THE EFFECTS OF IMPLEMENTING AN INTERACTIVE STUDENT RESPONSE SYSTEM IN A COLLEGE ALGEBRA CLASSROOM

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An Abstract of the Thesis Presented
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During the spring 2005 semester at The University of Maine, an interactive student response system was implemented in a traditional college algebra (MAT 111) lecture classroom. This thesis studies the effects of this implementation.

First, to determine if the use of an interactive student response system increases academic achievement in college algebra, a common exam was administered to five sections of MAT 111 after the 4th week of instruction. Four sections comprised the control group and one section the treatment group. Prior to the exam, the control group received traditional lectures, while the treatment group received instruction that included use of an interactive student response system. Statistical analysis of the exam scores revealed that the treatment groups' mean scores were not statistically significantly higher than the control groups' mean scores. However, a time constraint, which limited the interactive system's use, as well as variations between MAT 111 sections may have affected the results of this study.

Second, to determine students' attitudes toward the interactive student response system (Qwizdom), a preliminary questionnaire, an attitude survey, and a post-study continuation survey were administered to the treatment group. Although there were technical problems with the system, the students' attitudes were positive otherwise. Overall, students generally liked using Qwizdom and felt that they had benefited from its use. The surveys revealed that students perceived that the use of Qwizdom provided problem-solving practice, increased their understanding and was a good learning tool, increased attentiveness, and made math more interesting and fun. Furthermore, the system's anonymity encouraged participation in class. However, the attitude survey also revealed that the use of the interactive system had no affect on class attendance.

Third, to determine the instructor's attitude toward the interactive student response system, my thoughts were recorded in a daily journal throughout this study. In particular, I feel that Qwizdom's Interactive Learning System is a well-designed, user-friendly, and versatile wireless response system. Although we experienced some technical problems with the system, these problems have been, or can be, resolved with further programming and system upgrades. In general, I enjoyed using the interactive system because the students enjoyed using it and it provided an interactive component that previous classes I had taught were lacking. When not using the system, the students in this study did not ask many questions and generally appeared uninterested in the lecture material. When using the system, however, the students were engaged and appeared to be having fun – a positive atmosphere I believe most instructors would prefer. Unfortunately, due to the fast pace, set schedule, and predefined curriculum of

MAT 111 at The University of Maine, I do not believe that this traditional course is an ideal setting for an interactive student response system, however.

To conclude, I review the results of the study regarding academic achievement, students' attitudes, and instructor's attitude to conjecture if the interactive student response system is an effective tool for instruction in a traditional college algebra lecture environment. I also explore ideas and questions for future research studies.

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CHAPTER 1 - INTRODUCTION

At The University of Maine, College Algebra (MAT 111) is typically taught using a traditional lecture-style format (procedural content is emphasized), with little or no interaction between the students and between the students and the teacher (i.e. passive learning). In this thesis, I will report on research conducted to study the effects of implementing an interactive student response system in a MAT 111 class to determine if it is an effective tool for instruction in a traditional college algebra lecture environment.

In my experience as a student and a mathematics lecturer, the content of lectures often is directly extracted from the text. In addition, the traditional lecture style includes only superficial, if any, student interaction between the students and between the students and teacher. I suspect that for most students, this makes it very difficult to remain interested and attentive during class, and may often result in decreased attendance. For example, in high school, I found I could do well on most exams by studying the textbook on my own, and that my attendance did not increase my understanding of the subject. As a college undergraduate, I found class attendance to be critical as many of my undergraduate classes consisted of the instructor telling us, at a very fast pace, what we needed to know. Consequently, I spent the entire class period trying to capture, in my notes, everything that the instructor said or demonstrated, leaving no time for me to process the information. As a result, I was unable to recognize confusing concepts and to ask questions during the lecture. In fact, questions were rarely, if ever, asked by the students or by the instructor; there was little or no classroom interaction.

As a teacher, I would like to incorporate more interaction in my classrooms, avoiding, or at least minimizing, the traditional passive lecture environment that I experienced as a student. I believe the use of interactive technology is one way to accomplish this.

In this research study, I investigated the following questions:

1. Does the use of an interactive student response system increase academic achievement in college algebra, as measured by standard exams?
2. What are students' attitudes towards the interactive student response system?
3. What is the instructor's attitude towards the interactive student response system?
4. Overall, is an interactive student response system an effective tool for instruction in a traditional college algebra lecture environment?

CHAPTER 2 – LITERATURE AND TECHNOLOGY REVIEW

Tell me, I forget.

Show me, I remember.

Involve me, I understand.

Chinese proverb

Introduction

Driscoll (2002) uses the preceding Chinese proverb to illustrate "the importance of getting learners mentally involved in learning activities, generating connections between what they already know and what they are being asked to learn, and constructing meaning from their experiences" (p. 2). As this proverb suggests, learning is active. Moreover, learning is social. Piaget (1976) considered the role of social interaction in learning and argued, "social interaction is a necessary condition for the development of logic" (p. 80). Likewise, "Mathematics is inherently a social activity" (Schoenfeld, 1992, p. 335).

Brown & Palincsar (1989) discuss the active and social aspects of learning, and argue that it is necessary to reconsider the traditional lecture format, where the teacher lectures at the board and students sit passively at their desks, and to give serious consideration to a type of interactive learning known as reciprocal teaching. In reciprocal teaching students are typically in small groups discussing a problem or task. As students master a task, they become teachers to those who are still learning. Furthermore, Lloyd (1999) cites three studies that support this type of interactive learning and states, "When students work in groups to communicate their ideas and questions, agree and disagree among themselves, and negotiate joint theories and ideas, rich mathematical learning can occur" (p. 228).

Interactive Student Response Systems

As the references above point out, learning is active and social. In other words, learning is interactive. One way to incorporate interactive learning in the classroom is with the use of interactive student response systems, including variations known as classroom communication systems, classroom performance systems, personal response systems, student response systems, wireless response systems, and electronic response systems.

Interactive student response systems use wired or wireless communication systems in which the students are able to answer questions electronically while in the classroom. One advantage of this approach is that students are able to get immediate feedback to their answers, either in the form of a histogram showing class results, and/or as a signal on their individual remotes/keypads. This immediate feedback can then be used in reciprocal teaching, where the students learn from each other by discussing their correct/incorrect answers in collaborative groups. The interactive system also informs the instructor, in real time, of student understanding, which enables him/her to focus on misconceptions and concept areas that are confusing. Of course, this depends on the question asked. For example, asking, "Do you understand this," and getting a reply of "yes" does not guarantee understanding.

History of Interactive Student Response Systems

According to Judson & Sawada (2002), "The use of electronic response systems in large lecture courses, particularly science classes, can easily be dated to the

1960s" (p.168). These systems were hard-wired, and consisted of knobs or buttons mounted at the students' seats. The instructor station had gauges that indicated the percentage of students responding to each choice on a particular multiple-choice question. The goal of these early systems is also a goal of modern systems - instant feedback.

Research from the 1960s and 1970s did not support an increase in student achievement, as measured by standard exams, when electronic response systems were used (Judson & Sawada, 2002). However, despite the lack of evidence of increased academic achievement, Judson & Sawada cite several studies that show students' endorsement of the system. In those studies, "positive attitude toward the class, feeling of the usefulness of the system, acceptance of the system, and feeling of increased understanding were all highly supported by the student survey data" (p. 173).

Research that is more recent, particularly from the 1990s, also shows student support for the systems, but "the issue of academic achievement remains open" (Judson & Sawada, 2002, p. 175). For example,

> In the 1990s investigations reporting student academic achievement were found only within the discipline of physics. The use of electronic response systems was not a distinct characteristic among high achieving physics courses, however, electronic response systems were viewed as one mechanism to elevate student interaction in large lecture halls. Among physics studies, improved student achievement was detected when the pedagogy was distinguished as constructivist in nature, thus promoting interactive engagement among students. (p. 176)

Examples of physics investigations that support the claim that electronic response systems promote academic achievement include studies by Hake (1998) and Mazur (1997), both of which I review later.

Interactive student response systems have evolved from wired systems that required a dedicated classroom to portable one-way and two-way wireless systems. Classtalk, a wired system developed by Better Education, Inc., was a very common system used in research studies of the 1990s. Better Education, Inc. has discontinued Classtalk, but there are other wireless systems, such as CPS by eInstruction and PRS by EduCue Inc., replacing this popular system. Another popular system, and the one used in this study, is the Interactive Learning System by Qwizdom, Inc.

Qwizdom's Interactive Learning System

Qwizdom's Interactive Learning System is a wireless response system that uses two-way (send and receive) infrared or radio frequency communication to provide instant assessment and feedback to every participant in a classroom setting.

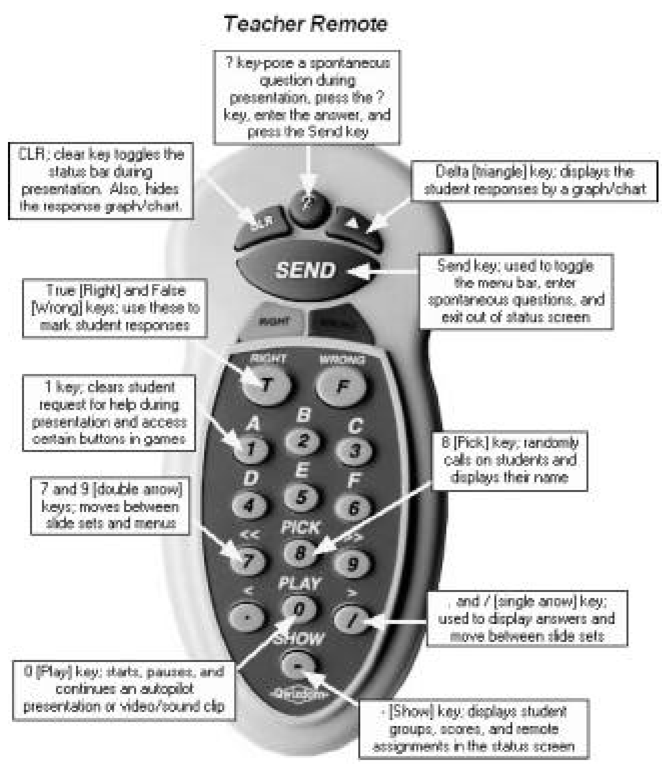
Qwizdom currently has three different systems that use either the Q3 (infrared), Q4 (radio frequency), or Q5 (radio frequency) remotes. It is the Q3 version that we used in this study, and the one that I describe here.

The Qwizdom Q3 system consists of interactive software (Interact), a receiver unit that attaches to the USB port of any computer, an instructor remote, and a specified number of response (student) remotes. Up to 255 student remotes can be used at once, with a working range up to 100 feet (Qwizdom.com, 2004).

The Q3 student and instructor remotes (Qwizdom, Inc., 2004) are shown in Figure 1 and Figure 2, respectively.

Figure 1: Qwizdom's Q3 Student Remote

Figure 2: Qwizdom's Q3 Instructor Remote



The keypad on the student remote enables the student to log into the system by ID, and to answer multiple choice, true/false, numeric, or yes/no questions. The student remote also has instant visual feedback via a LED flashing light. At the discretion of the instructor, the students may receive immediate confirmation if their response is correct (green "right" LED) or incorrect (red "wrong" LED). The students' individual responses are anonymous, but the class results may be displayed in the form of a histogram (i.e. bar graph) for group discussion.

The instructor remote frees the instructor from the computer and enables him/her to present activity slides, randomly call on individuals, display summaries of responses or scores (e.g. bar graphs), play or pause audio and video, and spontaneously pose questions from anywhere in the room (Qwizdom.com, 2004). The presentation of activity slides is very similar to a Microsoft PowerPoint presentation. In fact, the Qwizdom Interact software enables you to import PowerPoint slides into a Qwizdom activity.

Qwizdom offers a variety of ready-to-use curriculum packages. Packages include pre-made lessons; quizzes; review activities; learning games; photographs, illustrations, and animations; and hundreds of question and answer sets. All content can be edited and used in any of the software's presentation or printing formats (Qwizdom, Inc., 2004, product brochure).

Previous Studies with Interactive Student Response Systems

In their literature Qwizdom, Inc. refers to several studies which show that when "using a system like the Interactive Learning System – students: understand subjects better, enjoy class more, come to class prepared, pay more attention in class, and most importantly show dramatic learning gains" (Qwizdom Inc., 2004, product brochure). In addition, "independent studies show that interaction and learning increase when keypads are used" (Qwizdom.com, 2004, software/remotes p. 2).

Interestingly, none of the referenced studies (discussed below) actually used Qwizdom's Interactive Learning System. Qwizdom, Inc. acknowledged that fact with the following disclaimer, "Many of these articles refer to radio frequency response units which cost significantly more than Qwizdom's response system but have almost identical functionality…" (Qwizdom.com, 2004, software/remotes p. 2).

Studies Referenced by Qwizdom, Inc.

The studies referenced by Qwizdom, Inc. are summarized in the following paragraphs, and include: Mazur (1997), Burnstein & Lederman (2001), Hake (1998), Sokoloff & Thornton (1997), Horowitz (1988), and MacDonald (1999).

In addition to being referenced by Qwizdom, Mazur (1997) is the most referenced publication that I found for articles discussing active learning and interactive student response systems in the classroom. In 1991, Mazur began developing what is known as "Peer Instruction" in his physics classes at Harvard. Many instructors worldwide have since adopted this method of teaching, which involves students in the teaching process and focuses their attention on underlying concepts.

Instead of covering the detail normally found in textbook or lecture notes, the Peer Instruction lectures are comprised of short presentations of key points, each followed by a ConcepTest (sic). The ConcepTest has the following general format (Mazur, 1997, p 10).

1. Question posed — 1 minute
2. Students given time to think — 1 minute

3. Students record individual answers (optional) 1-2 minutes

4. Students convince their neighbors (peer instruction) 1-2 minutes

5. Students record revised answers (optional)

6. Feedback to teacher: Tally of answers

7. Explanation of correct answer 2+ minutes

If most students choose the correct answer, then the instructor moves on to the next topic. If the percentage of correct answers is too low (% up to instructor), the instructor is immediately aware that s/he should revisit the topic with further explanation and discussion, so as to avoid students' confusion.

The convince-your-neighbors (peer instruction) step of the ConcepTest "systematically increases both the percentage of correct answers and the confidence of the students" (p. 12). Mazur gives the following explanations for this:

> There is always an increase and never a decrease in the percentage of correct answers. The reason is that it is much easier to change the mind of someone who is wrong than it is to change the mind of someone who has selected the right answer for right reasons. The observed improvement in confidence is also no surprise. Students who are initially right but not very confident become more confident when it appears that neighbors have chosen the same answer or when their confidence is reinforced by reasoning that leads to the right answer. At times, it seems that students are able to explain concepts to one another more effectively than are their teachers. A likely explanation is that students who understand the concept when the question is posed have only recently mastered the idea and are

> still aware of the difficulties involved in grasping the concept. Consequently, they know precisely what to emphasize in their explanation… As time passes and a lecturer is continuously exposed to the material, the conceptual difficulties seem to disappear and therefore become harder to address. (pp. 13-14)

In my experience, explaining concepts to others increases my own understanding. Therefore, I can see where the peer instruction approach of thinking for yourself and putting your thoughts into words, as well as hearing others' explanations, would increase conceptual understanding.

Mazur also stresses that the convince-your-neighbor discussion, and the different perspectives that his students offer, gives him a feel for how students think and how they may have reasoned their way to an incorrect answer. This allows him to refocus his lecture and address the issues that are confusing. The discussions also help him keep in touch with the class.

To assess students' learning, Mazur uses the "Force Concept Inventory" (Hestenes, Wells, & Swackhamer, 1992) and the "Mechanics Baseline Test" (Hestenes & Wells, 1992). Both of these tests were designed to test students' conceptual understanding of Newtonian mechanics. The Force Concept Inventory (FCI) is a multiple-choice test that probes students understanding of the Newtonian concept of force by forcing a choice between Newtonian concepts and commonsense alternatives (preconceptions or misconceptions). This test was given as a pre-test (before instruction) and a post-test (after instruction). The Mechanics Baseline Test (MBT) is a problem-solving test, which was given after instruction. While the FCI was designed to be meaningful to students without formal training in mechanics and to elicit their preconceptions about the subject, the MBT emphasizes concepts that cannot be grasped without formal knowledge about mechanics (Hestenes & Wells, page 159).

Mazur's results from these tests showed a marked improvement when Peer Instruction was implemented. The pre and post FCI scores increased from a gain of 8% in 1990 using the conventional (or traditional) method to a gain of 21% in 1995 using Peer Instruction. The MBT scores increased from 67% in 1990 using the conventional method to 76% in 1995 using Peer Instruction (Mazur, 1997, p. 16, Table 2.1). Based on these results, Peer Instruction seems to be more effective in increasing conceptual understanding than the traditional lecture style.

Feedback is a very important element in teaching and learning. The more immediate the feedback the more effective it is. Peer Instruction allows immediate feedback from student-to-instructor and instructor-to-student. Although a show-of-hands can be used to elicit responses and tally answers, it is not anonymous and may have adverse effects on students. An electronic response system, however, gives anonymity to the students. Mazur chose to implement an interactive student response system called Classtalk, developed by Better Education, Inc. With this system, students answered the ConcepTest questions on their hand-held devices. Their responses were immediately sent to the instructor's computer and the instructor was then able project the class results for the entire class to view and discuss. Anonymity was retained since the results displayed were class results and not individual results.

Mazur makes an interesting and important point regarding textbook problems and traditional teaching methods. "I don't think we should be satisfied when a student just knows how to plug numbers into an equation in a given situation, how to solve a differential equation, or how to recite a law of physics. …we need to look deeper than the standard textbook problem does" (p. 31). Later he goes on to say, "a disturbingly large fraction of students develop strategies for solving problems without achieving even the most basic understanding of the concepts involved" (p. 39). In my own experience as a student in math and physics classes that used traditional methods, doing as many of the textbook problems as I could and passing exams with similar type problems constituted success and understanding; I did not necessarily develop a strong conceptual understanding.

Mazur recognizes that when incorporating the Peer Instruction method it is not possible to cover the amount of material typically covered in a traditional lecture. Thus, more responsibility must be given to the students. For example, they must read assigned material before class. He stresses to his students that they are responsible for all material in the assigned reading even if he does not cover it in class, and routinely gives homework problems and exam questions on such topics. He initially enforced this assigned reading by giving reading quizzes, which counted toward the final grade. The reading quizzes have since been replaced with web-based assignments to ensure that students read the material and come to class prepared (Crouch & Mazur, 2001; Kim-Shapiro, Yip, Kerr, & Concannon, 2000). Web-based assignments would eliminate the class time required for reading quizzes. However, the in-class reading quizzes could provide an opportunity to implement an interactive student response system. The response system could then be used to automatically do the grading, freeing the instructor from this task later.

Even though Peer Instruction focuses on conceptual understanding, students must still understand how to solve problems. Since problem solving has essentially been removed from the lecture in Peer Instruction, Mazur gives homework assignments and offers problem-solving sessions to help develop problem-solving skills. In regards to examinations, he gives conceptual essay questions as well as standard textbook problems. "Mixed examinations are the best way to make students aware of the increased emphasis on concepts" (Mazur, 1997, p. 23).

Understanding that students tend to resist change, Mazur devoted a whole chapter of his book to motivating the students (chapter 3). He begins the first lecture by setting the tone – announcing to the students that he will not be lecturing straight out of his notes or out of the textbook. He stresses that it would be a waste of his time and theirs, since they are fully capable of reading the material on their own. He explains how passive lectures do not promote learning, and that they need to learn how to be critical thinkers – to learn how to analyze a situation and not just how to plug numbers into an equation. He tells the students that he will provide a formula sheet on exams, to discourage memorization and to provide the opportunity to focus on the meaning of the equations.

Another important point that he makes to his students is that Peer Instruction is about cooperation and not competition. This applies to the convince-your-neighbor discussions as well as to the ConcepTests. He tells the students that their performance on the ConcepTests will not affect their final grade. However, they will be required to participate. It is reasonable to assume that students will be more apt to interact when they know that they will not be penalized for an incorrect answer. As Byrnes states, "a child who is engaged in a classroom activity is an active, attentive, curious, willing participant" (Byrnes, 2001, p. 94).

Mazur's approach to student motivation deals with establishing a classroom culture, or classroom norms. In mathematics education, these classroom or social norms are called sociomathematical norms. Social norms are ways in which members of the community interact and exchange ideas, while sociomathematical norms are normative interactions specific to mathematics (Stylianou & Blanton, 2002).

Unfortunately, traditional mathematics classrooms are highly individualistic, and prone to the social norm of sitting quietly while listening to the teacher. For example, Young (2002) describes establishing a mathematical community in her classrooms, where everyone was encouraged to participate with equal value and authority. Students worked in groups and were expected to explain and justify their solutions, to try to make sense of others' explanations, and to think about and discuss alternative solutions. She states that many students were uncomfortable with this interactive arrangement because such an approach was so different from their previous (passive) experiences in mathematics classes. Furthermore, Young states that students often perceive their mathematical knowledge as something that someone in authority (e.g. teacher, textbook author) has told them or shown them, i.e. it is someone else's knowledge. This idea is compounded in a passive classroom where the students are "told" what they need to know.

A collaborative community, such as Mazur's Peer Instruction classroom, can encourage intellectual autonomy, however. "If the students learn how to justify and explain their solutions (sociomathematical norms) their chances of becoming intellectually autonomous are increased. Intellectual autonomy occurs when students are encouraged to take responsibility for their knowledge construction in conjunction with other class members" (Young, 2002).

To continue with the studies referenced by Qwizdom, Burnstein & Lederman (2001) felt that the traditional passive lecture style in their typically large physics classes at the Illinois Institute of Technology was ineffective and impersonal. They wanted to improve the lecture experience by actively involving the students in the lecture. In 1995, they implemented an interactive student response system manufactured by Fleetwood Group, Inc. The system consisted of two-way wireless keypads, which were assigned to each student at the beginning of class so they could enter responses during lecture.

> Questions that could be answered by 'yes'/'no' or multiple choice (1-10) were woven into the lecture and made relevant to what just happened or what was just about to happen. There were also questions to test whether students prepared for class. When appropriate, peer instruction was encouraged by asking students to rework a keypad question through discussion with their teammates (usually two others) and arrive at a consensual response. (pp 8-9)

The responses were projected for the class in the form of a histogram. The responses were saved and used later for grading purposes. They awarded 10 points for a correct answer, 3 points for any answer, and 0 points if no answer was received. They reduced the weighting of homework problems in the final grade since the keypad questions could be used to check for understanding of homework concepts.

Burnstein & Lederman used the keypads to check for student preparation by asking questions pertaining to the assigned reading (reading quizzes). These answers were recorded and used in the final grade. Their motivation was that students would be more apt to read the material if they knew they would be tested on it with keypad questions, and thus would come to class better prepared.

Although they did not cite specific studies, Burnstein & Lederman found that using keypad answers in the final grade increased attendance and attentiveness during the lecture. "We find that when keypad scores count for greater than 15% of the term grade, there is a dramatic improvement in attendance that reaches the 80-90% level and, in addition, the students make genuine attempts to prepare for the reading quizzes and remain alert throughout the lecture period" (p. 10). Furthermore, by asking questions during the lecture, the instructors were able to ascertain, in real time, if students recognized and understood concepts and remembered important facts. This enabled the instructor to repeat or modify topics to increase understanding.

Hake (1998) and what he calls "interactive engagement" are referred to in many articles on active learning. In his "six-thousand-student survey," he surveyed pre/post test data for 62 introductory physics courses (6542 students) at various institutions. He categorized the courses into either traditional or interactive engagement (IE), which he defines as follows:

> (a) "Interactive Engagement" (IE) methods as those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors, all as judged by their literature descriptions.

(b) “Traditional” (T) courses as those reported by instructors to make little or no use of IE methods, relying primarily on passive-student lectures, recipe labs, and algorithmic-problem exams.

(c) “Interactive Engagement” (IE) courses as those reported by instructors to make substantial use of IE methods. (p. 2)

In his study, Hake sought to answer the question, “Can the classroom use of IE methods increase the effectiveness of introductory mechanics courses well beyond that attained by traditional methods?” (p. 3). To answer this, he compared pre- and post-test data of T versus IE courses using the Force Concept Inventory (FCI) (Hestenes, Wells, & Swackhamer, 1992) and post-test data from the Mechanics Baseline Test (Hestenes & Wells, 1992).

Hake developed the average normalized gain to measure the effectiveness of a course in promoting conceptual understanding. He defined average normalized gain to be the ratio of the actual average gain to the maximum possible average gain. He found this quantity to be a figure of merit for the FCI: courses that made substantial use of IE methods achieved almost two standard deviations of average normalized gain above that of traditional courses. He concluded by stating that comparison of traditional and IE courses implies that IE methods enhance problem-solving ability and that the classroom use of IE methods can increase the effectiveness of introductory mechanics courses well beyond that attained by traditional methods (which answered his initial research question).

Although Hake did not actually mention classroom communication systems in his research, the idea still applies since their use would fall under “Interactive Engagement.”

In fact, some of his data sources, such as Mazur (1997) – discussed earlier, did use such systems.

Sokoloff & Thornton (1997) discuss the use of microcomputer-based Interactive Lecture Demonstrations (ILDs) to increase student involvement in physics classes at the University of Oregon and at Tufts University. The ILDs consist of a sequence of physical experiments, which are demonstrated using microcomputer-based laboratory (MBL) tools. The students make a prediction of what they think will happen and discuss their predictions with others in their group. They then record their final prediction, which consequently may have changed based on the discussion in their group. After eliciting student predictions from the entire class, the instructor carries out the demonstration, and the results are discussed. The instructor then discusses other physical situations that are based on the same concepts, thus increasing conceptual understanding.

The ILD method is not quite the same thing as the interactive student response system that we are investigating, but it does support the use of active learning and interactive engagement. In their article, Sokoloff &Thornton mention that other researchers have used a similar procedure (to their ILD method) to engage their students during lecture using student reasoning or problem solving. "A number of these other strategies involve a system that collects individual student responses and feeds them into a computer for display to the instructor and, if desired, to the class" (p. 341). Mazur (1997) is mentioned as one example of this.

Using the Force and Motion Conceptual Evaluation (Thornton & Sokoloff, 1998) to assess conceptual understanding of kinematics and dynamics, Sokoloff & Thornton found that after traditional instruction, introductory students did not commonly understand these fundamental concepts. However, their studies showed improved learning and retention of these concepts by students who participated in ILDs.

Horowitz (1988) describes the Advanced Technology Classrooms developed at the IBM Corporate Management Development Center. The student response system is a major component in these classrooms. "This system enables each student to participate by responding to questions during the learning process. This interactive process was designed to increase the students' attentiveness, aid in individual knowledge discovery and increase retention of key learning points" (paragraph 2).

The prototype classroom incorporated a wired student response system by Reactive Systems, Inc., that included keypads that allowed the students to answer yes/no, true/false, multiple choice, numeric entry, and rating type questions. In this classroom, the facilitator used the keypads to solicit responses. Students were often put into groups, where each group answered questions and the results from each group were displayed to the class. The group response sequences "further stimulate interest by promoting healthy competition among groups. The 'Game' environment creates a peer pressure to participate and the desire to win encourages higher levels of attentiveness in order to provide correct answers and contribute to the success of the Group" (paragraph 23).

Horowitz compares traditional and interactive classroom environments in areas such as student interaction, reaction, attentiveness, and retention. In the traditional (lecture-style) classroom environments, he observed that

> Participation was not evenly distributed among students. In a typical class, between 10 and 20 percent of the students dominated the discussion, i.e., these vocal students asked the most questions, offered most of the

> unsolicited comments and were more likely to volunteer to answer the questions posed by the instructor. The remaining 80 to 90 percent of the students contributed only occasionally to the discussion unless specifically asked to do so by the instructor. (paragraph 6, observation 4)
>
> Students' apparent interest and attentiveness while course material was presented tended to decrease during pure lectures which did not encourage student participation and increased as the instructor served more as a facilitator/enabler who encouraged students towards interaction and participation. (paragraph 6, observation 5)

Horowitz also observed attentiveness, and developed an index scale to measure it.

> An index of 100 indicates attentiveness of every student at every observation point. In the lecture style, this index was 47 or just under half of the class. This index of attentive behavior increased to 68 for the class taught with facilitation style. (paragraph 12)

The level of attentiveness increased even further in classrooms that combined facilitation with student response systems where an index of "83" (paragraph 28) was found.

In terms of retention, test scores were higher in the interactive environment – "from the 19 percent improvement reported for the facilitation style to 27 percent when this style was coupled with the student response system" (paragraph 28).

Students were also surveyed to determine their reaction to the interaction and feedback provided by the student response system. Using a scale of 1 to 7, where 1 indicates a strong vote for the traditional approach, 7 indicates a strong vote for the student response system, and 4 represents an equal attitude between the two classroom approaches. "The results were a 6.6 out of 7 in favor of student response systems" (paragraph 29).

Based on his experiments and findings, Horowitz concluded that interactive classrooms, which use student response systems, improve the learning process.

MacDonald (1999) discusses ways to improve audience participation in meetings, but some of the issues he addresses could pertain to a classroom as well. The author, a facilitator with the Central Intelligence Agency (CIA), discusses interactive response keypad systems as one of four technologies that facilitators might use to increase the efficiency and effectiveness of group activities. He mentions that these keypad systems are more effective than a show of hands when trying to get participants' inputs in a group setting. The keypads allow the responses to be anonymous, which may affect the number of responses as well as the response itself. The keypads also give every member a chance to participate, which may be difficult to accomplish in a traditional setting, especially when the group is large.

The following is a partial list of the advantages of interactive response keypads mentioned by MacDonald (section 2, paragraph 3):

- Keeps your session participants involved – active participants stay alert, learn and retain more information – especially in large groups.
- Provides instant feedback – find out their opinions, what are they thinking?
- Helps promote discussion within the group – individuals who see that their peers share a common idea are more willing to express their opinions openly – and helps the facilitator to manage the discussion.

Additional Studies

As mentioned earlier, the studies referenced by Qwizdom, Inc. did not actually use Qwizdom's Interactive Learning System, but rather, similar systems. In fact, with the exception of a few testimonials on Qwizdom's website and product brochure (Qwizdom.com, 2004; Qwizdom, Inc., 2004, product brochure), at the time of this literature review I could not find any studies that had explicitly used Qwizdom's system.

I did, however, find additional studies regarding other interactive student response systems in physics education (e.g. Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Cue, 1998; Abrahamson, 1999; Nicol & Boyle, 2003; and Beatty, 2004). Since my research involves implementing an interactive student response system in a college algebra classroom, I was curious if there were any studies specifically related to mathematics. At the time that this literature review was completed, only one such study was found – Cornell University's GoodQuestions project.

In 2003, Cornell University started researching Mazur's Peer Instruction method (Mazur, 1997) in first semester calculus with their GoodQuestions project (Terrell, 2003).

During the fall 2004 semester, I was in email contact with Dr. Maria Terrell regarding Cornell's GoodQuestions project. They had a small NSF DUE "proof of concept" project that experimented with the use of "clickers" (i.e. an interactive student response system) and what they called "Good Questions" in teaching first semester calculus. The official results from the project have not been published. However, the preliminary results (released after the start of my own study), were discussed in a list-serv email from Dr. Maria Terrell on March 11, 2005:

> What we have found is that instructors who asked the questions but who did not have the students discuss their vote – their students did not do any better than instructors who did not use the questions at all. Instructors who used questions regularly with peer discussion and re-vote – their students did measurably better on the common exams. Our conclusion – using clickers might help the instructor learn what the students' don't know, but just telling them again is not effective, peer instruction is a better use of time. We also found that the kind of questions you ask students to discuss is important. Deep conceptual questions rather than numerical or graphical 'standard math' questions were more effective in helping students do well on both the computational and conceptual parts of the exams.

As Dr. Maria Terrell discusses above, they found that the questions and "clickers" alone did not make a difference with the students' academic achievement. Only when they incorporated Mazur's Peer Instruction approach did they notice an improvement.

Conclusion

The studies discussed in this literature review highlight the importance of active or interactive learning, and how interactive student response systems can be used to support this type of learning. Many studies have been conducted in Physics using, or based on, the Peer Instruction method developed by Eric Mazur. Mazur's method incorporates group discussion and ConcepTests, which are implemented using an interactive student response system.

Mazur's Peer Instruction method, using conceptually oriented questions in college algebra, would be an interesting study to undertake. However, Mazur recognizes that the amount of material covered in a traditional lecture is not possible when incorporating the Peer Instruction method. Therefore, to incorporate this method, the pedagogy of MAT 111 would also need to be changed. In this study, we would like to determine how MAT 111 would be affected if we changed only one variable, i.e. including the use of an interactive student response system without changing the traditional pedagogy of MAT 111. In other words, we would like to determine if the interactive student response system itself is an effective tool for instruction in a "traditional" college algebra lecture environment.

CHAPTER 3 – METHODOLOGY

This chapter describes the methods used in carrying out the study, with the goal of answering the following research questions: (1) Does the use of an interactive student response system increase academic achievement in college algebra, as measured by standard exams; (2) What are students' attitudes towards the interactive student response system; (3) What is the instructor's attitude towards the interactive student response system; and (4) Overall, is an interactive student response system an effective tool for instruction in a traditional college algebra lecture environment?

To investigate these research questions, both quantitative and qualitative methods are used. To determine if the use of an interactive student response system increases academic achievement in college algebra, a controlled experiment is performed in which the control and treatment groups' exam grades are quantitatively compared and statistically analyzed. To determine students' attitudes toward the interactive student response system, quantitative and qualitative measurements are used, whereas those used to evaluate the instructor's attitude are purely qualitative. To conjecture if the interactive student response system is an effective tool for instruction, the quantitative and qualitative results of the other research questions are discussed and summarized.

The Research Context

The study took place in college algebra (MAT 111) classrooms at The University of Maine during the Spring 2005 semester. The University of Maine, located in the town of Orono – 8 miles north of Bangor, was established as the Maine College of Agriculture and the Mechanics Arts in 1862. In 1897, the original name changed to The University of Maine. The University of Maine has approximately 11,400 students from all over the world, and offers 88 bachelor's degree programs, 64 master's degree programs, and 25 doctoral programs. The University of Maine is one of New England's premier universities; ranked in Kiplinger's annual 100 best values in public colleges and selected by the Princeton Review as one of America's best 361 colleges. Furthermore, The University of Maine is one of just 151 institutions (4%) nationwide to be classified by the Carnegie Foundation for the Advancement of Teaching as a "Doctoral Research – Extensive" university, the highest classification possible (UMaine, 2005).

The Research Participants

The participants are students enrolled in college algebra (MAT 111) during the Spring 2005 semester at The University of Maine.

There are two groups defined for the purposes of this study – a control group and a treatment group. The control group includes four sections of MAT 111 (sections 500, 502, 503, and 504) taught by four different instructors, and the treatment group is a fifth section of MAT 111 (section 501) taught by me. There are approximately 40 students registered in each section.

The mathematics topics covered in the control and treatment groups were the same, based on the same course syllabus and textbook (Blitzer, 2002). The exams for MAT 111 are "common," meaning that the students from all of the sections take the same exam at the same time and place. These exams are procedural in nature; comprised of problems similar to problems discussed in lecture and in the textbook.

To establish that the groups are comparable academically, a statistical analysis was conducted on the participants' SAT scores. "The SAT measures critical thinking, reasoning, and writing skills that students develop over time, both in and out of school, which are related to successful performance in college" (The College Board, 2005).

To test the null hypothesis that the mean SAT scores of the five sections of MAT 111 are not statistically significantly different, a one-way ANOVA (analysis of variance) was performed. The ANOVA descriptives are in Appendix A, and the results are shown below in Table 1.

Table 1: One-way ANOVA of SAT Scores (alpha = .05)

		Sum of Squares	df	Mean Square	F	Sig.
satv	Between Groups	9548.704	4	2387.176	.451	.772
	Within Groups	1153892.551	218	5293.085		
	Total	1163441.256	222			
satm	Between Groups	14368.438	4	3592.109	.674	.611
	Within Groups	1161817.213	218	5329.437		
	Total	1176185.650	222			
sat	Between Groups	21641.463	4	5410.366	.344	.848
	Within Groups	3429928.941	218	15733.619		
	Total	3451570.404	222			

The ANOVA resulted in the following significance or p values: verbal (satv) = .772, quantitative (satm) = .661, combined (sat) = .344. Because these values are all greater than .05, the null hypothesis is retained. That is, the mean SAT scores of the five sections of MAT 111 are not statistically significantly different.

<u>Control Group</u>

The control group is comprised of four sections of MAT 111 (500, 502, 503, and 504) taught by four different instructors using a traditional lecture approach. By "traditional," I mean that the instructors lecture from their notes and course textbook with little or no interaction required by the students.

Even though I taught the treatment group in this study, I am familiar with the methods used by the control group. During the Fall 2004 semester, I observed another instructor teaching MAT 111 using the traditional lecture approach, and I subsequently taught a section of MAT 111 using the same approach.

Several meetings were also held with the instructors of the control group to discuss any variations in assessment, such as homework and attendance. For example, some instructors assigned and graded homework, while others left it up to the students to complete the suggested exercises. Some instructors took attendance, while others did not. Furthermore, the weighting of various assessment methods varied between instructors. For example, some instructors had quizzes and exams weigh more heavily toward the student's final grade than did other instructors. These variations between sections are discussed in more detail in Chapter 4, as possible factors contributing to the results of this study.

Treatment Group

The treatment (or experimental) group consists of one section of MAT 111 (section 501). As the instructor of the treatment group, I used the same notes and lecture format that I used in my previously taught traditional MAT 111 class, with the addition of one variable: The common lecture materials were supplemented with interactive questions and sessions mediated through an interactive student response system manufactured by Qwizdom, Inc.

During these interactive sessions, students answered numerical, true-false, and multiple-choice questions, via their wireless Qwizdom remote controllers ("remotes"). The students received immediate confirmation via colored LED lights on their remotes, indicating correct or incorrect answers. The students' individual remote responses were anonymous (available to me, but not available to other students), but a histogram displayed to the class showed the class results for group discussion. The histogram showed the students how the rest of the class answered the question. More importantly, it showed me what fraction of the class understood how to solve the problem and if I needed to spend additional time covering the material and solution steps.

To receive credit for attending class, students were required to participate in the Qwizdom sessions. To encourage participation, attendance and class participation counted for 10% of their overall course grade. Students were not graded on the accuracy of their answers, but on participation by answering questions with their remotes. I used the automatic scoring and recording feature of the Qwizdom system to keep track of student participation. Here is an excerpt from my course syllabus regarding class participation:

> On a daily basis, we will be using an Interactive Student Response System called Qwizdom. Your answers to questions using this learning tool will be recorded. You will not be penalized for incorrect answers, but you will be expected to participate, with 10% of your grade based on this participation. A separate handout with directions on how to log into the system will be posted in the [on-line] course conference.

I believe this policy helped to ensure the subsequent active participation of the entire class in responding to questions using Qwizdom. This contrasts strongly with the few students who typically answer questions in a passive (traditional) lecture environment.

To ensure all students understood how to log into the system, a class handout was developed, titled "Student Remote and Login." In this handout (also posted on our course conference), the complete login process was explained and a digital photograph of the student remote device (as shown in Chapter 2, Figure 1) was included.

Initially, I had planned to incorporate the interactive questions throughout the lecture period. For example, in my traditionally taught section the previous semester, I solved example problems throughout the lecture period to demonstrate the content being covered that day. Immediately following my demonstration, students worked on an example, with volunteers answering the question or describing the problem-solving steps. For the treatment group, example problems were also solved throughout the lecture period, but the Qwizdom interactive sessions were limited to the beginning and/or to the end of each class due to the time involved in setting up the system presentation. I discuss this in more detail in Chapter 6.

Unfortunately, in order to cover the required material before the first scheduled exam date, we had to discontinue using Qwizdom at the end of chapter 2, a whole chapter short of my intended goal. This is discussed further in Chapter 6.

Data Collection

Three different instruments were used in collecting data for this study. First, a common exam was given to both groups (i.e. all sections of MAT 111), and the mean scores were statistically compared, to determine if academic achievement increased with the use of the interactive student response system.

Second, three surveys were administered to students in the treatment group to determine their attitudes toward the interactive student response system. The first survey was a preliminary questionnaire, administered after the third class period, to probe for students' first impressions of the interactive student response system. The second survey was an attitude survey, administered at the end of the study (after the first exam), to determine students' attitudes after having used the interactive student response system. The third survey was a post-study continuation survey, administered at the end of the study, to determine if students wanted to continue using the interactive student response system throughout the rest of the semester, if time permitted.

The third instrument was a daily journal that I kept during the study. This journal would ultimately assist in determining the instructor's (i.e. my) attitude toward the interactive student response system.

Data Collection – Academic Achievement

As discussed earlier, the treatment group consists of one section of College Algebra (MAT 111), taught by me, during the spring 2005 semester at The University of Maine. The control group consists of the other four sections of MAT 111, taught by four different instructors during the spring 2005 semester at The University of Maine. Following the fourth week of instruction, a common exam was administered to all five sections of MAT 111. This exam covered chapter 1 (algebra, mathematical models, and problem solving), chapter 2 (functions and linear functions), and chapter 4 (inequalities and problem solving) of the course textbook (Blitzer, 2002). This exam was procedural in nature and similar to exams given in MAT 111 in previous semesters. A copy of the exam is in Appendix B.

The instructors for each section graded the original exams and returned them to the students. Before returning the exams, the instructors gave copies to me for purposes of this study. To remove any inconsistencies in grading between instructors, I re-graded the control group exams for this study. To avoid any inconsistencies in my grading, I checked only for correctness in the answers given by the students in the applicable answer blanks (i.e. partial credit was not considered). I determined that a maximum raw score of 35 was possible for the entire exam and a raw score of 27 was possible for that portion of the exam related to chapters 1 and 2 (i.e. through problem #21). A separate raw score was collected for chapters 1 and 2 because the treatment group received instruction that included use of the interactive student response system while covering chapters 1 and 2 only. The exam scores, as tabulated raw data, are in Appendix C.

Data Collection – Students' Attitudes

Preliminary Questionnaire

The interactive student response system (Qwizdom) was introduced to the students on the first day of class, with interactive sessions beginning on the second day. I was very interested in their initial reactions and first impressions of the system, so after the third class period, I asked students to respond in writing to the following questions.

> What is your first impression of the Qwizdom Interactive Student Response System? Do you think you will enjoy using it? Do you think it will aid in or distract from your learning? Any feedback (positive or

negative) you wish to provide is appreciated, and will not affect your grade in any way! Thanks.

<u>Attitude Survey</u>

At the end of the study, an attitude survey was administered to all students in the treatment group. The study officially ended at the first common exam (Wednesday, February 9, 2005). Initially, I had planned to administer the survey immediately following the exam, but due to revisions, it was administered two weeks later (Friday, February 25, 2005).

Initially, the survey had several Likert scale statements and an open-response question, but as I became more familiar with the Qwizdom system during its use in my MAT 111 classroom, I realized that there were additional survey questions that would benefit this study. To encourage the students to explore their thoughts and feelings regarding the system, several open-response questions were added. Blank lines were also included below the Likert scale statements to give students the opportunity to comment. The final attitude survey has 14 Likert scale statements (with comments) and 8 open-response questions. The survey is in Appendix D.

Because the survey is quite long and because I wanted students to spend time thinking about the questions and their answers, students were asked to take the survey home rather than using class time to complete it. A better response rate may have resulted if the surveys were completed during class time, but it was believed that increased detail and quality of answers would result if students had more time to complete them. Students were allowed as much time as needed to return the surveys, but were reminded daily. Ultimately, 23 out of 37 students returned their surveys.

Post-study Continuation Survey

During the class period following the first exam, the following anonymous survey question was given (using the Qwizdom remotes) to determine if students would like to continue using the system even though the research study had officially ended.

> This is completely anonymous. Think about how you feel about Qwizdom and how its use has affected your learning, etc. Assuming that I will still take attendance (participation grade); would you like to continue using Qwizdom (not daily, but as time permits)? Yes or No.

The Qwizdom system automatically recorded their responses so I could tally them later.

Data Collection – Instructor's Attitude

During the course of the study, a journal was kept to record my thoughts regarding the use of an interactive student response system in MAT 111 in general, as well as my thoughts regarding Qwizdom's Interactive Learning System in particular.

Data Analysis

Data was compiled and analyzed for three main areas of study: academic achievement, students' attitudes, and instructor's attitude. Academic achievement was measured for the control and treatment groups using a common exam, and statistically analyzed using a t-test for independent samples. Qualitative student attitudes were obtained in three areas: a preliminary questionnaire given during the third class period; an attitude survey given following use of the system and first exam; and a continuation survey, given to determine if the students wanted to continue using the system after completion of the study. The third area of study was the subjective experience and attitudes of the instructor regarding the use of the interactive system.

Data Analysis – Academic Achievement

With an interactive student response system, I believe students will be more attentive and engaged in class, and that they will find class to be more interesting and enjoyable. Ultimately, I believe this increase in interest and attentiveness will reflect positively on their grades.

Therefore, my research hypothesis posits that students who receive instruction using an interactive student response system in College Algebra (treatment group) will score higher on measures of academic performance than students who do not receive this treatment (control group).

H_0 (null hypothesis): $\mu 1 - \mu 2 = 0$

There is no statistically significant difference in mean scores. The mean score for the treatment group is not statistically significantly higher than the mean score for the control group.

H_1 (alternative hypothesis, i.e. research hypothesis): $\mu 1 - \mu 2 > 0$

Qwizdom has a positive effect on mean score, i.e. the mean score is statistically significantly higher for the treatment group than for the control group.

Statistical Tests

The t-test for independent samples tests the hypothesis by comparing the mean scores for two independent groups. In this test, group 1 is the treatment (Qwizdom) group and group 2 is the control group. These independent groups (or samples) represent the population of students that may take college algebra in the future.

Since the treatment group received instruction that incorporated the interactive student response system while covering chapters 1 and 2 only, statistical analyses were performed for the entire exam and for that portion of the exam that covered chapters 1 and 2. The data analysis feature of Microsoft Excel was used to perform this analysis, while Coladarci, Cobb, Minium, & Clarke (2004) and Fitz-Gibbon & Morris (1987) were used as reference guides.

Before the t-test for independent samples could be performed, a statistical analysis of variances (F-test) had to be conducted to determine if the variances of the control and treatment groups are statistically significantly different. In the F-test, F is defined as the variance of scores for control divided by the variance of scores for treatment, where variable 1 is the control group and variable 2 is the treatment group. The results of these analyses are discussed in Chapter 4.

Data Analysis – Students' Attitudes

Preliminary Questionnaire

Of the 40 students registered in the class when the preliminary questionnaire was administered, 20 students responded.

To analyze the responses from the preliminary questionnaire, the replies were read and general themes were recorded. These replies and themes are discussed in Chapter 5.

Attitude Survey

Of the 37 students registered in the class after the first exam when the attitude survey was administered, 23 students returned their surveys.

To analyze the responses from the attitude survey, the replies were read and reread from which general themes emerged. These replies and themes are discussed in Chapter 5.

Post-study Continuation Survey

Since the Qwizdom system automatically records answers when using the remotes, I was able to tally the students' yes or no responses regarding the continuing use of Qwizdom. There were 31 (of 37 total) students in class that day, so not everyone was able to respond to this question using the Qwizdom remotes. This question was also posted on our on-line course conference, and students were told that they could reply anonymously, but no additional replies were received. The results of the post-study continuation survey are discussed in Chapter 5.

Data Analysis – Instructor's Attitude

To analyze and interpret the instructor's attitude, the journal entries were read from which general themes emerged. These themes are discussed in Chapter 6.

Summary of Methodology

The following four paragraphs summarize the methodology used to answer the four research questions of this study.

To determine if the use of an interactive student response system increases academic achievement in college algebra, a common exam was administered to all five sections of MAT 111. Four sections comprised the control group and one section the treatment group. Prior to the exam, the control group received traditional lectures, while the treatment group received instruction that included the use of an interactive student response system (Qwizdom). The results of the academic achievement question are discussed in Chapter 4.

To determine students' attitudes toward the interactive student response system (Qwizdom), a preliminary questionnaire, an attitude survey, and a post-study continuation survey were administered to the treatment group. The students' attitudes are discussed in Chapter 5.

To determine the instructor's attitude toward the interactive student response system, I kept a daily journal while preparing for and conducting this study. I discuss my thoughts regarding the use of an interactive student response system in general, and Qwizdom in particular, in Chapter 6.

To conclude, in Chapter 7, I review the results of the study regarding academic achievement, students' attitudes, and instructor's attitude to conjecture if the interactive student response system is an effective tool for instruction in a traditional college algebra lecture environment.

CHAPTER 4 – ACADEMIC ACHIEVEMENT

In this chapter, I discuss the results of the first MAT 111 examination to answer the following question: Does the use of an interactive student response system increase academic achievement in college algebra, as measured by standard exams?

Review of Findings

In Chapter 3, it was hypothesized that students who receive instruction using an interactive student response system in College Algebra (treatment group) score higher on measures of academic performance than students who do not receive this treatment (control group). This hypothesis proved to be false. The t-test for independent samples revealed that the mean exam scores of the treatment group were not statistically significantly higher, as discussed below.

First, the results of the F-test (statistical analysis of variances) reveal an F value for the entire exam of 1.257 and an F value for chapters 1 and 2 of 1.210, both of which are less than the critical value of 1.597, as shown in Table 2. Therefore, the variances of the control and treatment groups' scores are not statistically significantly different, and equal variances can be assumed in the t-test.

Table 2: Statistical Analysis of Variances (F-test)

Statistical Analysis of Variances: F-Test
To determine if the variances of the control and treatment groups are statistically significantly different. Consequently, this will determine which t-test (equal variances or unequal variances) will be performed.
Note: variable 1 is the control group and variable 2 is the treatment group for this test, where F = variance of scores for control / variance of scores for treatment.

As shown below, F < Fcritical for Entire Exam and for Chapters 1&2. Therefore, difference in variances not significant - can assume equal variances in t-test.

F-Test Two-Sample for Variances (Entire Exam)

	Variable 1	*Variable 2*
Mean	21.72049689	23.67567568
Variance	49.02763975	39.003003
Observations	161	37
df	160	36
F	1.257022177	
P(F<=f) one-tail	0.212509072	
F Critical one-tail	1.596750809	

F-Test Two-Sample for Variances (Chapters 1&2)

	Variable 1	*Variable 2*
Mean	17.8136646	19.13513514
Variance	28.11506211	23.23123123
Observations	161	37
df	160	36
F	1.21022695	
P(F<=f) one-tail	0.254880755	
F Critical one-tail	1.596750809	

Next, the results of the t-test, using a confidence level of alpha = .05 and assuming equal variances, reveal a t Stat of 1.561 for the entire exam and a t Stat of 1.389 for chapters 1 and 2, both of which are less than the one-tailed t Critical value of 1.653, as shown in Table 3. Thus, the null hypothesis is retained; the mean score for the treatment group is not statistically significantly higher than the mean score for the control group, neither for the entire exam nor for chapters 1 and 2.

Table 3: t-test for Independent Samples

Statistical Analysis: t-test for Independent Samples
Group 1 = Treatment (Qwizdom)
Group 2 = Control
alpha = .05 (confidence level or level of significance)
Variances are equal as determined by F-test
H0 (null hypothesis): mean 1 - mean 2 = 0
No statistically significant difference in mean scores. The mean score for treatment group is not statistically significantly higher than the mean score for control group.
H1(alternative "research" hypothesis): mean1 - mean 2 > 0 (one-tail)
Qwizdom has a positive effect on mean score, i.e. mean score is statistically significantly higher for treatment group than for control group.

Results (as shown below):
t Stat < t Critical one-tail (for Entire Exam and for Chapters 1&2).
Therefore, RETAIN the Null Hypothesis (H0). The mean score for treatment group is NOT statistically significantly higher than the mean score for control group (for neither the entire exam nor for chapters 1&2).

t-Test: Two-Sample Assuming Equal Variances (Entire Exam)

	Variable 1	*Variable 2*
Mean	23.67567568	21.72049689
Variance	39.003003	49.02763975
Observations	37	161
Pooled Variance	47.18637994	
Hypothesized Mean Difference	0	
df	196	
t Stat	1.561202903	
P(T<=t) one-tail	0.06004453	
t Critical one-tail	1.65266506	
P(T<=t) two-tail	0.12008906	
t Critical two-tail	1.972141177	

t-Test: Two-Sample Assuming Equal Variances (Chapters 1&2)

	Variable 1	*Variable 2*
Mean	19.13513514	17.8136646
Variance	23.23123123	28.11506211
Observations	37	161
Pooled Variance	27.21803195	
Hypothesized Mean Difference	0	
df	196	
t Stat	1.389345729	
P(T<=t) one-tail	0.083151986	
t Critical one-tail	1.65266506	
P(T<=t) two-tail	0.166303972	
t Critical two-tail	1.972141177	

Discussion of Results

Having only implemented the interactive student response system for a short time, i.e. during two chapters of instruction (approximately 3 weeks), these results are not unexpected. It is still believed, however, that over time, the increase in interest and attentiveness in class when using an interactive student response system will reflect positively on students' grades.

Other factors, besides the time constraint, that may have affected the results are the variations between MAT 111 sections. These variations include homework, attendance, and weighting of various assessment methods, as discussed in the following paragraphs.

First, some instructors assigned and graded homework, while others made it the students' responsibility to complete the suggested homework exercises. If homework is required, it may be assumed that students are more likely to do the homework and keep up with the course material, which should ultimately reflect positively on their grades. Homework was suggested, but not required to be turned in, for the treatment group. It is my belief, based on observations made while teaching two semesters of this course, that many students will not complete the suggested homework if it is not "mandatory." This may be a reason why the exam scores of the treatment group were not statistically higher than the control groups' scores, as two of the four instructors in the control group required homework.

A second variation between MAT 111 sections is attendance requirements. Three of the four control group instructors included attendance in the students' course grades, essentially making attendance mandatory. Attendance was not mandatory in the treatment group; however, participation points were included in students' grades when using Qwizdom. Although it is recognized that many students who are not graded on attendance still regularly attend class, it is possible that this variation between sections influenced the results.

A third variation is the weighting of the various assessment methods of the course, that is, the percentage of overall course grade for quizzes, exams, homework, and attendance varied for each instructor. In my opinion, if a student knows that a larger percentage of their course grade is dependent on their quiz grades, for example, it is likely that he or she would expend the effort to prepare for the quizzes. Quizzes comprised 15% of the treatment group's course grade, as did one of the control group's sections. Three of the four control group sections had quiz grades count for a larger percentage (20%, 30%, and 40%). In addition, the exam scores counted for different percentages between MAT 111 sections. The results of the first common exam comprised 25% of the course grade in the treatment group. In the control group, one instructor had a larger percentage (30%), one instructor had the same percentage (25%), and two had smaller percentages (20%).

It is possible that both the time constraint (limiting the interactive system's use) and the number of variations between MAT 111 sections affected the results of this study. However, further research may help to determine if these factors do in fact affect academic achievement. Furthermore, the pedagogy of MAT 111 should also be considered.

CHAPTER 5 – STUDENTS' ATTITUDES

In this chapter, I discuss the students' responses to the preliminary questionnaire, attitude survey, and post-study continuation survey to answer the following research question: What are students' attitudes towards the interactive student response system?

Preliminary Findings

From the preliminary questionnaire, four themes emerged regarding the students' first impressions with Qwizdom: anonymity encourages participation; Qwizdom increases individual and classroom attentiveness; Qwizdom is enjoyable and fun; the system has technical problems, but overall attitudes are positive.

Some representative replies from the preliminary questionnaire are listed below, categorized under the four themes.

Anonymity encourages participation:

- "I actually, really think I will enjoy the Qwizdom because I am shy and have a hard time with class participation, therefore the Qwizdom will give me the opportunity to participate without actually speaking!"
- "I like Qwizdom. I like participating so that I can figure out what I'm doing wrong, but I feel stupid raising my hand and making a spectacle out of my misunderstandings."

Qwizdom increases individual and classroom attentiveness:

- "I think it will keep me focused in class."
- "It seems like a good way to keep everyone involved."

Qwizdom is enjoyable and fun:

- "Qwizdom seems like fun, something new, I've enjoyed it so far."
- "I thought it was a good idea. I think it is fun."

System has technical problems, but overall attitudes are positive:

- "I think it's a great idea! It seems like a great tool and I will enjoy using it. (As long as it's working properly!)"
- "I like it so far. If things went a little quicker I'd be happier!"

Of the 20 students who responded to this questionnaire, only one student had a truly negative first impression by responding that Qwizdom distracts from learning. This student also expressed an adverse attitude towards technology, which may influence her reaction to interactive technology in the classroom. The other 19 students had positive first impressions, with ten of them mentioning the benefits of the system's anonymity. Although three students did mention technical problems with the system, most of the technical problems were eventually corrected, as discussed in Chapter 6.

Attitude Survey Results

As discussed in Chapter 3, the attitude survey was distributed to the treatment group two weeks after the first exam, and copies were available to students after that date. Ultimately, 23 out of 37 students returned the attitude survey. Detailed survey results of the Likert scale statements and open-response questions follow.

Likert Scale Statements

The first part of the survey consists of 14 Likert scale statements. Students rated each statement by circling a number between 1 and 5. The Likert statements, descriptions of rating scale, and tabulated results are shown in Table 4.

Table 4: Likert Statement Results

	SURVEY RESULTS Likert (23/37 response rate)	1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree
1	I liked using *Qwizdom*.	7	13	2	1	0
		30.4%	56.5%	8.7%	4.3%	0.0%
2	material.	5	10	7	1	0
		21.7%	43.5%	30.4%	4.3%	0.0%
3	The use of *Qwizdom* increased the likelihood that I would attend class (for reasons <u>other</u> than being graded on participation or attendance).	2	5	14	2	0
		8.7%	21.7%	60.9%	8.7%	0.0%
4	*Qwizdom* helped me stay attentive in class.	10	11	1	1	0
		43.5%	47.8%	4.3%	4.3%	0.0%
5	*Qwizdom* helped me to identify problem areas that I needed to study prior to quizzes and exams.	6	8	8	0	1
		26.1%	34.8%	34.8%	0.0%	4.3%
6	I feel I would have learned more in class if *Qwizdom* had <u>not</u> been used.	0	2	5	8	8
		0.0%	8.7%	21.7%	34.8%	34.8%
7	*Qwizdom* helped me be an active class participant, more than I typically would be in a regular lecture environment.	11	7	2	3	0
		47.8%	30.4%	8.7%	13.0%	0.0%
8	There are other classes in which using an interactive student response system, such as *Qwizdom*, would be of benefit to me.	5	7	6	4	1
		21.7%	30.4%	26.1%	17.4%	4.3%
9	I liked seeing the histogram of class results displayed after each question.	2	9	10	1	1
		8.7%	39.1%	43.5%	4.3%	4.3%
10	The automatic (right/wrong) feedback that the remotes provided through flashing LED lights was helpful.	7	15	1	0	0
		30.4%	65.2%	4.3%	0.0%	0.0%
11	When the automatic feedback indicated my answer was incorrect, I continued working to determine why.	7	12	3	1	0
		30.4%	52.2%	13.0%	4.3%	0.0%
12 *	It would have been helpful if the remotes had been enabled to allow more than one answer.	7	3	8	5	0
		30.4%	13.0%	34.8%	21.7%	0.0%
13	I blindly entered answers, so that I would receive credit for participating, without taking the time to think about the problem and attempting to solve it first.	0	0	1	6	16
		0.0%	0.0%	4.3%	26.1%	69.6%
14	Overall, using *Qwizdom* was a positive experience for me.	12	7	3	1	0
		52.2%	30.4%	13.0%	4.3%	0.0%

* Question #12 was ambiquous, so results may not be an accurate representation of students' attitudes.

As noted in the table, question (i.e. statement) #12 is ambiguous. The statement says, “It would have been helpful if the remotes had been enabled to allow more than one answer.” The statement’s intended meaning was that the students could enter an additional answer if their original answer was incorrect. Some students thought the statement referred to responding to questions that had multiple answers. Out of 23 surveys, 15 had comments for this statement. Eleven (11) of those 15 appeared to understand the statement as intended, four (4) did not. Since eight (8) did not comment, it cannot be determined if they understood the statement when rating the Likert scale. Therefore, results for this statement may not be an accurate representation of students' attitudes.

Although the Likert scale reveals a general idea of the students' attitudes, in my opinion it is the students' own words (given as comments under each statement) that are most revealing. Not every student chose to comment, and those that did, did not necessarily comment on each statement. However, the detailed remarks that some students made suggest they spent time thinking about their responses. In the following paragraphs, the students' Likert scale responses are discussed and the students' verbal responses to each statement are summarized.

Statement #1 (I liked using Qwizdom) and statement #14 (Overall, using Qwizdom was a positive experience for me) evoke the students' general attitudes toward the interactive student response system. The majority of students agreed or strongly agreed that they liked using Qwizdom (86.9%) and that overall, using Qwizdom was a positive experience (82.6%).

Seven (7) students agreed or strongly agreed to statements #1 and #14 stating that Qwizdom was "fun", kept their attention, and "was a good change of pace from regular class." Eight (8) students, who also agreed or strongly agreed to statements #1 and #14, mentioned Qwizdom's use as a review tool to check for understanding of the material, resulting in one student feeling "more confident" in his/her answers.

Three (3) students explicitly mentioned the benefits of the system's anonymity, appreciating the ability to participate in spite of their shyness in class.

The time factor involved in using Qwizdom and system "quirks" are recurrent themes also mentioned by at least 10 of the students. I discuss these issues in more detail in Chapter 6.

Statements #2 and #5 evoke the students' opinions toward Qwizdom's ability to increase understanding of the course material and to identify problem areas. The majority of students agreed or strongly agreed that Qwizdom increased their understanding of the course material (65.2%), and that Qwizdom helped them identify problem areas that they needed to study prior to quizzes and exams (60.9%).

Students identified both the step-by-step and visual aspects of Qwizdom as factors which improved their understanding. The time limits imposed served to challenge students as well, who "liked having to work quickly to get [their] answers in…"

Students also appreciated that Qwizdom helped them to identify problem areas that they needed to study prior to quizzes and exams (statement #5). The immediate feedback and increased participation helped to identify "the small steps I was leaving out in the process of answering a question…," and encouraged students to "think about" their answers, rather than "…just copy[ing]…" the example from the board.

Seven (7) students (30.4%) expressed a neutral stance towards Qwizdom's ability to increase understanding of the course material (statement #2) and eight (8) students (34.8%) responded neutrally to Qwizdom identifying problem areas prior to quizzes and exams (statement #5).

One student, who expressed a neutral stance to both statements, commented, "We haven't done too much with it so far, or not enough that it would increase my understanding more than reading and the teacher. If we had had more time with it, I am confident it would have helped pick out key trouble areas."

Class attendance did not seem to depend on the use of Qwizdom, as revealed by statement #3: The use of Qwizdom increased the likelihood that I would attend class (for reasons <u>other</u> than being graded on participation or attendance). The majority of students (69.6%) disagreed or responded neutrally to this statement, whereas only 30.4% agreed or strongly agreed. Individual reasons varied, but one student reflected the general consensus by remarking, "Qwizdom didn't necessarily increase the likelihood that I would attend class, but it did make class more interesting."

Even though Qwizdom did not affect attendance levels, it did increase students' attentiveness and participation in class, as revealed by statements #4 and #7, respectively. The majority of students agreed or strongly agreed that Qwizdom helped them stay attentive in class (91.3%) and that Qwizdom helped them be an active participant, more than they typically would be in a regular lecture environment (78.2%).

Students' comments on reasons for increased attentiveness ranged from the need "to enter an answer every time…," to "it definitely kept my interest; therefore I was more attentive to the lesson." Several students state or imply that the system's anonymity was the reason for their increased participation. "We were able to be actively participating without having to be vocal in front of the entire classroom." Others cite Qwizdom's response system as a motivating factor that showed "…that each and every student is participating."

One student felt that attentiveness actually decreased and was the only student who disagreed with statement #4. This student commented, "I think Qwizdom actually took away from attentiveness due to the nature of the whole situation, such as: getting started, doing the problem, and then trying to make sure my data was inputted into the system." Once again, the reoccurring time factor theme emerges as a negative aspect of using Qwizdom.

The Likert scale results for statement #6 (I feel I would have learned more in class if Qwizdom had not been used) reveal that the majority of students (69.6%) disagree or strongly disagree with this statement, with an additional 21.7% responding neutrally.

Interestingly, regardless of the student's response to the question (negative, neutral, or positive), most commented negatively on the time factor involved with setting up, using, and debugging the system during class. I believe, however, that with longer use and increased familiarity with the system, the negative time factor would decrease in significance. Also interesting to note is that four (4) respondents liked Qwizdom enough to suggest a longer class period to accommodate the extra time required in using the system.

When asked if there are other classes in which using an interactive student response system, such as Qwizdom, would be of benefit to them (statement #8), the majority of students (52.1 %) agreed or strongly agreed, while 26.1% responded neutrally and 21.7% disagreed or strongly disagreed.

Five (5) students who agreed or strongly agreed gave specific examples of classes that would benefit, such as geology and other science classes, business, English, and computer classes. Other students suggested its use in all classes, with one stating that "…in a larger lecture style class where there is simply no time to hear everyone's opinion, Qwizdom would be a benefit." Another student suggested any class would benefit due to students' different learning styles, "it can help any class, keeping in mind that every student learns a different way and some students find non-interactive long lectures difficult to follow."

Statements #9 and #10 relate to the feedback features of Qwizdom, i.e. the histogram of class results (statement #9) and the flashing right/wrong LED lights on the remotes (statement #10).

The histogram (or bar graph) is a response graph that shows the number of student responses with the available choices. This graph was typically displayed after students answered each multiple choice or true/false question. Initially, a graph was displayed for numeric answers as well, but as I discuss in Chapter 6, it did not work well for this type of answer.

The histogram helped me, the instructor, assess overall student understanding of the material. The students had mixed feelings, however. Statement #9 (I liked seeing the histogram of class results displayed after each question) revealed a fairly even split between those that agreed or strongly agreed (11 students or 47.8%) and those that felt neutral (10 students or 43.5%). Only two (2) students disagreed or strongly disagreed with this statement.

Students commented that it was helpful "to see that you are not the only one having trouble or vice versa." Several students felt the histogram display was useful to the instructor (in that "it shows progress, or lack of it"), but varied in their response to its usefulness to them personally.

The students' responses regarding the other feedback feature of Qwizdom, the flashing right/wrong LED lights on the remotes, was overwhelmingly positive. When responding to statement #10 (The automatic [right/wrong] feedback that the remotes provided through flashing LED lights was helpful), 22 of the 23 students (95.6%) agreed or strongly agreed. No one disagreed or strongly disagreed, and only one (1) student responded neutrally.

Six (6) students liked the automatic feedback because "it's nice to know right away whether you got it right or wrong." Four (4) students also mentioned that "…the immediate flashing red/green [lights, give you] more time to figure out why you were wrong (or right)." Immediate feedback is an important element of Qwizdom, and the premise behind the next statement (#11) in the survey.

Three (3) students also thought that the LED lights did not blink for "a long enough period" and were sometimes missed. The brevity of the LED light seems to hinder this valuable feedback feature, which I discuss in Chapter 6.

I encouraged students who got the answer incorrect to try to determine why and to discuss with their neighbors, while everyone else finished answering the question. I was curious if students actually did take the time to go back through their work if their answer was incorrect, which is why statement #11 was included (When the automatic feedback indicated my answer was incorrect, I continued working to determine why). The majority of students (19 students or 82.6%) agreed or strongly agreed with statement #11, while three (3) students responded neutrally, and one student disagreed.

Generally, students were motivated to continue to work on the problem if answered incorrectly, as "it's the only way to learn." Two (2) students who agreed or strongly agreed mentioned errors when hitting the buttons on the remote, or not pressing the buttons hard enough. I discuss this problem with the remotes in Chapter 6.

Regarding the automatic feedback that the remotes provided, I was curious if students would like to be able to enter additional answers after receiving the red LED light, which indicated an incorrect answer. This is the premise behind statement #12, as I had programmed the remotes to restrict the input to one answer per question. Unfortunately, as discussed earlier, statement #12 is ambiguous. Consequently, the Likert results for this statement may not be an accurate representation of students' attitudes.

Statement #13 (I blindly entered answers, so that I would receive credit for participating, without taking the time to think about the problem and attempting to solve it first) was designed to determine how motivated students are, regarding opportunities for learning. Particularly, whether or not students blindly entered answers when their grade depended only on participation (i.e. entering answers) and not on answering correctly. An overwhelming majority of students (95.7%) disagreed or strongly disagreed with statement #13. This is interesting, as I suspect most people believe that students do not take these kinds of things seriously, unless they are graded right/wrong.

An interesting comment to statement #13 came from a student who strongly agreed stating, "I am competitive and want to do well on Qwizdom." This competitive student, and others, may have enjoyed Qwizdom's built-in games, which were not used due to time constraints. Would the students' attitudes be significantly different from this study if the games had been used? Would the use of games affect academic achievement? These are questions to consider for future research studies.

Open-Response Questions

The second part of the student attitude survey consists of eight (8) open-response questions. As with the Likert statements, not every student chose to answer the questions, but the detailed remarks of those that did suggest they spent time thinking about their answers. In the following paragraphs, I list each question, categorize the students' responses to each question into common themes, and include some example quotes.

1. Suppose a friend asked your advice on which math class to take. Two sections of the same class were offered at the same time and both had good instructors. One class used an interactive student response system, such as Qwizdom, one did not. Which would you recommend and why?

The majority of students (20) said that they would recommend Qwizdom, for reasons such as: Qwizdom is a good learning tool; makes class fun; not as boring; a nice change of pace; and Qwizdom increases participation and attentiveness. None of the students explicitly said that they would not recommend Qwizdom; however, three students did have mixed reactions. The students' responses are summarized below.

Qwizdom is a good learning tool:

- "I'd recommend the Qwizdom class because it really helped my learning experience."
- "I would recommend the one with Qwizdom because it is a good way to tell how well one understands the material."

Qwizdom makes class fun, not as boring, and a nice change of pace:

- "We were still able to learn a lot during the class and still able to mix it up and have some fun!! It made class a bit rushed, but I enjoyed it."
- "Hands down – I would most definitely suggest an instructor that uses Qwizdom because it is beneficial and fun at the same time."

Qwizdom increases participation and attentiveness:

- "I would recommend the class with an interactive system, because it keeps your attention and is more hands on. Without it, one may tend to daydream or not feel like participating in lecture, but Qwizdom gets students involved."
- "It also makes the student more comfortable to participate, ask questions, and stay focused."

Mixed reactions:

- "If it were only a 50 minute class I would not recommend one with an interactive student response system because there is too much information to teach and not enough time."
- "I would have to look at the friend's interests. If they like technology, then Qwizdom, if they want fast paced math, the other."

2. Did you prefer having the Qwizdom examples the same day as the lecture topic or at the beginning of the following class period? Why?

Initially, Qwizdom was implemented at the end of each lecture period. As the study progressed, however, I had to wait until the following class period because of time constraints, as discussed in Chapter 6. I considered that this delay might be beneficial, in that incorrect Qwizdom answers would alert me to specific areas in the material that needed additional review with the class.

Interestingly, and contrary to what I suspected based on my own opinion, the majority (13) of the students said, the same day, for reasons such as reinforcement and practice of what they just learned in lecture. Seven (7) students indicated that they preferred waiting until the following class period to better process the material, and considered Qwizdom a good review tool. The students' responses to question #2 are summarized below.

Same day – reinforcement and practice of material just learned:

- "Same day because it imprinted everything into your mind and made clear what you didn't understand."
- "I like having Qwizdom examples the same day as lecture material. Doing it different days mixes it up and makes it confusing."

Following class period – time to process material and a good review:

- "At the beginning of the next class because it allows for time to assimilate the information."
- "I think that the examples helped me more after I had the chance to take home the material and practice them myself. If they were given directly after the material was introduced, I might not yet fully understand it, and made working through the problem in class more stressful because I didn't feel that I was doing it right."

3. If you answered a Qwizdom question incorrectly, did you discuss the problem with classmates around you to help determine why it was incorrect? If so, did this collaborative approach help you to better understand the problem? Explain.

Students were encouraged to discuss the Qwizdom examples with their classmates, and although there appeared to be some discussion between students, I thought there could have been more. I attribute this limited discussion to sociomathematical norms, discussed in Chapter 2, and to the classroom size. Our classroom was a large (95-student) lecture hall; students tended to spread out, not sitting next to anyone for discussion.

I asked this question because I was curious how many students were using this collaborative opportunity and what their thoughts were regarding this approach. The results revealed 10 students indicating "yes," 10 saying "no," and 2 "sometimes." One student did not answer the question.

The 10 students who did discuss their responses with classmates cited reasons such as: helps with finding errors, helps both students learn, one-on-one discussion helpful, and learning from peers rather than from instructor.

Yes responses:

- "Yes, I did. And discussing it helped me because sometimes it's easier to ask one person one-on-one rather than in front of the entire class."
- "I definitely asked the person around me, and I found it helpful because one may tune out a professor, but a peer who got it correct may have an insight for way to approach a problem. Like they say, 2 brains is better than one."

I find this last quote to be very compelling, that students may tune out an instructor and that a peer may have an insightful way to approach a problem. This agrees with Mazur (1997), as discussed in Chapter 2.

The 10 students who said they did not discuss with classmates cited reasons such as: would rework and catch mistakes on own, waited for solution, did not sit by anyone, not enough time, and do not like group work. In addition, two (2) students said "sometimes," and one student did not answer.

No responses:

- "No, not enough time between questions."
- "No, I don't like group work."

4. Which types of questions were most effective for your learning: multiple choice and True/False questions, or open-ended questions with numeric answers? Please explain.

The majority of students (16) said open-ended questions (numeric answers) are more effective for learning. Fourteen (14) of those 16 students stated that open-ended questions are more challenging (have to think more) and/or that you cannot guess the answer as you can with multiple choice, while the other 2 students commented that open-ended questions are good practice and more similar to a test. Three (3) students said multiple choice or T/F because they show options and you can guess. Four students said a combination of all.

Open-ended:

- "I think that the open-ended questions helped me more because with the multiple choice questions, <u>especially</u> in a math class, I find it pretty easy to guess the correct answer, which doesn't help me to go through a problem and generate my own answer. In math, it's more important to learn <u>how to</u> do a certain type of problem, rather than guess the answer."
- "Open ended questions because it required more active problem solving techniques which were good for practice."

Multiple choice or true/false:

- "Multiple choice were most helpful, since it showed other options."
- "Multiple choice and true/false because then you know."

The results to this question were unexpected. I thought most students would prefer multiple choice and true/false because they already have the answer; they just have to figure out which one it is, which requires less effort.

5. Some students may spend a significant amount of time waiting for everyone else to enter their answers in the Qwizdom remotes. Do you feel this lag time is taking away from time spent on learning? Do you have any suggestions on how we can address this lag time and keep all students engaged?

As an instructor, I found this to be an issue (discussed in Chapter 6), and thought the students would offer both useful feedback and recommendations for change. The responses were split, with 12 students saying yes, that lag time does take away from time spent on learning, and 11 students saying no.

Yes responses:

- "I do think valuable class time was used waiting, but you can't really rush people any more – it won't benefit them."
- "Sometimes there was a lot of lag time. What if there was a more challenging problem for students to work on during this lag time? A problem similar to the one asked, so the students who take more time won't be missing out?"

No responses:

- "I think the extra time is good. If I have a wrong answer, I spend the extra time trying to figure out what I did wrong."
- "No. Teachers would have to take extra time to teach slower students either way."

6. Compare this course with another math course you have taken that was similar in the manner it was taught and/or the content covered. Through comparison, discuss the effects of Qwizdom on your learning and success.

Six (6) students stated that Qwizdom provides problem-solving practice and increases understanding, 5 students commented that Qwizdom increases participation and attentiveness, and 2 students remarked that Qwizdom makes math more fun. In addition, 4 students said that they had nothing to compare to; for example, this is their first math class, indicating that they did not realize that they could have compared to high school math courses.

Qwizdom provides problem-solving practice and increases understanding:

- "In other math classes, we weren't given the opportunity to work the problems on our own. It's difficult telling if you are comprehending the material without actually solving the problem by yourself."
- "I really struggled through HS pre-calculus and trigonometry, and felt that I was the only one who had trouble. The Qwizdom really helps me understand the concepts."

Qwizdom increases participation and attentiveness:

- "…Qwizdom counted for class participation and in a larger class which I could have easily sat back and coasted, Qwizdom kept me involved."
- "I like that Qwizdom is anonymous. In other classes, I did poorly in participation because I'm too embarrassed to do problems in front of the class."

Qwizdom makes math more fun:

- "Qwizdom didn't help me learn a lot more, it just made it more fun."
- "It gives you a chance to practice what you have learned and it makes it fun, like a game almost."

7. Discuss other ways that Qwizdom might be used in class and why.

Students provided some good ideas for Qwizdom's use, such as: quizzes, homework and review, polling and voting, and games.

- "I think if it was used at the end of class we could almost view it as a mini quiz of the information we went over that class period – that way we have more of a reason to really pay attention and work hard to grasp the information."

- “For attendance, maybe on exams, entering homework answers if we have an extra credit assignment.”

Using Qwizdom to both administer and grade quizzes (or homework) would be very time efficient for the instructor. The instructor, however, would not be able to assess the students’ step-by-step problem solving skills or offer valuable feedback (or partial credit) regarding errors made during these steps. I believe assessment and feedback are critical to student understanding.

8. Please add any other comments, or elaborations, below (use the back if needed).

Six students offered comments or elaborations. Listed below are quotes which are indicative of the students responses.

- “Qwizdom was very helpful, and I would enjoy using it more often.”
- “Overall, I think Qwizdom was a positive experience. I think with better time management, such as doing practice problems from the previous lesson in the beginning of class or just doing a few problems after teaching a lecture, Qwizdom could develop into a very useful program or teaching aid.”
- “The only negative aspect was the seemingly constant glitches of getting peoples names in or their controllers not working because of the short range of the remotes that took away from class time.”

Summary of Findings from Preliminary Questionnaire and Attitude Survey

Several common themes appeared throughout the preliminary questionnaire and attitude survey regarding the Interactive Student Response System (Qwizdom). For example, students believed that the use of Qwizdom provided problem-solving practice, increased understanding and was a good learning tool, increased attentiveness, and made math more interesting and fun. Furthermore, Qwizdom's anonymity encouraged participation in class. However, the students also reported that the use of Qwizdom had no effect on class attendance.

Although there were technical problems with the system, the students' attitudes were positive otherwise. Overall, students generally liked using Qwizdom and felt that they had benefited from its use.

Post-study Continuation Survey Results and Other Findings

As discussed in Chapter 3, during the class following the first exam, an anonymous survey question was given (using the Qwizdom remotes) to determine if students would like to continue using the system even though the research study had officially ended.

Of the 31 students that were in class, 30 students responded with "yes" – they would like to continue using Qwizdom! The one student that responded with "no" told me after class that she was the one that answered this way. This student had indicated a negative attitude toward technology throughout this study, so I was not surprised by her response. Given that this student is an anomaly, however, her attitude is less likely to merit consideration given the rapid technological infusion in education, sometimes even to the benefit of the student.

As the semester progressed, several students verbally expressed that they really liked using Qwizdom and asked when we were going to use it again. Unfortunately, even though I had developed question slides for some of the material covered, the time needed to get through the required course material did not allow for its continued use.

However, near the end of the semester, I was able to reintroduce Qwizdom during the last 15 minutes of class. Everyone appeared engaged and the classroom was very active with much collaborative discussion. It was obvious to me that the students were having fun, some even said as much. Even though I realized (from personal observation and experience) that students typically appear quiet, uninterested, and bored in a traditional passive lecture environment, on that day I witnessed a sudden and dramatic difference in both attitude and participation when using the interactive student response system. In my opinion, this observation alone justifies the use of interactive technology in the classroom, and at the minimum justifies further study of its use.

CHAPTER 6 – INSTRUCTOR'S ATTITUDE

In this chapter, I review my journal entries to answer the following research question: What is the instructors' attitude towards the interactive student response system? In the following paragraphs, I discuss my thoughts regarding the use of an interactive student response system in MAT 111.

My experience using Qwizdom's Interactive Learning System and specifics regarding its implementation are discussed in Appendix E. Since I have not had the benefit of experimenting with other types of interactive student response systems, the comments that follow may or may not apply to systems in general.

Time-Related Issues

Time-related issues and system "quirks" (i.e. technical problems) are recurrent themes among the students' attitudes, discussed in Chapter 5; I concur. Although many of the technical problems with Qwizdom were resolved, some were not (as discussed in Appendix E). As the instructor, I found the following three time-related issues to be problematic to the classroom environment: system setup, system use, and coverage of the required material.

System Setup

A significant amount of time, that could have been spent on instruction and learning, was spent setting up the interactive system. For example, as discussed in Appendix E, getting the presentation started and logging into the system for each presentation took valuable classroom time.

Furthermore, I feel than an interactive system should be flexible enough to allow for interruptions in the presentation. For example, I was hoping to incorporate interactive questions periodically throughout the lecture period, similar to what I do in a typical class. Unfortunately, this is not feasible with the Qwizdom system because each presentation has to be initiated separately and students have to log in each time.

Moreover, once a presentation starts, students are not able to log in. Therefore, on days in which we had the Qwizdom examples at the beginning of class, students that were a few minutes late could not participate, and consequently, missed the automatic feedback opportunity.

System Use

In addition to time spent starting the presentations and logging in, using the system in general takes time. For example, there is a significant amount of time expended waiting for each student to answer the questions, as some students are inherently slower than others are. This caused somewhat of a dilemma for me. Of course, I wanted ALL students to participate, but I also did not want students waiting for an extended period between questions. I considered the possibility that this lag time may be taking away from the time spent on learning. However, in retrospect, I do not believe it was time wasted because students used this time to collaborate with their neighbors to resolve incorrect answers.

Coverage of Required Material

In order to keep pace with the predefined schedule and curriculum, there is a significant amount of material to cover each day. Therefore, I had to establish some sort of time limit in which students were required to enter their answers. There is a timer feature on the Qwizdom presentation screen, but it is designed for presentations that are in autopilot. I did not want the presentations to run on their own, however, because I wanted to spend as much time as the students needed to discuss the solution slides. In retrospect, I could have used a separate timer to establish a set time for each question. Instead, I announced a "last call" for entries when the majority of students were finished. Incorporating more multiple-choice and true/false questions, rather than open-response questions that required numeric answers, did seem to speed things up a bit. However, as the student attitude surveys reveal in Chapter 5, students preferred the challenge of open-response questions.

Due to the time involved with setting up, logging in, and using the interactive system, I was unable to keep pace with the predefined schedule and curriculum of MAT 111. Initially, I incorporated Qwizdom examples at the end of class, as a review of that day's material. However, as the study progressed and as we got further and further behind schedule, I found I was incorporating the Qwizdom examples at the beginning of the following class period because we ran out of time during the previous class. Unfortunately, in order to get through the required material before the scheduled exam date, we had to abandon Qwizdom at the end of chapter 2, a whole chapter short of my intended goal.

Although the study had officially ended at the first exam, I was hoping to integrate Qwizdom throughout the semester (not daily, but as time allowed) because the students enjoyed using it and requested that we continue. Unfortunately, except for one occasion towards the end of the semester, the time needed to get through the required course material did not allow for its continued use.

Attitude in General

I really enjoyed using the interactive student response system in class, partly because I like working with technology, but mainly because the students seemed to enjoy using it. In addition, it incorporated an interactive component that I feel most classes are lacking, as discussed in the Introduction. When not using the system, the students did not ask many questions and generally appeared less interested in the lecture material. When using the system, however, the students were engaged and appeared to be having fun – a positive atmosphere I believe most instructors would prefer.

However, due to the fast pace, set schedule, and predefined curriculum of MAT 111 at The University of Maine, I do not believe that this traditional course is an ideal setting for an interactive student response system like Qwizdom. Since all sections take common exams, all sections must keep pace with the predefined curriculum and schedule. Because Qwizdom takes time to set up and to use, and because each class is only 50 minutes long, the treatment group got further and further behind schedule. Consequently, I felt rushed and, ultimately, students began complaining that I was going too fast. It is for this reason that I decided to cut the study short (stopping at the end of chapter 2 rather than at the end of chapter 4), and why we were not able to continue using the system as the semester progressed. Thus, due to the time factor issue, as a course instructor I do not recommend using an interactive student response system such as Qwizdom in a traditional college algebra lecture environment, particularly one that is only 50 minutes long as is typically the case. However, if the pedagogy of the course were changed, then I believe implementation of an interactive system is worth further exploration.

CHAPTER 7 – CONCLUSION

In this concluding chapter, I discuss the results of this study to answer the fourth and final research question: Overall, is the interactive student response system an effective tool for instruction in a traditional college algebra lecture environment? I also explore ideas and questions for future studies.

An Effective Tool for Instruction?

The student attitude surveys, discussed in Chapter 5, revealed that students perceived that the use of the interactive student response system (Qwizdom) provided problem-solving practice, increased understanding and was a good learning tool, increased attentiveness (but not attendance), and made math more interesting and fun. Furthermore, Qwizdom's anonymity encouraged participation in class. Overall, students generally liked using Qwizdom and felt that they had benefited from its use. Based on these positive student attitudes, I believe an interactive student response system is an effective tool for instruction, in general.

However, based on my (the instructor's) attitude, discussed in Chapter 6, I do not believe it is an effective tool for instruction in a "traditional" college algebra lecture environment. That is, due to the fast pace, set schedule, and predefined curriculum of MAT 111 at The University of Maine, and the time involved with incorporating an interactive student response system, this traditional course (as it is currently taught) is not an ideal setting for an interactive student response system such as Qwizdom. I believe that Qwizdom would be better suited for a course that is more flexible in its structure, schedule, and content. As discussed in Chapter 2, it is not possible to cover the amount of material typically covered in a traditional lecture when incorporating Mazur's Peer

Instruction method, which typically includes an interactive student response system (Mazur, 1997).

Furthermore, academic achievement was not statistically significantly higher for the section of MAT 111 that used the interactive student response system (treatment group) versus the sections that did not (control group). This supports the results of Cornell University's GoodQuestions project (Terrell, 2003), as discussed in Chapter 2. That is, the questions and "clickers" (i.e. interactive student response system) alone did not make a difference with the students' academic achievement in the GoodQuestions project. Only when they incorporated Mazur's Peer Instruction method did they notice an improvement.

However, "Interest can affect the degree to which a student persists in an activity… [and] interest has also been linked to deeper processing of information during learning…" (Byrnes, 2001, p. 103). Therefore, I still believe that over time, the increase in interest (enjoyment) and attentiveness in class when using an interactive student response system, as revealed by the student attitude surveys, could positively impact students' grades.

Based on these results, I believe it would be beneficial to instructors and to students if the traditional instruction method of college algebra were revised in order to effectively implement an interactive system. Therefore, maybe the research question should not have asked if the interactive student response system was an effective tool for instruction in a traditional college algebra lecture format, but rather, if a traditional college algebra lecture is an effective format for an interactive student response system.

Ideas and Questions for Future Studies

The following paragraphs explore some ideas and questions for future research studies.

Qwizdom's Lesson Slides

I found the Qwizdom curriculum "lesson" slides to be well written. In fact, I would have enjoyed incorporating these lessons into my own lectures like a Microsoft PowerPoint presentation, and I wonder how students would have responded to that approach. Unfortunately, incorporating PowerPoint-like lectures would be an additional change from the traditional lecture environment, and thus, may have skewed the results of this study. Presentation of "lesson" slides is something to consider for future studies, however.

Qwizdom's Radio Frequency Remotes

As discussed in Chapters 5 and 6, the line-of-sight infrared (Q3) remotes used in this study imposed some challenges or "quirks" that frustrated the students. Qwizdom now has radio frequency (Q4 and Q5 remotes) that eliminate the line-of-sight issues and other technical problems experienced with the Q3 remotes, as discussed in Chapter 6. Would students' attitudes significantly change if these newer/better remotes were used?

Qwizdom's Interactive Games

Unfortunately, as mentioned in Chapter 5, we did not have time to use Qwizdom's built-in games. I wonder what students' attitudes would be if the games were used. Would they be significantly different from this study? Would the use of games affect academic achievement?

The Novelty Factor

The overall student attitudes toward the interactive system were positive. However, I wonder if students' attitudes would change if the system had been used for a longer period of time. That is, would the novelty factor wear off after extended use?

Time Constraint and Variations between Sections

It is possible that both the time constraint (limiting the interactive system's use) and the number of variations between MAT 111 sections affected the academic achievement results of this study. However, further research may help to determine if these factors do in fact affect academic achievement.

Multiple-Choice versus Open-Response Questions

In the open-response section of the student attitude surveys, I asked, "Which types of questions were most effective for your learning: multiple choice and True/False questions, or open-ended questions with numeric answers." Based on their responses, students prefer to be challenged. I wonder, and wish I would have asked, what their answers would have been if they were "graded" on their response (i.e., if correct or not) rather than just on their participation?

Qwizdom in a Non-traditional Lecture Environment

I believe Qwizdom has the potential of being a very effective tool for instruction in a non-traditional lecture format, and its implementation is worth exploring. For example, Mazur's Peer Instruction method (Mazur, 1997) using conceptually oriented questions in college algebra and an interactive student response system would be an interesting study to undertake. Would academic achievement increase in this environment? Mazur's results, and others, suggest that it would.

Final Remarks

The attitude surveys show that the students enjoyed class more, and they seemed to think they were learning more, using Qwizdom, but the empirical evidence on academic achievement is that they did not learn more. The results of this and other work (e.g., Cummings, Marx, Thornton, & Kuhl, 1999) indicate that simply incorporating new technology into a traditional class without also including pedagogical changes matched to the new technology is ineffective at anything but affective improvement. The attitude improvement alone justifies further study, but lack of learning gains strongly implies that future work should include appropriate pedagogical techniques.

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*Note: PDF file is corrupted (missing text).

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APPENDICES

Appendix A: One-way ANOVA of SAT Scores Descriptives

Table A. 1: One-way ANOVA of SAT Scores Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
satv	500	35	514.00	59.863	10.119	493.44	534.56	420	640
	501	49	521.63	66.186	9.455	502.62	540.64	360	690
	502	47	505.11	72.946	10.640	483.69	526.52	360	660
	503	46	522.61	76.054	11.213	500.02	545.19	390	710
	504	46	518.70	83.894	12.370	493.78	543.61	280	710
	Total	223	516.55	72.393	4.848	506.99	526.10	280	710
satm	500	35	502.00	60.624	10.247	481.17	522.83	380	680
	501	49	488.98	82.190	11.741	465.37	512.59	360	790
	502	47	503.19	70.437	10.274	482.51	523.87	350	690
	503	46	508.48	69.024	10.177	487.98	528.98	400	670
	504	46	511.52	77.459	11.421	488.52	534.52	300	690
	Total	223	502.69	72.788	4.874	493.08	512.30	300	790
sat	500	35	1016.00	96.137	16.250	982.98	1049.02	860	1270
	501	49	1010.61	124.640	17.806	974.81	1046.41	730	1300
	502	47	1008.30	132.687	19.354	969.34	1047.26	760	1350
	503	46	1031.09	119.782	17.661	995.52	1066.66	810	1300
	504	46	1030.22	142.556	21.019	987.88	1072.55	580	1220
	Total	223	1019.24	124.690	8.350	1002.78	1035.69	580	1350

Appendix B: Common Exam #1

MAT 111 – Spring 2005
Common Exam #1 – February 9th

Name: _______________ Instructor: ____________Class Time: _________

- ✳ Please write your name on ALL pages.
- ✳ You have 2 hours for the exam.
- ✳ **Show work** to receive partial credit.
- ✳ Place one **simplified** final answer in each blank provided, as applicable.
- ✳ You may **not** use a calculator.
- ✳ Make sure your test contains **25 problems**.
- ✳ Each problem is worth a total of 4 points (100 points possible).

1. Evaluate:

$5 + 3(x - 3)^3$ for $x = 5$

1. _______________

2. A football is kicked straight up from a height of 4 feet with an initial speed of 60 feet per second. The formula below describes the ball's height above the ground, h (in feet), t seconds after it was kicked. What is the ball's height 3 seconds after it is kicked?

$h = 4 + 60t - 16t^2$

2. _______________

3. Simplify completely:

$$\frac{7 - 5(5 - 8)^3}{4 - 2 \cdot 3}$$

3. _______________

4. Simplify completely:

$|12 - 15| - |9 - 10|$

4. _______________

5. Simplify completely:

$3 - 4(5 - 2x) + 3(1 - x)$

5. ________________

6. Solve the following equation for x:

$5x - (2x + 2) = x + (3x - 5)$

6. ________________

7. Solve the fractional equation for x by <u>clearing the fractions</u>:

$$5 + \frac{x-2}{3} = \frac{x+3}{8}$$

7. ________________

8. Solve the formula $C = \frac{5}{9}(F - 32)$ for F.

8. ________________

9. A rectangular swimming pool is three times as long as it is wide. If the perimeter of the pool is 240 *feet*, what are its dimensions?

9. ________________

10. Simplify completely: $\left(-3x^4y^{-2}\right)^{-2}$

10. ________________

11. Simplify completely: $\left(\dfrac{-45x^{-2}y^2}{9x^6y^{-5}}\right)^2$

11. ________________

12. Answer a & b for the following relation: $\{(-1,2),\ (3,2),(1,-3),(2,-1),(-2,3)\}$

a) Give the domain and range of this relation.

Domain: _________________

Range: _________________

b) Is this relation a function? Why or why not?

13. Let: $g(x)=4x^2-3x+5$

Find the function value: $g(-3)$

13. ________________

14. Determine the domain of the function: $f(x)=\dfrac{3x}{x-3}$

14. ________________

15. Let: $f(x) = x^2 - 3x$ and $g(x) = 3 - x$

a) Evaluate: $(f + g)(-2)$

15.
a) ____________

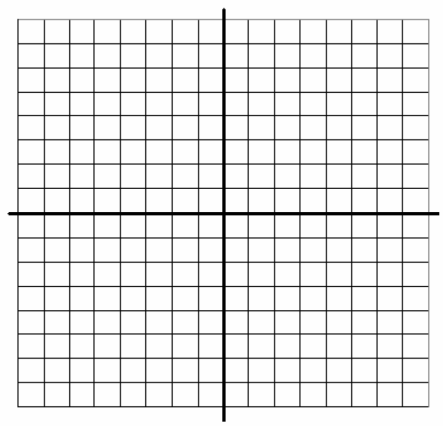
b) Evaluate: $\left(\dfrac{f}{g}\right)(1)$

b) ____________

16. Graph the following equation using method of your choice (i.e. point-plotting, intercepts and checkpoint, or slope-intercept):

✱ **Please remember to label and scale axes** (otherwise graph has no meaning in relation to the equation).

$4x + 3y = 12$



17. Find the slope of the line passing through the points:
(-2, 6) and (3, -4)

17. slope = ________

18. Find the slope and y-intercept of the equation:
2x – y = 6

18. slope = _______

y-intercept = _______

19. Which pair of functions are perpendicular, and which pair are parallel?

$f(x) = \frac{3}{4}x + 5$

$g(x) = 4x - 6$

$h(x) = -\frac{4}{3}x + 2$

$j(x) = 4x + 9$

$k(x) = \frac{1}{4}x - 3$

Perpendicular: ____________________

Parallel: ____________________

20. Give the **slope-intercept** form for the equation of the line satisfying the following condition:
slope = -2, and passing through (3,-5).

Slope-Intercept Form: __________________

21. Give the **point-slope** and the **slope-intercept** forms for the equation of the line passing through (-3,6) and (3,-2).

Point-Slope Form: _____________________

Slope-Intercept Form: __________________

22. Solve the following inequalities and compound inequalities. Express solutions using both **inequality** and **interval** notation, and then **graph** on number line.

a) $5(3 - x) \le 3x - 1$

Inequality Notation: _________________

Interval Notation: ___________________

b) $3x < 3$ or $2x > 10$

Inequality Notation: ________________

Interval Notation: ___________________

c) $3x = 15$ and $2x > -6$

Inequality Notation: ________________

Interval Notation: ___________________

d) $-6 < x - 4 \leq 1$

Inequality Notation: ________________

Interval Notation: ___________________

23. Solve the following absolute value inequalities. Express solutions using both **inequality** and **interval** notation, and then **graph** on number line.

a) $|x - 1| < 5$

Inequality Notation: ________________

Interval Notation: ___________________

b) $|x + 2| > 5$

Inequality Notation: ________________

Interval Notation: ___________________

24. Solve the following absolute value equation:

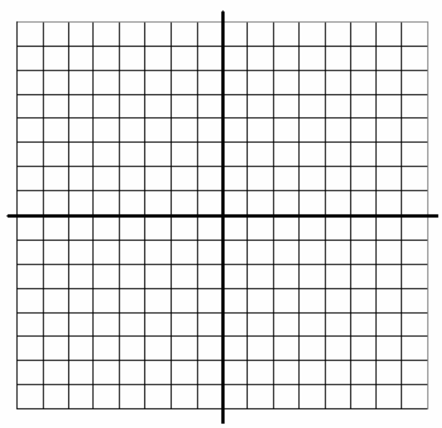
$|2y - 6| = |10 - 2y|$

24. _______________

25. Graph the following inequality:

✵ Please remember to label and scale axes (otherwise graph has no meaning).

$2x - y < 4$



Appendix C: Raw Data – Exam Scores

Table C. 1: Raw Data - Exam Scores (entire exam)

Entire Exam (chapters 1, 2, & 4)
Raw score = 35 max
(35 answer blanks and/or parts - completely correct to receive credit)

	TREATMENT (501)	CONTROL #1 (500)	CONTROL #2 (502)	CONTROL #3 (503)	CONTROL #4 (504)	COMBINED CONTROL
	8	35	17	26	20	
	27	17	13	30	20	
	12	30	18	22	24	
	21	23	22	24	25	
	25	26	19	19	21	
	27	26	28	35	22	
	17	21	11	31	32	
	23	17	24	22	18	
	30	29	17	12	24	
	27	22	22	22	33	
	33	13	7	27	18	
	33	29	25	21	5	
	23	31	14	25	21	
	25	29	18	21	15	
	31	33	8	23	30	
	23	23	16	18	32	
	24	28	21	7	14	
	13	22	29	19	18	
	21	22	24	13	29	
	26	15	28	27	16	
	25	31	9	33	25	
	31	29	22	28	18	
	30	34	21	6	21	
	21	19	10	15	15	
	22	9	16	29	24	
	24	12	11	28	24	
	29	22	20	27	12	
	13	24	32	16	23	
	19	27	22	11	20	
	27	23	23	26	30	
	29	20	5	30	18	
	29	29	30	27	18	
	25	22	24	23	17	
	23	13	30	17	10	
	23	19	10	25	23	
	27	27	13	22	22	
	10	24	12		28	
		33	28		17	
		30	14		24	
			9		25	
			27		32	
			31			
			29			
			13			
			27			
MEAN	23.676	24.051	19.311	22.417	21.537	21.72
MEDIAN	25	24	20	23	21	22
MODE	27	29	22	22	18	22
STD DEV	6.245	6.505	7.507	6.967	6.257	7.002
VARIANCE	39.003					49.028

Appendix C - continued

Table C. 2: Raw Data - Exam Scores (chapters 1 & 2)

Partial Exam (through problem #21 = Chapters 1 & 2)
= Period of Qwizdom use
Raw score = 27 max
(27 answer blanks and/or parts - completely correct to receive credit)

	TREATMENT (501)	**CONTROL #1** (500)	**CONTROL #2** (502)	**CONTROL #3** (503)	**CONTROL #4** (504)	**COMBINED CONTROL**
	7	27	12	23	20	
	24	15	13	25	17	
	10	24	15	20	19	
	16	21	17	20	17	
	20	24	16	14	17	
	22	20	21	27	17	
	13	17	11	25	24	
	20	15	21	20	15	
	25	22	15	10	18	
	23	18	21	20	25	
	26	12	7	23	14	
	26	21	20	19	5	
	19	25	10	20	18	
	19	24	14	17	14	
	24	25	8	19	23	
	20	16	13	17	24	
	18	22	14	7	11	
	12	19	22	15	17	
	17	17	22	13	21	
	20	13	22	24	12	
	19	23	9	27	20	
	23	23	18	23	14	
	23	26	14	6	17	
	20	15	5	15	12	
	19	8	15	23	17	
	20	9	11	25	19	
	22	17	16	20	10	
	10	17	24	16	16	
	17	20	19	10	19	
	20	19	22	19	24	
	25	17	5	27	16	
	22	23	25	23	16	
	21	18	20	19	14	
	20	9	25	17	10	
	19	16	10	20	20	
	19	22	11	17	20	
	8	17	12		22	
		26	23		15	
		23	12		20	
			9		19	
			23		24	
			24			
			25			
			10			
			25			
MEAN	19.135	19.103	16.133	19.028	17.366	17.814
MEDIAN	20	19	15	20	17	18
MODE	20	17	22	20	17	17
STD DEV	4.820	4.887	5.960	5.358	4.386	5.302
VARIANCE	23.231					28.115

Appendix D: Student Attitude Survey

Interactive Student Response System Survey

For the first part of this survey you are asked to rate (and comment on) statements that may or may not describe your attitudes about the *Qwizdom* interactive student response system that we used this semester. For the second part of this survey you are asked to answer open response questions.

Part 1:

Please rate each statement by circling a number between 1 and 5 where the numbers mean the following:

1 Strongly Agree
2 Agree
3 Neutral
4 Disagree
5 Strongly Disagree

Read the survey items carefully. For each statement circle the number that *best expresses how you feel*. If you do not understand a statement, leave it blank. If you understand, but have no strong opinion one way or the other, circle the 3.

Please comment on each statement after rating. Try to be as explicit as you can.

		1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree
1.	I liked using *Qwizdom.*	1	2	3	4	5

Comments:____

____

____

____

____

____

		1	2	3	4	5
		Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
2.	*Qwizdom* increased my understanding of the course material.	1	2	3	4	5
3.	The use of *Qwizdom* increased the likelihood that I would attend class (for reasons other than being graded on participation or attendance).	1	2	3	4	5
4.	*Qwizdom* helped me stay attentive in class.	1	2	3	4	5

2. *Qwizdom* increased my understanding of the course material.

Comments:______________________________________
____
____
____
____
____

3. The use of *Qwizdom* increased the likelihood that I would attend class (for reasons other than being graded on participation or attendance).

Comments:______________________________________
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4. *Qwizdom* helped me stay attentive in class.

Comments:______________________________________
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		1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree
5.	*Qwizdom* helped me to identify problem areas that I needed to study prior to quizzes and exams.	1	2	3	4	5
6.	I feel I would have learned more in class if *Qwizdom* had not been used.	1	2	3	4	5
7.	*Qwizdom* helped me be an active class participant, more than I typically would be in a regular lecture environment.	1	2	3	4	5

Comments (item 5): ______________________________

Comments (item 6): ______________________________

Comments (item 7): ______________________________

		1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree
8.	There are other classes in which using an interactive student response system, such as *Qwizdom*, would be of benefit to me.	1	2	3	4	5
9.	I liked seeing the histogram of class results displayed after each question.	1	2	3	4	5
10.	The automatic (right/wrong) feedback that the remotes provided through flashing LED lights was helpful.	1	2	3	4	5

8. Comments:____

9. Comments:____

10. Comments:____

		1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree
11.	When the automatic feedback indicated my answer was incorrect, I continued working to determine why.	1	2	3	4	5
12.	It would have been helpful if the remotes had been enabled to allow more than one answer.	1	2	3	4	5
13.	I blindly entered answers, so that I would receive credit for participating, without taking the time to think about the problem and attempting to solve it first.	1	2	3	4	5

11\. When the automatic feedback indicated my answer was incorrect, I continued working to determine why.

Comments:____

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12\. It would have been helpful if the remotes had been enabled to allow more than one answer.

Comments:____

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13\. I blindly entered answers, so that I would receive credit for participating, without taking the time to think about the problem and attempting to solve it first.

Comments:____

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		1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree
14.	Overall, using *Qwizdom* was a positive experience for me.	1	2	3	4	5

Comments:____

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Part 2 – Open Response:

1. Suppose a friend asked your advice on which math class to take. Two sections of the same class were offered at the same time and both had good instructors. One class used an interactive student response system, such as *Qwizdom*, one did not. Which would you recommend and why?

2. Did you prefer having the *Qwizdom* examples the same day as the lecture topic or at the beginning of the following class period? Why?

3. If you answered a *Qwizdom* question incorrectly, did you discuss the problem with classmates around you to help determine why it was incorrect? If so, did this collaborative approach help you to better understand the problem? Explain.

4. Which types of questions were most effective for your learning: multiple choice and True/False questions, or open-ended questions with numeric answers? Please explain.

5. Some students may spend a significant amount of time waiting for everyone else to enter their answers in the *Qwizdom* remotes. Do you feel this lag time is taking away from time spent on learning? Do you have any suggestions on how we can address this lag time and keep all students engaged?

6. Compare this course with another math course you have taken that was similar in the manner it was taught and/or the content covered. Through comparison, discuss the effects of *Qwizdom* on your learning and success.

7. Discuss other ways that *Qwizdom* might be used in class and why.

8. Please add any other comments, or elaborations, below (use the back if needed).

Appendix E: Instructor's Experiences using Qwizdom

The comments that follow are directed towards Qwizdom's Interactive Learning System. Since I have not had the benefit of experimenting with other types of interactive student response systems, these comments may or may not apply to systems in general.

Interact Software Program

When I started familiarizing myself with Qwizdom's Interactive Learning System during the summer of 2004, it was operating with a software program called T.A. I found this program to be very non-intuitive and laborious to use. Fortunately, in the fall of 2004, Qwizdom introduced a new software program called Interact. This program is Windows based, very similar to Microsoft PowerPoint, and is very intuitive and user-friendly. (The upgrade was for PC platforms only, but it is my understanding that they are currently working on a Mac version.)

As with any new software program, there were "bugs" to work out. I was in contact with technical representatives from Qwizdom almost daily, as we tried to identify and troubleshoot these technical problems before my study began in the spring. Consequently, three different upgrades to the Interact Software package were sent to us. I discuss some of these difficulties in the "Technical Problems" sections below.

Curriculum Packages

As discussed in Chapter 2, Qwizdom offers a variety of ready-to-use K-12 curriculum packages. Since "All content can be edited and used in any of the software's presentation and printing formats" (Qwizdom, Inc., 2004, product brochure), I used the question/answer sets in the Algebra I and II series as templates for developing interactive question and answer slides for this college algebra course. That is, I took the series' existing slides and modified the questions and answers to more accurately reflect the material covered in our college algebra textbook (Blitzer, 2002).

In addition to the question/answer sets, I found the lesson slides in the curriculum package to be informative and nicely presented. In fact, I would have enjoyed implementing the lesson slides into the course, but this PowerPoint-like presentation would have incorporated an additional change from the traditional lecture environment, possibly skewing the results of this study.

Although I find the curriculum packages to be respectable, there is room for improvement. Unfortunately, I did not have time to review all of the slides for content, but as with most textbooks, I did find a few errors to which I notified the Qwizdom representative. In addition, I find that the answer slides are not as detailed or complete as they could be. There can be up to 5 slides per question/answer set, but they rarely use all 5 slides. In fact, some questions only show the answer (2 slides total) without showing any of the solution steps. Consequently, I modified the solution slides (that I used as templates) so that they showed detailed solutions for class discussion.

Technical Problems – Resolved

Except for problems with the remotes, the following technical problems were not problems of which the students were aware of, and should not have affected their attitudes. However, they did affect me as the instructor.

Importing Class Lists

A nice feature of Qwizdom is the ability to import class lists from other applications. Unfortunately, this feature was not working with the initial Interact upgrade. After several days of troubleshooting with Qwizdom's technical representative, we discovered that we had an old (prior to 12/16/04) version of Interact. Subsequently, an upgrade was received and I was able to successfully import my class data, avoiding the need to enter each name and ID manually.

Login ID

Once my class list was imported, I assigned each student an ID number – the last 4 digits of their social security number – that the student would enter on a remote to log into the system.

One limitation to this method of ID number assignment is that Qwizdom does not recognize leading zeros, which, incidentally, is not mentioned in the Qwizdom Interact Help and User Guide (Qwizdom, Inc., 2004). Students that had leading zeros in the last 4 digits of their social security number were advised (in the Student Remote and Login handout) to enter only those numbers after the leading zeros.

Length of names in class list is another limitation not mentioned in the Help and User Guide. When I imported the class lists, I imported the entire name of each student given (i.e. including middle name). When logging in remotes by ID, six of the IDs failed with the following error message: "An unhandled exception has occurred in your application… Index and count must refer to a location with the string…" The technical representative at Qwizdom received the same error with my class list. Unable to determine why this was happening, she passed the problem on to the programmers. The programmers ascertained that the names for the IDs that failed were too long, and recommended that I remove the middle names. Fortunately, this worked, and all students were able to log into the system by the second day of class.

Curriculum Folder Organization

To help with organization, the activities and curriculum folders can be neatly arranged in a content tree, which comes up when the Interact application is opened. When installing curriculum packages, the content folders should automatically arrange under the applicable curriculum series folder. However, when I installed the Algebra I curriculum package, the content folders for that series were not within the Algebra I folder, but randomly distributed throughout the content tree. I subsequently re-arranged the folders manually, but they reverted to the random distribution the next time the Interact program was opened. Qwizdom was able to repair this problem and sent us update files on 1/31/05.

% Wrong Flag

The % wrong flag appears if a preset percentage of students (set in the presentation window) answered incorrectly. Although this sounds like a useful feedback feature, I did not find it helpful because the flag does not come up until you advance to the next question, and then only briefly. Preferably, it would appear while the presentation is still on the question that the students got wrong. Then you can spend time discussing the solution since the solution slides are part of the question/answer set. However, I may have found the % wrong flag to be more useful if I had more time to use it. It was not working until late in the study, after installing the third software update.

I found the histogram (bar graph) of class results to be a useful feedback tool. The histogram was very helpful to me as an instructor because it alerted me to material with which students had trouble understanding. This allowed me the opportunity to resolve any questions in real-time, i.e. while the lecture material was still fresh in the students' minds. The histogram worked well for multiple-choice and true/false questions, but unfortunately, not for questions that required numeric entries because of the wide range of possible answers.

Remotes

The remotes used in this study operate with 2-way infrared technology, which is constrained to line-of-sight. That is, each remote and the receiver must have a clear and direct "line-of-sight" path between them. This caused many problems for the students when trying to log in and when entering answers, and I believe this is one of the system "quirks" that students were referring to in the attitude surveys.

We started the semester in a very small classroom that had desks on the same level. I did not foresee this as a problem because I thought the students could work around the heads that were in front of them, blocking their line-of-sight. I was mistaken. Fortunately, a tiered lecture hall was available for our use.

Moving to a tiered lecture hall helped, but did not resolve the line-of-sight problems. Students still struggled with their remote entries not being acknowledged, even when I stressed the importance of pointing the remote directly at the receiver. Finally, I told them to think of the receiver like a television (TV) and their remote like a TV remote. This was something they could relate to and it helped. Unfortunately, it was not until the end of the study that most students successfully conquered the line-of-sight issue.

On a daily basis, at least one student (not necessarily the same student) could not get their remote to work and elected to try another one. I typically performed an operational check on all remotes before class to ensure they were working, so I do not believe the remotes were faulty. Rather, I believe the students were still struggling with line-of-sight issues as well as issues with the remote buttons (discussed in the unresolved section below). However, there was one occasion in which we did have a faulty remote (remote #3), in which the False button did not work. Upon further inspection, I discovered a corroded circuit card and leaking/corroded batteries. Since the system was relatively new and the batteries were included with the system, Qwizdom replaced the remote at no charge. However, to eliminate this problem in the future, I highly recommend removing the batteries if the remotes are not being used for an extended period of time.

The remotes used in this study were the Q3 version, which uses 2-way infrared, where line-of-sight between the remotes and the receiver is critical. According to Qwizdom's website (www.qwizdom.com), accessed on 8/22/05, they now have Q4 and Q5 remotes that use a 2-way radio frequency. Thus, "all data is received without the 'line of sight issues' typically associated with infrared (Q3) remotes." Although for the most part we were able to work around the line-of-sight issue, I believe the students' attitudes towards the systems' "quirks" would have been different if we had been using radio frequency remotes.

Technical Problems – Unresolved

Although the problems below remain unresolved, the only problems that directly affected the students were issues surrounding logging in and the remotes. I discussed many of problems with the technical representative at Qwizdom, and offered my suggestions. She said that she would pass the suggestions on to the programmers for possible future upgrades.

Logging In

As many students pointed out in the student surveys, it takes a significant amount of time to get everyone logged into the system. Each student has to enter their assigned ID, and then verify that their login has registered. Unfortunately, students have to log in each time you go into presentation mode (i.e. for each activity). To expedite the logging in process, it would be helpful to be able to log in at the beginning of the class period for all Qwizdom presentations that day. As soon as students arrive, they could pick up a remote and log in, thereby reducing and possibly eliminating the amount of class time required for this process. This is especially important for a class period that is only 50 minutes, as was the case for this course.

Furthermore, once a presentation starts, students are not able to log in. Therefore, on days in which we had the Qwizdom examples at the beginning of class, students that were a few minutes late could not participate. If Qwizdom, Inc. would redesign the system, making the logging in process separate from the presentations, I believe this problem and the problem in the previous paragraph would be resolved.

An additional problem with the logging in process concerns the login screen. Since it would take too long for me to verify that everyone was logged in, I displayed the login screen to the students so they could verify that their login was accepted. The login screen only shows the first 10 logins. To see the others, the instructor has to scroll down the list. Unfortunately, each time another person logs in, the screen reverts to the top. Therefore, those that log in after the first 10 cannot see their name (i.e. verify their login) until everyone has completed logging in and the instructor is able to scroll down to the bottom of the list. It would be helpful, and more time-efficient, if the system did not revert to the top, but continued to scroll down as new names are added.

Remotes

Even though the line-of-sight issue is an inherent problem with infrared remotes, we were able to work around it, for the most part anyway, as discussed above. Several problems with the remotes could not be resolved, however, due to the design of the remote or to the software program. Examples of these unresolved remote problems include default remote numbers, momentary LED lights, and small buttons with the inability to verify entries.

The software assigns default remote numbers to each student, which is overridden when students log in by ID. If students do not log in by ID, then the software only recognizes the default remote numbers assigned to each student. For example, if you have 40 students on the class list, then the software recognizes 40 remotes – remotes numbered 1-40. Unfortunately, the system does not recognize additional remote numbers (e.g. 41-48). Of course, we discovered this the hard way. On a day when I decided not to take the time needed to login by ID, students who picked up remotes numbered 41-48, were not able to participate.

The right/wrong LED lights on the remotes do not stay on long enough to ensure they are seen by the student. The light comes on as soon as the student's answer is acknowledged, but stays on only briefly (approximately 1-2 seconds). Unless the student is looking directly at the remote when he or she sends the answer, the student will miss this valuable feedback opportunity. This caused some frustration with the students, as indicated by the attitude surveys in Chapter 5.

The buttons on the remotes are somewhat small and require a certain level of pressure before the student's entry is acknowledged. Unfortunately, there is no way to verify entries with the type of remote used in this study. Consequently, what the student "thought" they entered may have been a correct answer, but the automatic feedback showed otherwise. This inconsistency tended to confuse students. At the very least, it frustrated them, as revealed by the attitude surveys discussed in Chapter 5. The small, pressure-dependent, buttons also caused problems with logging in, making that time-consuming process even longer.

The newer Q4 and Q5 versions of the remote have an LCD panel (larger on the Q5 version) that allows users to see the answer and question number. This would have been very helpful to the students in this study. For example, it would have eliminated the problem with students receiving a wrong answer (or invalid login) when their answer on paper was correct. If the students had been able "see" what they were entering, then I believe their attitudes regarding some of the systems' "quirks" would have been different.

The Q5 version also has a rocker switch that allows users to enter text-based answers. This is one of the issues I have with the Qwizdom system we used, that the only type of open-response question that can be answered with the Q3 remotes is one that requires a numeric entry only. Of course, the Qwizdom slides can be used to discuss other types of questions (e.g. fill in, short answer, essay, etc.), but students would have to answer verbally or on paper. If answering verbally, then the benefits of anonymity are negated. Having remotes that allow text-based answers opens up many possibilities for the types of questions that can be asked.

Slide editor screens

The slide editor (very similar to Microsoft PowerPoint) is where you create and edit up to 5 slides (screens) for each question/answer set. Unfortunately, you cannot move existing screens within the slider editor; you can only insert new screens before/after the existing screens. Therefore, if you want to rearrange the order of the screens, you cannot. I was able to work around this by copying/pasting and inserting/deleting screens, but this is a little cumbersome.

Grade Book

Interact is able to track student answers, scores, and overall grades. This grade book is available to the instructor only. Since I only graded students on participation, I referred to the grade book to verify which students participated that day.

Unfortunately, the grade book does not allow comments where the scores for each activity are located. Thus, I had to keep a separate log of students that had approved absences (e.g. University sponsored events, athletes, etc.), or students who arrived to class late (i.e. after login opportunity), so I would not penalize them for that day's participation/attendance grade.

Overall Attitude towards Qwizdom

Overall, I feel that Qwizdom's Interactive Learning System is a well-designed, user-friendly, and versatile wireless response system. Although we experienced some technical problems with the system, these problems have been, or can be, resolved with further programming and system upgrades.

BIOGRAPHY OF THE AUTHOR

Dina L. Blodgett was born in Jackson, Michigan in 1965. She grew up in a small lakeside community in southern Michigan until age 17, when she moved to Roswell, New Mexico with her parents. Upon graduation with honors from Roswell High School in 1983, she attended New Mexico State University in Las Cruces and Eastern New Mexico University in Roswell while working as a mortgage loan clerk for a local financial institution.

In 1989, Dina joined the United States Navy, where she spent nine years active duty as an aviation electronics technician, work center supervisor, and quality assurance inspector. While serving her country, she received a Bachelor of Science in Sociology from The University of the State of New York.

Upon her honorable discharge from the United States Navy in 1998, Dina returned to school to study engineering. In 2002, she graduated summa cum laude with a Bachelor of Science in Electrical Engineering and a Biology minor from the University of Southern Maine.

While studying engineering, Dina realized that she would like to teach. She worked as an associate process engineer until the opportunity to pursue an advanced teaching degree became available in 2003. Dina is actively pursuing State of Maine certification to teach secondary level mathematics, and would like to teach mathematics at the college level as well. She is also pursuing certifications in secondary level physical and life sciences, and in adult education. Dina is a candidate for the Master of Science in Teaching (MST) degree from The University of Maine in May 2006.