Integrating Technology into the Mathematics Classroom
An Action Research Study

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Abstract: The purpose of this action research study was to compare the effects of technology-enhanced algebra instruction and traditional algebra instruction in terms of student academic achievement, student motivation, and student attitude towards algebra. In doing this comparison, I also hoped to gain an understanding of how technology was being used by teachers and students in algebra instruction. In my study, I concentrated on comparing two methods of instruction--technology-enhanced algebra instruction and traditional algebra instruction-- in three areas: student achievement, student motivation, and student attitude. The study included four teachers and 92 ninth-grade students in five algebra classes. Students in technology-enhanced classes had higher achievement scores, were more motivated, and had a more positive attitude than those in traditional algebra classrooms. Based on these results, I reached conclusions which were presented to stakeholders at my school, and I recommended that schools should increase the use of technology and the amount of technology integration into secondary algebra classrooms.

Introduction

In 1989, the Organization for Economic Cooperation and Development (OECD) began to investigate how science, mathematics, and technology education were changing. Of the thirteen countries participating in the study, no country was satisfied with its existing programs in science or mathematics education (Atkin, 1998). Internationally, educational researchers have expressed high expectations for the computer and other technology in improving the teaching and learning of mathematics (Kaput & Roschelle, 1997). However, the utilization of technology in the mathematics classroom can range from simple information delivery and drill-and practice exercises to an environment of authentic practices and problem solving (Papert, 1992).

In *Curriculum and Evaluation Standards for School Mathematics* (1989) and *Principles and Standards for School Mathematics* (2000), the National Council of Teachers of Mathematics (NCTM) stated that technology is an essential tool for teaching and learning math. It influences mathematical content as well as the way teachers teach mathematics, and it enhances student learning. NCTM recommended that technology be used wisely by well-informed teachers to support mathematical understanding.

There is much debate concerning the effects of using technology in mathematics instruction. In many traditional mathematics classrooms, the teacher leads a large group demonstration of skills followed by individual practice. The students sit in rows watching the teacher as she demonstrates the procedure to be learned with a shift to student eyes intent on papers as they practice what the teacher has demonstrated (Dossey, Mullis, Linquist, & Chambers, 1988). Fortunately, this picture of a traditional mathematics classroom is changing. Encouraged by the National Council of Teachers of Mathematics, use of technology in the mathematics classroom has increased, and technology-enhanced classrooms are becoming more prevalent.

A number of different technologies are being used in today's mathematics classrooms with varying degrees of success. Technologies such as graphing calculators allow students to explore more difficult problems than educators would have dared to assign years ago. Graphing calculators allow investigation of functions through tables, graphs and equations in ways that were not possible before their proliferation. Further, graphing calculators allow the focus to be on understanding and setting up and interpreting results (Dick, 1992; Hopkins, 1992).

The positive effects of mathematics and technology instruction such as computer-mediated learning are becoming more prevalent in the mathematics classroom. Replacing "drill and kill" worksheets, software that is one-on-one, self-paced, and provides immediate feedback can help remediate and can enhance student understanding. The researchers in one study, using the Mediated Learning approach in introductory and intermediate college algebra, found that students who took two mediated learning courses received a higher proportion of grades C or better than those who took two courses in the traditional form, and students who took two Mediated Learning courses did better than those who took one traditional algebra course and one Mediated

Learning course (Baker, Hale, & Gifford, 1997). Recent research indicates that the purposeful use of computers in classroom instruction can indeed enhance student outcomes (Archer, 1998; Milheim, 1995). Studies involving computer assisted algebra instruction (Brunner & Sheehan, 1997; O'Callaghan, 1998) and instruction with graphing calculators (Adams, 1997) have had similar positive results.

My school, located in southwestern Georgia, serves approximately 590 ninth grade students. Out of a faculty of 47 teachers, principals, media specialists, and counselors, all have at least a four-year degree, and 51.1% have a masters degree or higher. The percentage of students in the school that are eligible to receive free or reduced-price lunches is 43.6%. The student population consists of 39.9% Black, 54% Caucasian, and 5.8% Hispanic (Georgia Department of Education, 2000). In the 2001- 2002 school year, the school began implementing block scheduling for the first time.

For the past three years, the school has been integrating technology into classrooms through a comprehensive Technology Improvement Plan. Presently, there are ten InTech- certified teachers at the school, and there are plans to certify the rest of the faculty in the next three years. The mathematics department has six sets of graphing calculators, scientific calculators, and a calculator-based laboratory. This year, the school installed an Algebra Logic Lab that provides computer-focused learning for students taking a year-long Algebra 1 course. In this, the third year of the Technology Improvement Plan, the school's teachers and administrators need to assess the effects of the newly integrated technology on student learning. Also, on the eve of the institution of end-of-the-course tests including one in algebra, the school is concerned with identifying classroom instruction that maximizes student achievement. As a member of the school Technology Committee, mathematics department head, and computer applications teacher, I am especially concerned with the effects of technology on student achievement.

Much is available on how technology can be useful in the mathematics classroom. Although research concerning the effects of technology on mathematics is increasing, most studies are set in elementary or post-secondary environments. There is little research concerning the effects of technology on mathematics achievement in secondary algebra. This lack of research suggests that an investigation of the differences between a technology-enhanced algebra classroom and a traditional algebra classroom in affecting mathematics achievement would be a valuable addition to the literature.

The purpose of this action research study was to compare the effects of technology-enhanced algebra instruction and traditional algebra instruction in terms of student academic achievement, student motivation, and student attitude towards algebra. In doing this comparison, I hoped to gain an understanding of how technology was being used by teachers and students in algebra instruction. In my study, I concentrated on comparing two methods of instruction, technology-enhanced algebra instruction and traditional algebra instruction. I defined technology-enhanced algebra instruction as instruction that included at least one of the following: computerized instruction (student-focused or teacher-focused), graphing utilities, and Internet use. Traditional algebra instruction was instruction that did not include computer-related technology such as software, graphing calculators, and the Internet but may include print technologies or other non-computerized media such as overhead projectors.

The areas in which I was studying the effects of the instruction were student academic achievement, student motivation, and student attitude. Student academic achievement was an increase on measures of academic performance such as written tests or performance assessments. Student motivation was a student's willingness to learn algebra as evidenced by student participation. Student attitude was defined as a student's feelings and beliefs towards using technology in the classroom.

Research Questions

1. How does technology-enhanced algebra instruction compare with traditional algebra instruction in student academic achievement, student motivation to learn algebra, and student attitude towards technology?
2. How is technology being used by teachers and students in algebra instruction? To what extent? How frequently? What are the types of use?

Method

Participants

The study included four teachers and ninety-two ninth-grade students. There were approximately the same number of male and female students (54% male and 46% female), and there were one male teacher and three female

teachers involved in the study. The majority of the student participants were White (67% White, 20% African-American, and 13% Other). The student participants were enrolled in first-year and second-year algebra courses.

In order to complete my study, I had to gather a pool of participants to study. To gain access to the three classes that I did not teach, I sought the assent of the other teachers. After ensuring the permission and participation of all the teachers involved, the other teachers and I distributed permission/consent forms for the students and the parents of the students to sign. Ninety-two percent of the students in five classes returned signed forms, and they were included in the study.

Each participating teacher identified one student from each class as a high achiever and one student as a low achiever without taking into consideration motivation or attitude towards technology. From the ten students identified, I randomly chose four participants for achievement case studies. The students chosen to be interviewed concerning their attitudes towards technology in mathematics were randomly selected from the set of participating students.

Intervention

In order to study the effects of integrating technology into the algebra classroom, I studied several interventions that were already being implemented in the classrooms. The interventions included (1) using the Algebra Logic lab for completely computerized instruction, (2) using graphing utilities in addition to teacher-led instruction, (3) using PowerPoint presentations to enhance teacher-led instruction, and (4) using online activities such as Web-Quests in addition to teacher-led instruction. These interventions were used to teach algebra primarily to present information and to practice algebraic concepts, and they were present in three of the five classrooms studied. In the two traditional classrooms, none of the aforementioned interventions were believed to be present.

Measures

In order to compare technology-enhanced algebra instruction with traditional algebra instruction in student academic achievement, student motivation, and student attitude towards algebra, I used a variety of measures. To measure student achievement in both the traditional and technology-enhanced classes, I used the algebra final exam as a pretest and a posttest, administered student achievement surveys, and completed case studies using student work, teacher comments, and student interviews. To measure the level of student motivation, I administered a student motivation survey to the students and a student motivation survey to the teachers. Also, I observed the mathematics classrooms using a student participation checklist. In order to determine student attitudes towards technology in mathematics, I administered a student attitudinal survey and performed student interviews. Finally, using a classroom observational checklist in classroom observations, I documented how technology was being used by teachers and students in algebra instruction.

Procedures

My study involved five algebra classes. I chose to include both of my second year algebra classes in the study because those classes were the ones to which I had immediate and extensive access. Because I regularly use technology in my classes, I decided to use my classes as examples of technology-enhanced classes. Then, I decided to include the other second year algebra class taught by a more traditional teacher as an example of the traditional mathematics classroom. In my class, I use PowerPoint presentations, graphing utilities, student computers, and other technology in addition to teacher-focused mathematics instruction.

Because of the recent inception of the Algebra Logic Lab and the subsequent concerns of its effectiveness, I decided to include one class of first-year algebra students in the Algebra Logic Lab for additional study as a technology-enhanced classroom. To have a comparison group for the computer-enhanced algebra, I added an additional traditional first-year algebra class. I randomly selected one of the three first-year Algebra Logic Lab classes and one of the three traditional first-year algebra classes for inclusion. The Algebra Logic Lab employs self-paced computerized instruction in first-year algebra with a teacher acting as a facilitator.

All data was collected in the mathematics classrooms during the regular class period. Each student was assigned a number with which to code the tests, surveys, and interviews to preserve confidentiality but maintain a link among the data measures for analysis. The content-based pretests and posttests were administered at the beginning of the semester and the fourteenth week of the eighteen-week semester. Each time, the regular classroom teacher administered the tests, and the students were allowed one hour for the testing period. All three student surveys were administered at the same time, and the surveys were administered by the regular classroom teacher. The students took approximately twenty minutes to complete all three surveys. No special instructions were given other than the initial description of the study given on the permission forms and a definition of technology.

There were 52 participants in the technology-enhanced classes. In one of my two second-year algebra classes there were 17 participating students, and there were 19 participating students in the other class. Sixteen students in the technology-enhanced Algebra Logic Lab participated. There were 25 participating students in the first-year algebra traditional class, and there were 15 student participants in the second-year algebra traditional class.

The achievement case studies were completed after the surveys were analyzed. They included brief interviews with the teacher concerning the student, a review of the student's work, an observation of the student in class, and a ten-minute interview of the student outside of the classroom during the regular class period. The four participating students were randomly chosen and came from classes with class sizes 19, 16, and 25. There were two students selected from the 25 member class. Similarly, the attitudinal interviews were completed during class time outside of the classroom. The participants were two randomly-selected students from each class with class sizes 17, 19, 16, 15 and 25. To complete my data collection, I observed each classroom two times for twenty minutes each time using a student participation checklist to measure student participation and a classroom observational checklist to measure technology use.

After collecting all the data, I analyzed the data to seek answers to the research questions. To compare the technology-enhanced mathematics classrooms with the traditional mathematics classroom, I organized the data collected from the classroom observations, the case studies, and from the various surveys into a Microsoft Excel workbook. I organized the data by the students' assigned numbers, and I used Excel to calculate the descriptive statistics and to count the frequency of descriptive data.

Results

Student achievement

The results of my study were varied. The data concerning how technology-enhanced (TE) algebra instruction compares with traditional algebra (TR) instruction in student academic achievement was especially interesting. According to student achievement surveys, after using technology in the technology enhanced classes (TE), 54% of the students reported higher grades, 42% reported having the same grades, and only 4% said they had lower grades than when they did not use technology. Ninety-eight percent of the students reported having grades of "C" or better. In the traditional (TR) classroom, 26% of students reported having higher grades despite not using technology, 67% said their grades were the same, and 8% reported lower grades. Eight-seven percent of the students reported having grades of "C" or better— 11% less than the TE classes. Overall, students in technology-enhanced classrooms reported having higher grades.

	Technology-enhanced	Traditional
Higher	54%	26%
Same	42%	67%
Lower	4%	8%
Grades "C" or better	98%	87%

Table 1: Student reporting of grades after using technology (TE) or not using technology (TR)

The students took part in a pretest and a posttest to measure achievement. On the pretest, the average number correct for the TE classes was 23.0, and the average number correct for the TR classes was 19.9. The standard deviation for the TE classes was 8.41, and the standard deviation for the TR classes was 6.17. On the posttest, the average number for the TE classes was 36.9 with a standard deviation of 8.58. The average number correct for the TR classes was 29.6 with a standard deviation of 8.38. Both had an increase between the two measures. The percentage change for the TE classes was 22%, and there was a 15.4% change for the TR classes. Overall, technology-enhanced classes reported more of a gain (6.6% more) in correct answers from the pretest to the posttest.

	Technology-enhanced	Traditional
Pretest (average # correct)	23.0	19.9
Standard deviation	8.41	6.17
Posttest (average # correct)	36.9	29.6
Standard deviation	8.58	8.38
% Change	22%,	15.4%

Table 2: Pretest and Posttest Results

In interviewing high achievers and low achievers in both types of classroom, I found that the high achieving students were more likely to disregard the use of technology as a factor in their achievement. Both students said that they liked mathematics and had always done well. The student from the traditional class claimed that he liked technology and loved computers, but he said, " I don't think that technology could help me in algebra. The book and the teacher are enough for me to understand." Similarly, the high achiever from the technology-enhanced classroom stated that he liked the use of technology, especially the PowerPoint presentations. He said, "The PowerPoint presentations are genius. They help me take notes and understand the materials. I think I would still have good grades without them, because I am good at math." Conversely, the technology-enhanced low achieving student thought that without technology, she would be failing algebra and frustrated with her mathematics class. The traditional low achieving student remarked that technology "just confused" her and that she needed a teacher who could explain things better – in terms she could understand. She also stated that if the teacher used technology more often and explained how to use it, it might help her, but that she was not sure.

Student motivation

In reference to the research question concerning how technology-enhanced algebra instruction compares with traditional algebra instruction in student motivation to learn algebra, 62% of TE students claim to be motivated to learn algebra, and 54% of TE students claim that technology makes them more motivated. In the traditional classroom, 65% of the students report being motivated to learn algebra, and 55% of students report that using technology would make them more motivated. Concerning participation in their algebra classes, 84% of TE students report that they participate in algebra class, and 56% report that technology makes them participate more. In the TR classes, 75% claim to participate in their algebra class, and 45% of TR students claim that technology would make them participate more. In my observations, I found that approximately 90% of students in TE classes participated one or more times in class compared to approximately 79% of students participating in TR classes. All the teachers reported that using technology would make their students more motivated to learn algebra, that their students participated in class, and that the students would participate more if technology were used.

	Technology-enhanced	Traditional
Motivated to learn algebra	62%	65%
Technology makes more motivated	54%	55%
Participate in algebra	84%	75%
Technology makes participate more	56%	45%

Table 3: Student motivation in algebra and in using technology in algebra

When asked what would make them learn algebra, students provided a variety of answers. In the TE classes, 7% suggested adding more technology, 30% suggested changes in the way the content was taught, including more "fun" activities and more teacher explanation. Twenty-two percent claimed that knowing the material would be helpful in everyday life or in future career goals would make them want to learn algebra. Twenty-four percent reported that money or other prizes or incentives would increase their motivation. The remaining 14% claimed that nothing external would increase their motivation. In the TR classes, 5% suggested adding more technology, 38% suggested changes in the way the content was taught, including more "fun" activities and more teacher explanation. Five percent claimed that knowing the material would be helpful in everyday life or in future career goals would make them want to learn algebra. Eight percent reported that individual incentives would increase their motivation. The remaining 44% claimed that nothing external would increase their motivation. Teachers reported that intrinsic and extrinsic motivators can make students want to learn algebra, including fun lessons, a desire to succeed, good grades, and technology.

	Technology-enhanced	Traditional
Adding technology	7%	5%
Changing the way the class is taught	30%	38%
Every-day use or future application of algebra	22%	5%
Money, prizes, or other incentives	24%	8%
Nothing	14%	44%

Table 4: Student reports of what would make them more motivated to learn algebra

When asked what technology had to do with their motivation in algebra class, 33% of the TE students said nothing and 9% of the students answered everything. Also in the TE classes, 29% said that technology makes algebra easier to understand and 29% said that it makes algebra more interesting. In the TR classes, 58% of the students said that technology had nothing to do with their motivation or that they had not used technology in algebra enough to know. Also in the TR classes, 42% said that technology would make algebra easier to understand and more interesting. The teachers reported that using technology would increase student motivation in algebra class for a variety of reasons.

	Technology-enhanced	Traditional
Nothing	33%	58%
Everything	9%	0%
Easier to understand	29%	21%
More interesting	29%	21%

Table 5: Student reports of the relationship of technology and their motivation in algebra

Student Attitude

In reference to the research question concerning how technology-enhanced algebra instruction compares with traditional algebra instruction in student attitude towards technology, 85% of the TE students answered that they enjoyed using technology in algebra, and 85% answered that technology makes algebra easier to learn. In the TR classes, 80% answered that they would enjoy using technology in their algebra class, and 68% answered that technology would make algebra easier to learn. When asked if using technology in algebra is important, 72% of TE students agreed, and 40% of TR students agreed. When asked if learning algebra was important, 65% of the TE students agreed, and 75% of the TR students agreed.

In my student interviews concerning student attitude towards technology in algebra, almost all of the students in both types of classes gave positive responses. Concerning technology, the comments range from “fascinating” and “fun” to “sometimes confusing, but fun” and “fun but not essential.” Some of the negative responses included “it takes too long to learn to use a new technology,” but they were tempered with the disclaimers that, “I still enjoy using technology in algebra. It gives me something different to do even if it is challenging.” There was little difference between the traditional and technology-enhanced classes in responses concerning student attitude toward technology in algebra instruction.

Attitude	Technology-enhanced	Traditional
Enjoy/would enjoy using technology in algebra	85%	80%
Technology makes algebra easier to learn	85%	68%
Using technology in algebra is important	72%	40%
Learning algebra is important	65%	75%

Table 6: Student Reports of Their Attitude Towards Using Technology in Algebra

Technology Use

In reference to the research question concerning how technology was being used by teachers and students in algebra instruction, the extent, frequency and the types of use, I collected survey data and observation data. In student surveys, 96% of the students in the TE classes reported that their teacher uses technology daily, compared with 10% of the TR students reporting that their teacher uses technology daily. In the TE classes, 4% of students reported that their teachers used technology monthly or weekly and no student reported that the teacher never used technology. In the TR classes, 19% of the students reported that their teacher used technology weekly or monthly and 71% reported that their teacher never uses technology. Students in the TE class reported that they use technology daily (79%), monthly or weekly (19%), or never (2%). Students in the TR classes answered that they use technology daily (29%), monthly or weekly (23%), or never (49%).

	Technology-enhanced	Traditional
Daily	96%	10%
Weekly or monthly	4%	19%
Never	0%	71%

Table 7: Frequency of teacher use of technology in class as reported by students

Student use of technology	Technology-enhanced	Traditional
Daily	79%	29%
Weekly or monthly	19%	23%
Never	2%	49%

Table 8: Frequency of student use of technology in class as reported by students

In my observations, I observed that both TE teachers were using technology in both observations and that one of the TR teachers was using technology in one of my four observations. Teachers of TE classes reported that they and their students use technology daily, one TR teacher reported that he and his students use technology on a weekly basis, and the other TR teacher reported that she and her students never use technology in algebra class. The types of technology that I observed in use were computer-focused learning in the Algebra Logic Lab, PowerPoint presentations, Internet use, and graphing calculator exploration activities. Also, I noticed the presence of scientific calculators in all of the classes. However, I noted that students in TE classes used their calculators more often and for more varied activities.

Discussion

The purpose of this action research study was to compare the effects of technology-enhanced algebra instruction and traditional algebra instruction in terms of student academic achievement, student motivation, and student attitude towards algebra. In doing this comparison, I also hoped to gain an understanding of how technology was being used by teachers and students in algebra instruction. After analyzing the results of my study, I found that most of my preconceived notions were supported. However, there were a few surprises.

Student Achievement

In reference to my first research question concerning how technology-enhanced algebra instruction compared with traditional algebra instruction in student academic achievement, my results indicated that TE students had higher achievement scores. This supported my prior belief that students in technology-enhanced classes would have higher grades. The students in technology-enhanced classes reported having higher grades, a greater percentage had “C’s” or higher, scored better on both the pretest and the posttest, and had a larger percentage increase from the pretest to the posttest. Although the difference in grades could be due to different teacher grading policies or grade inflation, the higher gain in the content-based tests suggested that students in technology-enhanced classes have higher achievement scores based on a better understanding of the content. In a similar study using the Mediated Learning approach in introductory and intermediate college algebra, the researchers found that students who took two mediated learning courses received a higher proportion of grades C or better than those who took two courses in the traditional form, and students who took two Mediated Learning courses did better than those who took one traditional algebra course and one Mediated Learning course (Baker, Hale, & Gifford, 1997).

In the achievement interviews, I found that the high achieving students were more likely to disregard the use of technology as a factor in their achievement. Those students had been successful in the traditional classroom and did not see a need for change. The low achieving students, however, could benefit from using technology as evidenced by the positive reaction of the technology-enhanced student. Without having used technology, the traditional student was unsure of the effectiveness of technology in enhancing her academic achievement, but the traditional classroom was clearly not fulfilling her needs. Too often, the integration of technology is focused on higher-level classes. I believe that lower level students may benefit from using technology even more than the upper level students who, for the most part, are already successful in their studies. More research should be done concerning lower level mathematics classes.

Student Motivation

In reference to the research question concerning how technology-enhanced algebra instruction compares with traditional algebra instruction in student motivation to learn algebra, the results concerning student motivation were somewhat similar. A majority of the students in both types of classes claimed to be motivated to learn algebra and that technology makes them more motivated. Concerning participation in their algebra classes, more students in technology-enhanced classes reported that they participate in algebra class and that technology makes them participate more. However, a majority of students in both types of classes claim to participate by asking and answering questions. In my observations, I found that students in TE classes participated more times in class compared with the TR students. Students using technology may participate more because they are more confident in their answers as a result of using the technology. From my observations, personal experience, and student interviews, I noted that students were also more likely to defend their answers in class when using technology. This indicated that they are more confident in their answers when they use technology. I was surprised that both types of classes claimed to be motivated to learn algebra, but the greater participation of the technology-enhanced students supported my prior assumptions that technology-enhanced students would participate more in class.

All the teachers reported that using technology would make their students more motivated to learn algebra, that their students participated in class, and that the students would participate more if technology were used. However, the traditional teachers did not support their claims by using technology in their classrooms. This leads me to believe that further research is needed to understand why teachers who believe in the benefits of technology and have access to it do not use it more often. Previous studies have found that investments of resources in computer technology have resulted in only slight changes in the instructional practices of public schools (Bitter & Fredrick, 1989), and that mathematics teachers have been slow to introduce computers into their classroom activities, even when the hardware has been accessible (Rosen & Weil, 1995). Many authors have made links between teachers' beliefs and attitudes towards the use of computers (Jacobs & Clements, 1999; Marcinkiewicz, 1994; Sarama, Clements, & Jacobs, 1998). In my study, the technology-enhanced teachers were younger teachers with five to seven years of teaching experience, including training in using technology. The traditional teachers were older, and one of them had thirty years of experiences with plans to retire after this year. The other traditional teacher was a first-year teacher with little or not experience with technology. Both may have had beliefs or experiences that may affect their willingness to use technology in the classroom.

When asked what would make them learn algebra, students in both classes provided similar answers, but the frequency of each response differed. For example, a small percentage of students in both classes thought that adding more technology would help, and a large percentage suggested changes in the way the content was taught would improve their desire to learn algebra. More TE students claimed that knowing the material would be helpful in everyday life or in future career goals would make them want to learn algebra. Although using technology seems to motivate TE students to learn and to participate more, the students still seek authentic situations for learning. Many teachers are using technology to help students search for authenticity in their mathematics. By adding a practical dimension to learning, technology can enhance the academic tradition (Atkin, 1998). In fact, Roth (1992) supports using technology in mathematics to provide a context for problem solving. Also, students stated that money or other prizes or incentives would increase their motivation. Although some students claim to be internally motivated, many students seek extrinsic rewards as motivators. Therefore, even secondary students may want to consider offering material incentives as motivators—a practice that is often evidenced in elementary and middle school classrooms.

More TR students claimed that nothing external would increase their motivation. Perhaps, these students have set ideas concerning mathematics and their success in mathematics classes. Or, because these students have little or no experience of using technology in their mathematics classes, they do not have the experiences that the technology-enhanced had. The teachers reported that both intrinsic and extrinsic motivators make students want to learn algebra. Based on the varied results of the students, they were correct. Therefore, teachers must endeavor to meet the needs of their students, including using more "fun" activities, authentic learning experiences, and offering incentives for good performance.

When asked what technology had to do with their motivation in algebra class, more TR students claimed technology had nothing to do with their motivation. Many suggested that they had not used technology enough to know whether or not it would motivate them to learn algebra. However, more TR students said that technology would make algebra easier to understand and more interesting. Although such results seem contradictory, I believe that they are a result of the students' lack of contact with technology in the context of algebra. After all, a majority of these students claimed to never use technology in algebra. Similarly, all the teachers reported that using technology would increase student motivation in algebra class. Again, such statements seem contradictory given the traditional teachers' lack of use of technology. The statements could be a result of lack of previous technology experience.

Student Attitude

In reference to the research question concerning how technology-enhanced algebra instruction compares with traditional algebra instruction in student attitude towards technology, a large percentage in both classes claimed that they enjoyed or would enjoy using technology in algebra. More students in the TE classes said that technology makes algebra easier to learn than in the TR classes, perhaps because they had more experience with technology. Similarly, when asked if using technology in algebra is important, 32% more of TE students agreed. When asked if learning algebra was important, a majority in both classes agreed, but 10% more of the TR students agreed. A majority of students in both types of classes seemed to have a positive attitude towards technology.

In my student interviews concerning student attitude towards technology in algebra, almost all of the students in both types of classes gave positive responses. Most considered technology an interesting change from "regular" instruction. There was little difference between the traditional and technology-enhanced classes in responses concerning student attitude toward technology in algebra instruction. Perhaps, the similarities in student attitude relate to a general positive attitude towards technology in their daily lives. With games and digital devices selling in record numbers to the teen population, technology is considered the "cool" thing to use. In the words of one of the traditional teachers, "students are surrounded by high-tech gadgets daily; it is something they understand." Overall, the results of my study support my prior ideas that students in both classes would have a positive attitude towards technology.

Technology Use

Concerning how technology was being used by teachers and students in algebra instruction, the results of my study were, again, similar to my prior beliefs. In student surveys, almost all of the students in the TE classes claimed that their teacher uses technology daily, and no student reported that the teacher never used technology. In the TR classes, a majority of students reported that their teacher never uses technology, and only 10% reported that their teacher uses technology daily. Based on the designation of classes as technology-enhanced and traditional algebra classes, such results are to be expected. Similarly, a majority of the students in the TE class reported that they use technology daily, and most TR students claimed to never use technology in algebra.

In my observations, I observed both TE teachers using technology extensively and the TR teachers using technology in only a limited manner or not at all. Although the lack of technology use in classes labeled traditional is to be expected, it is disheartening given the efforts made to integrate technology into the classroom. In a survey of 3,560 public school teachers conducted by the National Center for Education Statistics (1999), only 20% of teachers reported that they felt very well prepared to integrate educational technology into their teaching methods. Teachers must understand the benefits of technology and barriers to teacher's adoption of technology must be minimized or eliminated for technology in the classroom to have positive effects. Perhaps, by offering more technology-based staff development and further technology training through programs such as Georgia's state-sponsored InTech, more traditional teachers can become technology-enhanced ones.

The types of technology that I observed in use were computer-focused learning in the Algebra Logic Lab, PowerPoint presentations, Internet use, and graphing calculator exploration activities. Also, I noticed the presence of scientific calculators in all of the classes. However, I noted that students in TE classes used their calculators more often and for more varied activities. I believe that the TE students were more comfortable using their calculators because their teachers served as positive technology role models. Also, a greater amount of student technology use fostered familiarity and increased technology skills.

Limitations

There are many possible limitations to my research. For one, my school is unique in that it is an exclusively ninth-grade school. Therefore, the results cannot be immediately applied to secondary schools housing grades 9-12. Also, although I made a determined effort to be objective, as a devout user of technology, my pro-technology bias could have easily affected the outcome of my research. Finally, the length of my study was limited to less than a semester. A more lengthy study may reveal differences in student achievement, motivation, and attitude over time.

Communication of Findings

I communicated the findings of my action research after school in the school media center. I invited the faculty and staff of my school as well as Central Office members, but the majority of those attending were mathematics teachers and members of the school technology committee. Most of the attendees were prime stakeholders in integrating technology into the mathematics classroom and were interested in the positive results of my study. A student member of the technology club videoed the presentation, and attendees received packets of handouts to be used for future reference. In my presentation, I recommended that the members of the school technology committee consider the positive results of my study when they draft the new technology plan. Also, I encouraged the administration to continue seeking funding so that all the mathematics teachers could be In-Tech certified and receive more technology training. Finally, I suggested further research into the effects of technology on lower level and pre-algebra students—an often-underrepresented set of students when it comes to technology.

Implications

The implications of my study are that integrating technology into the mathematics classroom can increase student achievement, increase student motivation, and foster positive student attitudes. My results are similar to other studies that indicate that the use of technology in classroom instruction enhances student outcomes (Adams, 1997; Archer, 1998; Brunner & Sheehan, 1997; Milheim, 1995; O'Callaghan, 1998). However, my study also indicated that seeing positive results and having positive beliefs concerning using technology do not guarantee immediate technology integration. In my school, I believe that teacher beliefs and experiences impact their use of technology in the classroom. Other studies investigated the reasons mathematics teachers in some technology-rich secondary schools rarely use computers in their teaching and found individual teachers' resistance was related to their beliefs about mathematics teaching and learning and their existing pedagogies (Norton, McRobbie, & Cooper, 2000). With careful planning, I believe that, given preexisting positive teacher attitudes towards technology, teacher technology training can be successful in increasing the integration of technology in the mathematics classroom. And, with the integration of technology into the mathematics classroom, more of the students at my school will be able to experience the positive results indicated in my study. Therefore, this action research, with additional research and technology planning, can snowball into a full-scale technology integration.

References

Adams, T.L. (1997). Technology makes a difference in community college mathematics teaching. *Community College Journal of Research & Practice, 21*, 481-493.

Archer, J. (1998). The link to higher test scores, *Education Week 18*(5), 10-21

Atkin, J.M. (1998). The OECD study of innovations in science, mathematics, and technology education. *Journal of Curriculum Studies, 30,* 647-660.

Baker, W., Hale, T., Gifford, B.R. (1997). From theory to implementation: The mediated learning approach to computer-mediated instruction, learning and assessment. *Edcom Review, 32*(5), 1-15.

Bitter, G.G., & Fredrick H. (1989). Techniques and technology in secondary school mathematics. *NASSAP Bulletin,73(*5), 22-28.

Brunner, A., & Sheehan, S. (1997). The algebra launching PAD. *Mathematics Teacher, 90,* 696-702.

Dick, T. (1992). Super calculators: Implications for calculus curriculum, instruction, and assessment. In J. T. Fey (Ed.), *Calculators in mathematics education, 1992 yearbook,* (pp. 145-157). Reston, VA: National Council of Teachers of Mathematics.

Dossey, J. A., Mullis, I.V.S., Lindquist, M.M., & Chambers, D.L. (1988). *The mathematics report card: Are we measuring up?* Princeton, NJ: Educational Testing Service.

Georgia Department of Education. (2000). *1999-2000 Georgia Public Education Report Card: Northeast Campus, Tift County High School*. Atlanta, GA.

Hopkins, M. (1992). The use of calculators in assessment of mathematics achievement. In J. T. Fey (Ed.), *Calculators in mathematics education, 1992 yearbook*, (pp.158-166). Reston, VA: National Council of Teachers of Mathematics.

Jacobs H. J., & Clements, D. H. (1999). Challenges for teachers attempting to integrate a mathematics innovation. *Journal of Research on Computing in Education, 31*, 240-260.

Kaput, J., & Roschelle, J. (1997). Deepening the impact of technology beyond assistance with traditional formalisms in order to democratize access to ideas underlying calculus. In E. Pehkonen (Ed.), Proceedings of the 21st Conference. *International Group for the Psychology of Mathematics Education,* (pp. 105-112). Helsinki, Finland: University of Helsinki.

Marcinkiewicz, H. R. (1994). Computers and teachers: Factors influencing computer use in the classroom. *Journal of Research on Computing in Education*, *26*, 220-237.

Milheim, W. D. (1995). Interactivity and computer-based instruction. *Journal of Educational Technology Systems, 24*, 225-233.

National Center for Education Statistics. (1999). *Teacher quality: A report on the preparation and qualification of public school teachers* (NCES 1999-080). Washington, DC: US Department of Education.

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Norton, S., McRobbie C. J., & Cooper, T. J. (2000). Exploring secondary mathematics teachers' reasons for not using computers in their teaching: five case studies. *Journal of Research on Computing in Education, 33*(1), 87-110.

O'Callaghan, B.R. (1998). Computer-intensive algebra and students' conceptual knowledge of functions. *Journal for Research in Mathematics Education, 29*(2), 21-41.

Papert, S. (1992). *The children's machine: Rethinking school in the age of the computer.* New York: Basic Books.

Roth, W. M. (1992). Bridging the gap between school and real life: Toward an integration of science, mathematics, and technology in the context of authentic practice. *School Science and Mathematics, 92*, 307-317.

Sarama, J., Clements, D. H., & Jacobs, H. J. (1998). Network of influences in an implementation of a mathematics curriculum innovation. *International Journal of Computers for Mathematical Learning, 3*, 113-148.