) mathematics 10 students in Edmonton, Alberta, who had previous CAI experience.

All subjects studied two units of mathematics 10 using CAI. In the treatment condition subjects completed a computer managed instruction test and received feedback (advisement), a few days prior to writing the end of unit final test, on their mastery of each instructional objective along with the suggestion that they study unmastered objectives. In the control condition students completed an attitude survey.

Subjects who received advisement scored significantly higher on end of unit examinations than those who had not received advisement. An analysis of the repeated measures data suggests that advisement may assist students in learning meta-cognitive techniques. No significant interactions were found between advisement and strength in mathematics, or advisement and gender.

Results support previous research which suggests that computer advisement has a positive effect upon learning outcomes. Lack of differential effect for ability levels or gender suggests that computer advisement may be equally effective for both groups, although the numbers of females in the subject pool may have been too small to draw reliable conclusions.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I: INTRODUCTION

This study is in the tradition of Allen, Baker and Tennyson who sought to improve learning via Computer Assisted Instruction through the use of advisement--giving learners detailed learning prescriptions based on diagnostic tests. These learning prescriptions can be used to turn control (lesson sequence, content, learning strategy, etc.) over learning to the learner, with little or no negative impact on academic achievement. Learner control is considered to be desirable (Tennyson, 1980) in order to foster student responsibility and involvement in the learning process. Without this student involvement learners may be less likely to develop lifelong learning skills. This study looked into learner characteristics that may affect the success of implementing learner control.

This study explored the effect of advisement and the aptitude treatment interactions of students in a CAI environment learning Mathematics 10 between a) advisement and aptitude in Mathematics 10, and b) advisement and gender.

There is a possibility that advisement in CAI environments may benefit lower ability learners more than higher ability learners. In non-CAI situations there is evidence (Whitener, 1989) that advisement benefits higher ability students more than [illegible]er [illegible]bility students.

Should CAI advisement be more beneficial for lower aptitude learners, then advisement can be used to assist them in reducing their educational disadvantage.

The Problem and Its Setting

Statement of the Problem

What are the main and interaction effects on mathematics achievement at the 10th grade level, when taught by Computer Assisted Instruction (CAI), regarding selected learner characteristics and providing/not providing learners with review advisement.

Hypothesis

The first hypothesis is that students learning from CAI with advisement will reach a higher level of mathematics achievement than students learning from CAI without advisement.

The second hypothesis is that advisement will assist mathematically weaker learners, more than mathematically stronger learners, in reaching a higher level of mathematics achievement.

The third hypothesis is that there will not be an interaction effect between advisement and gender, as measured by mathematics achievement.

Importance of the Study

Computer Assisted Instruction (CAI) and Computer Managed Instruction (CMI) are promising but relatively new teaching methodologies, having originated in the late 1950's. Lee's (1990) recent meta-analysis study has found that students using current tutorial CAI to study mathematics on the average would have their achievement raised by slightly over one standard deviation (effect size = 1.058), shifting the position of the average treated student from the 50th percentile to the 85th percentile of a control group.

As promising as this finding is, optimal CAI strategies have not yet been determined. One strategy that promises to make CAI even more effective is to provide learners with personalized learning diagnoses and prescriptions (advisement).

There are consistent research results (Tennyson, 1980, 1981 and Schloss, Wisniewski & Cartwright, 1988) indicating that advisement may improve student decisions related to terminating learning and academic achievement. In a related area, CAI based aptitude treatment interaction research, a number of studies (Fry, 1972, Gay, 1986, Seidel et al, 1975) found that less able students tend to do less well (in studies without advisement) when it comes to making decisions related to terminating learning. There is an apparent shortage of studies tying the two findings together: is the improvement in student decision making, after advisement, due to the lower ability students benefiting from the advisement? Hativa (1988) observed that few of the key studies on CAI in schools considered students' ability levels.

One specific purpose of this study is to investigate if advisement in a CAI setting is more effective in general, and specifically for lower aptitude learners than for higher aptitude learners. Meta-analyses (Lee, 1990, Roblyer et al, 1988 and Samson et al, 1986), have consistently shown that CAI instruction particularly benefited lower aptitude learners. Non-CAI research (Whitener, 1989), has found that advisement particularly benefited higher aptitude learners.

If, in a CAI setting, advisement assists weaker learners more than stronger learners, CAI could be a powerful tool in reducing educational inequities. To date the meta-analytic literature has been silent on the issue of CAI and prescriptive advisement.

Delimitations

The present study may not be generalizable to non-CAI instruction, or CAI topics other than mathematics at the junior high school level.

This study may not be generalizable to inexperienced CAI students--students with less than five months experience in CAI instruction.

This study did not attempt to distinguish the contribution of the CMI testing component from the overall CMI advisement effect.

Assumptions

The first assumption is that by using learners who are experienced in CAI the novelty effect would be eliminated or greatly reduced.

The second assumption is that the chosen pre-test score is valid for estimating the learner's aptitude for learning Mathematics 10.

The third assumption is that, within this experiment, the effectiveness of a method of instruction is independent of the method that preceded it.

The fourth assumption is that the sample, consisting of the population of Academic Challenge Mathematics 10 students at an urban high school in Alberta are representative of above average ability Alberta Mathematics 10 learners.

Definitions of Terms

Advisement. Advisement refers to learners in a learner-control mode receiving "meaningful information by which the learner can participate fully in the management and responsibility of his or her learning program" (Tennyson, 1984 p 133). In this study advisement is operationally defined as both the formative test and the subsequent feedback, including a learning prescription for achieving mastery, on individual instructional objectives as provided by a computer-based mathematics 10 program.

CAI delivered tests. CAI delivered tests are operationally defined as the tests incorporated in a computer-based mathematics 10 program.

Computer Assisted Instruction (CAI). Computer Assisted Instruction includes "tutorial ... drill-and-practice and computer-based interactive instructional simulations" (Hall, 1982 p 353). In this study CAI is operationally defined as the instructional components of a computer-based Mathematics 10 program, supplemented by a classroom instructor.

Computer Managed Instruction (CMI) "Computer Managed Instruction employs the computer as a record-keeping device and does not provide any direct instruction to learners" but can provide a "diagnostic-prescriptive strategy based on the learner's responses to material stored in the computer system" (Hall, 1982 p 353). In this study CMI is operationally defined as a lesson which diagnostically tests each individual student over a specific set of objectives, and prescribes specific lessons to teach unmastered objectives.

Experienced CAI learners. Experienced CAI learners are those who have used CAI to the extent that the novelty effect has diminished or been eliminated. In this study experienced CAI learners was operationally defined as learners who have received at least five months of CAI mathematics instruction of at least 70 minutes three times per school week.

Level of achievement. In this study level of achievement is operationally defined as a score determined from the CAI delivered tests. Baseline mathematics achievement is assessed through the Unit Four examination, while the criterion is assessed via exams for Units Five and Six.

Mathematically stronger learners. In this study Mathematically stronger learners was operationally defined as those mathematics 10 learners who scored at or above the pre-test's median split for the sample group.

Mathematically weaker learners. In this study Mathematically weaker learners was operationally defined as those mathematics 10 learners who scored below the pre-test's median split.

Mathematics 10. In this study Mathematics 10 was operationally defined as the Alberta grade 10 Mathematics curriculum.

CHAPTER II: LITERATURE REVIEW

> Can researchers and teachers devise teaching-learning conditions that will enable the majority of students under group instruction to attain levels of achievement that can at present be reached only under good tutoring conditions? (Bloom, 1984 p 4)

The purpose of this literature review is to describe aptitude treatment interactions (ATIs) between student characteristics and prescriptive advisement, as they apply to Computer Managed Instruction (CMI). Prescriptive advisement in CMI, advisement based on a diagnostic test that provides detailed study recommendations, is a strategy used to support learner control of instruction. The following literature review therefore considers learner control and is organized as follows.

A context for Computer Assisted Instruction (CAI) and advisement in mathematics instruction will be provided. From this context, a contribution that the study of aptitude treatment interactions may make to CMI will be identified.

Research in the areas of CMI and achievement, learner aptitude, and gender will be summarized and used to develop the hypotheses.

Computer Based Instruction

> The success of education depends on adapting teaching to individual differences among learners. (Yuezheng, 4th Century BC, cited in Corno and Snow, 1986)

CAI is not an instructional methodology, so much as an instructional vehicle. As Clark (1985, p 259) so eloquently overstated, "Computers make no more contribution to learning than the truck which delivers groceries to the market contributes to improved nutrition in the community." What the computer can do is deliver the instructional methodology: a) on a one-to-one basis, b) with a flexible schedule, c) patiently, d) with a minimum of anxiety for the learner, e) with simulations, and f) keep accurate records.

Since CAI is, to a large extent, a delivery vehicle, one may therefore conclude that it is particularly important for CAI programs to utilize sound instructional paradigms and design features that are tailored to capitalize on student strengths and compensate for their weaknesses. As Clark (1985, p 249) also points out, "achievement gains...in these CBI studies are...actually due to...robust instructional methods embedded in CBI treatments."

One of these "robust instructional methods" may be prescriptive advisement, in which the computer is used to test the student's knowledge and provide a detailed remedial learning prescription. Such prescriptions provide four major benefits, they:

1. provide advice to the learner on the instructional areas requiring remediation;
2. serve as organizers for students who lack appropriate learning strategies;
3. serve to prompt or cue the learner that a review is required, and;
4. provide a motivator leading to further review.

Aptitude treatment interactions can be used to look into student characteristics that are related to benefiting from advisement, and also uncover characteristics that may contraindicate advisement. The present study will concentrate on the learner aptitudes of mathematical ability (generally referred to as aptitude) and gender.

Aptitude Treatment Interactions

> The goal of ATI research has been to adapt instruction to individual learners by tapping aptitudes the learners have or compensating for abilities they lack. (Cronbach & Snow, 1977)

Tobias (1989, p 213) described aptitude treatment interactions as the "knowledge base for adapting instruction to student characteristics..., that is, ... the interactions between student characteristics and instructional treatments."

Notwithstanding the name aptitude treatment interaction, studies often include non-aptitude characteristics such as gender, age, socio-economic status, etc. In this study the wider definition is used, as is common practice in the literature.

Salomon (1972) proposed a three part model of how different instructional treatments could be benefit different people:

1. The remedial approach, where treatments are designed to compensate for a learner's lack of prior knowledge. Assuming that learning can not progress until the student has the necessary background knowledge, remedial instruction is made available to those who need it. This relates to

the first of the four benefits of prescriptive advisement described earlier.

2. The compensatory approach, provides support for learners in the form of organizers or course sequence control. By compensating for learning strategies that are lacking in the students, the treatment assists the student in learning the current material. Stronger learners do not necessarily receive this support. This relates to the second of the four benefits of prescriptive advisement described on page 12.

3. The preferential approach, attempts to identify and use the student's preferred learning style or strategy. This is the only one of the three that attempts to utilize the student's strengths, the others make up for weaknesses.

The present study is concerned with the:

1. remedial approach, in that advisement can assist students in identifying areas where they require remedial instruction, and

assist students by organizing their review requirements and helping the student to take a review (both learning strategies) before continuing.

The preferential approach is not addressed by advisement, in this study.

Tobias' (1989) article outlined a number of weaknesses in ATI research, including the following assumptions:

1. different instructional methods induce students to use different types or frequencies of macroprocesses (learning strategies that students are aware of and are under student control, eg. review, note taking, etc.) and;

2. Macroprocesses (that the treatments attempt to elicit) are in some way related to student characteristics.

Regarding point 1, above, Tobias' (1989, p 218), in a series of five experiments that were designed to track the types and frequencies of macroprocesses used, found that "in the absence of external intervention, student's use of macroprocesses was relatively ineffective in promoting learning", due to their inconsistent use.

Neither was the second supported by Tobias (1989). In the CBI program mentioned earlier, students were monitored as they selected various macroprocessing learning strategies (adjunct questions, review of text already read). Although main effects were evident, the macroprocessing activities that were tracked were largely unrelated to students' aptitudes (anxiety, domain-specific knowledge or reading ability).

To overcome these difficulties, Tobias recommends that rather than relying on a learner's aptitude to automatically elicit the macroprocess, the learner be cued by a prompt, requirement, or an explanation of the value of a review or other macroprocess. This relates to the third of the four benefits of prescriptive advisement described on page 12.

This opinion is supported by the research of Steinberg (1977), Fry (1972) and Fisher, Blackwell Garcia and Green (1975) who found that learners are unskilled at making instructional choices--a type of macroprocess.

Further, it was found (Fry, 1972, and Gay, 1986) that high aptitudes learners can manage their own learning. Tennyson (1980, 1981), Tennyson & Buttrey, 1980) and others (Steinberg, Baskin & Hoffer, 1986, Schloss, Winiewski & Cartwright, 1988) demonstrated that most learners, if given advisement, can effectively control their instruction. No meta-analytic studies have been found on the topic of advisement in CAI environments.

It would appear that learner control is not harmful to able learners, and may in fact help develop in the learners a responsibility for their own learning.

From the above, we may conclude that different instructional methods may induce some students (particularly high aptitude students) to use different types or frequencies of macroprocesses; however, for lower ability students suggesting a specific learning activity may be appropriate.

The fourth benefit of prescriptive advisement involved motivating students to take a suggested review. Frase (1971) in a study on the timing of motivation, found that motivation introduced prior to the learning activity improved performance on both adjunct and post-test questions. However, if the motivators were introduced just prior to the post-test, they had little effect.

These studies suggest motivation improves learning, but is relatively ineffective at stimulating recall. Therefore, in order to improve the student's performance, advisement should be provided prior to a substantial review opportunity, to permit the detailed learning prescription to operate as a motivator.

Meta-cognition

> "Meta-cognition" refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in meta-cognition ... if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as a fact; if it occurs to me that I had better scrutinize each and every alternative in a multiple choice type task before deciding which is the best one . . . . Meta-cognition refers, among other things, to the active monitoring and consequent regulation and orchestration of those processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective. (Flavell, 1976 p 232)

According to Collins and Seely (1986) meta-cognition and self-regulation are similar in nature and, when a part of a person's learning skills, are thought to be applied in a variety of circumstances. Requiring active involvement on the part of the learner, meta-cognition also entails an awareness not only of the demands of a particular task but, more importantly, of the learner's own capabilities. Self-interrogation and sensitivity to the task's characteristics is used to evaluate and supervise the learner's cognitive behaviour, which can then lead to changes in learning strategy.

Collins and Seely (1986, p 7), in defining meta-cognition, emphasise that self-regulation becomes meta-cognition when the student's "acquisition processes (receiving stimuli, tracking information, self-reinforcement) becomes involved in information transformation (discriminating relevant from irrelevant information, connecting new information with prior knowledge or skills, and planning performance routines)." Meta-cognition can be seen as a control process that governs the actions of more basic cognitive skills.

Novices and children may fail at a task due to a lack of ability and also because they do not regulate their actions or have conscious awareness of them (Brown & DeLoache, 1978). When novices and children lack familiarity with a given task, they often inadequately monitor their learning and make poor activity selections. Brown and DeLoache hypothesized that: (a) novices do not engage in self-regulation; (b) self-regulation becomes increasingly important as learners gain experience and knowledge; and (c) for experts their routines may become so automatic that less self-regulation is required.

Because of the computer's ability to record and report learners activities, the computer could provide a powerful, motivating tool for focusing the students' attention directly on their own thought processes, and thereby improve their ability to learn.

Collins and Seely (1986), in a study involving the WAMPUS game at the Junior High School level, found that higher performing students displayed more self regulated learning, on the basis of computer feedback, than lower performing students.

Salomon and Gavriel (1988) in a reading comprehension study of 75 Israeli 7th graders reported that software that provided meta-cognitive questions embedded in the lesson led to improved performances over similar software.

One month later, the students who had received the meta-cognitive support still performed significantly higher than the control group. It was also found that, after having the meta-cognitive skills modeled by the software, the students' performances in other subjects improved as well.

Advisory CMI testing can be viewed as meta-cognitive support. Salomon and Gavriel's (1988) findings that students learn from meta-cognitive models, and may apply the new skills both in other situations and over a period of time, has implications regarding a method of instruction being independent of the one that precedes it. (Please see assumption three, page 6).

Meta-analysis

> I believe that in the long run we will learn a great deal about ATIs from meta-analysis. That is, to find out which treatments are most effective for which people, we should not only look within studies..., we should also look across collections of studies.... If we use this strategy, I think we'll get consistent results; second we'll get stimulating results; and third, we'll get results we can use. (Kulik, 1981 p 2)

Meta-analysis, introduced by Glass in 1976, was developed to cope with a quantity of inconsistent studies in the social sciences. Glass (1976. p 3) described three types of analysis:

- primary analysis, "the original analysis of data in a research study"
- secondary analysis, "the re-analysis of data for the purpose of answering the original research question with better statistical techniques..."
- meta-analysis, "the analysis of analyses,... the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings".

Due to a variety of methodological problems inherent in education research (Tobias, 1989, Clark, 1985, Glass, 1976, Lee, 1990, Slavin, 1984), single studies have not generally been productive in providing definitive evidence of the existence of ATIs (Whitener, 1989). Since 1976 meta-analysis has been used in a number of educational research studies (Kulik, et al, 1980, 1985, Lee, 1990, Roblyer et al, 1988, Samson et al, 1986, Bangert-Drowns et al, 1986, Burns and Bozeman, 1981, Glass, 1976) as a technique to overcome limitations of generalizing from single studies.

Central to meta-analysis is the concept of "effect size" (ES) which Lee (1990, p 12) defined as "the difference between the mean of the experimental group and that of the control group, divided by the standard deviation of the control group."

Lee's (1990) recent meta-analysis study has found that students using current tutorial CMI, studying mathematics, on the average, would have their achievement raised by slightly over one standard deviation (effect size = 1.058), shifting the position of the average treated student from the 50th percentile to the 85th percentile of a conventional instruction control group.

Concerns Regarding Meta-analysis

Meta-analysis is not without its disadvantages. As an analysis of analysis, the definitions are necessarily broad. In the original research, the variables would be operationally defined. In a meta-analysis these definitions may become generic, vague, and occasionally misleading.

Slavin (1984) pointed out that not all research topics lend themselves to meta-analysis--attitude research for example does not lend itself to the numerical analysis required. Kulik (1985), Roblyer (1988) and Whitener (1989) all remarked on how few studies report the data (ATI statistics, sample size, sample description, reliability of measures of aptitude and achievement, use of a conventional instruction control) required to perform meta-analysis, and are on topics appropriate for meta-analysis.

Hativa (1988) has expressed a concern regarding meta-analyses using a different instructional methodology for its baseline. The baseline in CAI is normally conventional instruction. Should this baseline be unreliable, the meta-analytic results would be affected.

Despite these concerns meta-analysis currently provides one of the better statistical interpretive methods for summarizing ATI data.

This study is designed to look into the effects of formal prescriptive advisement. Since no meta-analytic studies have been found on prescriptive advisement and CMI, a surrogate is needed. Tutorial instruction, which includes feedback-corrective procedures (Bloom, 1984) must provide at least some degree of advisement to the student. Therefore, tutorial mode CMI may provide an indication of the effects of formal advisement. Consequently, in the following section on research findings, an emphasis was placed on tutorial CMI.

Research Findings

CAI & Achievement at High School

Mathematics

TABLE 1
CAI and High School Mathematics Achievement
(data from Lee, 1990)

Grade Level
Mean Effect Size: CMI vs Traditional

	D & P	Tutorial	Simu/ Gaming	Total Mean
Elementary	0.342*	0.492*	0.236	0.342*
Junior High	0.408*	0.854*	0.451*	0.584*
Senior High	0.192	0.280*	0.632	0.282*

* $p < 0.05$

Effect Sizes reflect differences from conventional instruction control groups.

Lee's (1990) meta-analytic study (TABLE 1) indicated that CAI is more effective than traditional instruction, and that Tutorial may be the most effective mode of CMI, at least until the end of junior high school. Unfortunately, for the junior high analysis, Lee only had two simulation/gaming studies with a wide Standard Error of the Mean, so despite the large effect size, it's probability only reached .417. A pattern of similar overall (total mean) effectiveness of mathematics CMI instruction at the high school level, as compared to conventional instruction, is indicated by other meta-analytic studies. Please see TABLE 2.

TABLE 2
CAI and Mathematics Achievement at High School

Study	Effect Size* Elementary		Effect Size* Secondary	
Roblyer et al, 1988	0.32	$p < 0.05$	0.19	$p < 0.05$
Kulik, Kulik & Shwalb, 1966	0.47	$p > 0.05$	0.36	$p > 0.05$
Burns & Bozeman (1981)	0.43	$p > 0.01$	0.52	$p < 0.01$
Bangert-Drowns et al, 1985	0.16	$p > 0.05$	0.29	$p > 0.05$
Samson et al, 1986			0.31	$p < 0.01$

* Effect Sizes reflect differences from conventional instruction control groups.

As mentioned earlier, Lee's (1990) meta-analysis study found that students using recently developed tutorial CAI, studying mathematics, on the average, would have their achievement raised by slightly over one standard deviation (effect size = 1.058), shifting the position of the average treated student from the 50th percentile to the 85th percentile of a control group.

CAI, Advisement & Achievement

Tennyson and Buttrey (1980), Tennyson (1980), Tennyson, Tennyson and Rothen (1989), Ross and Rankow (1981) and Park and Tennyson (1983) expressed concerns regarding the possibility that adaptive computer control (where the computer adapts the instruction to the student's needs) may prevent students from developing responsibility for their own learning.

No meta-analytic studies were found on CMI and advisement; however, the meta-analyses reported in the previous section indicate that Tutorial mode, with its inherent advisement, can be a very effective method.

Mathematics

Ross and Rankow (1981) found that learners who were able to terminate learning were likely to do so before the mastery criteria were reached. They called for fewer examples and therefore completed the lesson much more quickly. Unfortunately the quality of learning was not as good as in the control group where the session was under computer-adaptive control.

<u>Non-mathematics</u>

Tennyson (1980), Tennyson, Tennyson and Rothen (1989), also found that learners tended to terminate learning before the mastery criteria were reached.

Tennyson's (1980) study compared learner control with prescriptive advisement versus adaptive computer control and versus learner control without prescriptive advisement. He found that students using learner control without advisement tended to exit the program before they mastered the task. When advisement was provided, whether given to the students or used to control the program, students performed better on the post-test. The benefit of learner control with adaptive information was not only in the quality or quantity of learning but, also, in encouraging learner responsibility.

Tennyson and Buttrey (1980) obtained similar results--students with prescriptive advisement performed significantly better than students who terminated early without the benefit of advisement.

Steinberg, Baskin and Hoffer (1986), concluded that the significant variable was not learner or computer control. They found that the presence of feedback during instruction improved performance.

Summary, Advisement and Achievement

Tennyson (1980, 1981), Tennyson & Buttrey (1980) and Steinberg, Baskin & Hoffer (1986) demonstrated that most learners, if given advisement, can effectively control their instruction.

It is tempting to hypothesise that elementary and junior high school students who: 1) may not have developed macroprocessing strategies, and 2) are learning more basic skills, may need the advisement, structure and external control that drill/practice and tutorial CAI provide. In senior high school they may no longer need the regimentation, and prefer the involvement of simulations and gaming. However, Lee's (1990) simulation/gaming results at the senior high level were not statistically significant.

CAI, Advisement, Achievement & Aptitude

Snow (1980), pp 152-153) counselled that learner control (implemented through the use of advisement) is simply not for everyone since "learner control cannot be expected to overcome the persistent fact that individual characteristics not under the control of the individual will determine to a significant extent what and how much that individual will learn in a given instructional setting". A classic individual characteristic is learner aptitude (ability).

Mathematics

In meta-analytic research studies, CAI tutorial instruction consistently has been more effective for lower aptitude learners than higher aptitude learners. Two of these studies, Lee (1990) and Burns and Bozeman (1981), focused on mathematics. Both researchers found significant positive effects for lower aptitude learners, but no significant effects for higher aptitude students. Please see TABLE 3.

TABLE 3
Tutorial CAI, Aptitude and Mathematics Achievement

Study	Effect Size* Lower Aptitude	Effect Size* Higher Aptitude
Lee, 1990	0.620 $p < 0.05$	0.163 $p > 0.05$
Burns and Bozeman, 1981	0.57 $p < 0.01$	0.28 $p > 0.01$

* Effect Sizes reflect differences from conventional instruction control groups.

Goetzfried and Hannafin (1985) in their study of seventh grade remedial mathematics, did not find any significant differences between computer-adaptive control, learner control with advisement, and linear computer control (instruction not adjusted to learner performance). However, students who performed well on a pretest also performed better on rule recall, rule application and application items.

Fry (1972) and Gay (1986) found that high aptitude learners can manage their own learning, even without advisement.

Judd, Bunderson, and Bessent (1970) researched learner control in a college remedial mathematics course. It was found that students under learner control, contrary to their hypothesis, had performed ss well than students under computer control. This was particularly true of students who performed poorly on the pretest.

Non-mathematics

Three meta-analysis that are not exclusively on mathematics achievement are available. Again, consistently, lower aptitude learners benefited more than high aptitude learners from CAI instruction.

TABLE 4
Tutorial CAI, Aptitude and Non-mathematics Achievement

Study	Effect Size* Lower Aptitude		Effect Size* Higher Aptitude	
Roblyer et al, 1988	0.45	$p < 0.05$	0.32	$p < 0.05$
Samson et al, 1986	0.55	$p < 0.001$	0.16	$p < 0.001$
Bangert-Drowns et al, 1985	0.46	$p < 0.05$	0.24	$p < 0.005$

* Effect Sizes reflect differences from conventional instruction control groups.

Bunderson (1976), cited in Steinberg (1977, p 85), found that in a Brigham Young University English course the "lower 30% were helped more by (CMI), but the upper 30% were helped more by faculty. At Phoenix College, Morrison (1976) confirmed these results using the same program.

Other

Whitener's (1989) meta-analysis of 20 non-CMI research studies at the primary, secondary and college levels, provides the only known meta-analysis on the effectiveness of advisement. Her analysis found that:

> "ATIs were present and ... the average slope difference was approximately .11. The difference between slopes was such that the slope of the higher support treatment was greater than the slope for the lower support treatment. This is consistent with the hypothesis that students who have higher prior achievement benefit more than students with lower prior achievement from an increase in instructional support. Such students may be able to capitalize on the support, increasing their learning performance more than their lower achieving classmates." (p. 79)

Whitener's non-CAI study used a somewhat different meta-analytic technique, so an effect size is not available; however the probability was less than 0.10.

Summary, Advisement, Achievement and Aptitude

Meta-analytic studies on Computer Assisted Instruction, both on mathematics and non-mathematics topics consistently found that lower aptitude learners benefited more from CMI than higher aptitude learners.

Whitener's (1989) non-CAI study indicates that advisement may work to the advantage of higher aptitude students more so than for lower aptitude students. This stands is sharp contrast to the CAI work of Judd, Bunderson, and Bessent (1970), Bunderson (1976), and Morrison (1976), who found the reverse situation--lower aptitude students benefited more than higher aptitude students.

Hativa (1988) cautions that meta-analytic studies compare the learn' achievement of students under CAI with students learning by conventional means. Therefore, in interpreting meta-analytic findings, it should be recognized that the stronger effect of advisement on lower aptitude students reflects a combination of advisement's stronger effect on CAI low aptitude learners and advisement's weaker effect on conventionally instructed low aptitude students.

Should the CAI and conventional advisement X aptitude interactions exist, as hypothesised, the meta-analytic relationship between advisement and aptitude under CAI may be artificially inflated--the conventional instruction baseline measurement may not be consistent.

CAI, Achievement & Gender

Mathematics

There is a strong tendency for CAI to benefit male students over female students. TABLE 5, following, outlines the overall effect size of all forms of CMI on achievement by gender in learning mathematics.

TABLE 5
CAI, Gender and Mathematics Achievement

Study	Effect Size* Female Students	Effect Size* Male Students
Lee, 1990	0.103 $p > 0.05$	0.336 $p < 0.05$
Burns and Bozeman, 1981	0.17 $p > 0.01$	0.42 $p < 0.01$

* Effect Sizes reflect differences from conventional instruction control groups.

Non-mathematics

TABLE 6
CAI, Gender and Non-mathematics Achievement

Study	Effect Size* Female Students	Effect Size* Male Students
Roblyer et al, 1988	0.17 $p > 0.05$	0.19 $p > 0.05$

* Effect Sizes reflect differences from conventional instruction control groups.

TABLE 6, on non-mathematics learning, follows the pattern established earlier; the effect size for males is higher. This table includes all forms of CAI, including Tutorial, Simulation, Drill and Practice.

Kinzie et al (1987, p 12), in response to a CMI study where high aptitude grade eight female subjects performed poorly on an achievement test, suggested that it "may possibly be related to less positive general attitudes of females toward computers". Kinzie concluded that the combination of a science topic, and computer presentation under program control, may have overwhelmed those subjects who, she found, had a less positive attitude towards both science and computers both before and after the study.

Summary, Advisement Achievement and Gender

Research studies consistently indicate that males tend to benefit more than females under CMI. Kinzie et al's (1987) suggestion, regarding the weaker performance of females under CAI program-control, was based on there being anxiety inherent in any new learning situation, particularly where unfamiliar equipment must be used and computer/program procedures need to be learned. Presumably the type of gender related aversion to computers, mentioned by Kinzie et al (1987), could be largely overcome by ensuring students have adequate CMI experience prior to collecting research data.

Interpretation, Hypotheses

Research by Tennyson (1980, 1981), Tennyson & Buttrey, (1980) and others (Steinberg, Baskin & Hoffer, 1986, Schloss, Winiewski & Cartwright, 1988) indicated that prescriptive advisement improves achievement and learners' ability to make lesson termination decisions. The meta-analytic literature cited throughout this literature review consistently found significant positive effect sizes in favour of Computer Assisted Instruction over conventional instruction.

This leads to the major hypothesis that prescriptive advisement will assist Computer Assisted Instruction with advisement learners more than Computer Assisted Instruction learners without advisement.

In the section on CAI and Achievement at High School, page 25, evidence of the effectiveness of Tutorial mode CAI instruction was presented. In the section on Computer Advisement, Achievement and Aptitude, page 29, a relationship between lower aptitude/greater benefit from CMI and higher aptitude/less benefit from CMI was supported by the literature. This contrasts with Whitener's (1989) non-CAI finding where higher aptitude learners benefited more from advisement than lower aptitude learners.

The reasons why CAI tutorials are so consistently and dramatically effective for lower aptitude learners are open to interpretation--one possible interpretation involves the previously mentioned inherent advisement. Based on this, there is a possibility that lower aptitude learners may benefit more from formal prescriptive CMI advisement, than higher aptitude learners.

This interaction seems feasible since, in conventional instruction, lower-aptitude students may perceive feedback from instructors as negative--or at least believe the instructor has marked and evaluated the learner's performance. The consequent defensiveness or stress on the part of the learner could, predictably, lead to continued poorer performance. In CMI the feedback is from a relatively impersonal machine, and can be made as positive, negative, or neutral as the designer chooses. Students should feel less defensiveness and interpersonal stress, and consequently may perform better.

By using CMI-delivered advisement it was assumed that the learner's defensiveness and anxiety levels would be reduced, leading to an improvement in achievement--if the students are given an opportunity to first become comfortable with the technology.

Since stronger aptitude learners have presumably developed the macro-processing skills of effective review, the weaker aptitude learners should benefit more. Also, the stronger aptitude learners have less improvement available to them.

This leads to the second hypothesis that lower aptitude students would benefit more from prescriptive CMI advisement, than higher aptitude students.

It appears that approximately one half of the CAI studies are 1,000 minutes or less in duration (estimate derived from Lee, 1990 p 89). Therefore, in many studies, students may not have an opportunity to become comfortable with the equipment and the program. There is a possibility, due to the reported females' less positive attitude (Kinzie et al, 1987) towards computers, that this would have a greater negative effect on female students.

This leads to the third hypothesis that there will not be an interaction effect related to gender in this study, as all students had at least six months prior experience with the software and equipment.

The next chapter on methodology will describe how these hypotheses were tested.

CHAPTER III: RESEARCH METHODOLOGY

The purpose of this study is to explore the effect of advisement and its interactions with strength in grade 10 mathematics and gender of subject on mathematics achievement. It was hypothesised that all subjects would experience higher achievement scores from advisement; but that lower mathematics 10 ability subjects would benefit more than higher ability subjects, and that females and males would benefit equally.

This chapter describes the treatment conditions, subjects, assignment of subjects to groups, collection of data and how the data was analyzed.

The following hypotheses were examined:

- The first hypothesis is that students learning from CAI with advisement will reach a higher level of mathematics achievement than students learning from CAI without advisement.
- The second hypothesis is that advisement will assist mathematically weaker learners, more than mathematically stronger learners, in reaching a higher level of mathematics achievement.

- The third hypothesis is that there will not be an interaction effect between advisement and gender, as measured by mathematics achievement.

Treatment Conditions

The three independent variables are: (1) levels of advisement during instruction, (2) mathematical ability as measured by scores on a previous unit of Mathematics 10, and (3) gender. The dependent variable (on which learning conditions effects were judged) was the subjects' mathematics 10 achievement as measured on Unit Five and Six examinations.

Two treatment conditions were established:

1. The experimental condition, CWA (CAI With Advisement) consisted of the subjects receiving two CMI exams that provided feedback on mastery or non-mastery of specific learning objectives, along with a recommendation to study lessons pertaining to unmastered items. A sample prescription is provided in the Appendices.

2. The control group, CWO (CAI Without Advisement), instead of receiving advisement, completed a computer delivered attitude survey.

FIGURE 1
Research Design

CWO
CAI Instruction——> Attitude Survey——> Review Opportunity——> Summative Test
(equalize instructional time, placebo)

CWA
CAI Instruction——> Formative Test——> Review Opportunity——> Summative Test
(detailed advisement given)

This class met for 70 minutes, three times per week, to study Units Five and Six Mathematics 10 by CAI. The CAI instruction began in October 1990. The subjects completed 12 classes on Unit Five and 9 classes on Unit Six.

Instruction was primarily by Computer Assisted Instruction; the teacher rarely supplemented CAI with conventional instruction. Individual assistance was provided to subjects on request. The subjects progressed through the lessons at their own pace; however, they had a schedule and all wrote unit exams at the same time. Additional computer lab time was readily available for subjects who requested it. Prior to the CAI delivered end of unit tests the teacher offered out of class assistance on a group basis. The subjects did not receive CMI advisement tests until unit five.

by conventional existed but was not available to take part in this study.

Variables that were controlled (so they did not confound the study) included:

1. subjects having unequal prior experience in learning mathematics by CAI (CAI learners had six months prior experience);

2. subjects in the CAI without advisement condition bypassing the experimental design to obtain advisement (subjects had access to the advisement programs for a limited time);

3. subjects receiving different amounts of instructional classtime (the CWO control group completed an attitude survey that required an equivalent amount of time to balance the CWA treatment group's testing time);

4. distribution of subject characteristics between the treatment conditions was minimized by a stratified random assignment to groups.

Instructional Content

Mathematics 10, is the name given to a CBI version of the Alberta tenth grade mathematics curriculum. It was developed by Alberta Education, Alberta Correspondence School (now Alberta Distance Learning Resource Centre), and a CBI consulting company between September 1989 and December 1990. Pilot testing occurred during the 1990-91 academic year.

The curriculum consists of 111 lessons (one per objective), 8 unit examinations, and 8 CMI examinations, developed for the Apple Macintosh using Authorware Professional Version 1.5.2. Permission has been granted to reproduce the test items from Units Four, Five and Six in the Appendices.

This highly visual program emphasises the tutorial mode of instruction, not drill and practice. The classroom teacher provided supplementary paper based exercises. Mathematics 10's lessons are interactive, requiring the student to remain alert and attend to task in order to proceed.

In addition to the Mathematics 10 program, prescriptive advisement was given, and the resulting data collected, from Units Five (Coordinate Geometry and Graphing) and Six (Systems of Equations) in Mathematics 10. Please see the Appendices for the instructional objectives of Units Five and Six.

Subjects

The study was conducted in one urban high school in Alberta. One of two Academic Challenge classes of 25 subjects was assigned by the school to Computer Assisted Instruction to learn Mathematics 10. An Academic Challenge class is formed with a group of students deemed to be of higher ability, subject to scheduling restrictions. A complete set of data for 22 subjects was collected. Three subjects, out of the original sample of 25, withdrew for reasons unrelated to the study. This class was the only one learning Mathematics 10 by CAI and was one of two classes composed of Academic Challenge subjects. During the semester that this class started there was a total of 10 Mathematics 10 classes started. This indicates that the subjects in this study were above average in mathematics ability. The class was ethnically diverse, with 14 male and 8 female subjects.

Groups

Two groups were created, and each group received two different treatments as shown in TABLE 7.

TABLE 7
Treatment Schedule

Group	Unit 5 Treatment	Unit 6 Treatment
A	CWA	CWO
B	CWO	CWA

During Unit Five of Mathematics 10 Group A received the experimental treatment while Group B acted as the control. The treatments were reversed in Unit six of Mathematics 10, so Group A served as the control while Group B received the experimental treatment.

Assignment of Learners to Groups

Subject to receiving permission from the appropriate individuals and administrations, each subject received the CAI treatment and was ranked on their performance in an end of Unit four test. On the basis of the end of Unit four test, the subjects were ranked and assigned to groups. The subject with the highest mark was assigned randomly to Group A, the remaining subjects were alternately assigned to Group A or B.

Data Collected

This study generated data on CMI learning prescriptions and test scores, by 25 subjects taking Mathematics 10. Complete data was collected on 22 subjects.

Several end-of-unit examinations were administered by CAI.

1. Unit four test to provide an initial baseline and establish the groups' performance means. This exam had a Hoyt's ANOVA (Hoyt, 1941) reliability of 0.59 using the Lertap program. This lower score indicates that the exam did not measure a unitary trait; however it was considered adequate to be used to divide the subjects into 2 groups.

2. Unit Five test to determine if there were any significant differences between the groups at the end of instruction on Unit five. This exam had a reliability level of 0.84.

3. Unit Six test to determine if there were any significant differences between the groups at the end of instruction on Unit 6. Initially this exam had a reliability level of 0.52. Subsequent analysis resulted in the removal of four items, (questions 12, 19, 22, 27) resulting in a reliability estimate of 0.67.

The following individual learner data was collected:

1. learner name and identification number;

2. overall, and detailed scores by instructional objective, from unit Five and Six formative tests, at the middle of each unit and on completion of the material but a few days prior to the end of unit test;

3. overall scores, from Units Four, Five, and Six end of unit tests;

4. release forms signed by learners and a parent or guardian.

The data was stored on a removable floppy disk that was collected by the researcher at the end of the exam. A file on that disk recorded the subjects' performance data. These files were printed out after each test for analysis.

Data Treatment

To confirm the equivalence of Groups A and B a Hoyt's ANOVA on the reliability of the Unit Four exam was performed, and the means and standard deviations of the test's results were examined.

The relative effectiveness of the two treatments (CWA and CWO) was assessed by end of unit tests after Units Five and Six. Complete data was collected on 22 subjects, 11 from Group A and 11 from Group B.

To test the first hypothesis on subjects under Computer Assisted Instruction with advisement reaching a higher level of mathematics achievement than subjects under Computer Assisted Instruction without advisement, the mathematics scores for Groups A and B in units Five and Six were converted to standardized scores and then combined into a single groiup for each condition (CWA and CWO). A two-factor ANOVR (repeated measures ANOVA), by mathematics ability and advisement, was performed on the CWA and CWO conditions.

To test the second hypothesis on the interaction between strength in mathematics and advisement, the mathematics scores were converted to standardized scores then a two-factor ANOVR (Glass & Hopkins, 1984), by mathematics ability and advisement, was performed on the CWA and CWO achievement math scores.

To test the third hypothesis on the interaction between gender and advisement, the mathematics scores were converted to standardized scores then a two-factor ANOVR, by gender and advisement, was performed on the CWA and CWO achievement (math) scores.

In all cases the significance criteria was .05.

CHAPTER IV: RESULTS

This study explored the main and interaction effects of advisement on mathematics achievement at the 10th grade level, when taught by Computer Assisted Instruction (CAI). The interaction effects examined were a) advisement and strength in Mathematics 10, and b) advisement and gender.

Description of the Results

The probability level of 0.05 was used to determine significance.

Group Equivalence

A 2-tail t-test was calculated on the scores of Unit four for Group A and Group B to verify the success of the stratified assignments to the experimental conditions. Three subjects from the original sample of 25 withdrew from the experiment for reasons unrelated to the study. The hypothesis of no significant difference between Group A and Group B was accepted (t = 0.61, p = 0.55), as shown in TABLE 8.

TABLE 8
t-test of Group A and Group B on Unit 4 (Pretest)

DF: 20 Unpaired t Value: 0.61 Probability (2-tail): .55

Group:	N:	Mean:	Std. Dev.:	Std. Error:
Group A	11	64.36	10.95	3.30
Group B	11	61.09	13.98	4.22

The assumption of equivalence of the Unit Five and Unit Six tests was not examined. However, scores were converted to a standardized form prior to analysis.

Hypothesis One--Achievement With/Without Advisement

The first hypothesis is that students learning from CAI with advisement would reach a higher level of mathematics achievement than students learning from CAI without advisement.

For this analysis the group mathematics scores on Units Five and Six were converted to standardized scores and then combined into a single group for each condition (CWA and CWO). A two-factor ANOVR (repeated measures ANOVA), by mathematics ability and advisement, was performed on the CWA and CWO conditions.

TABLE 9
Repeated Measures Analysis of Variance for Strength in Mathematics by Advisement on Combined Standardized Achievement Scores for Units 5 and 6.

Source	df	SS	MS	f	p
Strength in Mathematics	1	5.02	5.02	4.17	0.05
subjects w/in groups	20	24.09	1.21		
Advisement	1	2.73	2.73	5.71	0.03
Strength X Advisement	1	0.61	0.61	1.27	0.27
advisement X subjects w/in groups	20	9.56	0.48		

Means z and (raw) Scores

Treatment	Groups: Stronger	n	Groups: Weaker	n	Rows
Advisement	0.47 (85.50)	11	-0.03 (78.19)	11	0.25 (81.84)
No Advisement	0.21 (80.17)	11	-0.70 (69.53)	11	-0.25 (74.85)
	0.35	22	-0.35	22	

The null hypotheses of no difference between students receiving or not receiving advisement in Mathematics 10 was rejected ($p < 0.03$) as shown in TABLE 9. As expected, mean scores revealed students who received advisement scored significantly higher than those not receiving advisement.

In order to further identify the difference, separate analyses were conducted on the two unit exam scores. 1-

tail t-tests were calculated on the Unit Five and Six scores of Group A and Group B to examine the effect of advisement on learning Mathematics 10. The hypothesis of no difference between subjects receiving advisement or not receiving advisement was rejected for Unit Five, (p = 0.05) and accepted for Unit Six (p > 0.05), as shown in TABLE 10. Advisement students scored significantly higher on Unit 5 and higher on Unit 6.

TABLE 10
t-test, Group A and Group B raw scores, Units 5 and 6

Unit 5

DF: 20 Unpaired t Value: 1.72 Probability (1-tail): 0.05

Group:	N:	Mean:	Std. Dev.:	Std. Error:
Group A (CWA)	11	89.44	8.67	2.61
Group B (CWO)	11	78.85	18.48	5.57

Unit 6

DF: 20 Unpaired t Value: -0.68 Probability (1-tail): 0.25

Group:	N:	Mean:	Std. Dev.:	Std. Error:
Group A (CWO)	11	70.86	13.28	4.00
Group B (CWA)	11	74.24	9.83	2.96

Hypothesis Two--Interactions Between Strength/Advisement

The second hypothesis is that advisement would assist mathematically weaker learners, more than mathematically stronger learners, in reaching a higher level of mathematics achievement.

For this analysis the group mathematics scores on Units Five and Six were converted to standardized scores and then combined into a single group for each condition (CWA and CWO). A two-factor ANOVR (repeated measures ANOVA), by mathematics ability and advisement, was performed on the CWA and CWO conditions.

TABLE 9 provides the ANOVR summary table. The null hypothesis of no interaction between strength in mathematics and advisement was supported. Advisement did not differentially affect students, in this sample, performing at different levels of mathematics achievement as measured by scores on the Unit 4 examination.

Stronger students scored higher than weaker students ($p < 0.05$).

Hypothesis Three--Interactions Between Gender/Advisement

The third hypothesis is that there would not be an interaction effect between advisement and gender, as measured by reaching a higher level of mathematics achievement.

For this analysis the group mathematics scores on Unit Five and Six were converted to standardized scores and then combined into a single group for each condition (CWA and CWO). A two-factor ANOVR (repeated measures ANOVA), by gender and advisement, was performed on the CWA and CWO conditions.

As predicted, TABLE 11 indicates acceptance of the hypothesis of no significant interactions between gender and advisement. Both male and female subjects, in grade 10 mathematics, benefited by CMI advisement at the 0.05 significance level.

TABLE 11
Repeated Measures Analysis of Variance for Gender and Advisement on Combined Standardized Achievement Scores for Units 5 and 6.

Source	df	SS	MS	*f*	*p*
Gender	1	0.37	0.37	0.26	0.62
subjects w/in groups	20	28.74	1.44		
Advisement	1	2.73	2.73	5.37	0.03
Gender X Advisement	1	0.00	0.00	0.00	0.96
advisement X subjects w/in groups	20	10.16	0.51		

Means (z-scores)

	Groups				
Treatment	Male	n	Female	n	Rows
Advisement	0.18 (79.12)	14	0.38 (86.61)	8	0.25 (81.84)
No Advisement	-0.31 (75.35)	14	-0.14 (73.98)	8	-0.25 (74.85)
	-0.08 (77.24)	28	-0.22 (80.29)	16	

CHAPTER V: DISCUSSION OF RESULTS

The purpose of this study is to explore the effect of advisement on learning Mathematics 10 and the interactions with strength in grade 10 mathematics and gender of subject. It was hypothesised that all subjects would benefit from advisement; lower mathematics 10 ability subjects would benefit more than higher ability subjects, and that females and males would benefit equally.

This chapter begins by discussing the findings of the study as they relate to each of the hypotheses tested, and influences that may have affected the subjects' performances, and the study's results. The discussion continues with implications drawn from these findings, and how they may affect learners who posses these attributes as they study mathematics by CAI.

Discussion of the Hypotheses Tested

The First Hypothesis

The first hypothesis on the main effect--subjects under Computer Assisted Instruction with advisement reaching a higher level of mathematics achievement than subjects under Computer Assisted Instruction without advisement was supported by the ANOVR analysis reported in TABLE 9. In t-tests it was supported in Unit 5, but not Unit 6.

In TABLE 10 the difference between CWA and CWO test results on Unit Five was 11%, favouring CWA which received the advisement.

However, in Unit Six of the same table, there was only a 3% benefit from advisement. This mixed finding raises an interesting question--was there a reason that advisement had a reduced apparent effect on the subjects in this unit?

This could be a result of the subjects finding Unit Five (Coordinate Geometry and Graphing) more visual, less difficult and less abstract than Unit Six (Systems of Equations). If Unit Six was very difficult for the students it may have overwhelmed any effect due to advisement. This possibility is supported by comments from students and TABLE 10 where the class average was 12% lower in Unit Six compared to Unit Five.

Also, the Hoyt reliability score for Unit Five was 0.82, and Unit Six was 0.67. A Hoyt reliability of 0.67 is considered marginal.

A third plausible hypothesis comes meta-cognititive research (page 18). There are indications that students could learn me[illegible]gnitive techniques after they had been modeled for them. If this were the case, then in Unit Six instead of Group B not benefiting from the advisement, their relative improvement may have been masked by an improved performance by members of Group A. This could occur if the Group A subjects had learned to recognize when they did not know specific objectives, and then compensated by using better learning techniques. As Unit 5 was the first time they were exposed to CMI advisory tests this explanation appears to be reasonable.

If this is the case, advisement tests could be used not only to give advisement but also to teach meta-cognitive techniques. This is potentially an area of research that could provide significant benefits.

The Second Hypothesis

The Second Hypotheses on the interaction between strength in mathematics and advisement; predicting that advisement would assist mathematically weaker subjects more than stronger subjects was not supported by the data.

Figure 2 shows the effect of advisement on the subject's end of unit tests. The standard deviations of the standardized scores in both the Unit four Pretest and the CWO condition are similar; however, the variance of the scores under CWA is markedly reduced--due to there being fewer lower marks.

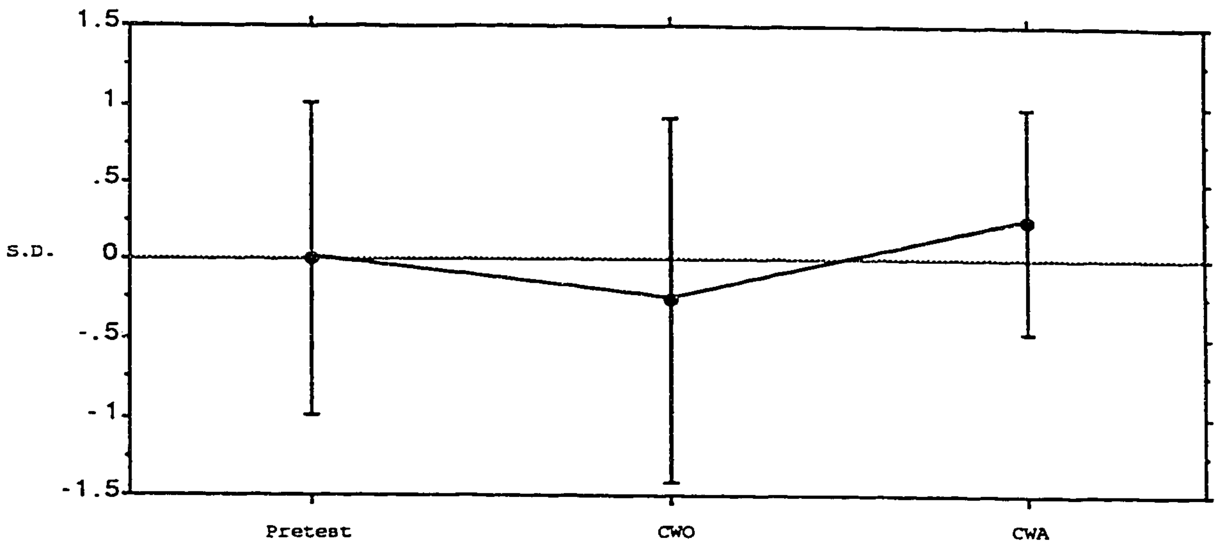
TABLE 9 supports this interpretation. Under advisement stronger students improved on the average (85.5 - 80.2) 5.3%, weaker students improved by (78.2 - 69.5) 8.7%.

This interaction was predicted on the basis of a consistent interaction in the CAI meta-analytic literature. A plausible explanation for the lack of significance can be derived from Hativa (1988), who warns that in CAI meta-analysis the baseline measurement is conventional instruction, and Whitener (1989) who found support for advisement benefiting higher aptitude students more than lower aptitude students under conventional instruction (see page 32, 33).

Therefore, it is possible that the CAI results are not as strong as indicated in the meta-analyses--some of the reported CAI interaction strength may be a result of using conventional instruction as a baseline. This inflation could occur if the two opposite interactions act on the CAI meta-analyses, which measure the difference between CAI and conventional instruction. If this is the situation the aptitude/advisement interaction would be weaker than the meta-analytic literature suggests, or not exist at all.

Two other explanations could also account for this lack of significance. Significant results may not have been found due to the small sample size. Or, advisement may be helpful in raising low marks, but may have less positive effect on subjects who are very strong in mathematics. This could be due to a ceiling effect, if the better academic challenge students had already performed at their maximum. The latter hypothesis seems likely, in the Academic Challenge group stronger subjects were typically performing in the 90% range.

FIGURE 2
Variance of Scores by Treatment



The Third Hypothesis

The Third Hypotheses on the interaction between gender and advisement; predicting that there would be no interaction between gender and advisement relating to achievement in Mathematics 10 was supported.

Most research on CBI have involved short term studies. This study is unusual in that the subjects had all been learning Mathematics 10 by CAI for the previous six months. It was hypothesised that there would not be a deleterious effect on female subjects as they would have had an opportunity to overcome any anxiety over using computers prior to the study beginning.

TABLE 11 indicates that males benefited by a z-score of (0.18 + .31) .49, while females benefited by (.34 + .14) .44. The probability of .96 supports the hypotheses of no significant gender-advisement interactions.

Summary, Conclusions and Implications

This summary will outline the conclusions and implications that can be made about advisory CMI testing on the basis of the research questions posed in Chapter 2.

Assistance for Students Learning Mathematics

It seems that advisory CMI testing may be a useful tool to assist students in improving their achievement in mathematics 10. Whether this improvement is the result of practice, drill, providing a meta-cognitive knowledge of mastery, or a combination of the three, is uncertain as CMI advisement inherently provides all three benefits to the student.

These benefits appear to be robust, the literature consistently finds appropriate CBI to be an effective means of instruction.

Assistance for Students Weak in Mathematics

Most ATI studies include a wide range of student ability levels. The subjects in this study were members of an Academic Challenge class, and therefore represent above average students.

Given this limitation, on the basis of this study and an interpretation of the meta-analytic literature in the light of Hativa (1988) and Whitener's (1989) works, it appears possible that advisory CMI testing may have less of an effect favouring lower aptitude learners than the meta-analyses would indicate. Hativa also suggests that, in situations where CAI students can progress at their own pace, the gap between weaker and stronger students may continue to widen.

No Significant Gender Related Interactions

On the basis of this study, it appears that there should be little concern regarding female students learning mathematics by Computer Assisted Instruction, or receiving advisory CMI testing. Kinzie's (1987) observations in this area may be the result of her younger female students being less experienced in the use of computers.

In this study it was hypothesised that as all students had approximately six months experience learning mathematics 10 by CAI, female students would have largely overcome any anxiety they may have experienced. The strategy of ensuring an adequate orientation to computers would assist any student, male or female, who is uneasy with computers.

The reliability of these results may be weak due to the small numbers of females available for this study.

Modelling Meta-cognitive Skills with CMI Testing

In the study, it was found that students in Group A received a significant benefit from the advisory CMI testing during Unit 5. However, when Group B received their advisory CMI testing in Unit six, less improvement relative to Group A was apparent.

One plausible explanation is that Group A students could have used improved meta-cognitive techniques, identified and overcome learning deficiencies, and by their improved performance masked Group B's improvement. If so, this would mean that the students in Group A learned meta-cognitive skills due to their advisement during Unit Five, and then applied them during Unit Six.

If students can learn certain meta-cognitive skills by having them modeled in an advisory CMI exam, it would provide a long term benefit that could positively affect other subject areas as well. As this type of meta-cognitive training may be of significant benefit to learners it is an area worthy of further research.

Suggestions For Further Research

The complex nature of CAI and advisement means that a number of variables can affect the research results. Some of these variables offer opportunities for further research; opportunities that may lead to effective instructional strategies.

This study examined gender/advisement interactions, but not the gender differences in mathematics ability that have been reported in the literature. TABLE 11 reveals that there were no significant differences in mathematics achievement between males and females in this study. Also, on the basis of the Unit Four test, 7 of the 14 males in the final sample rated as stronger, as did 4 of 8 females. At this point the subjects had six months of learning mathematics 10 by CAI. There are a number of hypotheses that could be posed to examine this.

1. CAI may reduce the gender gap in mathematics performance, by lowering male and/or raising female test scores.
2. The sample size may have been too small to detect a difference.
3. The female sample in the study may have had stronger than usual mathematical skills.

The sample used in the study was not randomly selected, they were an Academic Challenge class composed of generally stronger mathematics students. Due to the pre-selection of subjects the full range of student abilities and possible gender differences may not be represented. Considering Lee's (1990) and Burns & Bozeman's (1981) findings (TABLE 5) that CAI benefits males learning mathematics more than females, it is likely that those observations in this study are due to the Academic Challenge students being invited to take the course based on prior academic achievement.

Some potentially significant research opportunities identified in this study include:

1. does the effect of CAI advisement favour lower aptitude learners as strongly as the meta-analytic literature suggests, or is it in part an artifact caused by the conventional instruction baseline used,

2. is the finding in this study that female and male subjects benefited equally from advisement, a result of the six month familiarization with CAI, or a result of the pre-selection involved in an Academic Challenge class,

3. in Unit 6 was the lack of significant main effect from advisement due to CMI advisement working better for less difficult, abstract, and/or more visual topics, or were the effects obscured by the lower reliability of the test used in Unit 6, or a result of subjects learning new meta-cognitive skill, and

4. can CAI be used to teach meta-cognitive skills as a by-product of advisement.

5. are the benefits from CMI advisement due to the diagnostic test's additional drill and review, or due to the prescriptive advice given.

Generalizability of Findings

One issue that must be addressed is the generalizability of the findings of a study to populations other than the subject group. In this study the subject population was a group of ethnically diverse students in an urban Alberta Mathematics 10 Academic Challenge class. Due to the small number of female students (8), and small total sample size (22) the findings for female students should be regarded with caution.

The results of this study should be generalizable to a wide cross-section of Alberta High School mathematics students with better than average mathematics skills. It should be noted that in the study the terms weaker and stronger in mathematics referred to the range of abilities in the Academic Challenge subject group.

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APPENDIX 1 Consent Form

University of Alberta
Department of Adult Career and Technology
Thesis Title: Computer Assisted Instruction and Advisement

Consent Form

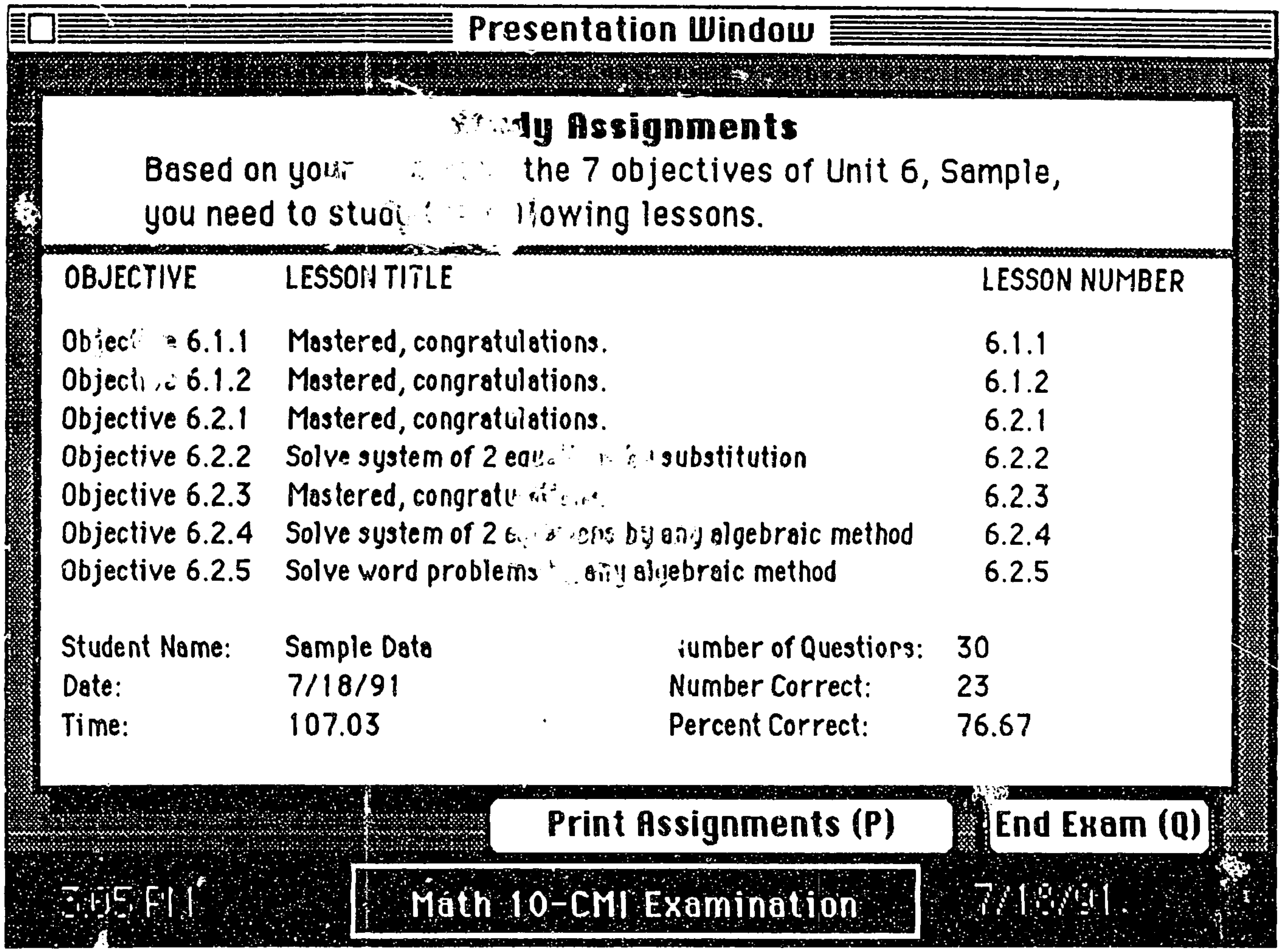
Having been asked by Evans Forsyth, a graduate student in the Department of Adult Career and Technology, to be in a research project, I understand that:

- this study looks into instructional design, student characteristics, and success in learning Mathematics 10 by Computer Assisted Instruction.
- this study involves only my Mathematics 10 course.
- the research data collected as a part of this study will not affect my mark in Mathematics 10.
- the researcher will have access to my marks on units 4, 5, and 6 of Mathematics 10.
- all data regarding my progress in Mathematics 10 will be private.
- on all records regarding my progress in Mathematics 10 I will be known by an identification number, and only the researcher will have access to the master list matching names and code numbers.
- this study will last from approximately April 1 to May 15.
- my being in this study is completely my choice and that I may refuse to take part and/or quit the study at any time.
- I may express any concerns I might have about the study to my teacher, the researcher (Evans Forsyth, 450-8476), or the supervisor of this project (Dr. M. Szabo, Professor in the Department of Adult Career and Technology, 492-0715).
- to maintain privacy, my name will not be in any report or thesis.
- the thesis this study leads to will be available for examination at the University of Alberta Library.

On the basis of these understandings I agree to take part.

______________________ Student Name	______________________ Parent/Guardian Name
______________________ Student Signature	______________________ Parent/Guardian Signature
______________________ Date	______________________ Date

APPENDIX 2 Advisement Forms


Presentation Window
Assignments
Based on your the 7 objectives of Unit 6, Sample,
you need to stud lowing lessons.
OBJECTIVE
LESSON TITLE
LESSON NUMBER
6.1.1
Mastered, congratulations.
6.1.1
6.1.2
Mastered, congratulations.
6.1.2
Objective 6.2.1
Mastered, congratulations.
6.2.1
Objective 6.2.2
Solve system of 2 substitution
6.2.2
Objective 6.2.3
Mastered, congrat
6.2.3
Objective 6.2.4
Solve system of 2 by any algebraic method
6.2.4
Objective 6.2.5
Solve word problems algebraic method
6.2.5
Student Name:
Sample Data
umber of Questions:
30
Date:
7/18/91
Number Correct:
23
Time:
107.03
Percent Correct:
76.67
Print Assignments (P)
End Exam (Q)
Math 10-CMI Examination

APPENDIX 3 Hoyt's Reliability of CMI Exams

Data From Test 4

Questions omitted, none.

Number of Individuals	= 23.00	Number of Items	= 25.00
Mean	= 15.39	Highest Score	= 21.00
Standard Deviation	= 3.24	Lowest Score	= 7.00

Source of Variance	D.F.	S.S.	M.S.
Individuals	22.00	2.26	0.42
Items	24.00	36.23	1.51
Residual	528.00	90.57	0.17
TOTAL	574.00	136.06	0.24

Hoyte Estimate of Reliability = 0.59
Standard Error of Measurement = 2.03

Data From Test 5

Questions omitted, none.

Number of Individuals	= 24.00	Number of Items	= 31.00
Mean	= 25.79	Highest Score	= 31.00
Standard Deviation	= 4.56	Lowest Score	= 13.00

Source of Variance	D.F.	S.S.	M.S.
Individuals	23.00	15.42	0.67
Items	30.00	12.29	0.41
Residual	690.00	76.29	0.11
TOTAL	743.00	104.00	0.14

Hoyte Estimate of Reliability = 0.84
Standard Error of Measurement = 1.82

Data From Test 6

Questions omitted, 12, 19, 22, 27.

Number of Individuals	= 24.00	Number of Items	= 24.00
Mean	= 16.92	Highest Score	= 21.00
Standard Deviation	= 3.22	Lowest Score	= 9.00

Source of Variance	D.F.	S.S.	M.S.
Individuals	23.00	9.91	0.43
Items	23.00	35.49	1.54
Residual	529.00	74.42	0.14
TOTAL	575.00	119.83	0.21

Hoyte Estimate of Reliability = 0.67
Standard Error of Measurement = 1.80

APPENDIX 4 Unit 4 End of Unit Exam, Paper Format

Name : ___________________

INFORMATION:

1. The greatest common factor of $-4x^2$, $12x^4$, and $20\ x^3$ is

a. 2
b. 4
c. 2x
d. 4x
e. $4x^2$

2. A complete factorization of $16x^2+8x$ is

a. $4x(4x+2)$
b. $8(2x^2+x)$
c. $16x(x+0.5)$
d. $8x(2x+1)$
e. $8x(2x)$

3. Which of the following groupings would result in a correct factorization of $am^2+amn-km-kn$?

a. $(am^2+amn)+(-km-kn)$
b. $(am^2-km)+(amn-kn)$
c. $(am^2+amn)-(km-kn)$
d. a and b
e. a and c

4. The correct factorization of $x^2(x-3)+(x-3)$ is

a. $(x-3)(x^2+1)$
b. $(x-3)(x^2)$
c. x^3-3x^2+x-3
d. $(x^2)(x-3)^2$
e. $2x^2(x-3)$

5. What two integers have a product of -35 and a sum of 2.?

a. 5 and 7
b. -5 and 7
c. 5 and -7
d. -5 and -7
e. There are none.

6. A complete factorization of $r^2-3r-28$ is

a. $(r-7)(r-4)$
b. $(r+7)(r-4)$
c. $(r-7)(r+4)$
d. $(r+7)(r+4)$
e. $(r-14)(r+2)$

7. To factor $2x^2+13x+15$ the middle term, 13x, would be rewritten as

a. $15x-2x$
b. $30x-17x$
c. $10x+3x$
d. $-10x-3x$
e. $26x-13x$

8. A complete factorization of $4x^2+6x-4$ is

a. $2(2x^2+3x-2)$
b. $2(2x-1)(x+2)$
c. $2(2x+1)(x-2)$
d. $(4x-2)(x+2)$
e. $(2x-1)(4x+4)$

9. The value of k that would make $4x^2-12x+k$ a perfect square trinomial is

a. 9
b. 16
c. 25
d. 49
e. 64

10. Which one of the following is a perfect square trinomial?

a. x^2+x+1
b. $9x^2-6x+4$
c. $4x^2+2xy+y^2$
d. $x^2-10x-25$
e. $4x^2+14x+49$

11. The area of a square is $(16x^2-24x+9)$ square meters. If the perimeter of the square is 36 meters, the value of x is

a. 4
b. 9.75
c. 1.5
d. 3
e. 0

12. A correct factorization of $4x^2-4x+1$ is

a. $(2x-1)^2$ or $(1-2x)^2$
b. just $(2x-1)^2$
c. just $(2x+1)^2$
d. just $(1-2x)^2$
e. $(2x-1)^2$ or $(2x+1)^2$

13. The product of $3x+5$ and its conjugate is

a. $9x^2-25$
b. $9x^2+25$
c. $9x^2-30x+25$
d. $9x^2+30x+25$
e. 1

14. A complete factorization of $9x^2-25$ is

a. $(3x-5)^2$
b. $(3x+5)^2$
c. $(3x+5)(3x-5)$
d. $(9x-5)(9x+5)$
e. $(9x-5)^2$

15. A complete factorization of x^4-16 is

a. $(x^2-4)(x^2+4)$
b. $(x^2-4)^2$
c. $(x^2+4)^2$
d. $(x+2)(x-2)(x^2+4)$
e. $(x+2)^2(x-2)^2$

16. A complete factorization of $4y(x^2-1)-12(x^2-1)$ is

a. $(x^2-1)(4y-12)$
b. $4(x^2-1)(y-3)$
c. $4x^2y-4y-12x^2+12$
d. $4(x-1)(x+1)(y-3)$
e. $4(x-1)^2(y-3)$

17. A complete factorization of $2ar^2+4ar+2a$ is

a. $2(ar^2+2ar+a)$
b. $2(ar+a)(r+1)$
c. $2a(r+0)(r+1)$
d. $2ar(r+1)^2$
e. $2a(r+1)^2$

18. A complete factorization of $9x^4-37x^2+4$ is

a. $(3x+1)^2(3x-1)^2$
b. $(3x^2-2)^2$
c. $(3x+1)(3x-1)(x+1)(x-1)$
d. $(3x^2+2)^2$
e. $(9x^2-1)(x^2-4)$

19. The real zero(s) of x^3-7x^2+12x is (are)

a. 0
b. 3
c. 4
d. 3 and 4
e. 0,3 and 4

20. Which one of the following polynomials has zeros of 0.5 and -3?

a. $2x^2-11x-6$
b. $2x^2+7x+3$
c. $2x^2-5x-3$
d. $2x^2-7x+3$
e. $2x^2+5x-3$

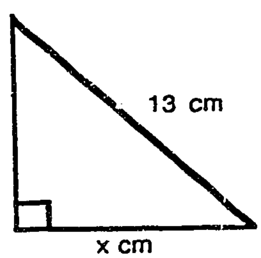
21. The roots of the quadratic equation $x^2+2x+1=64$ are

a. 7 and 9
b. -7 and 9
c. 7 and -9
d. -7 and -9
e. not real numbers

22. The roots of the equation $2x^2 = 4-7x$ are

a. 0.5 and 4
b. 0.5 and -4
c. -0.5 and 4
d. -0.5 and -4
e. { }

23.



If the perimeter of the above triangle is 30 cm, which one of the following equations could be used to determine the lengths of the two legs?

a. $x^2+(17-x)^2 = 13^2$
b. $x^2+(13-x)^2 = 13^2$
c. $x^2+17^2 = 13^2$
d. $x^2+(30-x)^2 = 13^2$
e. $x^2+(17-x)^2 = 30^2$

24.

The outside dimensions of a picture like the one above are 40 cm by 80 cm. If the area of the uniform border is 464 cm^2, then, which of the following equations could be used to determine the width of the uniform border?

a. $80x+80x+40x+40x = 464$
b. $(80-x)(40-x) = 2736$
c. $80x+80x+ x(40-2x) + x(40-2x) = 464$
d. a and b
e. a and c

25. A rock shot with a slingshot and given an upward velocity of **v** m/s achieves a height, **h**,in meters given by the formula $h = vt-0.5gt^2$ after time, **t**, in seconds.(**g** is the acceleration due to gravity)
How many seconds would it take a rock to return to the earth, if it was shot with an initial velocity of 15m/s ? (Use g=10)

a. 15 s
b. 1.5 s
c. 3 s
d. 0.3 s
e. 10 s

KEY

1. e
2. d
3. d
4. a
5. b
6. c
7. c
8. b
9. a
10. e
11. d
12. a
13. a
14. c
15. d
16. d
17. e
18. c
19. e
20. e
21. c
22. b
23. a
24. c
25. No solution given

APPENDIX 5 Unit 5 End of Unit Exam, Paper Format

Name : ____________________

MATH 10 UNIT V

INFORMATION:

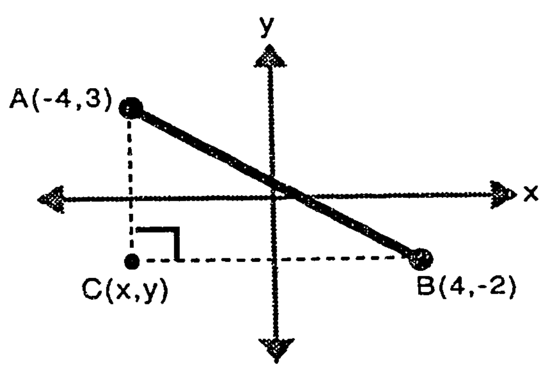
1. The point M(-3,5) is a point of

   a. Quadrant 1
   b. Quadrant 2
   c. Quadrant 3
   d. Quadrant 4
   e. the horizontal axis

2. The coordinates of a point of the vertical axis are

   a. (2,8)
   b. (-2,-1)
   c. (0,-3)
   d. (-6,0)
   e. (5,-1)

3.



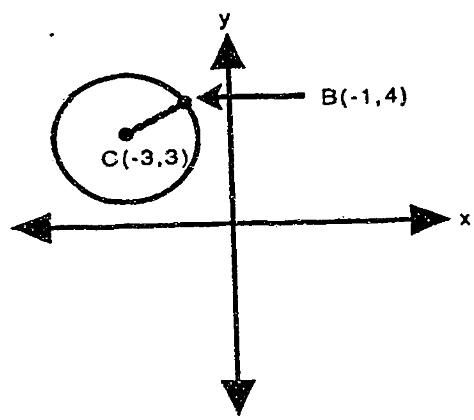
In the above diagram, what are the coordinates of C?

   a. (3,-2)
   b. (4,3)
   c. (-4,-2)
   d. (3,-4)
   e. (-4,4)

4. If A(3,2) and B(-5,-1), determine the distance from A to B to the nearest tenth unit.

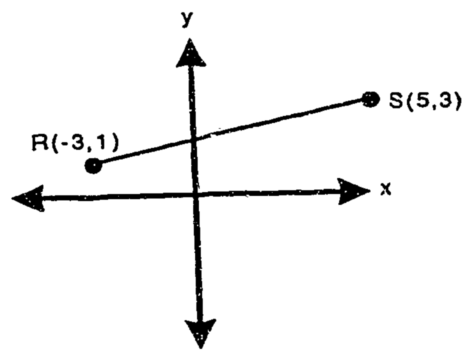
a. 2.2 units
b. 8.5 units
c. 3.3 units
d. 8.1 units
e. 8.0 units

5. If the center of the circle in the diagram is C and B is a point of the circle, then, to the nearest tenth of a unit, what is the length of the diameter of this circle to the nearest tenth?



a. 4.5
b. 8.2
c. 4.1
d. 2.2
e. 8.1

6. For the diagram at the right, what are the coordinates of the mid-point of segment RS?

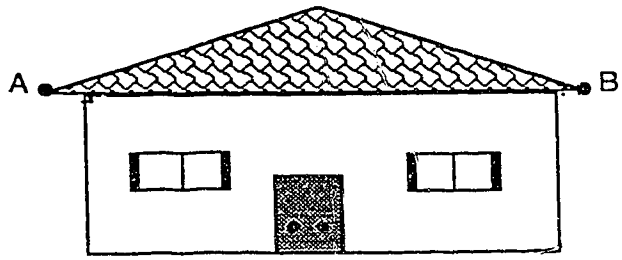


a. (1,2)
b. (2,1)
c. (4,2)
d. (2,4)
e. (0,2)

7. The coordinates of the mid-point of segment AB are (5,-1). If A(3,4), what are the coordinates of B?

a. (7,-6)
b. (4,1.5)
c. (0,-1.5)
d. (8,3)
e. (7,-5)

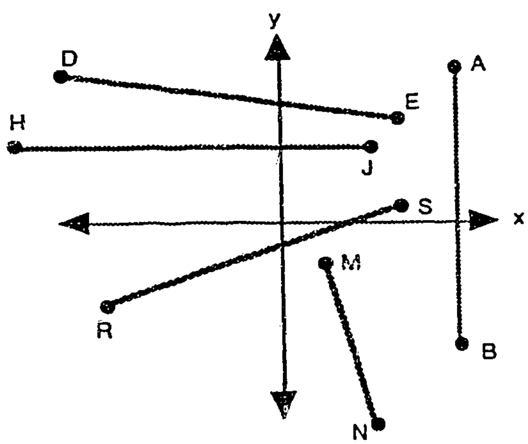
8.



The roof of the house in the diagram has a slope of 0.25. If the distance from A to B is 8m, what is the rise of the roof?

a. 2 m
b. 3 m
c. 32 m
d. 1 m
e. 16m

9.



Which line segment in the above diagram has a slope of zero?

a. $\overline{AB}$

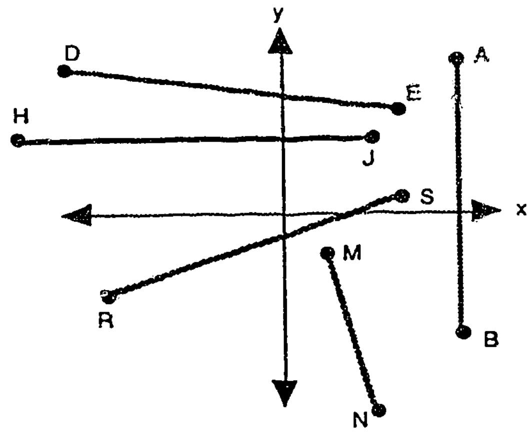
b. $\overline{MN}$

c. $\overline{HJ}$

d. $\overline{DE}$

e. $\overline{RS}$

10.



Which line segment in the above diagram has a slope of 0.4?

a. $\overline{AB}$

b. $\overline{MN}$

c. $\overline{HJ}$

d. $\overline{DE}$

e. $\overline{RS}$

11. Determine the slope of line AB, if A(-2,0) and B(0,4).

a. 2
b. - 2
c. 1 / 2
d. - 1 / 2
e. 0

12. What is the slope of a line parallel to a the line defined by the equation 3x-y+2 = 0?

a. 3
b. - 3
c. 1 / 3
d. - 1 / 3
e. 0

13\. What is the slope of a line perpendicular to a line with a slope of 1/2?

a. - 1 / 2
b. 1 / 2
c. 2
d. - 2
e. undefined

14\. If the slope of segment AB is equal to the slope of segment BC, then points A,B and C are

a. equal points
b. collinear
c. equidistant
d. interior points
e. parallel

15\. If A(2,5) and B(4,-2) are collinear with C(x,6), then what is the value of x?

a. 1 [illegible]
b. 1 3/[illegible]
c. 1 5/7
d. 1 7/9
e. 2 2/7

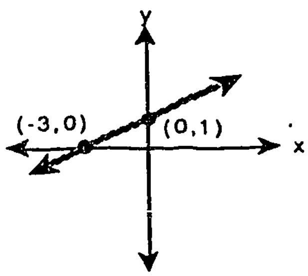
16\. The straight-line path of a moving object is defined by the linear equation 2x+3y = 6. Determine the x-coordinate of the object when its y-coordinate is-1.

a. 4.5
b. -4.5
c. 1.5
d. -1.5
e. 2.6...

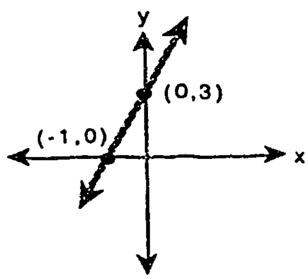
17.

The graph of the line with x-intercept of -1 and y-intercept of 3 is

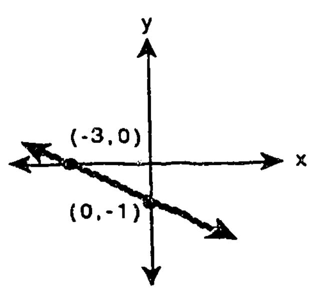
a.



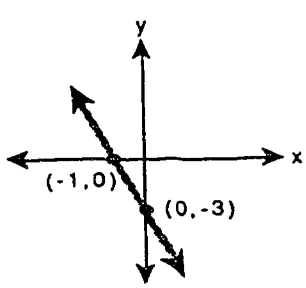
b.



c.



d.



e.

18. What is the y-intercept of the line defined by 3x-7y+15 = 0?

a. 5
b. - 5
c. 2 1/7
d. -2 1/7
e. -0.46...

19. Determine the x-intercept of the line defined by y = -3x+5.

a. 1 2/3
b. -1 2/3
c. 5
d. - 5
e. -0.6

20. The formula for the volume of a right rectangular prism is V = lwh. Solving this formula for h would result in h=

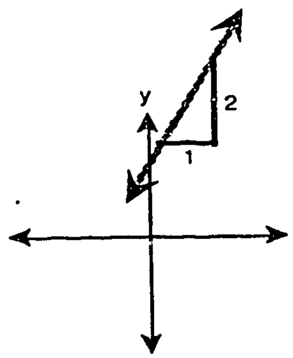
a. V-lw
b. lw-V
c. V/lw
d. lw/V
e. V-l-w

21. The slope and y-inytercept of the line defined by 3x+4y = 12 are, respectively

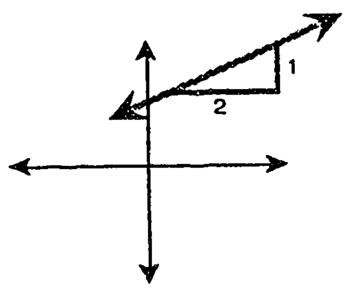
a. 4/3, 4
b. -4/3, 4
c. 3/4, 4
d. -3/4, 3
e. 3, -3/4

22. The graph of the line with slope of 1/2 and y-intercept 3 is

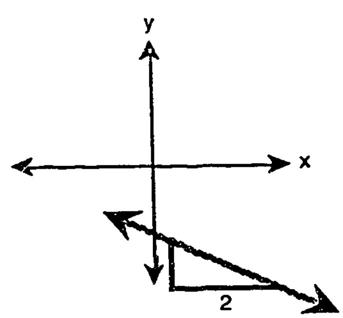
a.



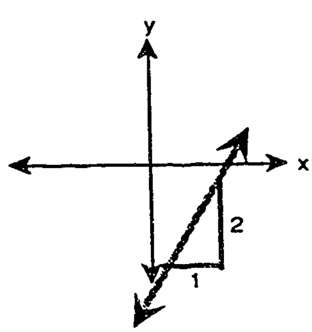
b.



c.



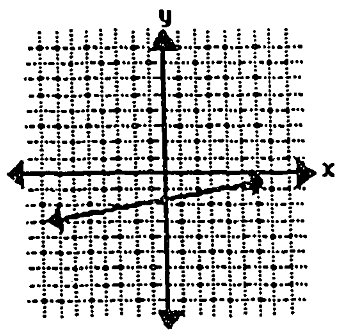
d.



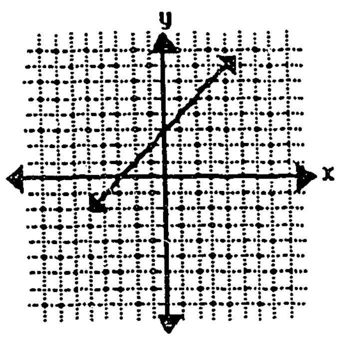
e.

23. .The graph of the line with slope 0.2 and passing through A(-1,2) is

a.



b.



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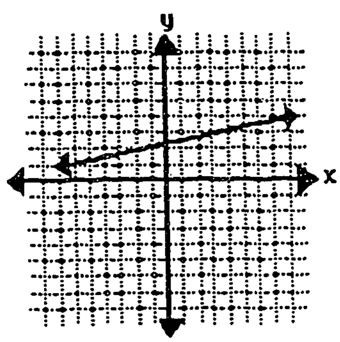

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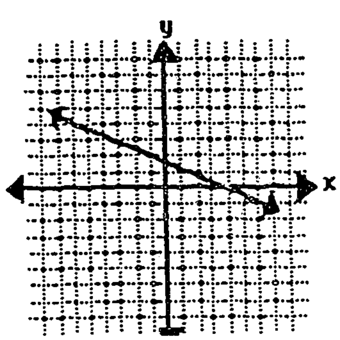
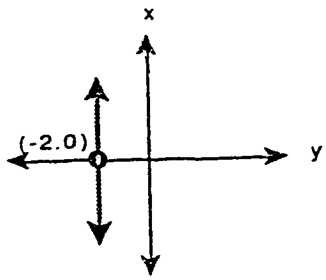
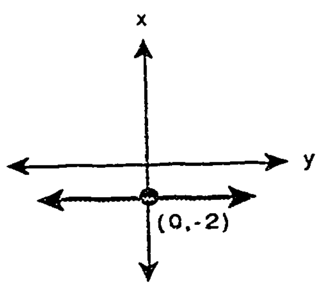


24. .
The graph of the line defined by y+2=0 is

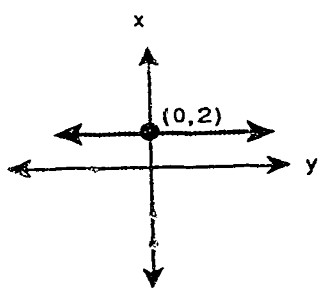
a.



b.



c.



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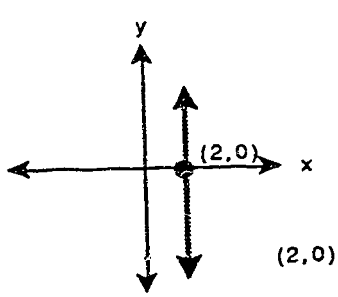
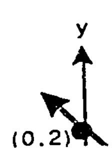


e.



25. The equation, y-4 = 3(x-2), expressed in the form Ax+By+C = 0 where A, B and C are integers is

a. 3x-y-2 = 0
b. -3x+y-2 = 0
c. 3x-y-10 = 0
d. -3x+y-10 = 0
e. 3x+y-10 = 0

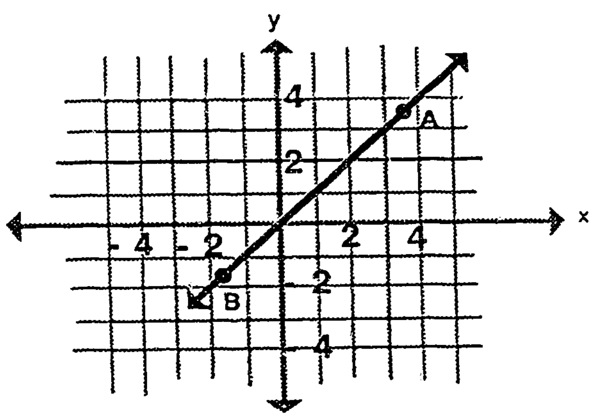
26. The equation of a line with slope -2 and y-intercept -6 is

a. 2x+y+6 = 0
b. x+2y+6 = 0
c. 6x+y+2 = 0
d. x+6y+2 = 0
e. 2x-y-6 = 0

27. The defining equation of the line passing through (5,-8) and (4,-2) is

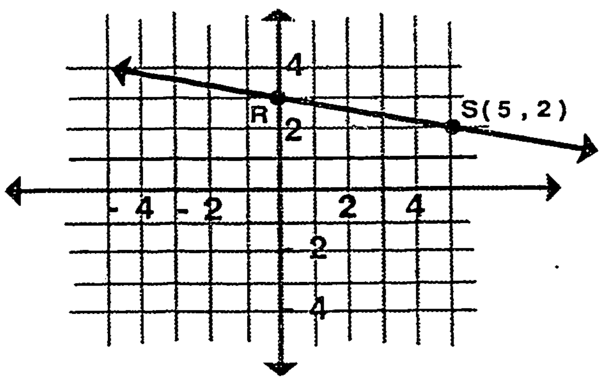
a. x-6y-13 = 0
b. x-6y-53 = 0
c. 6x-y-38 = 0
d. 6x+y-22 = 0
e. x+6y+13 = 0

28.



For the above diagram, the defining equation of line AB is

a. x+y = 0
b. x-y = 0
c. x-2y = 0
d. x+2y = 0
e. x-y = 2

29. 

The defining equation of line RS in the above diagram is

a. y = (1/5) x+3
b. y = -(1/5) x+3
c. y = 5x-3
d. y = -5x+3
e. x-5y = 0

30. The defining equation of the line parallel to the vertical axis and passing through W(5,8) is

a. x-5 = 0
b. x+5 = 0
c. y+8 = 0
d. y-8 = 0
e. x-8 = 0

31. The equation of the line passing throuigh (-3,-2) and perpendicular to the line defined by 2x+3y = 9 is

a. 2x-3y+6 = 0
b. 2x-3y = 0
c. 3x-2y+13 = 0
d. 2x-y+1 = 0
e. 3x+2y-13 = 0

MATH 10 UNIT V
KEY

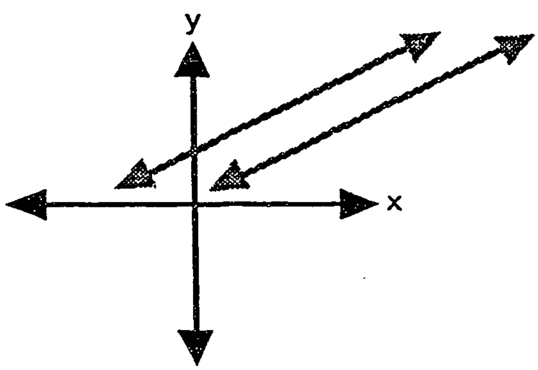
1. b
2. c
3. c
4. b
5. a
6. a
7. a
8. d
9. c
10. e
11. a
12. a
13. d
14. b
15. c
16. a
17. b
18. c
19. a
20. c
21. d
22. b
23. c
24. b
25. a
26. a
27. d
28. b
29. b
30. a
31. c

APPENDIX 6 Unit 6 End of Unit Exam, Paper Format

Name : ____________________

INFORMATION:

1.

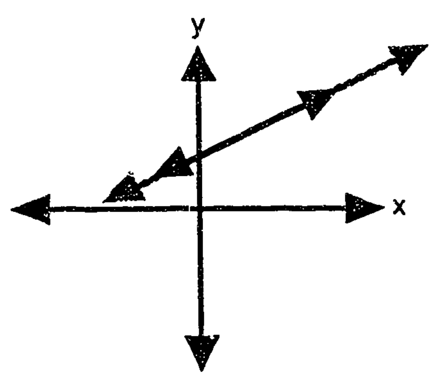


The graph of a system of two linear equations is given in the above diagram. The system could best be described as

a. independent
b. dependent
c. inconsistent
d. intersecting
e. coincident

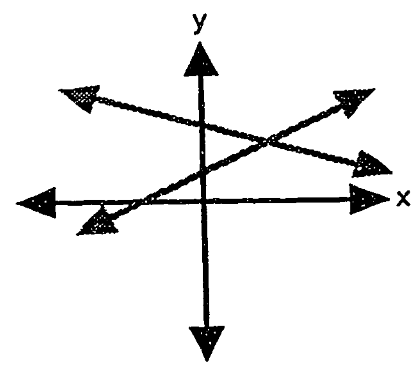
2. The graph of a system of two linear equations is given at the right. This sysytem could best be described as

a. independent
b. dependent
c. inconsistent
d. intersecting
e. parallel



3. The graph of a system of two linear equations is shown at the right. This system could best be described as

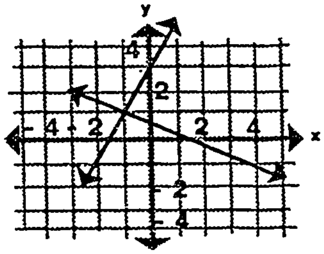
   a. independent
   b. dependent
   c. inconsistent
   d. parallel
   e. coincident



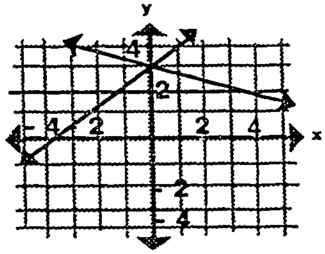
4. .Which diagram, below, is the graphical solution for the following system of linear equations?

2y-x=-3
y-x=-2

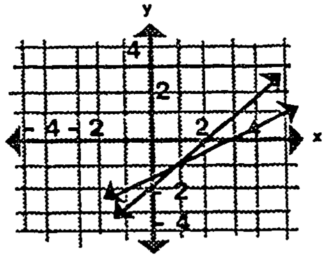
a.



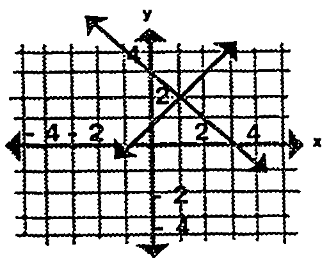
b.



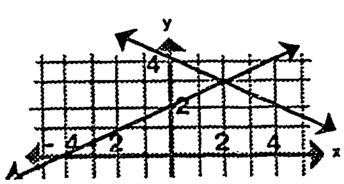
c.



d.



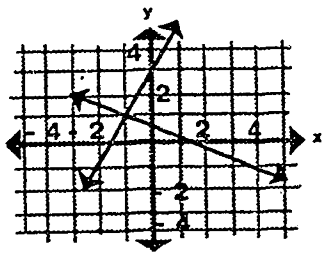
e.



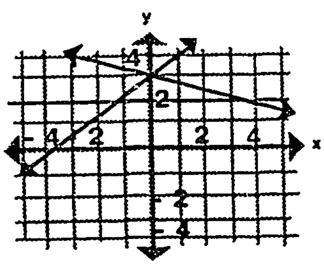
5. Which diagram, below, is the graphical solution for the following system of linear equations?

$$x+2y=8$$
$$2y-x=4$$

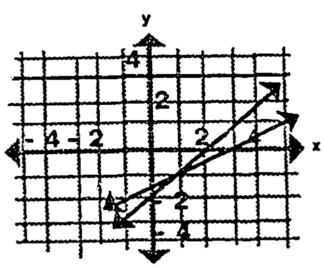
a.



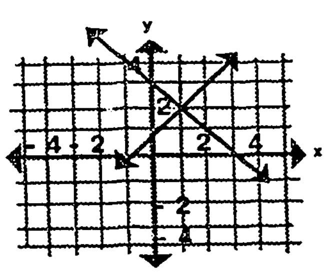
b.



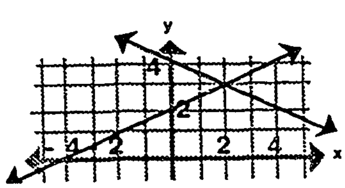
c.



d.



e.



6. How many ordered pairs are there in the solution of an independet system of two linear equations?

   a. none
   b. exactly one
   c. exactly two
   d. infinitely many
   e. exactly three

7. How many ordered pairs are there in the solution of a dependent system of two linear equations?

   a. none
   b. exactly one
   c. exactly two
   d. infinitely many
   e. exactly three

8. How many ordered pairs are there in the solution of an inconsistent system of two linear equations?

   a. none
   b. exactly one
   c. exactly two
   d. infinitely many
   e. exactly three

9. For an independent system of two linear equations, the two lines of the system would have

   a. different slopes
   b. same slopes
   c. same intercepts
   d. same slopes and intercepts
   e. same slopes and different intercepts

10. For a dependent system of two linear equations, the two lines of the system would have

   a. different slopes
   b. same slopes
   c. same intercepts
   d. same slopes and intercepts
   e. same slopes and different intercepts

11. For an inconsistent system of two linear equations, the two lines of the system would have

   a. different slopes
   b. same slopes
   c. same intercepts
   d. same slopes and intercepts
   e. same slopes and different intercepts

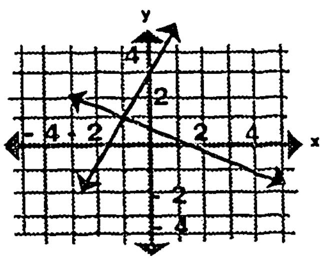
12. Comparing the equations of the system $x-2y=-3$ (1) $x+4y=3$ (2) would result in the equation

a. $2y+3=4y-3$
b. $2y+3=4y+3$
c. $2y+3=3-4y$
d. $2y-3=3-4y$
e. $2y-3=4y+3$

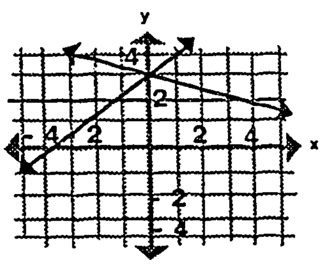
13. .Which diagram, below, is the graphical solution for the following system of linear equations?

$$x+2y=1$$
$$2x-y=-3$$

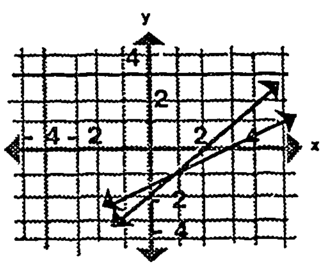
a.



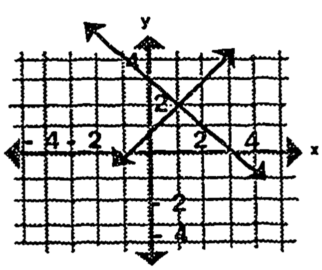
b.



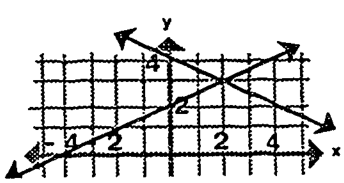
c.



d.



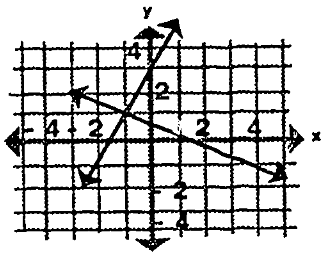
e.



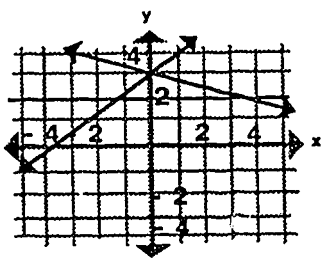
14. .Which diagram, below, is the graphical solution for the following system of linear equations?

x+3y=9
x=y-3

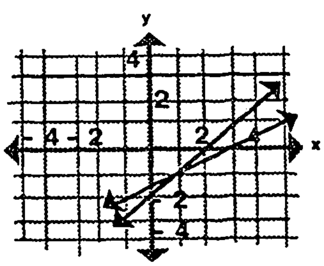
a.



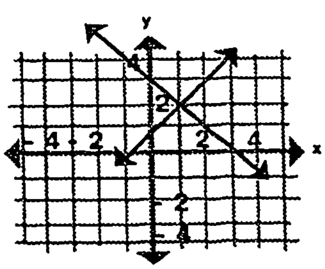
b.



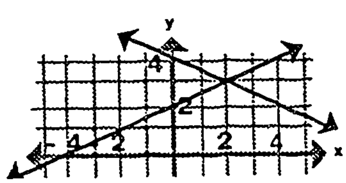
c.



d.



e.



15. $x-2y=6$ (1)
$3x+y=11$ (2)

The solution set of the above system of equations could be determined by solving

a. $2y+6-2y=6$
b. $x-6x+22=6$
c. $y=11-3x$
d. $x=6+2y$
e. $6y+18+y=11$

16. If $3(x-1)+y= -2$, then

a. $y=3x-1$
b. $y=3x-3$
c. $y=-3x-1$
d. $y=3x-5$
e. $y=1-3x$

17. For which of the following systems is (2,-3) a solution?

a. $x-y=5$
$3x+4y=-6$
b. $2x+y=7$
$x-3y=10$
c. $4x-y=11$
$-12x-3y=33$
d. $5x+3y=19$
$2x-4y=16$
e. $x-y=5$
$3y+4x=-6$

18. $4x-5y=-8$ (1)
$2x-3y=-4$ (2)

In solving the above system of equations, equation (1) is multiplied by 3, equation (2) is multiplied by 5 and the resulting equations are subtracted. After subtracting,the equation obtained is

a. $2x-30y=-44$
b. $12x-15y=-24$
c. $2x=-24$
d. $2x=-4$
e. $2x-30y=-44$

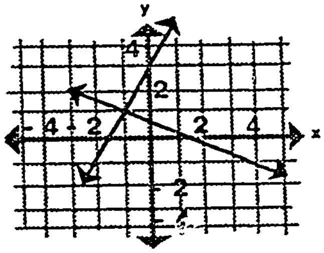
19. The equation $3x - \frac{(y+1)}{2} = 7$ is equivalent to

a. $y = 6x - 8$
b. $y = 6x - 6$
c. $y = 6x - 16$
d. $y = 6x - 15$
e. $y = 6x - 3$

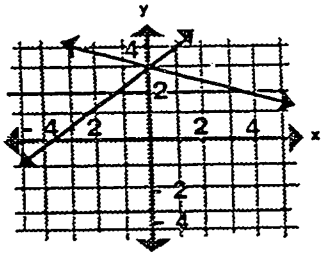
20. .Which diagram, below, is the graphical solution for the following system of linear equations?

$$x-y=-1$$
$$x+y=3$$

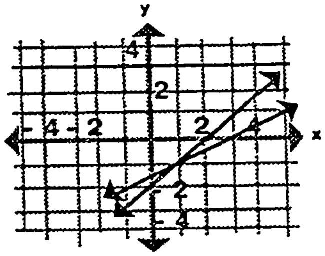
a.



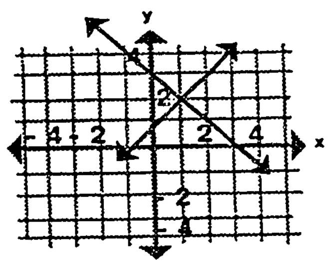
b.



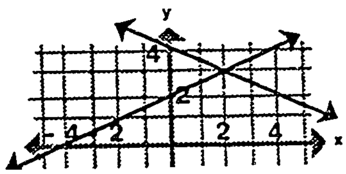
c.



d.



e.



21. The ordered pair (-1,2) is the solution of the following system of linear equations.

$$2mx-ny=6$$
$$3mx-2ny=2$$

The values of m and n, respectively, are

a. -2 and 1
b. 1/2 and 1
c. 2 and 1
d. -1/2 and 1
e. -2 and -1

22. Solve. $2x-5y=4$ (1)
$3x+2y=-13$ (2)

a. (2,0)
b. (0,-6.5)
c. (-3,-2)
d. (3,0.4)
e. { }

23. Solve. $3x+y=3$ (1)
$7x-2y=20$ (2)

a. (0,3)
b. (2,-3)
c. (3,0.5)
d. (0.5,1.5)
e. { }

24. If there are d dimes and q quarters in a coin purse , what algebraic expression would represent, in cents, the total value of the coins?

a. d+q
b. .25d+.1q
c. .1d+.25q
d. 25d+10q
e. 10d+25q

25. The perimeter of a rectangle is 64 cm. Twice the width is 4 cm more than the length. What are the dimensions of the rectangle?

a. 5 cm by 6 cm
b. 6 cm by 8 cm
c. 8 cm by 12 cm
d. 10 cm by 16 cm
e. 12 cm by 20 cm

26. Igot Cash has a total of $580 in $5-bills and $10-bills. If Igot has 76 bills in all, how many $10-bills does he have?

a. 36
b. 40
c. 58
d. 116
e. 76

27. Cindi Cate invested $3300, part at at 8% and the rest at 10%. At the end of a year she noticed that the interest from the 8% investment was $84 more than the interest from the 10% investment. How much was invested at 10%?

a. $2300
b. $1000
c. $840
d. $1050
e. $414

28.

$$2x-3y=8$$
$$-4x+6y=r$$

For the above system, the value of r that would make the system inconsistent is

a. 8
b. -8
c. 16
d. -16
e. any real number

KEY

1. c
2. b
3. a
4. c
5. e
6. b
7. a
8. d
9. a
10. d
11. e
12. d
13. a
14. b
15. e
16. e
17. a
18. d
19. d
20. d
21. a
22. c
23. b
24. e
25. e
26. a
27. b
28. d

APPENDIX 7 Data Collected

	I.D.	Group	Gender	U4 Pre	U5 FE	U6 FE	Strength	SS-Pre	Raw-CWA	Raw-CWO	SS-CWA	SS-CWO
1	A1	Group A	Male	60.00	77.42	83.33	weaker	-.22	77.42	83.33	-.45	.94
2	A2	Group A	Female	64.00	100.00	66.66	weaker	.10	100.00	66.66	1.05	-.51
3	A3	Group A	Female	52.00	74.19	45.83	weaker	-.87	74.19	45.83	-.66	-2.32
4	A4	Group A	Male	84.00	100.00	87.50	Stronger	1.72	100.00	87.50	1.05	1.30
5	A5	Group A	Male	76.00	90.32	66.67	Stronger	1.07	90.32	66.67	.41	-.51
6	A6	Group A	Male	64.00	96.77	66.67	Stronger	.10	96.77	66.67	.84	-.51
7	A7	Group A	Female	68.00	93.55	75.00	Stronger	.43	93.55	75.00	.62	.21
8	A8	Group A	Female	64.00	90.32	79.17	Stronger	.10	90.32	79.17	.41	.57
9	A9	Group A	Female	72.00	90.32	87.50	Stronger	.75	90.32	87.50	.41	1.30
10	A10	Group A	Male	60.00	80.65	54.42	weaker	-.22	80.65	54.42	-.23	-1.57
11	A11	Group A	Female	44.00	90.32	66.67	weaker	-1.51	90.32	66.67	.41	-.51
12	B1	Group B	Female	60.00	96.77	79.17	weaker	-.22	79.17	96.77	.57	.84
13	B2	Group B	Male	68.00	90.32	83.33	Stronger	.43	83.33	90.32	.94	.41
14	B3	Group B	Male	28.00	61.29	70.83	weaker	-2.81	70.83	61.29	-.15	-1.51
15	B4	Group B	Male	60.00	86.67	75.00	weaker	-.22	75.00	86.67	.21	.17
16	B5	Group B	Female	76.00	74.19	75.00	Stronger	1.07	75.00	74.19	.21	-.66
17	B6	Group B	Male	68.00	87.10	79.17	Stronger	.43	79.17	87.10	.57	.20
18	B7	Group B	Male	64.00	70.97	58.33	Stronger	.10	58.33	70.97	-1.23	-.87
19	B8	Group B	Male	80.00	96.77	83.33	Stronger	1.40	83.33	96.77	.94	.84
20	B9	Group B	Male	60.00	100.00	83.33	weaker	-.22	83.33	100.00	.94	1.05
21	B10	Group B	Male	60.00	61.29	54.17	weaker	-.22	54.17	61.29	-1.59	-1.51
22	B11	Group B	Male	48.00	41.94	75.00	weaker	-1.19	75.00	41.94	.21	-2.80

APPENDIX 8 Instructional Objectives Units 5 & 6

Objectives of Mathematics 10, Units 5 & 6

Source: Alberta Correspondence School (Now Alberta Distance Learning Resource Centre) Curriculum Guide

Unit 5: Coordinate Geometry and Graphing

Topic 1: Distance Between Two Points
- Activity 1: Use terminology and graphing skills related to the graphing of ordered pairs.
- Activity 2: Find the distance between two points.
- Activity 3: Develop and use the distance formula to solve problems.

Topic 2: Finding the Midpoint
- Activity 1: Develop and use the midpoint formula for finding the midpoint of a line segment.
- Activity 2: Solve problems which involve the use of the midpoint formula.

Topic 3: Slope of a Line
- Activity 1: Define slope of a line segment as rise over run.
- Activity 2: Develop and apply the formula for slope.
- Activity 3: Identify and use the relationship between slopes of parallel lines.
- Activity 4: Identify and use the relationship between slopes of perpendicular lines.

Topic 4: Collinear Points
- Activity 1: Identify conditions for determining collinearity.
- Activity 2: Determine if points in a plane are collinear.

Topic 5: Graphing Linear Equations
- Activity 1: Develop a table of values and sketch the graph of a linear equation.
- Activity 2: Determine x- and y-intercepts.

Topic 6: Slope and y-intercept
- Activity 1: Change the subject in formulas.
- Activity 2: Rewrite linear equations in the form y=MX+b and identify the significance of ma and b.
- Activity 3: Determine the slope and y-intercept of a line from its equation and draw the graph.
- Activity 4: Graph linear equations using slope and another point on the line.

Topic 7: Vertical and Horizontal Graphs
- Activity 1: Describe and graph equations of lines parallel to the x-axis and parallel to the y-axis.

Topic 8: Equations with Unique Conditions
- Activity 1: Rewrite linear equations in the form Ax+By+C=0.
- Activity 2: Determine the equation of a line given the slope and a point on the line.
- Activity 3: Determine the equation of a line passing through two given points.
- Activity 4: Determine the equation of horizontal and vertical lines.
- Activity 5: Determine the equation of a line given one point and the equation of a line parallel or perpendicular to it.

Unit 6: Systems of Equations

Topic 1: Solving Systems of Equations Graphically
- Activity 1: Solve and classify a system of two linear equations by graphing.
- Activity 2: Classify a system of two linear equations as dependent, independent or inconsistent according to the slopes and y-intercepts of the equations.

Topic 2: Solving Systems of Equations Algebraically
- Activity 1: Solve a system of two linear equations by comparison.

Activity 2:	Solve a system of two linear equations by substitution.
Activity 3:	Solve a system of two linear equations by addition or subtraction.
Activity 4:	Solve a system of two linear equations by any algebraic method.
Activity 5:	Solve word problems using any algebraic method.

APPENDIX 9 Copyright Release for Test Questions

M E M O R A N D U M

TO: EVANS FORSYTH

FROM: DR. M. SZABO

DATE: 1991 08 16

SUBJECT: COPYRIGHT

This memorandum will authorize you to use the Unit 4, 5 and 6 Math 10 End of Unit tests and CMI exams for research purposes, and reproduce them in a thesis.

Michael Szabo

Dr. M. Szabo

APPENDIX 10 CMI Program Disks