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ABSTRACT

This study looks at the roles that competition and context of advisement play in transfer, advisor use, attitude toward mathematics, and attitude toward instruction in a computer-based simulation game that required the use of mathematics skills. It is concluded that for transfer training, non-competitive simulation games might be the best choice, better at least than simulation games that include a time-pressure factor. Advisement appeared to be a good way to promote transfer and positive attitude toward mathematics and instruction, the latter two of which can indirectly promote future performance. (Contains 248 references.) (ASK)

THE EFFECT OF ADVISEMENT AND COMPETITION ON TRANSFER, ADVISOR USE, AND ATTITUDE TOWARD MATHEMATICS USING A COMPUTER-BASED SIMULATION GAME

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INTRODUCTION

Much of the research on instructional games and simulations supports their use in many contexts and subject areas (e.g., Bright et al., 1985; Dempsey et al., 1997; Jacobs & Dempsey, 1993). Because games and simulations are capable of supporting situated learning and anchored instruction, it is reasonable to assume they may be successful in promoting transfer. This has not been examined in the literature, nor have any differences between the two modes, which are delineated primarily by the presence or absence of competition, been explored.

Research on transfer has also suggested that prompting users to recall and use prior knowledge can promote transfer of learning. This has not been examined in the instructional simulation and gaming literature to date. Games and simulations often make use of built-in help systems or advisors (e.g., Fingar, 1999). It seems reasonable to expect that such help systems, or advisors, could be used to prompt learners to recall prior knowledge, although this has not been done prior to this study.

To explore these areas, a computer simulation game was developed that combined the elements of competition, advisement, and an authentic environment in which to promote transfer. Learners played a character helping to fix up a house for their aunt and uncle who are remodeling contractors. Learners had to calculate the amounts of materials needed to paint a room and put up wallpaper border.

This study looked at the roles that competition and context of advisement have on transfer, advisor use, attitude toward mathematics, and attitude toward the instruction in a computer-based simulation game requiring the use of mathematics skills. Advisor use was also examined in relation to transfer, attitude toward mathematics, and attitude toward instruction.

Competition referred to whether the participant was competing against a computer-generated character or not. Context of advisement referred to whether the advisor was a text-based reference book or a text-based reference book plus a video of the player's aunt and uncle walking into the room. With the addition of a control group who received only word problems in a computer-based tutorial format, this resulted in five conditions:

1. Control (a word problem-based computer version of the content in the simulation game and simulation)
2. Competitive simulation game and high-contextual advisement (video of aunt and uncle plus the reference book)
3. Non-competitive simulation and high-contextual advisement
4. Competitive simulation game and low-contextual advisement (text based reference book of formulas only)
5. Non-competitive simulation and low-contextual advisement

Advisement use was expected to be related to transfer of mathematics skills overall. High-contextual advisement, i.e., video-based, was expected to result in higher transfer of mathematics scores than low-contextual advisement. It was also hypothesized that high-contextual advisement would lead to higher ratings of the instruction and attitude toward mathematics and result in higher advisement use.

The low-contextual version was expected to result in lower advisement use, lower transfer of mathematics scores, lower ratings of the instruction, and lower attitude toward mathematics, primarily because transfer tasks in authentic environments might be expected to constitute new learning, which has been shown to be negatively impacted by competition. Also, because certain types of competition place a premium on time as well as accuracy, learners might be expected to take less time for processing information, searching the problem space, and seeking advisement, thereby leading to lower transfer scores.

BACKGROUND

Transfer

Despite the importance of transfer of learning in education, learners in general do not transfer learning (Thurman, 1993; Asch, 1969; Brown, 1989; Perfetto, Bransford, and Franks, 1983; Gick & Holyoak, 1980; Reed, Ernst, & Banerji, 1974; Simon & Hayes, 1976; Weisberg, DiCamillo, & Phillips, 1978; CTGV, 1992a, 1992b; Van Haneghan, 1990). Some researchers attribute the failure to transfer learning to a lack of similarity between the learning and performance contexts (e.g., Osgood, 1949) or the lack of similarity between new and old problems, lack of previous experience with similar problems, and lack of instruction about how to conceptualize and solve problems (Rogoff & Gardner, 1984). Others explain the failure to transfer learning as the lack of perceived similarity between the learning and performance contexts. This latter assertion is what cognitivists such as Gick and Holyoak (1980) call the perceptually bound hypothesis.

Context alone is not responsible for the failure to transfer. Context can also interact with the medium and with learner characteristics such as attitude toward transfer (Tessmer & Richey, 1997). Low self-efficacy and attitude toward content may also cause failure to transfer (Kraiger, Ford, & Salas, 1993). There is also evidence that problem solving and transfer are largely domain specific, so transfer is not likely to occur as the result of general problem-solving instruction (Larkin, 1989), but instead requires multiple practice opportunities in a variety of contexts (Gagné, Briggs, & Wager, 1992).

One means of promoting transfer of learning involves making the connection between the learning context and performance context explicit through prompting, cueing, or other means (Adams et al., 1988; Lockhart et al., 1987; Brown, 1989; Gick & Holyoak, 1980; Hayes & Simon, 1977; Perfetto et al., 1983; Reed et al., 1974; Simon & Hayes, 1976; Weisberg et al., 1978). Likewise, for insight problems (those that require reconceptualizing the problem), helping learners to think about the problem in a new way has been shown to increase transfer of learning (Lockhart et al., 1987).

The context of mathematics learning in formal instruction often consists of word problems and textbooks, yet learners are routinely required to apply mathematics skills in contexts in the real world that often differ, sometimes radically, from traditional word problems. Transfer in this study is categorized as horizontal transfer because the participants will be applying previously learned mathematics skills in a new context beyond what may be found in most traditional mathematics instruction. Specifically, students who studied area, volume, perimeter, addition, subtraction, multiplication, division, and calculation of equivalent measurements were required to apply this prior learning to determine the amount of paint and wallpaper border needed to remodel a room in a house.

Operational Definition

Transfer in this study, then, may be considered positive horizontal transfer. Positive horizontal transfer is the activation, retrieval, and application of previously acquired mathematics skills to the successful solution of a problem set in a novel context. Novel, using Royer's (1979) terminology, refers to a context in which the stimulus elements differ from the stimulus elements in the original learning context. In this study, transfer as defined above will be measured by the ability to select and apply relevant formulae to the solution of two problems in a simulation game.

Attitude

Research has found that "pleasant items are usually processed more efficiently and more accurately than less pleasant items" in perception, language, and decision making (Matlin, 1998, p. 143). This principle is known as the Pollyanna Principle. We recall pleasant items first (Matlin, 1998). Other research has shown that pleasant words are recalled more easily and with higher frequency than are neutral or negative words, especially when there is a long delay between learning and performance (Matlin & Stang, 1978).

The ability of affective response toward pleasant stimuli and content to improve learning and performance may extend as well to stimuli and content that are considered interesting, which is not necessarily the same thing. Theory holds that if the learner enjoys or is interested in the content, he or she may increase the cognitive elaboration and effort put forth in processing that material (e.g., Brophy, 1987; Hidi & Baird, 1986; Greene & Lepper, 1974; Malone, 1981; Collins, Brown, & Newman, 1989). Bandura

(1977) believes that changes in self-efficacy and attitude toward content lead to changes in effort and, subsequently, to changes in performance.

The issue of making instruction interesting is perhaps of particular importance to mathematics, since interesting content may promote positive attitude towards mathematics in general. Performance in mathematical problem solving is related to beliefs about mathematics (Schoenfeld, 1983, 1985), and attitude toward mathematics can determine the likelihood of continued study and perseverance (Lehman, 1987).

Poor attitude toward content can result in poor learning and performance in mathematics areas (Gal & Ginsburg, 1994). Attitude toward the content, in particular students' expectations of success, is positively correlated with student's persistence and success. For instance, self-efficacy may predict performance (Kraiger et al., 1993) and has been linked to performance and persistence (Barling & Beattie, 1983; Stumpf, Brief, & Hartman, 1987; Weinberg et al., 1979). Attitudes, therefore, perhaps especially in mathematics, are important considerations in learning.

Operational Definition

This research measured self-reported affective response toward mathematics as a content area and toward the game. This is a common definition and approach in educational research, with good support in the literature, particularly with mathematics (e.g., Gagné et al., 1992; Kraiger et al., 1993; Lehman, 1987).

Anchored Instruction

Anchored instruction, as developed and explicated by John Bransford, Robert Sherwood, T. Hesselbring, C. K. Kinzer, and S. M. Williams (1990), the Cognition and

Technology Group at Vanderbilt (CTGV), and Van Haneghan et. al. (1992), is an approach to learning that stresses the importance of embedding (or anchoring) the learning within a meaningful, problem-solving context. It is related to situated cognition theory, which says that learning that takes place in a realistic context will be more effective than learning that does not.

According to anchored instruction, a learner who is studying basic mathematics skills such as addition, multiplication, and division will have great difficulty if he or she studies the formulas and rules outside of a meaningful context. This is why mathematics curricula often make use of word problems, which attempt to situate the skills in "real-world" problems. The higher the fidelity between the situation and the "real world," according to anchored instruction, the higher the transfer should be. Anchored instruction has been experimentally shown to promote performance and transfer (Sherwood & the Cognition and Technology Group at Vanderbilt [CTGV], 1991; CTGV, 1993; Van Haneghan et al., 1992) and to be more effective in teaching mathematical problem-solving skills than traditional instruction (Griffin, 1995).

Computers and Gaming

Instructional games present an excellent opportunity for problem-solving skills and transfer of prior learning. They are, if well designed, motivating and entertaining. According to Dempsey et al. (1997), "computer games have been employed effectively in all areas of traditional schooling—from preschool . . . through higher education . . . and continuing education of the elderly" (p. 1). Among the many potential strengths of instructional games are complex problem-solving skills (Hayes, 1989). Instructional games have been used successfully in teaching social theory (Coleman, 1989), mathematics (Bright, Harvey, & Wheeler, 1985), and combat skills (Kent, 1999; Wood, 1997) and have been suggested for teaching language fluency (Baltra, 1990).

Most research in instructional games has been designed to address achievement, problem solving, attitude, retention, and continued motivation (Dempsey et al., 1993). Transfer in simulations and games has be virtually ignored (Jacobs & Dempsey, 1993). Simulation games should be successful in promoting transfer by incorporating anchored instruction principles.

A review of the literature suggests that CBI and simulation games are also good for improving attitude and motivation (Druckman, 1995; Seginer, 1980; Thurman, 1993; Hannafin & Peck, 1988; Heyman, 1982; Brophy, 1987; Duin, 1988; Lepper & Chabay, 1985; Sedighian & Sedighian, 1996). In fact, CBI and games may be an ideal medium for studying the motivational effects of different instructional activities and processes overall (Lepper & Milojkovic, 1986).

Operational Definition

For the purposes of this study, simulation games are defined as an interactive experience that contains some representation of a world, real or imagined, that behaves according to a coherent (if not realistic) set of rules, in which the participant(s) often have a clear goal, the pursuit and attainment of which may result in an entertaining, rewarding experience. In this study, competition is viewed as a separate variable, which may be present or absent in a simulation game.

Competition

According to Klein, Freitag, and Wolf (1990) there is a schism in the field of instructional gaming research regarding the effectiveness of games and this schism can be at least partially traced to differing views on the role of competition in gaming: "[some] educators argue that instructional games are effective for providing motivating practice of newly acquired skills and information . . . . Other scholars argue that the competition element decreases student motivation" (p. 330). Competition does not function identically in all situations, however, and to reduce the argument to the level of "competition is good" or "competition is bad" is an oversimplification that ignores some very important considerations. For instance, competition alone cannot make learners function beyond their maximum ability unless they have help, such as a coach, mentor, or advisor.

There is some evidence that competition can create anxiety, which can interfere with higher order intellectual skills such as problem solving (Goodman & Crouch, 1974), and while there is research that indicates competition can increase performance, the domains used in these studies rarely involved higher-order intellectual skills such as problem solving. This becomes a critical distinction later which might help explain the apparently contradictory research on the role of competition in learning.

While a great deal of research has been done on both transfer and competition in general, no studies could be found that examined the effects of competition on transfer. In theory, competition might be expected to increase anxiety and to reduce elaboration, both of which could inhibit transfer.

Some researchers have found that competition can increase performance (e.g., Julian & Perry, 1967; Craig, 1967; Fisher, 1976; Spalt, 1987/1988; Kraft Miller, 1981), while others have found just the opposite (e.g., Keefer & Karabenick, 1998; Cartmill, 1994; Thompson, 1972). It may be that competition can improve performance, but that the means and extent to which it does so are at least partially determined by the content, the complexity of the learning, familiarity with the content, the nature of who is competing against whom, and other situational characteristics. Likewise, it seems logical to conclude that there may be some conditions (e.g., learner characteristics, domain) under which competition can be detrimental. The research studies which show benefits of competition appear to focus on knowledge measures and content in non-problem solving contexts (i.e., at the rule and verbal information levels) and in nonauthentic contexts (i.e., school-based contexts rather than "real world" contexts). It might be expected that such learning requires less cognitive processing than higher-order learning such as problem solving (the most common venue for transfer learning studies).

Another factor which may account for the conflicting results of competition studies may lie in the level of expertise and familiarity in the content to be learned. Miller and Heward (1992) advocate using time trials, and kind of competition, to promote mathematics fluency. Knowing the correct answer to a mathematical operation, they say, is only a partial measure of competence; teachers should also look at how long it takes to generate the answer. Central to their argument and to the current discussion of competition is the stage learning the student has attained relative to the content. They identify two basic stages of knowledge acquisition, the acquisition stage and the practice stage. In the acquisition stage, the goal is for the learner to learn how to do the skill.

Instruction should therefore focus on teaching the student to perform the skill correctly and accurately. Time trials (competition) should not be used during this stage. Once the learner has begun to make more correct responses than erroneous responses, instruction should begin to shift into time trials. By extension, competition at the acquisition stage might then be expected to result in negative results in performance. There are few studies that examine how competition interacts with learner characteristics or mode of instruction in problem solving/transfer tasks.

Operational Definition

For the purposes of this discussion, competition is defined as any condition in which learners are able to compare their performance to some internal or external standard, or to significant others in the social environment in groups or individually, in such a way that they can tell if they are below, at, or above the reference performance mark.

In this study, competition was created by the presence or absence of a computer generated competitor. An argument could be made that competing against a computer-generated character is not competition in the same sense that competing against a human being is. On the other hand, some authors have said that simply adding a scoring mechanism to a simulation can qualify as competition because the player then has an external reference and is able to compete against themselves (Jacobs & Dempsey, 1993). Additionally, many video arcade games and console games use computer generated "competitiors." It is in this sense of the definition competition is used and discussed in this study.

Advisement

Studies have shown that CBI that uses learner control with advisement is as effective or more effective than adaptive control or learner control without advisement (Johansen & Tennyson, 1983; Tennyson, 1980a, 1980b; Tennyson & Buttrey, 1980). Decreases in instructional time under learner control with advisement were also found when compared with adaptive instruction (Gray, 1988; Tennyson, 1980a, 1980b, 1981).

Advisement as it has been discussed and examined in the literature generally refers to one of three things: advisement about the optimal path or sequence through the instruction, feedback advice about performance and suggestions for number of examples or practice items to attempt, or advice about whether or not to seek additional instruction (e.g., Gray, 1988; Johansen & Tennyson, 1983; Tennyson, 1980a, 1980b; Tennyson & Buttrey, 1980). Research in these areas has produced somewhat mixed results, but most researchers seem to agree that learners are generally not able to effectively manage their learning without advice (i.e., under learner control with no advice— Carrier, 1984; Fisher et al., 1975; Park & Tennyson, 1980; Reinking, 1983; Tennyson, 1980a, 1980b; Tennyson and Buttrey, 1980).

None of these various types of advisement help learners process content or clear up misconceptions—roles usually addressed by a teacher in traditional instruction. This type of advisement strategy can be found in several commercially available instructional multimedia programs. For example, *Shoot Video Like a Pro* provides talking-head "experts" who provide learners with tips to improve their emerging skills. The experts in this software are built into the camera-like interface, are both male and female, and come from a variety of ethnic backgrounds. Essentially, these advisors "coach" by explaining a different perspective from the main flow of the program, rather than adapting to, directing, or evaluating the learner's performance. It is this level of coaching help that can free teachers to address higher-order instructional needs. Some research is beginning to explore this idea (Dempsey & Van Eck, 1998; Wu, 1992; Zellermayer, Salomon, Globerson, & Givon, 1991).

Operational Definition

Advisement in the sense of a learning coach who prompts learners to find their own way through a problem will serve as the definition for this study. Specifically, advisement will be a system that is under learner control, and that will provide cues and prompts about how to approach a particular problem.

Context of advisement refers to the internal and external events associated with the delivery of advice. In this research, advisement has either a high or low level of correspondence between the learning context and the type of advisement. In the high-level condition, the advisors consist of two carpenters who discuss the process for solving the problem as well as a text-based reference book of formulas and facts (reference book) built into the game. This is considered high because the advisors are integrated into the story line. In the low-level condition, the advisor is just the text-based listing of the formula and facts (reference book). This is considered low-level because the advisor is abstract and unrelated to the story line.

Research Questions and Hypotheses

Advisement

Research shows that advisement is good for promoting learning and attitude toward instruction and content. No research could be located on how advisement may impact transfer, however. Because failure to transfer is usually the result of a failure to recognize the relevance of prior knowledge in novel contexts, advisement could theoretically promote transfer by making these connections specific. Instruction that uses advisement to train learners to recognize these connections on their own should lead to improved transfer in future contexts. Researchers seem to have ignored the use of advisement in the context of games or anchored instruction. The inclusion of advisement, which acts like scaffolding, in a computer game can help support the teacher in the role of co-learner or coach , which is required by anchored instruction and situated learning. The impact of context of advisement (i.e., whether the advisement is related to the instructional metaphor or not, or whether the advisement is interesting or not) on learning, attitude, and advisor use has also not been explored. By making the advisor entertaining, the learners may select it more often.

Related Research Questions:

1. Does advisor use affect transfer of mathematics skills?
2. Does advisor use affect attitude toward instruction?
3. Does advisor context affect advisor use?
4. Does advisor context affect attitude toward instruction, mathematics, and the simulation game?

Related Alternative Hypotheses:

1. Participants who select advisement will have higher transfer of mathematics scores.
2. Participants who select advisement will have higher attitude toward mathematics scores.
3. Participants with access to high-contextual advisement will select advisement more often than those who have access to low-contextual advisement.
4. Participants with access to high-contextual advisement will have higher transfer of mathematics scores than those who have access to low-contextual advisement.
5. Participants with access to high-contextual advisement will have more positive attitude toward mathematics.
6. Participants with access to high-contextual advisement will have more positive attitude toward the computer simulation game than those who have access to low-contextual advisement.

Competition

Games often involve competition, so it is logical to build competition into an instructional game. But limited research on competition in instructional games and mathematics instruction exists, and what does exist does not provide a definitive answer on the benefits or detriments of competition. Time stress and competition have been shown to build fluency but have shown detrimental effects in learning in studies of mathematics and language acquisition, as well as on attitude and self-efficacy. Because the transfer problems in this study require higher-order intellectual skills, and because they are likely to constitute learning at the acquisition stage rather than the practice stage (Miller & Heward, 1992), it might be expected that competition will have a negative effect on transfer. Likewise, competition in this study may promote advisor use and transfer (through a heightened desire to perform well), or it may raise anxiety, which can interfere with performance, especially in those with mathematics anxiety already.

Related Research Questions:

1. Does competition affect transfer of mathematics skills?
2. Does competition affect advisor use?
3. Does competition affect attitude toward instruction, mathematics, and the computer game?

Related Alternative Hypotheses:

1. Participants in the competitive simulation game conditions will not differ from those in the non-competitive simulation game conditions in terms of transfer of mathematics scores.
2. Participants in the competitive simulation game conditions will not differ from those in the non-competitive simulation game conditions in terms of advisement use.
3. Participants in the competitive simulation game conditions will not differ from those in the non-competitive simulation game conditions in terms of attitude toward mathematics

4. Participants in the competitive simulation game conditions will not differ from those in the non-competitive simulation game conditions in terms of attitude toward the computer game scores.

Anchored Instruction

Anchored instruction has been shown to promote transfer of mathematics skills. It is usually of a non-interactive nature, however, and does not take the form of a game, but of a lesson. Computer games have been shown to increase learning, and promote persistence and positive affective response toward instruction. Anchored instruction has been shown to promote transfer, but it is unclear if a game can function in a similar fashion.

Related Research Questions:

1. Can an instructional simulation game promote transfer learning?
2. Does an instructional simulation game have an effect on attitude toward mathematics?

Related Alternate Hypotheses:

1. Participants in the instructional competitive and non-competitive simulation game conditions will not differ from those in the control condition in terms of transfer of mathematics scores.
2. Participants in the instructional competitive and non-competitive simulation game conditions will not differ from those in the control condition in terms of attitude toward mathematics scores.

METHOD

Participants

The target population for this study is middle-school-aged children in grades 7 through 8, with a range in age from 11 years to 14 years old. This population was available at several middle schools, of which four were selected: School A ($\underline{n}$ = 75), School B ($\underline{n}$ = 50), School C ($\underline{n}$ = 123), and School D ($\underline{n}$ = 80). Schools B and A were used for pilot testing and field trials (respectively) of the game, and School D was unable to participate in the last instance. Accordingly, the sample for this study included students at School C only. Standardized reading and math scores were unavailable for School C. Participants have regular access to the computer lab and access to an edutainment game on math as well as other knowledge and entertainment games during free lab time.

Demographic data were collected via self-reported instruments developed for this study.

Materials and Instruments

Lesson Content

The content of the lesson was delivered via a computer-based instructional simulation and simulation game and was developed using the NCTM 2000 mathematics curriculum standards which will form the basis of the Voluntary National Test of Mathematics (VNTM) currently under development at the national level. Because this instruction reflects the content outlined by the NCTM 2000 standards, learners will gain practice in the areas that will make up the VNTM. Learners were able to get practice in "real-world" scenarios, something that is specified by the NCTM 2000 standards. In particular, the content covered portions of NCTM 2000 content strands 1, 2, and 3[1].

Problems based on these goals and standards were developed and integrated into an instructional simulation game in which participants play a peer-aged character who is working for their aunt and uncle's home remodeling business. Participants are given a room in a house for which they must calculate how much paint and how much wallpaper border to purchase.

Lesson Materials

A computer-based instructional simulation game was developed using *Macromedia Authorware* for *Windows 95/98*. This simulation game made extensive use of graphics, sound, video, and interactivity. Participants entered a room in a computer-generated house and navigated around in it by clicking in the direction they wanted to go. They were able to use a variety of tools in the simulation game, including a tape measure to measure walls, doors, and windows, a workbook in which to record information used to solve the problem, a reference book to look up facts and formulas, a calculator, and, in some conditions, a walkie-talkie to call the video advisors for advice. Participants used these tools to learn about the environment (how long/high a wall is, for instance) and solve two problems: how much paint to buy for the walls and how much wallpaper border to put around the room at ceiling height. They recorded their observations in the

[1] Numbers and letters represent the numbering scheme developed for the NCTM standards. Not every component of every strand was represented in this study, which is why some letters do not appear in sequence (e.g., a, d, e instead of a, b, c, d, e).

workbook built into the simulation game. The room was rectangular in shape and had a square window, a round window, a rectangular window, one door, and one doorway. The ceiling of the room was vaulted, resulting in a triangular prism (two walls were triangles, the other two were rectangles). The shapes thus represented in the room were ten rectangles, two triangles, one circle, and one square. Participants in the control group were given word problems identical to those in the computer simulation game in the form of a computer tutorial to minimize any differences or resentment due to medium.

Context of Advisement

Advisement was available to all participants in the simulation game. Because of the short length of the invervention (50 minutes) and the difficulty in assessing the correctness of formulas as entered or described by participants, a reference book containing a variety of facts and formulas was provided in both the simulation game. The goal was to measure the ability to apply prior knowledge, not to see if participants had memorized the relevant formulae. Such support devices are common in many computer games. In addition to this reference book, some participants received video-based advisement in which their Aunt Ann and Uncle Bob discussed the problem and the solution process. This type of advisement has a high contextual relevance to the storyline of the game itself. These two conditions of advisement are referred to in this study as high- and low-contextual advisement.

Competition

Competition was determined by the presence or absence of a computer-generated competitor. In the competitive environment, participants were told to work quickly because they were competing against a computer character. They were asked to indicate the level of competitor they want, either below average, average, or above average. The goal was to solve the problem faster and more accurately than their competitor. This competitor would randomly make comments about his or her progress throughout the game. In the noncompetitive environment, participants had no opponent to compete against for time or accuracy, but they were encouraged to work quickly and accurately.

Controls

Controls were given computer-based word problems that were identical to those in the simulation game and simulation. They had no access to advisement, nor was any element of competition involved.

Assessment Instruments

Six assessment instruments were used in this study: a demographics survey, an attitude toward mathematics inventory, a pretest, an attitude toward a computer game scale, a debriefing questionaire, and a posttest transfer of mathematics skills assessment game.

Demographics Survey

In order to collect data for possible use as covariates and for post hoc examinations, a demographic survey was developed to collect data on age, sex, ethnic background, computer experience, mathematics experience, game playing behavior, hours spent on schoolwork and other activities. This scale had a Flesch-Kincaid Grade Level reading score of 3.1.

Pretest

A pretest was developed to assess incoming mathematics skills. This was necessary because while students have had the relevant content, no objective measure of mastery is available. Pretest scores were collected to verify that students were capable performing the mathematical computations required in the simulation game and simulation. This instrument had a Flesch-Kincaid Grade Level reading score of 5.2.

Attitude Toward Mathematics

This construct was measured by the Mathematics Beliefs Scale: a 64-question, five-item, Likert-type scale compiled by James P. Van Haneghan and Daniel Hickey in 1993. This scale, provided to the researcher by Dr. Van Haneghan, was compiled from several scales. Table 1 presents the scales and their origins.

Table 1

Math Beliefs Survey Scales by Originating Authors

Scale	Author
Task Orientation	Nicholls, 1990)
Ego Orientation	Nicholls, 1990)
Work Avoidance	Nicholls, 1990)
Math Anxiety	Van Haneghan & Hickey, 1992; Fennema & Sherman, 1976
Confidence in Math Ability	Van Haneghan & Hickey, 1992; Fennema & Sherman, 1976
Interest	Nicholls, 1990
Understanding	Nicholls, 1990
Competititveness	Nicholls, 1990
Effort	Kloosterman & Stage, 1992
Time Consuming	Kloosterman & Stage, 1992
Challenging	Van Haneghan & Hickey, 1992
Utility	Kloosterman & Stage, 1992

This scale is composed of 12 different mathematics beliefs scales, with Cronbach alphas ranging from .44 to .91, with four falling below .70. Past principle components analyses indicated the presence of three components, accounting for 62% of the variance: confidence in mathematics ability, task orientation/causes of success in mathematics, and work avoidant/ego orientation.

Attitude Toward Computer Game

This construct was measured by the *Computer Game Attitude Scale* developed by Kelly Chappell and Catherine Taylor (1997). Based on the *Computer Attitude Scale* (Loyd & Gressard, 1984), this scale is designed to evaluate attitudes toward educational software games. This scale is comprised of 20 questions, each with a four-item, Likert-type response. A factor analysis revealed two factors: comfort and liking. Cronbach alphas were .86 for the comfort subscale and .84 for the liking subscale. Overall test Cronbach alpha was .88. This scale had a Flesch-Kincaid Grade Level reading score of 3.8.

Transfer Assessment Simulation Game (Posttest)

Transfer of mathematics skills was assessed via a second computer-based instructional simulation identical in structure and general content but differing in the setting. Whereas the simulation game and simulation context in the intervention consisted of a room in a house, the transfer posttest was assessed by a simulation set in a movie theater. Instead of calculating the amount of paint needed for the walls, participants calculated the amount of material to buy to replace the movie curtain; instead of the number of rolls of wallpaper border needed for a room in a house, participants calculated the number of aisle carpet rolls needed to replace the carpet running around the outside of the theater seating area. The skills and formula required are identical to the earlier simulation game and simulation, but the context and calculations varied. No advisement was available, nor was there any element of competition present in this simulation. Transfer was measured both by the ability to select the correct formula and to solve the problem correctly (i.e., either was counted as correct). While transfer might theoretically be measured by the selection of the formula alone, some participants are more sophisticated problem-solvers and may be able to solve the problem intuitively (i.e., without selecting the formula from the reference book). Because no formulas beyond the correct one for a given problem would produce the same answer, and because the likelihood of guessing the right answer without using the correct formula was small, it was felt that a correct answer indicated having used the correct formula.

Debriefing Questions

Debriefing questions were formulated to gather specific information after the study. This instrument had a Flesch-Kincaid Grade Level reading score of 3.2.

Research Design

There were ten research questions examined in this study, each resulting in the following alternative hypotheses:

1. Participants who select advisement more often than others will have higher transfer of mathematics scores.
2. Participants who select advisement more often than others will have more positive attitude toward mathematics scores.
3. Participants with access to high-contextual advisement will select advisement more often than those who have access to low-contextual advisement.
4. Participants with access to high-contextual advisement will have higher transfer of mathematics scores than those who have access to low-contextual advisement.
5. Participants with access to high-contextual advisement will have more positive attitude toward mathematics than those who have access to low-contextual advisement.

6. Participants with access to high-contextual advisement will have more positive attitude toward the computer simulation game than those who have access to low-contextual advisement.
7. Participants in the competitive simulation game conditions will have lower transfer of mathematics scores than participants in the non-competitive simulation game conditions.
8. Participants in the competitive simulation game conditions will select advisement less often than do participants in the non-competitive simulation game conditions.
9. Participants in the non-competitive simulation game conditions will have more positive attitude toward mathematics than do participants in the competitive simulation game conditions.
10. Participants in the non-competitive simulation game conditions will have more positive attitude toward the game scores than do participants in the competitive simulation game conditions.
11. Participants in competitive and non-competitive simulation game conditions will have higher transfer of mathematics scores than do participants in the control condition.
12. Participants in competitive and non-competitive simulation game conditions will have more positive attitude toward mathematics scores than do participants in the control condition.

The experimental design for all research questions was a randomized pretest-posttest design with two independent variables and four dependent variables, resulting in a non-crossed 2 X 2 with control group design (see Table 2). Participants were randomly assigned to conditions beforehand, but participated as a class during their normal class time. Because the dependent variables were deemed unrelated, each was examined using a separate statistical analysis procedure. Independent variables include context of advisement (advisement as either a text-based formula or text-based formula plus video-based discussion of problem, process, and formula) and mode of instruction (with or without competition). Dependent variables include attitude toward mathematics, attitude toward game, transfer scores, and advisor use.

Table 2

Research Design of Study

Context of Advisement	Competition		
	Competition	No Competition	Control
Low-Contextual Advisement:			
(Reference Book Only)	26	24	
			24
High-Contextual Advisement:			
(Reference Book & Video Discussion)	25	24	

Null Hypotheses

The research questions resulted in the following 16 null hypotheses:

1. Participants who use advisement more often than others will not differ in transfer of mathematics scores.

2. Participants who use advisement more often than others will not differ in attitude toward mathematics scores.
3. Participants in the high-contextual advisement conditions will not differ from participants in the low-contextual advisement conditions in terms of advisement use.
4. Participants in the high-contextual advisement conditions will not differ from participants in the low-contextual advisement conditions in terms of transfer of mathematics scores.
5. Participants in the high-contextual advisement conditions will not differ from participants in the low-contextual advisement conditions in terms of attitude toward mathematics scores.
6. Participants in the high-contextual advisement conditions will not differ from participants in the low-contextual advisement conditions in terms of attitude toward the computer game scores.
7. Participants in the non-competitive simulation game conditions will not differ from those in the competitive simulation game conditions in terms of transfer of mathematics scores.
8. Participants in the non-competitive simulation game conditions will not differ from those in the competitive simulation game conditions in terms of advisement use.
9. Participants in the non-competitive simulation game conditions will not differ from those in the competitive simulation game conditions in terms of attitude toward mathematics scores.

10. Participants in the non-competitive simulation game conditions will not differ from those in the competitive simulation game conditions in terms of attitude toward the computer game scores.
11. Participants in the competitive and non-competitive simulation game conditions will not differ from those in the control condition in terms of transfer of mathematics scores.
12. Participants in the competitive and non-competitive simulation game conditions will not differ from those in the control condition in terms of attitude toward mathematics scores.
13. There will be no interaction of context of advisement and competition on transfer of mathematics scores.
14. There will be no interaction of context of advisement and competition on attitude toward mathematics scores.
15. There will be no interaction of context of advisement and competition on attitude toward game scores.
16. There will be no interaction of context of advisement and competition on advisor use.

Procedures

Formative Evaluation: The Simulation Game

The simulation game was piloted on twenty members of the target population and revised accordingly. The simulation game was then formatively evaluated on 10 members of the target population and modified further. The simulation game was then field tested on 75 members of the target population, and minor changes were made based on observations of their performance.

Experiment

Participants were selected from seventh- and eighth-grade classes at a local middle school and assigned in a stratified random manner to one of five conditions: low-contextual advisement with competition, low-contextual advisement without competition, high-contextual advisement with competition, high-contextual advisement without competition, or control. After random assignment to conditions, participants were run by existing class, that is, members of each mathematics class were randomly assigned and run as an intact group for the duration of the study.

Session/Day 1 (each class)

All participants were given a participant number and read the same orienting instructions explaining the purpose and process of the study. This process took approximately 10 minutes. They were then able to ask questions by raising their hand. Participants were then given the demographics survey, the *Math Beliefs Survey*, and the pretest, all in computer form, which took approximately 45 minutes to complete.

Session/Day 2 (each class)

Participants returned two days later and began the simulation game tutorial, which was designed to orient them to such issues as the program interface (including all tools within the game) and navigation. They were unable to proceed until they had demonstrated the use of each tool and element of the interface one time. The orientation tutorial took approximately five minutes to complete.

Participants then began playing the simulation game (experimental groups) or working with the identical on-line word problems (controls). The computer session lasted approximately 45 minutes. Data were collected during the game via the computer and stored as text files for later retrieval. A debriefing form was given to the participants to be filled out and returned later. The teachers were instructed not to discuss or teach the content of the game (i.e., area and perimeter) between sessions.

<u>Session/Day 3 (each class)</u>

One week after the second session, the posttest (the transfer simulation), Mathematics Beliefs Survey and the *Computer Game Attitude Scale* were administered. Participants were then debriefed about the actual nature of the study and informed that they can all play the game whenever their teacher gives them time to do so.

Data from the instruments and the game and computer-based word problems (controls) were input directly from the computer-generated files into *SPSS*. After data screening for outliers and normality, and after checking for appropriate statistical assumptions, ANOVA, MANOVA, bi-variate correlation, and chi-square analyses were performed to test the null hypotheses.

RESULTS

Introduction

In the interests of space, only those null hypotheses which were not supported are discussed. All other null hypotheses were supported.

Data Screening

Variables were screened for outliers, normal distribution, skewness, and kurtosis. Outliers were removed on a case-by-case basis. Assumptions for the statistical measures used were checked. With the exception of the advisor-use variable, all fell within acceptable parameters for the inferential statistics used. Advisement use was found to be negatively skewed and was transformed (square root) prior to use in analyses.

Descriptive Statistics

Sixteen null hypotheses were examined to see if there were significant differences between and among various groups in terms of advisement use, transfer of mathematics scores, attitude toward mathematics, and attitude toward the game. Tables 3 and 4 present demographic data. Tables 5, 6, 7, 8, and 9 present means and standard deviations for dependent variables by condition.

Table 3

Age, Gender, Grade, and Pretest Math Scores

Age		Gender		Grade	
M	SD	Male	Female	7	8
12.8	0.67	54	58	41	48

Table 4

Ethnicity of Participants

African American	Hispanic	Asian	Caucasian	Other
5	2	1	99	4

Table 5

Advisor Use and Transfer of Mathematics Scores by Condition

	Condition											
	0 (n = 20)		1 (n = 17)		2 (n = 17)		3 (n = 12)		4 (n = 18)		Total (n = 84)	
Dependent Variable	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Advisor Use			8.29	4.62	5.28	3.97	4.42	2.87	3	2.5	5.28	4.08
Transfer Score	.88	.68	1.23	.85	.76	.83	.71	.69	.92	.84	.88	.79

Table 6

Attitude Toward Mathematics at Pretest by Condition

	Condition											
	0 (n = 20)		1 (n = 17)		2 (n = 17)		3 (n = 12)		4 (n = 18)		Total (n = 84)	
Scales	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Ego	3.50	0.86	3.61	0.90	3.38	0.87	3.68	0.78	3.80	0.81	3.60	0.84
Task Orientation	3.73	0.61	3.61	0.58	3.56	0.81	3.58	0.74	3.80	0.47	3.66	0.65
Work Avoidance	3.18	0.94	3.30	1.03	3.21	1.01	3.35	1.00	3.49	1.05	3.31	0.99
Interest	4.15	0.89	4.50	0.47	4.38	0.47	4.15	0.71	4.33	0.47	4.29	0.64
Understanding	3.94	0.56	3.98	0.49	3.95	0.52	3.96	0.44	4.03	0.45	3.97	0.49
Competition	3.17	0.71	3.13	0.92	2.83	0.81	3.32	0.85	2.75	0.85	3.04	0.84
Ability	3.69	1.02	3.94	0.66	4.17	0.45	3.83	0.76	3.77	0.66	3.87	0.75
Challenge	3.27	0.83	3.29	0.76	3.34	0.76	3.22	0.91	3.21	0.79	3.26	0.80
Anxiety	2.89	0.88	2.72	0.73	2.63	0.76	2.80	0.87	3.16	0.82	2.85	0.82
Utility	4.10	0.66	4.16	0.46	3.95	0.63	3.98	0.73	4.16	0.63	4.07	0.63

(table continues)

Table 6, continued

	Condition											
	0 (n = 20)		1 (n = 17)		2 (n = 17)		3 (n = 12)		4 (n = 18)		Total (n = 84)	
Scales	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Time Consuming	3.58	0.79	3.70	0.50	3.83	0.61	3.63	0.72	3.26	0.74	3.59	0.70
Effort	4.03	0.84	4.02	0.47	3.91	0.55	3.93	0.71	4.05	0.53	3.96	0.63

Table 7

Attitude Toward Mathematics at Posttest by Condition

	Condition											
	0 (n = 20)		1 (n = 17)		2 (n = 17)		3 (n = 12)		4 (n = 18)		Total (n = 84)	
Scales	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Ego	2.86	0.83	3.15	0.94	2.86	0.76	3.23	0.82	3.18	0.92	3.06	0.86
Task Orientation	3.57	0.83	3.47	0.71	3.78	0.72	3.40	0.76	3.57	0.66	3.55	0.74

(table continues)

Table 7, continued

	Condition											
	0 (n = 20)		1 (n = 17)		2 (n = 17)		3 (n = 12)		4 (n = 18)		Total (n = 84)	
Scales	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Work Avoidance	2.47	0.88	3.17	1.04	2.85	0.92	2.88	1.09	2.93	1.00	2.86	1.00
Interest	3.92	0.89	4.13	0.50	4.23	0.53	3.78	0.72	4.07	0.97	4.02	0.76
Under-standing	3.64	0.80	3.90	0.63	4.03	0.52	3.86	0.60	4.13	0.57	3.91	0.65
Competi-tion	2.92	0.69	2.97	0.77	2.78	0.72	3.25	0.55	2.81	1.15	2.95	0.80
Ability	3.63	0.90	3.95	0.56	3.88	0.58	3.68	0.87	3.72	0.63	3.77	0.73
Challenge	3.22	0.95	3.30	0.81	3.11	0.97	2.84	1.00	3.06	0.92	3.11	0.93
Anxiety	3.07	0.74	2.59	0.82	2.54	0.75	2.90	0.88	3.07	0.70	2.85	0.80
Utility	3.98	0.74	3.99	0.68	3.87	0.76	3.85	0.66	3.89	0.77	3.92	0.71
Time Con-suming	3.56	0.73	3.65	0.65	3.63	0.79	3.45	0.77	3.33	0.80	3.52	0.75
Effort	3.88	0.89	4.02	0.55	3.90	0.55	4.04	0.62	4.06	0.56	3.98	0.65

Table 8

Average Computer Game Attitude Scale (CGAS) Scores by Condition

Condition	M	SD
Control	2.75	.44
High-Contextual Advisor, No Competition	2.76	.41
High-Contextual Advisor, Competition	2.90	.34
Low-Contextual Advisor, No Competition	2.30	.58
Low-Contextual Advisor, Competition	2.86	.39
Total	2.74	.45

Table 9

Transfer Scores of Participants by Condition

Condition	Successful Transfer (n / %)
Control	10 (50%)
High-Contextual Advisement, No Competition	9 (53%)
High-Contextual Advisement, Competition	13 (77%)
Low-Contextual Advisement, No Competition	9 (75%)
Low-Contextual Advisement, Competition	11 (61%)

For all analyses that examined transfer as a dependent variable, only those participants who had completed the game (i.e., had not been forced to quit the game because of a computer problem or who had not accidentally exited the game prior to completing the problems) were included. This was done to control for differences in treatment time. This resulted in 16 participants not being included for analyses involving transfer. Table 10 presents the number excluded by condition.

Of those that were excluded, none had answered the first or second problem. Only one had used advisement (once) prior to exiting the game, and participants were evenly split between males and females. No other discernable characteristics appeared to differentiate these participants from those included in the analysis. Table 11 presents other characteristics of these participants in more detail.

Table 10

Participants Excluded from Analyses Involving Transfer by Condition

Condition	n
1 (High-contextual advisement without competition)	1
2 (High-contextual advisement with competition)	3
3 (Low-contextual advisement without competition)	7
4 (Low-contextual advisement with competition)	5

Table 11

Number, Pretest, and Math Beliefs Scale Scores for Participants Excluded and Included from Analyses Using Transfer

Condition	n	Pretest Score	Ego	Task Orient.	Work Avoid.	Interest	Under-standing	Comp.	Ability	Chal-lenge	Anxiety	Utility	Time Cons.	Effort
Excluded														
1	1	16	18	18	15	8	11	11	26	17	11	27	22	25
2	3	17.33	12.33	22.67	8.333	9	12.67	7.667	25	23.33	12.33	22.67	17.33	24.67
3	7	20.17	15.5	22	9.5	8.333	12.33	9.833	24.83	21.67	13.33	22.33	17.83	25.5
4	5	16.2	17	20.4	11.2	8.8	12	10.6	20.4	18	18.6	22.8	11.4	21.8
Total	16													
Included														
1	17	19.33	13	19.33	9.333	9.333	12	9	23.67	25	16.33	26	18.33	24.67
2	17	18.73	13.6	20.73	10.2	8.667	11.73	8.6	24.67	23.2	13.6	23.87	19.2	24.53
3	12	18	14.25	21.58	9.667	8.083	11.5	9.583	22.58	23.08	13.42	24.5	18.67	24.33
4	18	18.6	13.7	23.2	10.2	8.8	12.3	6.4	23.9	23.4	13.4	26.7	17.3	25.3
Total	64	18.6	13.7	23.2	10.2	8.8	12.3	6.4	23.9	23.4	13.4	26.7	17.3	25.3

Note. 1 = High-contextual advisement, no competition; 2 = High-contextual advisement, competition; 3 = Low-contextual advisement, no competition; 4 = Low-contextual advisement, competition.

Null Hypotheses

Null Hypothesis 2

Null Hypothesis 2: Participants who use advisement more often than others will not differ in attitude toward mathematics scores.

Regressions of the transformed advisor use variable on attitude towards mathematics as measured by the Math Beliefs Survey after posttest indicated that advisor use accounts for approximately 17% of the variance on the work avoidance scale and for 9% of the variance on the effort scale ($n = 56$, $F = 10.81$, $p = .002$, $r^2 = .167$; $n = 56$, $F = 4.912$, $p = .031$, $r^2 = .085$). This null hypothesis was not supported and the alternative hypothesis, that those who use advisement would have more positive attitudes toward mathematics, received support.

A follow-up one-way ANOVA was conducted because the work avoidance scale appeared to be related to advisement use and because participants in the competition conditions were able to select from three levels of difficulty represented by the math ability of their competitor: good at math, average at math, not very good at math. There were no significant differences in work avoidance scores by level of competitor chosen.

Null Hypothesis 3: Participants in the high-contextual advisement conditions will not differ from participants in the low-contextual advisement conditions in terms of advisement use.

This hypothesis was examined concurrently with null hypotheses 7 and 14 in a 2 x 2 ANOVA using the transformed (square root) advisor use variable as the dependent variable and competition and context of advisement as the independent variables. A main effect for context of advisement was significant, F (3, 60) = 10.26, MSE = .812, $p =$

.002). Participants in the competitive conditions used advisement less than those in the non-competitive conditions. Participants in the high-contextual advisement conditions selected advisement more often than those in the low-contextual advisement conditions. Caution must be used when interpreting the means as they represent the square root of the actual scores. This null hypothesis was not supported, and the alternative hypothesis, that those in the high-contextual advisement conditions would select advisement more often than those in the low-contextual advisement conditions, was supported. Tables 12 and 13 present these results in more detail. For the purposes of interpretation, the ANOVA was run with the untransformed advisor use variable with the same results. Participants in the non-competitive conditions used advisement an average of 2.4 times more than those in the competitive conditions, while those in the high-contextual advisement conditions used advisement an average of 3.2 times more than those in the low-contextual advisement conditions. Tables 14 and 15 present these data in more detail.

Table 12

ANOVA Table of Competition by Context of Advisement on the Transformed Advisor Use Variable

Source	df	F
Competition	1	5.44*
Context of Advisement	1	10.26**
Competition x Context of Advisement	1	.153

*$p < .05$ **$p < .01$

Table 13

Means, Standard Deviations, and Numbers of Advisor Use by Conditions from ANOVA in Table 12

Independent Variable	M	SD	n
Competition:			
Competition	1.76	.91	36
No Competition	2.43	.17	29
Context of Advisement:			
High-Contextual Advisement	2.38	.18	35
Low-Contextual Advisement	1.68	.16	30

Table 14

ANOVA Table of Competition by Context of Advisement on the Untransformed Advisor Use Variable

Source	df	F
Competition	1	5.87*
Context of Advisement	1	11.32**
MI x CA	1	.765
error	61	(13.214)

*$p < .05$ **$p < .01$

Table 15

Means, Standard Deviations, and Numbers of Advisor Use by Conditions from ANOVA in Table 14

Independent Variable	Mean	SD	n
Competition:			
Competition	4.14	3.47	36
No Competition	6.69	4.38	29
Context of Advisement:			
High-Contextual Advisement	6.74	4.5	35
Low-Contextual Advisement	3.57	2.7	30

Null Hypothesis 5

Null Hypothesis 5: Participants in the high-contextual advisement conditions will not differ from participants in the low-contextual advisement conditions in terms of attitude toward mathematics scores.

Because attitude toward mathematics was measured by twelve subscales of the Math Beliefs Survey, a multivariate approach was required. Running these analyses separately ran the risk of an inflated Type I error, so a bonferoni approach was used. To use a standard alpha of .05 would have resulted in too conservative a test, however (p values would have to have been .004 for significance). Accordingly, the overall experimental alpha for all twelve analyses was raised to .15 and a bonferoni approach was then used as recommended by Huberty and Morris (1989), resulting in p values of .01 or less being significant.

Null hypothesis 5 was examined concurrently with null hypotheses 9 and 14 using a mixed model MANOVA with one within-subjects factor (pretest mathematics beliefs versus posttest mathematics beliefs) and two-between subjects factors (competition and context of advisement). Results are discussed separately.

This MANOVA indicated that only the anxiety subscale showed a significant change from pre- to posttest mathematics beliefs, ($F = 6.99$, $p = .01$). Specifically, participants in the high-contextual advisement condition had lower scores on the anxiety subscale, 12.77, than those in the low-contextual advisement condition, 15.23. Null hypothesis 5 was not supported and the alternative hypothesis, that high-contextual advisement will result in a more positive attitude toward mathematics, was supported.

Null Hypothesis 6

Null Hypothesis 6: Participants in the high-contextual advisement conditions will not differ from participants in the low-contextual advisement conditions in terms of attitude toward the computer game.

Null hypothesis 6 was examined concurrently with null hypotheses 10 and 15 in a 2 x 2 ANOVA with competition and high-contextual advisement as the independent variables and scores on the Computer Game Attitude Scale as the dependent variable. A main effect for context of advisement was found, F (3, 75) = 5.26, MSE = 487.03, p = .025). Specifically, participants in the high-contextual advisement conditions rated the game higher, 57.01, than participants in the low-contextual advisement, 52.02. Null hypothesis 6 was not supported and the alternative hypothesis, that high-contextual advisement would lead to higher ratings of the game, was supported.

Null Hypothesis 8

Null Hypothesis 8: Participants in the non-competitive simulation game conditions will not differ from those in the competitive simulation game conditions in terms of advisement use.

This hypothesis was examined concurrently with null hypotheses 3 and 16 in a 2 x 2 ANOVA using the transformed (square root) advisor use variable as the dependent variable and competition and context of advisement as the independent variables. A main effect for competition was significant, F (3, 60) = 10.26, MSE = 4.417, p = .002. Participants in the competitive simulation game condition used advisement less than participants in the non-competitive simulation condition. Caution must be used when interpreting the means as they represent the square root of the actual scores. For the purposes of comparison, this analysis was also run on the untransformed advisor use variable with the same results, F (3, 61) = 5.872, MSE = 77.592, p = .001. This null hypothesis was not supported, and the alternative hypothesis, that those in the competitive simulation game conditions would select advisement less often than participants in the non-competitive simulation game conditions, was supported. Tables 12, 13, 14, and 15 present these results in more detail.

Null Hypothesis 13

Null Hypothesis 13: There will be no interaction of context of advisement and competition on transfer of mathematics scores.

This hypothesis was examined concurrently with null hypotheses 4 and 7 using a 2 x 2 ANOVA. This analysis indicated no significant interaction of competition and context of advisement. A similar 2 X 2 ANOVA post-hoc analysis was run using a transfer score based solely on the ability to complete the problems in the game correctly. Because participants were not required to select formulae, it was felt that those who chose correct formulae may have done so by chance or for some other unforeseen reason. Likewise, those who selected incorrect formulae may have realized they had done so but not bothered to then select the correct formula, choosing instead to work the calculations on their scratch paper. Finally, in addition to transfer, this measure reflects problem solving, which is the most authentic assessment of transfer possible. Levene's test of equality of error variances was significant, indicating the error variance of the dependent variable was not equal across groups. The cell numbers were large and equal (see Table

13). This analysis yielded a significant interaction of competition and context of advisement, F (3, 60) = 4.528, MSE = 3.024, p = .037 (see Table 18 and Figure 1). This hypothesis was not supported, and there was no alternate hypothesis proposed.

Table 18

ANOVA Table of Competition and Context of Advisement on Transfer Score

	df	F	Significance
Competition	1	.178	.674
Context	1	.414	.522
Interaction	1	4.528	.037

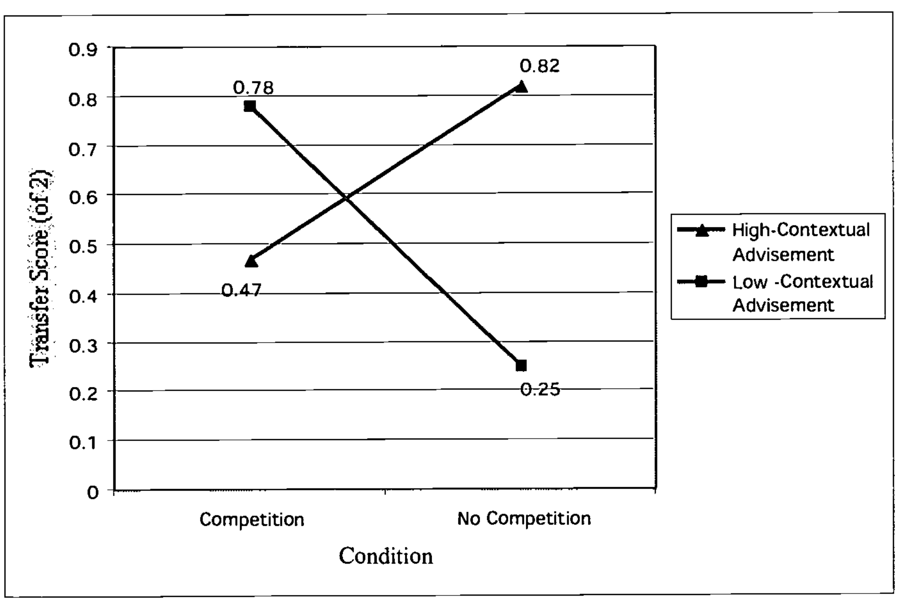


Figure 1. Interaction of competition and context of advisement on transfer of mathematics score.

Participants in the high-contextual advisement non-competitive condition had higher transfer of mathematics scores than participants in the low-contextual advisement competitive condition. Participants in the low-contextual advisement competitive condition had higher transfer of mathematics scores than those in the non-competitive conditions. No other differences were detected between or among the other conditions. To test whether pretest performance was responsible for any transfer effects, a chi-square of the two problems relating to area and perimeter in the posttest and in the game was conducted. There were no significant relationships between pretest and posttest scores on area and perimeter. No significant correlations were found between overall transfer scores and overall pretest scores, either. Finally, a regression of pretest scores on posttest transfer scores also failed to yield any significant predictive relationship.

DISCUSSION

Hypotheses

Hypothesis 1

Hypothesis 1: Participants who use advisement more often than others will have higher transfer of mathematics scores.

Findings

This hypothesis was not supported. Participants who selected advisement more often than others were no more likely to have higher transfer of mathematics scores than were any other participants.

Discussion

Advisement in this question was measured by the number of times the participants selected either the high-contextual advisement (video-based) or the reference book. It is important to remember that participants in the contextualized advisement conditions had access to both the video-based advisement and the reference book of facts and formulae, while those in the low-contextual advisement conditions only had access to the reference book. Transfer was measured in a different context, at a different time, using different problems. The transfer variable ranges from 0 to 2, which may not allow for enough variability to detect differences, at least with this number of participants. Additional research is needed over a longer period of time in order to allow for more transfer items and more practice opportunities. Also, the advisement itself was not piloted and evaluated using participants to determine if the advisement is effective in reformulating the problem space.

Hypothesis 2

Hypothesis 2: Participants who use advisement more often than others will have more positive attitude toward mathematics scores.

Findings

This hypothesis was supported. Advisor use accounted for approximately 17% of the variance in the work avoidance scale and the effort scale of the Math Beliefs Survey.

Discussion

Work avoidance measures the affective response to not having to work hard, working easy problems, not being asked to answer difficult questions, and so on. As such, a high score on this scale indicates that the respondent prefers not to work hard in mathematics. This may be due to a lack (or a perceived lack) of success in mathematics; learners would then be happiest when they are not called upon to do what they cannot (or believe they cannot) easily do. It may also be the result of not enjoying or liking mathematics, and therefore not being as willing to work as hard on it. In either case, one might expect that learners who score higher on this scale might be more inclined to seek help (i.e., advisement), either because they cannot solve the problem on their own or are not willing to solve it on their own.

The effort scale measures the belief that success in mathematics is proportional to the amount of effort put forth by the individual. Those who score high on this scale would tend to believe that if they work hard, they will get/do better in mathematics. It is conceivable that advisement use might reflect this belief as well in that advisement seeking might be considered being thorough and showing effortful by such learners. In other words, it could be that the advisor is perceived as an extra source of information and learning, and that advisement should be explored and utilized if one wants to improve.

Hypothesis 3

Hypothesis 3: Participants in the high-contextual advisement conditions will use advisement more often than participants in the low-contextual conditions.

Findings

This hypothesis was supported. Participants in the high-contextual advisement conditions selected advisement more often than those in the low-contextual advisement.

Discussion

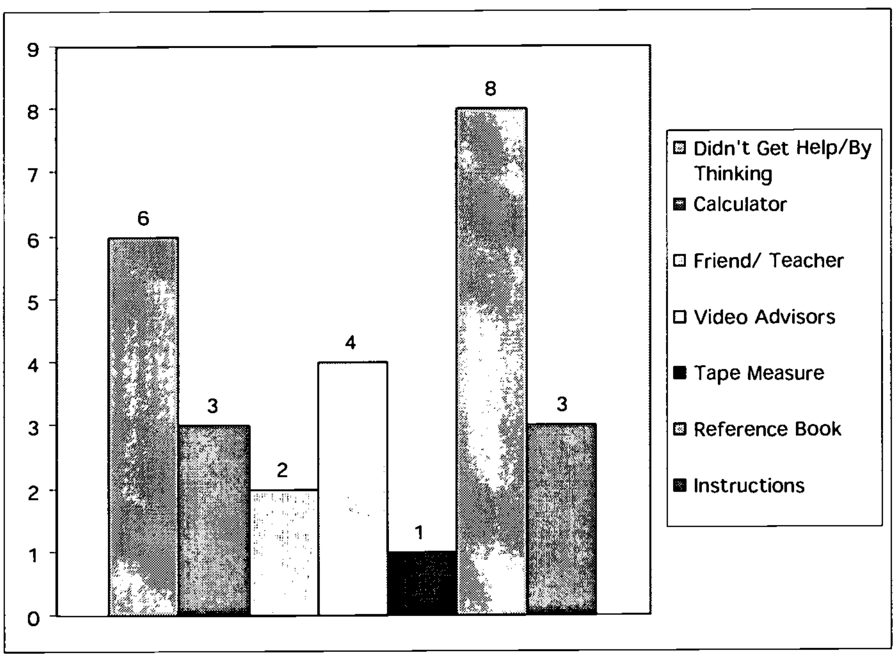
While this result may be partially related to mere presence of more advisement options in the contextual advisement conditions, it probably does not account for it entirely. The competitive and non-competitive conditions of the simulation game were structured in such a way that the reference book would have to be used equally in both contextual and low-contextual advisement conditions. The video-based advisement was comprised of the aunt and uncle discussing one or more aspects of the paint or wallpaper border problems. For example, they mention that the room is shaped like a rectangle if you look down on it from top, commenting that all that is needed a formula for calculating how far around it is around a rectangle. In no instance does the video provide the relevant formula. Accordingly, unless the learner has the relevant formula memorized, they would have to go to the book to look it up. While this prompt might double their advisement count for the first attempt, one would presume that the learner would quickly realize that the book has the formulae, and that there is no need to go to the video advisement unless something in the video advisement itself is of some use to them. Also, in order to get the relevant work spaces to show up in their workbook page (where learners calculate and submit their answers) they must go to the reference book and click on the formulas and facts they want to use. While it is possible to submit answers without doing this, to do so would require that they perform all calculations and representations in their heads or on the provided scratch paper.

It is also possible that high-contextual advisement resulted in higher advisement use because of the novelty effect of the video. Such results have been found and hypothesized in other research using multimedia-based instruction (e.g., Litchfield, 1993). If this were the case, however, one would expect that the novelty effect would be at least partially ameliorated by the presence of competition. Because of the time penalty involved with finishing after the competitor, one might expect the learners to be less likely to select advisement solely for its novelty.

A more likely explanation seems to be that the content of the advisement provided some instructional benefit. It is also possible that the presence of "human," and teacher-like elements mimics typical problem solving strategies (e.g., when we get stuck on a problem, we ask someone for help). There is some support for this in the literature (e.g., Gale, 1990).

It is also interesting to note that although, as mentioned earlier, participants tended not to choose advisement, this was not an unconscious choice on their part. When asked about their help seeking strategies, most of the respondents indicated they had used the reference book. This is as expected, since the reference book was available to all participants. The second most common response was that they had not sought help. Just as with transfer, the difference between successful and unsuccessful help seeking may be as simple as a prompt to seek help. An adaptive advisement system that offers help or simply prompts the learner to use the help system could go a long way toward increasing help seeking. Figure 2 presents participant responses regarding help seeking in the game.

Figure 2. Participant response to the question, "How did you get help in the game?"



Hypothesis 4

Hypothesis 4: Participants in the high-contextual advisement conditions will have higher transfer of mathematics scores than those in the low-contextual advisement conditions.

Findings

This hypothesis was partially supported. When transfer was measured solely by the participants' ability to solve the problem correctly, statistical analysis indicated that those in the high-contextual advisement conditions had higher transfer of mathematics scores than those in the low-contextual advisement conditions. This only occurred in the simulation condition. There was no significant difference in transfer of mathematics scores between high-contextual advisement and low-contextual advisement conditions under the competitive condition, although those in the competitive, low-contextual advisement condition of the simulation game scored higher on the transfer task than did those in the non-competitive, low-contextual advisement, condition.

Discussion

The initial analysis, which measured transfer both as the ability to select correct formulae for the given problem and the ability to solve the problem correctly, did not yield any support for this hypothesis. The most logical conclusion is that transfer and context of advisement are not related. Upon further consideration, an alternate explanation suggests itself, however. Transfer can be seen as a form of problem solving; much of the research on transfer uses problem solving and problem-solving contexts. Given the close relation of transfer and problem solving, and given that one of the goals in this study is to promote "real world" (i.e., authentic) transfer, measuring transfer by the ability to select the correct formula and not also by the ability to apply the formula correctly may result in only half the picture. When transfer was measured in this study as the ability to solve the problems correctly, a different picture emerged. High-contextual advisement in the simulation condition produced the highest transfer of mathematics scores of all the groups, indicating that it may be best suited for simulations. An argument could be made that such a definition is not truly transfer. Given that many researchers suggest that transfer be taught in problem-solving contexts over many sessions, however, it seems reasonable to assume that successful problem solving is an indicator of future transfer, assuming enough practice opportunities.

On this assumption, some analysis and interpretation of this result is warranted. It may be that the presence of competition creates an affective environment in which high-contextual advisement cannot be fully attended to or processed because learners are concerned about the time they have taken (which is displayed on screen) and with beating the competitor. The competitor character in the simulation game is always visible at the bottom right of the screen and randomly comments on how he or she (the competitor) is doing on the problem. The stress level involved with waiting for the advisement video to finish playing may interfere with accurate processing of the information. This may account for why the low-contextualized advisement in the competitive simulation game condition resulted in higher transfer of mathematics scores than it did in the non-competitive simulation condition, since learners are in control of how much time they spend in the reference book and have less to attend to while competing.

Hypothesis 5

Hypothesis 5: Participants in the high-contextual advisement conditions will have more positive attitude toward mathematics.

Findings

This hypothesis was supported. Participants in the high-contextual advisement conditions had lower anxiety toward mathematics scores than did those in the low-contextual advisement conditions.

Discussion

Although 12 subscales were used in the Math Beliefs Survey, only anxiety showed a significant change from pre- to posttest. These findings are consistent with earlier research (CTGV, 1992c) that found that experience with anchored instruction scenarios reduced math anxiety. Further analysis reveals that the initial mathematics attitude scores were high, indicating that there may not have been much room for change. The initial scores were all well above 3 on a 5-point scale (see Tables 6 and 7). It should also be noted that attitudes and beliefs usually take many interventions over a long period of time before changes occur (Gagné et al., 1992). The intervention in this case may not have been long enough to produce measurable differences. The survey has also not been validated in its current form, and may therefore not be measuring some of the constructs accurately enough. Some subscales may need additional items before they are sensitive enough to detect the kind of changes we might expect from a short intervention such as in this study.

Hypothesis 6

Hypothesis 6: Participants in the high-contextual advisement conditions will have more positive attitude toward the computer game scores than participants in the low-contextual advisement conditions.

Findings

This hypothesis was supported. Participants in the high-contextual advisement conditions had higher game rating scores than did those in the low-contextual advisement conditions.

Discussion

It appears that high-contextual advisement can promote positive attitude toward the instruction. Such effects can in turn promote similar effects on the content as well. It may be that high-contextual advisement increases what Csikszentmihalyi (1990) calls flow-like experiences. The more immersive, or flow-like, a game is, the more intrinsically motivating it should be, thus leading to higher ratings of the game. It may also be that the presence of a socializing agent (the humans in the video) makes the learners more comfortable.

Hypothesis 7

Hypothesis 7: Participants in the non-competitive simulation game conditions will have higher transfer of mathematics scores than participants in the competitive simulation game conditions.

Findings

This hypothesis was not supported. Participants in the non-competitive simulation game condition did best when they had access to high-contextual advisement. Participants in the competitive simulation game condition did best on transfer tasks when they had access to low-contextual advisement.

Discussion

It appears that advisement should be modified according to whether competition is present or not. Games that make use of a time element may be incompatible with high-contextual advisement, which by its nature takes longer and may be perceived as less relevant. Alternatively, it may be that time constraints and competition may be better suited for building fluency and automaticity than for learning relatively new material and processes, as the transfer problems in this study might well be considered.

Further research examining competition and cooperative learning might also help to explain these results, as some researchers maintain that cooperative learning is best for promoting problem-based learning and transfer (Bransford & Stein, 1993; Dalton, Hannafin, & Hooper, 1989; Reid, 1992; Young, 1993).

Interestingly enough, most participants reported enjoying the competitive conditions, and that they were trying to beat the competitor. It may be that just as learners prefer control but are often unable to use it wisely, enjoyment may not reflect effectiveness of learning. Of those who did not enjoy competing, the majority cited that it was hard or confusing as their reason. Figures 3, 4, and 5 represent participant responses about competing in the game.

Hypothesis 8

Hypothesis 8: Participants in the non-competitive simulation game conditions will use advisement more often than participants in the competitive simulation game conditions.

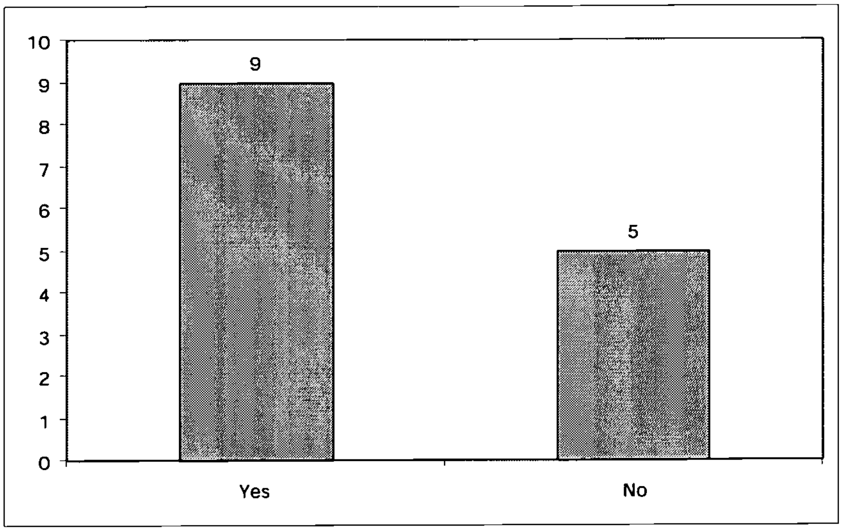


Figure 3. Participant response to the question, "If you played against another player, did you like that feature of the game?"

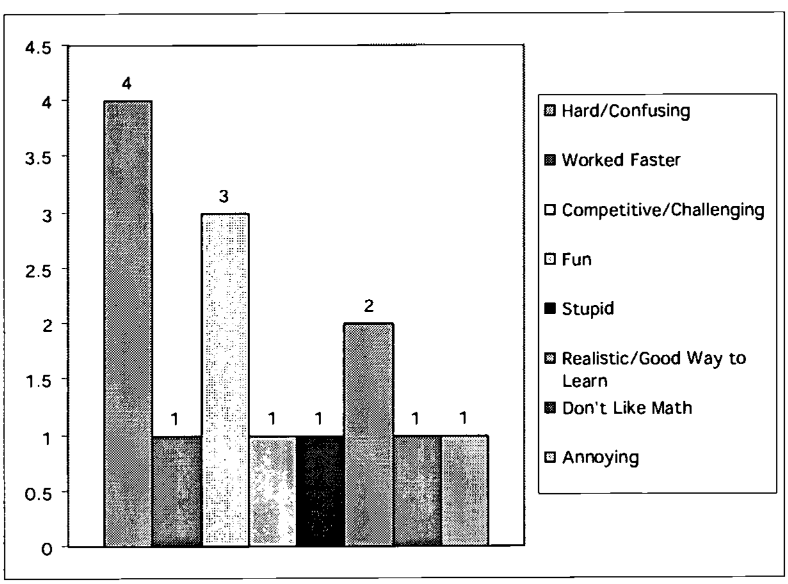


Figure 4. Participant response to the question, "Why or why not?" as a follow up to the question listed in Figure 3.

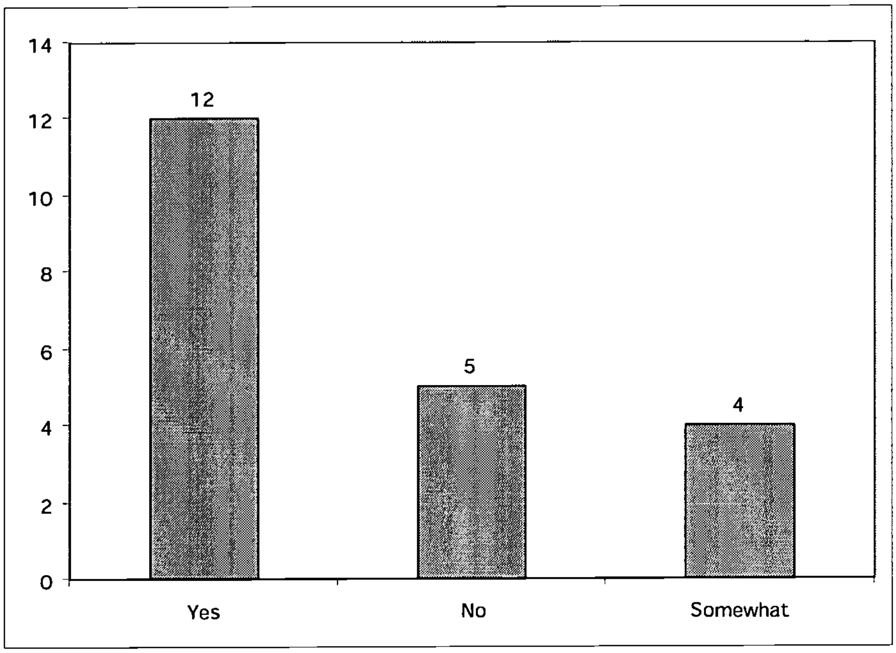


Figure 5. Participant response to the question, "Were you trying to beat [the competitor]?"

Findings

This hypothesis was supported. Participants in the non-competitive simulation game conditions used advisement more than those in the competitive simulation game conditions.

Discussion

The presence of competition and the time factor may have worked against advisement use in the non-competitive simulation game. As the learners in the competitive simulation game conditions are working, they are reminded at random intervals that they are competing against someone who is trying to finish faster than them. This is accomplished by playing recorded comments by the competitor chosen for the non-competitive simulation game. These comments take such forms as "Aha! Now I get it!" and "I'll have this problem solved in no time!" This may prompt the learner to want to move quickly through the simulation game, something that is at odds with selecting advisement often, especially if that advisement is video-based and must be allowed to play to completion before any other action can be taken.

Hypothesis 9

Hypothesis 9: Participants in the non-competitive simulation game conditions will have more positive attitude toward mathematics than those in the competitive simulation game conditions.

Findings

This hypothesis was not supported. There were no differences by competition in attitude toward mathematics.

Discussion

It was hypothesized that the presence of competition would work against attitude toward mathematics. In retrospect, however, these results may not be so surprising. In respect to the attitude toward mathematics scores, we are faced with the same concerns discussed in hypothesis 5, namely, that the initial mathematics attitude scores were high enough to create a ceiling effect, that the scales may not be sensitive enough, and that the duration of the intervention was not long enough to produce a detectable difference.

Hypothesis 10

Hypothesis 10: Participants in the non-competitive simulation game conditions will have more positive attitude toward the computer game scores than those in the competitive simulation game conditions.

Findings

This hypothesis was not supported. There were no differences by competition in attitude toward the computer game.

Discussion

It was hypothesized that the presence of competition would work against attitude toward mathematics and toward the instruction. In retrospect, however, these results may not be so surprising. Whether or not competition would impact attitude toward the content or the instruction may simply be a matter of whether one prefers competition or not. Certainly games with and without competition sell well enough in stores to suggest that many people enjoy one or the other. If preferences for competitive simulation games is normally distributed in the population, we might expect the results found in this study, assuming of course that our sample is representative.

Hypothesis 11

Hypothesis 11: Participants in the competitive and non-competitive simulation game conditions will have higher transfer of mathematics scores than participants in the control conditions.

Findings

This hypothesis was not supported. No differences in transfer were found between the control conditions and the combined competitive and non-competitive conditions.

Discussion

Given that there were no differences in transfer of mathematics scores solely as a result of either competition or context of advisement, it is perhaps not so surprising that controls did not differ from the other conditions. Controls had lower transfer scores than any other conditions, with a mean transfer score of .1335, while the transfer of mathematics scores for the other conditions ranged from .25 to .82. It may be that the measure of transfer in this study does not vary enough to detect differences because of a restriction of range. Transfer of mathematics scores ranged from 0 to 2, as they were based on the ability to select and apply the correct formulas for two problems. This was necessary because the intervention was limited by the schools to one 50-minute session, and situated learning is complex and requires elaborate processing; more than two problems could not have been finished by the learners in the allotted time.

Hypothesis 12

Hypothesis 12: Participants in the competitive and non-competitive simulation game conditions will have more positive attitude toward mathematics scores than participants in the control condition.

Findings

This hypothesis was not supported. No differences in attitude toward mathematics were found between those in the control conditions and those in the experimental conditions.

Discussion

The differences in attitude toward mathematics found in the earlier analyses, namely high-contextual advisement resulting in lower anxiety, and advisement use predicting scores on the work avoidance and effort scales, may not have been robust enough to remain detectable when mixed with the error terms of the other conditions. The previously stated concerns about the scale, intervention time, and high initial attitude scores are also relevant here.

Time on Task, Time in Advisement

Findings

Two 2 X 2 ANOVAs of competition and context of advisement on time on task and time spent during advisement indicated main effects for context. Participants in the low-contextual advisement conditions spent 42 seconds longer on task than did participants in the high-contextual advisement conditions ($F = 9.815$, $p = .003$). Participants in the high-contextual advisement conditions spent 42 seconds longer in advisement than on task.

Discussion

These differences may have little practical significance in the given context. Forty-two seconds longer on task is unlikely to produce much gain given the complexity of the problems. Forty-two seconds longer in advisement, where it might be expected that participants are elaborating on the strategies, rules, and concepts needed to complete the problems, could be practically significant. It should be noted, however, that the extra time in the high-contextual advisement is probably related to the extra video advisement available as well as to the length of time it takes for that video to complete.

Limitations

There are several factors that limit the internal and external validity of this study. It is important to keep these factors in mind when interpreting the results. What follows is a brief summary of these factors.

Instruments

The demographic survey (19 questions), pretest (26 questions), and Math Beliefs Survey (56 questions) had a combined length of 101 questions. Given that most of the questions required significant thought and processing, it may be that participants became tired of answering questions. Without fail, five or six people in each class made some comment to the experimenter regarding the length of these materials (e.g., "How many more of these questions are there?").

The Math Beliefs Survey has not been validated in its current form. It may not be sensitive enough to detect differences on all constructs, especially given the short duration of the intervention (50 minutes). Some scales may not have had enough items for reliable measurement. Scales ranged from two (n = 3) to seven (n = 1) questions, with a mode of three. Tables 19 and 20 present this data in more detail. Triangulation using personal interviews and other qualitative tools would make judgements about math beliefs more reliable and powerful.

Table 19

Number of Questions by Each of the First 6 Subscales on the Math Beliefs Survey

	Ego	Task Orientation	Work Avoidance	Interest	Understanding	Competitive
n	4	6	3	2	3	3

Table 20

Number of Questions by Each of the Last 6 Subscales on the Math Beliefs Survey

	Ability	Challenge	Anxiety	Utility	Time Consuming	Effort
n	6	7	5	6	5	6

Some of the questions may not have been fully understood by the participants, as well. Without exception, participants in every class during the pilot (30), field trial (75), and the sample used in this study (123) asked what the word "relevance" meant. It may be possible that there were other words they did not know or know well enough, but which they did not ask about. Many participants commented that "It keeps asking me the same thing over and over again." Many of the questions in the instrument are rephrased and asked again as an reliability check, but it could also be the case that some questions from different scales may have appeared quite similar to a seventh- or eighth-grade student. If students thought they were answering the same question that appeared earlier in the instrument, they might have put the same answer down; they might have answered differently if they'd known it was a different question.

The advisement itself was not validated for effectiveness with problem solving, although most of those asked indicated that the advisement was helpful (see Figures 6 & 7). A pilot study to evaluate the effectiveness of the advisement would have made the study stronger. This study also did not examine qualitative measures regarding advisement. Debriefing forms asking about the qualitative aspects and affective responses to the instruction were distributed and collected, but return rate was low.

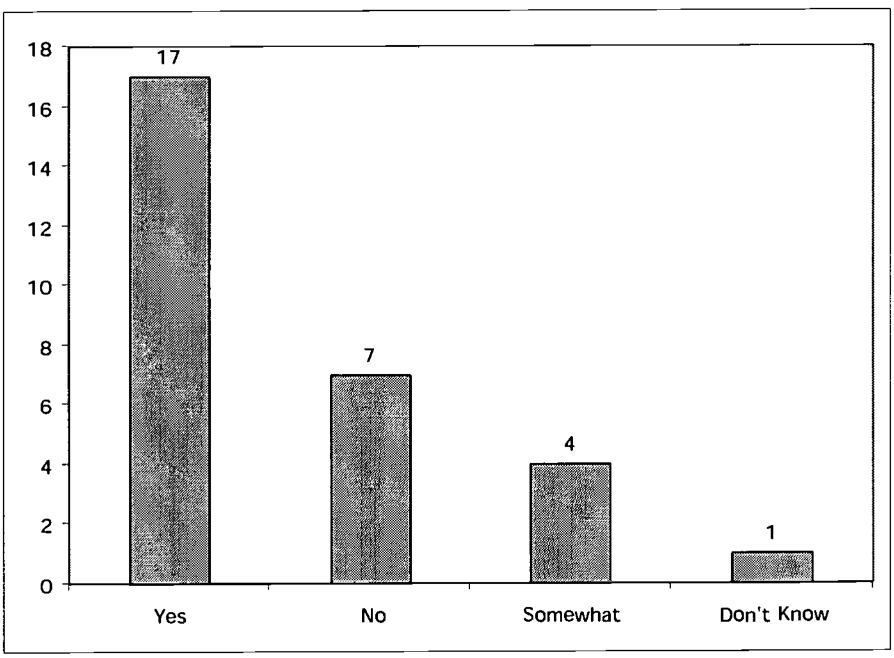


Figure 6. Participant response to the question, "Was the advisement/help in the game good?"

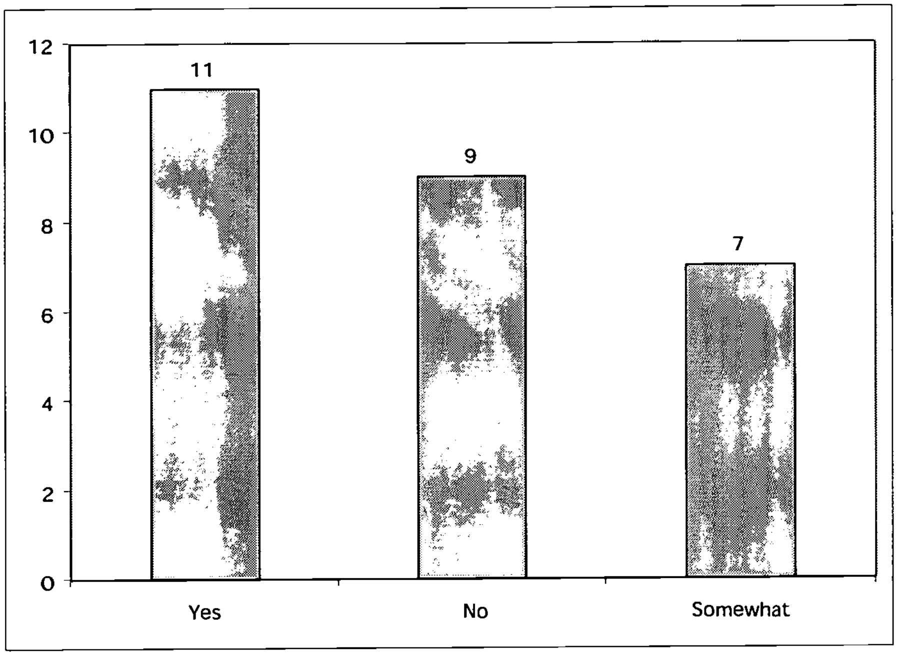


Figure 7. Participant response to the question, "Did the advisement/help in the game help you figure out what to do?"

Prerequisites, Training, and Prior Knowledge

The mathematics content of the simulation and game focused on solving two problems: one requiring area and the other requiring perimeter. These topics were selected because they are well suited to the game scenario. The target population was seventh- and eighth-grade students. This population was selected based on consultation with teachers at middle schools, mathematics textbooks in use in local public middle schools, and a K-12 curriculum expert at a Gulf Coast university. It was commonly agreed that students begin to study area and perimeter in the fifth grade, and continue to study it through the year in sixth grade. It was felt that by the time they got to seventh and eighth grade, they should be familiar enough with the concepts that they could be expected to work with these problems in the simulation/game format. Some problems were found with this assumption just prior to the study. While all participants were in seventh- and eighth-grade, some were in semi-remedial classes and were still working with these problems, while some others were in advanced mathematics classes. Because participants were randomly assigned, ability was controlled for throughout the conditions, but this did introduce some potential error into the statistical analyses. It would have been better to train the learners to mastery in the content, and then run the intervention weeks or months later.

There was not enough time available for the learners to work at their own pace. The school required that all sessions take place with intact classes, during the regular 50-minute class periods. As a result, some participants were unable to complete the game, and most had little time for reflection and processing, focusing instead on getting the work done in the allotted time. Those who did not finish the game were excluded from the analyses to minimize error. This may have resulted in an overly conservative test for differences among groups. It also created disparity in cell sizes, although the ratio of included-to-missing cases was better than 90/10. The fidelity of the treatment condition would have been higher had students been able to work at their own pace over a longer period of time. That there was not enough time for the participants to process all the information is borne out by their responses when asked how the game could be improved; the most common response was "more instructions and help." Figure 8 presents all their responses by category.

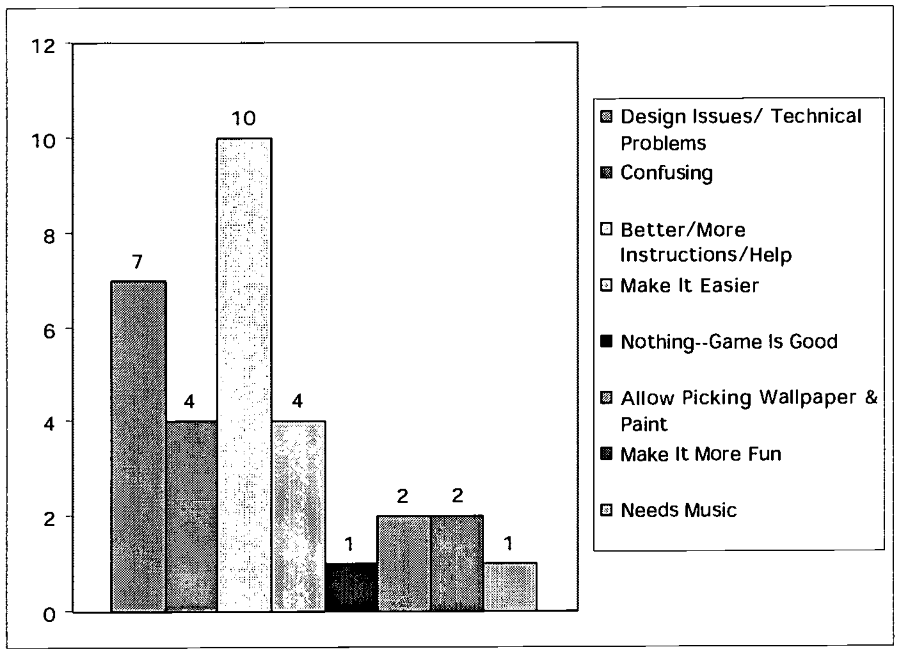


Figure 8. Participant response to the question, "What didn't you like about the game? What would have made it better?"

Variables

There were some variables that made inferential statistics difficult to run and/or interpret. The Math Beliefs Survey scores may not be uniformly reliable given the low number of items (2) on three of them (work avoidance, interest, and anxiety). As a result, these scales might not have produced valid scores. It should be noted, however, that the items in question are among the more stable and powerful constructs from the earlier test, (with approximate alphas of .87, .71, and .80 from the original factor analysis) and it is felt that these scales are stable enough to support fewer items.

Because there was not enough time to do more than two problems, transfer of mathematics scores had a restricted range, potentially leading to low variance and validity for this variable. Advisement use was negatively skewed and kurtotic. There is good reason to believe that this is the case in the population, as it has been shown that novice learners do not select advisement unless they are prompted (Dempsey & Van Eck, 1998). There were no prompts in the game beyond the initial game instructions to use the walkie-talkie to call for advice if they got stuck. However, it was felt that this variable should be transformed by taking the square root. When the statistical test for competition and context of advisement was run on the transfer scores using the untransformed advisement use variable, a significant interaction was found. This stands in stark contrast to the significant main effects found when using the transformed variable. Without more concrete data on this particular population and advisement use, it is not possible to say which variable or interpretation should be accepted. Because ANOVA assumes normal distribution (although it is robust to violations of this assumption), the transformed variable was used in the final analysis.

Population

The target population for this study is seventh- and eighth-grade students at Catholic middle schools. The sample selected was drawn from both seventh- and eighth-grade mathematics classes at a single school in a Gulf Coast city. External generalizability is therefore limited to this population. Originally, three public schools with differing standardized test scores were identified for inclusion in the study. One of these schools was unable to participate at the last minute and an alternate date was unavailable. A second school did not have a computer lab set up and had to use 10 laptop computers that required set up each session. This reduced the number of participants by a factor of one half. A pep rally was called during the second session of this school as well, and the data collection was suspended. No alternate dates could be found. The third school reported having 20 Pentium computers in a lab, but in reality had 6 Pentium computers and fourteen 486 computers running Windows 3.1. Additional computers were located in teachers' rooms and in the library, and data were collected in both places, but this also reduced the number of participants run and the time each participant had to complete the sessions. A pep rally was also scheduled for this school at the last minute, and five hours of data collection were lost during the game session. Some participants were rescheduled, but not all could complete the study. This also introduced a time factor that could possibly have introduced error. For this reason, the data in this study reflects only the Catholic school data despite having the data from 75 participants at the other school. Data are not available on whether or not the sample used in this study is representative of Catholic middle schools nationwide, let alone public schools. Replications with other schools and locations are needed before generalizability beyond the current sample is possible.

Design

Good interface design dictates that items and tools should be a logical extension of the metaphor being used. In this case, the metaphor is a room that is being remodeled/redecorated. Accordingly, advisement was selected by clicking on a reference book (low-contextual advisement) or clicking on either the reference book and/or a walkie-talkie (high contextual advisement). In order to allow the learners to move about the room to measure and collect information, it was necessary to give the tools as small a "footprint" as possible. While this did not prevent users from finding or using advisement, it may not have been as obvious as prior research has suggested it should be

(Dempsey & Van Eck, 1998). Consequently, advisement may not have been selected as often as it might otherwise have been.

Although participants had all received at least one year of training in the content, no external criteria of mastery was available. The study would have been stronger if it had been possible to provide training to mastery prior to the intervention. Finally, transfer and attitude change may require longer periods of time and multiple practice and interventions (Gagné et al., 1992; Larkin, 1989). The intervention was limited in this study because the schools could only provide three class days out of their normal curriculum. The instruments required one class period on their own up front, leaving one session for the game and one session for the posttest. More interventions over a longer period of time for longer periods of time and the inclusion of qualitative measures may have produced larger changes.

Because participants were able to type in their answer to either of the two transfer problems in the game and in the posttest without doing any calculations on screen and without selecting any formulae or facts, it is possible some participants entered answers that amounted to guesses. It was not possible to determine with any accuracy whether participants were guessing at the answers because some may have used their scratch paper to do the calculations. While this scratch paper was retained by the researcher, it is problematic to evaluate these sheets for this purpose. A few participants left without turning in their scratch paper. Some participants may have done some or all of their calculations in their heads; while that is not likely to result in a correct response, there is no way to evaluate the effort and mental calculations that went into their answers. Finally, while some participants may have guessed, all students spent the full 50-minute session actively engaged in the game and the solution to the problems. Some may have ended up putting down what amounts to a guess but did so after a sustained period of effort. No participants entered their answers early in the session.

Conclusions

Bearing in mind the considerations discussed in the preceding section it is appropriate to discuss what conclusions may be drawn from this study. This section will present summaries of the major conclusions in this study.

Transfer

Transfer can be promoted through computer-mediated intervention. One of the factors associated with increased transfer of mathematics scores seems to be whether and to what extent the learners avail themselves of advisement. Instruction that attempts to build in advisement should also explore ways to promote its use; presence alone is not enough.

Attitude and Advisement Use

Attitude toward mathematics and toward mathematics instruction may be increased through modified advisement use. This, again, requires not only the presence of advisement but ways to promote its use. Measures of work avoidance and effort seemed to be partially predicted by advisement use in general.

Promoting Advisement Use

Advisement use may be promoted by simulations rather than by games. Simulations, through the absence of competition involving time pressure, may encourage exploration and experimentation in the environment. Such exploration might naturally include selecting advisement.

Advisement can also be promoted by making the advisement an interesting, metaphorical part of the context in which it occurs. This is more than a novelty effect, as high-contextual advisement resulted in higher advisement use even under competitive conditions, which were found to result in lower advisement use than under the simulation conditions.

Context of Advisement and Transfer

Contextual advisement can promote transfer under non-competitive conditions. High-contextual advisement in non-competitive conditions produced the highest transfer of mathematics scores. This is probably a function both of the newness of the instruction and of the complexity of the instruction as much as it is a function of the competition. Transfer is a form of problem solving, which is in this case a higher-order intellectual skill involving accurate problem space representation, recall of prior knowledge, and the formulation of rules about when and where to apply that knowledge. Accordingly, the cognitive load involved may be higher than for lower-level intellectual skills. Competition may create an affective state of anxiety and pressure that is detrimental to the processing necessary for transfer learning to occur. There were no detectable differences between high-contextual and low-contextual advisement conditions in the competitive simulation game condition.

Context of Advisement and Mathematics Anxiety

Contextual advisement may decrease anxiety toward mathematics. Building high-contextual advisement into simulations or games may help lower mathematics anxiety. This may be the result of the humanizing features of the video, the conversation help with problem representation, or both.

Context of Advisement Versus Competition on Attitude

Contextual advisement may increase positive attitude toward the instruction independent of the competition. High-contextual advisement seems to be a more important consideration than is competition. This may be due partially to the novelty effect of built-in video in a computer context.

Summary

In summary, for transfer training of this nature, non-competitive simulation games might be the best choice, better at least than simulation games that include a time-pressure factor. Advisement seems to be a good way to promote transfer and positive attitude toward mathematics and the instruction, the latter two of which can indirectly promote future performance. High-contextual advisement, that is, advisement that is metaphorically tied to the context in which it is found and is interesting, may be the best form of advisement. This is true regardless of the presence or absence of competition but perhaps particularly so for non-competitive simulation games. It tends to promote advisement use, which in turn is associated with transfer and attitude toward mathematics. Finally, simulation games seem to be capable of representing authentic contexts, with and without competition, and may be useful in promoting transfer in a variety of subject areas.

Future Research

This study is intended to be generative in nature rather than definitive and should be replicated and expanded upon by others in the field of learning theory and instructional design. While this study has answered some questions, it has raised others. Taken in conjunction with previous studies on advisement (e.g., Boulet, 1993; Boulet et al., 1990; Dempsey & Van Eck, 1998; Tennyson, 1980a, 1980b, 1981) it would seem that advisement can help learners manage their own instruction, increase performance, and promote transfer. The issue may no longer be if advisement is necessary, but why it is, and how its use can be promoted. High-contextual advisement increased advisement use, as did the absence of competition. Studies should examine other ways to promote advisement in simulations and games. An earlier study showed that making the advisement option obvious on the screen can increase advisement use (Dempsey & Van Eck, 1998), but this may be contraindicated in simulations and games, where a premium is placed on the immersive quality of the experience. It may be possible to build a kind of adaptive advisement system similar to that developed by Tennyson (1980a, 1980b), but which sends contextual prompts to the learner (e.g., after three errors and/or long periods of inactivity, voices come over the walkie-talkie asking if they need any help). A similar form of advisement has been utilized in a game called Hangtown (Doolittle, 1995).

Questions and Variables

Further research is needed to determine which factors of the high-contextual advisement used in this study are responsible for the effects observed. High-contextual advisement could be delivered by sound only with no loss in contextual relevance. This would help to determine what kinds of novelty or modality effects may be at work. The observed decrease in anxiety may be due to the contexuality of the advisement or to the humanizing presence of the aunt and uncle characters. One might use similar video clips of people but make them generic advisors, unconnected to the context of the simulation or game.

Competition may inhibit elaboration. Future research might examine the role competition plays in elaborative processing. This should be done taking into account both time stress and competition as separate variables. While this study looked at competition as a factor, it might also be beneficial to examine cooperative learning in similar contexts. Research has shown that cooperative learning may be best for promoting transfer (Bransford & Stein, 1993; CTGV, 1992b; Keller, 1990; Young, 1993).

Design

Further research should consider a mixed methods approach, using think-aloud protocols, observational measures, and oral debriefing to begin to examine the why and how of the trends discussed in this study. Future research might also consider tracking errors and looking for patterns which might then be used to develop adaptive advisors. Future studies might also examine transfer issues in a more longitudinal fashion, perhaps over the course of one or more years.

Contexts

Gender

Further research should be done to examine what kinds of gender differences there are in advisor preference and preference for competition. There was a participant/competitor gender effect; it may be reasonable to expect the same kind of relation between gender of participant and gender of advisor. It would be useful to examine whether this had any effect on advisor use, which was one of the more robust variables in this study. Such an effect might also impact affect as well. Future studies might provide different gendered advisors and run conditions where gender of advisor and participant were crossed.

Public Versus Private

The population for this study are private Catholic school students. There may be a variety of cultural beliefs and attitudes in this population which might be expected to impact the variables in this study. Catholic school students may be less likely to be questioning of teachers, thereby leading to differences in advisement use. Private school students may be more advanced and have better problem-solving skills than public school students. Private school students may also have higher computing skills and abilities because computing technology is more prevalent in private than public schools. Public school populations should be studied in similar fashion to strengthen generalizability of results.

Age

The population under study was aged 12 to 14. The effectiveness of training and instruction using simulations and games should be studied at different age groups. Younger students exposed to this kind of training during instruction on the topic of interest, in this case area and perimeter, might be more successful transferring knowledge than those in this study, who were exposed after having studied the content exclusively in the abstract.

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