The Effect of Handheld Devices on Student Achievement in Algebra.

Irina Lyublinskaya

Nelly Tournaki

College of Staten Island /CUNY

2800 Victory Blvd

Staten Island, NY 10314

Irina.lyublinskaya@csi.cuny.edu

718-982-3714

718-982-3743 (FAX)

The Effect of Handheld Devices on Student Achievement in Algebra.

Abstract

This study compares the respective achievements of students in an integrated algebra course taught with two different types of handhelds over a period of one year. The experimental group was taught with TI-Nspire handhelds and was compared to the control group taught with TI-84 graphing calculators. The teachers of each groups received on-going professional development in the same format. Student achievement was measured via a midyear department test; Fall and Spring semester grades; and New York State Regents exam scores and passing rates. Results indicated that the group taught with the TI-Nspire outperformed the other group in all assessments, including passing rates on Regents but not on the Regents exam scores. Further analysis indicated that girls outperformed boys in an identical pattern. No significant differences in achievement by race were observed.

Keywords: handheld technology; gender differences; secondary education; algebra; student achievement.

The Effect of the Use of Handheld Devices on Student Achievement in Algebra

As recently as a few years ago, handhelds were widely considered to be useful organizers, though they were seen as compromised by their limited memory and low-resolution grayscale screens. Today, in a radically changed reality, educators are using handhelds for word-processing, Internet browsing, PowerPoint, grading, scheduling, attendance, lesson-planning, e-mailing, and data collection. Literally thousands of software applications abound for handheld devices (Curtis, 2005).

Given their relatively low cost (e.g., $100 to $400), lower maintenance and support cost, security, portability, ease of use (minimum computer skills required), flexibility (ready availability), and battery life (typically 6 to more than 100 hours), handhelds are increasingly becoming the compelling choice of technology for K-12 classrooms. Among other advantages, they enable a transition from the occasional supplemental use of classroom computers and school computer labs to the frequent integral use of portable computational devices (Soloway, Norris, Blumenfeld, Fishman, Krajcik, & Marx, 2001; Tinker & Krajcik, 2001). Furthermore research indicates that both teachers and students respond favorably to handheld devices, which have the potential to affect learning positively across curricular topics and instructional activities. Teachers have indicated that students are more motivated, spend more time using technology, collaborate and communicate more, and in general benefit when they are given a portable as a readily accessible tool (Vahey & Crawford, 2002). For their part students have found handhelds easy to use, fun, and useful for learning (van't Hooft, Diaz, & Swan, 2004). Further, researchers claim that classrooms with handheld computers differ fundamentally from those that have desktop computers, in that users of handhelds can interact with other computing devices as well as with each other at the same time (Cole & Stanton, 2003; Danesh, Inkpen, Lau, Shu, & Booth, 2001; Mandryk, Inkpen, Bilezkjian, Klemmer, & Landay, 2001; Roth, 2002). Overall, then, handheld computers have the potential to support both personalized and collaborative learning. Roschelle and Pea (2002), for example, highlight three ways in which handheld devices have been used to increase learning collaboratively – classroom response systems, participatory simulations, and collaborative data gathering – and suggest that many more such uses exist (Danesh et al., 2001; Mandryk et al., 2001; Roschelle, 2003). Finally, because of their small size, handheld computers support learning outside the classroom, anytime or on any day of the week (Bannasch, 1999; Inkpen, 2001; Sharples, 2000; Soloway et al., 2001; Tinker, 1996).

The above-mentioned advantages of handhelds – favorable responses from teachers and students, interaction with other computer devices, support for personalized and collaborative learning, support of learning outside the classroom – would serve a limited purpose if we didn't have evidence that handhelds increase student achievement as well. Given that in the past decades graphing calculators comprise the most common form of handheld devices used in the classroom, we will review the literature concerning their effectiveness. A meta-analysis by Ellington (2003) reviewed an inclusive set of 54 high-quality experimental studies. The meta-analysis showed a reliable positive effect of graphing-calculator-based interventions on student achievement. In addition, the studies suggest that when graphing calculators are allowed on tests, the gains to be seen extend from calculations and operations to conceptual understanding and problem solving performance. A second meta-analysis looked specifically at algebra. Khoju, Jaciw, & Miller (2005) screened available research using stringent quality-control criteria published by the U.S. Department of Education's What Works Clearinghouse. The authors selected eight high-quality studies examining the impact of graphing calculators on K-12 mathematics achievement. Four of these studies specifically assessed the impact on algebra learning. Across a wide variety of student populations and teaching conditions, use of graphing calculators with aligned instructional materials was shown to have a strong positive effect on algebra achievement. Further, a study by Heller, Curtis, Jaffe & Verboncoeur (2005) described and studied a model implementation, which included a new textbook, teacher professional development, and assessment – all aligned with the graphing technology by the theme of "Dynamic Algebra." This study established that the teachers and students who used graphing calculators frequently learned the most. The National Center for Educational Statistics signature report, "The Nation's Report," (National Center for Education Statistics, 2001, p. 144) concludes that frequent calculator use at the eighth grade level (but not at the fourth grade level) is associated with greater mathematics achievement:

> Eighth-graders whose teachers reported that calculators were used almost every day scored highest… In addition, teachers who permitted unrestricted use of calculators… on tests had eighth-graders with higher average scores than did teachers who did not indicate such use of calculators in their classrooms. The association between frequent

graphing calculator use and high achievement holds for both richer and poorer students, for both girls and boys, for varied students with varied race and ethnicity, and across states with varied policies and curricula.

The present study examines the efficacy of new generation of handhelds as compared to the existing graphing calculators. The student participants in the experimental group received instruction with the new TI-Nspire handhelds and the control group received instruction with the TI-84 graphing calculator – an existing technology. Undoubtedly new generations of technology will provide a variety of novel features that in their turn will need to be tested empirically for their effectiveness.

Kastberg & Leatham (2005) warn teachers that the mere addition to the teaching arsenal of calculator-based technology does not assure that a deep conceptual understanding of the mathematical basics will result. Such technology needs to be used in an inquiry-based learning environment, an environment that would make it possible for the students in the class to get involved in collecting real time data, analyzing that data, generating hypotheses, and drawing conclusions (Author, 2003a & b). Such a learning environment would increase student understanding of mathematical concepts and processes (Niess, 2001). Research indicates that it takes considerable education and experience to achieve the level of expertise in the use of technology necessary to make it a successful teaching tool (Fleener, 1995; Thomas & Cooper, 2000). When new technology is introduced, it is important to address the pedagogical issues surrounding its use. One suggestion is to provide teachers with a forum to examine their pedagogical perspectives for using the technology and to explore when and how to use it in the classroom.

In recent years schools that demonstrated improvement in student learning a) began to use technology as integral to their transformation, and b) instituted effective professional development programs in order to familiarize teachers with the technology and to help them adapt to appropriate teaching methods (Wolf, 2007). Thus, in addition to the manipulation of the technology, all the teachers in our study were supported in a year-long professional development program.

The research questions

The following research questions guided the study: Was TI-Nspire-supported instruction more effective than the instruction with graphing calculators in improving high school students' algebra achievement in different level courses as measured by (1) mid-year assessment; (2) Fall semester grades; (3) Spring semester grades; and (4) scores and passing rates on NYS Regents algebra exam? Lastly: (5) How are items (1)-(4) distributed by gender and race?

In the present study student achievement was measured via a variety of measures in order to determine whether the different measures indicated different results. More specifically, we compared semester grades given by the teachers (Fall and Spring) to the student scores on the department midyear test, to the scores and passing rates on the state-wide standardized exam. We hypothesized that differences between our two groups will be more apparent when students are assessed by their teachers and less apparent when they are assessed through the state-wide test (i.e., the NYS Regents). This is because large-scale assessments often face the difficulty of needing to be fair to multiple programs and educational jurisdictions – each practicing its own educational philosophy, each maintaining its own curriculum.. Historically, the problem of the disparate curricula was solved by testing a kind of intersection, focusing on lowest-common-denominator basic skills (Stancavage, Shepard, McLaughlin, Holtzman, Blankenship, Zhang, 2009).

Method

Student Participants

A high school in New York City was used as the site for the project. Student enrollment was 2,856, 160% of its planned size. The diverse population was roughly evenly divided among White (27%), Hispanic (30%), and African-American (37%), with a small Asian representation (6%). With 42% of students on free/reduced lunch, the school qualifies for substantial Title I aid. 7% of the students are English Language Learners and 14% are Special Education students. 58% of all students achieve passing grades in mathematics and score at least a 65 on NY State Regents algebra exams (NYC DOE report card 2007-2008).

The study was conducted with 13 sections of Integrated Algebra (formerly NY Mathematics A) at three attainment levels:

- Level F: regular freshmen Integrated Algebra, students performed at the grade level (levels 3 and 4) on the 8th grade city mathematics exam – 1 experimental, 3 control sections

- Level R: reduced size freshmen Integrated Algebra for students who performed below grade level (levels 1 and 2) on the 8th grade city mathematics exam – 3 experimental, 2 control sections.
- Level A: repeater section of Integrated Algebra for students who did not pass Math A Regents exam as freshmen – 1 experimental, 3 control sections.

The number of different level sections in the experimental and control groups was based on the teaching assignments made by the school during the first weeks of the academic year. Since this was done after the teachers volunteered to participate in the study, the control group ended up having more high level sections compared to the experimental group.

At the beginning of the school year, a total of 294 students in all participated, with 131 students enrolled in the five sections of the experimental (TI-Nspire) group and 163 students in the eight sections of the control (TI-84) group. The composition of experimental and control groups by course level, race, and gender are shown in Table 1.

Place Table 1 here

The school has high student mobility and a high dropout rate. By January the number of students in the experimental group had dropped to 105 and in the control group had increased to 178. By June, there were 107 students in the experimental group and 171 students in the control.

Teacher Participants

Experimental group: Four teachers volunteered to participate in the experimental group, knowing that they would receive training in a new technology, namely in TI-Nspire, and weekly professional development throughout the year. The demographics of the teachers in the experimental group are shown in Table 2.

Place Table 2 here

Control group: Of all teachers assigned to teach Integrated Algebra three volunteered to participate in the control group, knowing that they would receive weekly professional development with the existing technology used in the school.

In addition, one teacher (for further reference, this teacher will be referred to as Teacher A) who taught a section of the experimental group also taught two sections of the control group (i.e., using TI-Nspire in one of the sections and TI-84 graphing calculators in two sections of the course). We followed the case of Teacher A and conducted additional analysis on the scores of her students on each assessment, thus controlling for teacher effects. The demographics of the teachers in the control group are shown in Table 3.

Place Table 3 here

Further, multiple regression analysis was employed to determine whether there was a contribution of teacher effect on the study's dependent variables. More specifically, "teacher age" and "teacher experience" were put into the regression equation along with the independent variables of "control or experimental" and "course level". The R squared of .24 for midyear assessment, .080 for fall semester grades, .081 for spring semester grades, and .032 for Regents indicates that only a small and not significant, amount of the variance is explained in students' scores by the regression models.

Study Design

The baseline of student achievement was determined using an algebra readiness multiple-choice test developed by the school mathematics department and administered in September 2007. An independent *t*-test was used to compare the respective scores of the experimental and control groups prior to the treatment. Weekly professional development workshops started in October 2007 for both groups of teachers and continued through mid-May 2008. TI-Nspire technology was introduced to the experimental classrooms in mid-October, while TI-84 graphing calculators were used with control group students from the beginning of the school year. Student surveys were distributed in May 2008 in order to determine the frequency of technology use in the classroom.

Algebra grades and scores were analyzed using a 2×3 factorial analysis of variance (ANOVA). The two independent variables were Technology Instruction (Experimental group using TI-Nspire vs.

Control group using TI-84 graphing calculators) and Student Level (F/students on grade level vs. R/students who failed and repeat the same subject vs. A/students below grade level taking this course for the first time). The dependent variables were: (1) Midyear assessment scores in integrated algebra (a multiple choice test developed by the school's mathematics department) administered in January to assess students' progress towards NYS Regents Algebra exam). (2) Fall Semester grades, given by teachers in February. (3) Spring Semester grades, given by teachers in June. (4) NYS Regents Algebra exam scores and passing rates from the exam administered at the end of June.

Students were assigned to different levels of integrated algebra courses by the school administration based on their performance on NYC 8th grade mathematics exam or NYS Mathematics Regents exam. Within each course level, the placement was made to maintain equal diversity by race, gender, and socio-economic status between the sections as per school policy.

Materials

Technology Used in the Experimental and Control Groups.

The control group used classroom sets of TI-84 graphing calculators because that was the technology already adopted by the school. The experimental group used classroom sets of TI-Nspire™ handhelds. TI-Nspire was chosen for the experimental group because it represents not only a new generation of graphing calculator technology, but also an advance in the capabilities of a low-cost personal computing device that is reliable and easy to use, supporting a broad range of instructional models and advanced modes of assessment for teaching mathematics. The TI-Nspire™ incorporates two new features not available previously:

a. The ability to display multiple representations that are connected and in a single plane. That is, the multiple representation capability dynamically links graphical curves, axes, equations and tables in simultaneous displays, such that a change in one representation is transmitted to the others. This feature allows teachers to design new tasks for their students to address, for example, the NCTM standards focusing on connections between algebraic and geometric representations, inquiry-based approaches to teaching and learning mathematics, etc.

b. The ability to document content. This document-based content system is an organized presentation of multiple screens of mathematics, which can be saved, shared, annotated, and revisited, giving teachers new ways of assessing their students' understanding of mathematics and technology.

In both groups students had access to handhelds during mathematics lessons. However, the handhelds were not available for them at home.

Instruments Used to Measure the Dependent Variables

Mid-year assessment was developed by the mathematics department as a multiple-choice test similar to NYS Regents exam that covered topics of the curriculum students have learned by January.

Fall and Spring semester grades were based on student performance in in-class and out-of-class assignments, effort, and participation.

NYS Regents Algebra exam scores were reported by the school. The Regents Examination is one of several large-scale tests developed to measure the extent to which schools throughout New York State master the content, concepts, and skills contained in the learning standards and core curricula. The passing rates for each group were calculated with 65 being the lowest passing score.

Professional Development

In the present study teacher participants in both the control and experimental groups were supported through a year-long professional development program conducted in the same format.

Introductory Workshop to TI-Nspire Technology

In August 2007, the four high school mathematics teachers including the Mathematics Assistant Principal, volunteered to participate in a 3-day technology workshop given by one of the researchers. The workshop introduced the teachers to the TI-Nspire technology and its applications for teaching high school mathematics. These four teachers formed the experimental group.

Control group teachers were selected on a volunteer basis at the beginning of the school year. Three of these teachers did not receive training on the new technology, since they were going to employ graphing calculators that were already in use in mathematics teaching in the school. One teacher of the experimental group also taught two sections of the control group, using only graphing calculators.

Professional Development Workshops

Both groups of teachers, experimental and control, met separately on a weekly basis for professional development workshops in order to develop inquiry-based lessons. During the Fall semester the experimental group met 12 times and the control group met 11 times for two hours each time. During Spring semester both groups met 13 times for two hours each time. The purpose of the workshops was for the teachers to work cooperatively with their peers in planning and developing their own lesson activities while using either the new or the existing technology. In both groups the workshops were guided by a facilitator. The facilitators of both groups were master teachers with over 25 years of experience in teaching mathematics. Facilitators met regularly to coordinate the workshops. The professional development model cycled through the following stages of the content development with TI-Nspire or TI-84 technology: 1) to review the curriculum sequence for the two weeks following the workshop, to select the topic of the lesson, teaching objectives, and to brainstorm lesson activities appropriate for the TI-Nspire or TI-84 environment (as a whole group, in pairs, or individually – varied by group and time of the year); 2) to meet together as a group for developing a lesson plan and activity documents for the lesson – putting together work developed by the teachers outside the meetings; 3) to present the lesson and activity at the workshop with demonstration of the TI-Nspire or TI-84 activity to the group, facilitator, and/or one of the researchers, for peer review and critique – followed by any necessary modification of the lesson plan and documents; 4) to teach the lesson in class during the same week; teachers in both group were expected to teach the lessons they developed, but only the experimental group teachers were observed by the facilitator and/or one of the researchers; 5) to reflect and discuss teaching and learning experience at the group meetings following the teaching of the lesson; and 6) to finalize developed curriculum materials based on teaching experience and peer feedback.

As a result of these meetings both groups of teachers developed a series of lessons that have been peer reviewed and field tested. Lessons from the experimental group were collected for further analysis. There were a total of 13 lessons developed by the teachers in the experimental group, which included the following topics (in chronological order):

1. Writing Function Rule (written by whole group - October 2007)
2. Similar Figures (written by whole group - November 2007)

3. Solving Equations Graphically (written by whole group – December 2007)
4. Modeling with Real Function Rule (written by two teachers – February 2008)
5. Finding Rate of Change – (written by two teachers – February 2008)
6. Predicting Using Trend Lines – (written by two teachers – March 2008)
7. Using the Line of Best Fit to Make Predictions – (written by two teachers – March 2008)
8. Discovering Exponential Functions – (written by two teachers – March 2008)
9. Exploring Leading Coefficient of Quadratic Graphs – (written by two teachers – March 2008)
10. Discriminant (written by two teachers – April 2008)
11. Axis of Symmetry, Parabola (written by two teachers – April 2008)
12. What are trigonometry ratios? (written by two teachers– May 2008)
13. Discovering Trigonometry Ratios (written by two teachers – May 2008)

For example, in the lesson *Exploring Leading Coefficient of Quadratic Graphs*, students were able to use the “grab and drag” feature of the Graphs & Geometry application to explore the effect of coefficient a in the equation $y = ax^2$. The equation of the parabola and its graph appear on the same page. The algebraic and graphical representations of the function are linked, and thus, when students grab the parabola and change its shape, they immediately see the change in the numerical value of a (Figure 1).

Insert Figure 1

As the teacher was questioning students about the shape of the parabola and the existence of a maximum or minimum for different values of a, suggesting positive and negative values, values larger and smaller than 1, students were able to discover on their own how the magnitude and sign of a affect the shape of parabola.

Results

The number of assessed students varied from one assessment to the other. On each assessment the number of collected scores was lower than the initial enrollment. This could be explained by the high mobility, low attendance rate, and high dropout rate of the student body, which are typical for the New

York City Title I public schools. Also, since the school provides two types of high school diplomas – local diploma for students who pass all courses but do not pass or take Regents exams, and Regents diploma for students who pass NYS Regents exams – students who are not interested in continuing their education usually do not take the NYS Regents exams. The number of assessed students for each dependent variable is shown in Table 4.

Place Table 4 here

Analysis of collected data show that scores were missing for different students on different assessments and that on average all students in the experimental and control groups had the same attendance. Thus we can assume that all students had been exposed to about the same amount of instruction. Therefore, since the participants in each assessment were slightly different, we compared the scores of each group using the way it was constituted at that particular time.

Baseline Assessment

A multiple-choice algebra readiness test was developed and administered by the mathematics department of the school during the month of September. The scores of this test were used to compare the experimental and control groups before the TI-Nspire technology was introduced in the classroom. The mean for the experimental group was 50.91 (SD = 18.63 and N = 95) and the mean for the control group was 48.48 (SD = 23.60 and N = 134). A t-test for independent means indicated that the two groups were not significantly different in the beginning of the year t(227) = -2.428. The same analysis was performed on a sub-group of students taught by Teacher A - the teacher who taught both experimental and control groups. The mean for the experimental sub-group was 48.37 (SD = 15.98 and N = 19) and the mean for the control sub-group was 53.36 (SD = 20.60 and N = 25). A t-test for independent means indicated that the two sub-groups were not significantly different in the beginning of the year t(42) = 4.992.

A 2 (Type of Technology: experimental vs. control) × 4 (Black vs. Hispanic vs. White vs. Asian) ANOVA was conducted to determine whether Race had any interaction with Type of Technology. The analysis did not reveal main effects or interaction, indicating that there were no significant differences in the performance among students of different races (see Table 5a).

Similar analysis on gender, 2 (Type of Technology: experimental vs. control) × 2 (Male vs. Female) ANOVA revealed no main effects or interactions, indicating there were no significant differences in the performance of boys and girls (see Table 5b).

Place Table 5 here

Analysis of Effects

Algebra scores were analyzed using a 2×3 factorial analysis of variance (ANOVA). The two independent variables were Type of Technology (Experimental/using TI-Nspire vs. Control/using TI-84 graphing calculators) and Student Level (F/students on grade level vs. R/ students below grade level vs. A/ students who failed before and were repeating the same subject). The dependent variables were: 1) Midyear assessment scores; 2) Fall Semester grades 3; Spring Semester grades; and 4) NYS Regents Algebra exam scores and passing rates. Finally, the analysis of algebra scores for the students of Teacher A was performed using one-way ANOVA test.

Midyear Assessment

Descriptive statistics for the Midyear Assessment are presented in Table 6 a) for all teachers, and b) for the Teacher A

Place Table 6 here

A 2×3 ANOVA was conducted on the Midyear Assessment for the whole group. The analysis revealed a main effect for Type of Technology ($F(1, 1819.87) = 4.94$, $p < .05$), with the experimental group scoring significantly higher than the control group, except for students at Level A.. A two-way interaction (Type of Technology × Student Level) was not significant.

A one-way ANOVA on Midyear Assessment for Teacher A revealed no effect for either Type of Technology or Student Level.

Supplemental analysis was performed on Race. 101 students in experimental group and 166 students in control group reported their races. A 2 (Type of Technology: experimental vs. control) × 4 (Black vs. Hispanic vs. White vs. Asian) ANOVA was conducted to determine whether Race had any interaction with Type of Technology. The analysis did not reveal main effects or interaction, indicating that there were no significant differences in the performance among students of different races.

Supplemental analysis was also performed on Gender. To examine the interrelationships between independent variables, a 2 (Type of Technology: experimental vs. control group) × 2 (Gender: male vs. female) analysis of variance (ANOVA) was conducted on midyear assessment scores. Descriptive statistics for midyear assessment scores on Race are presented in Table 7.

Place Table 7 here

The analysis revealed a main effect for Gender ($F(1, 1903) = 4.10$ $p < .05$) with the female students performing significantly better than the males in the experimental group, but not in the control. Finally, a two-way interaction (Type of Technology × Gender) was not significant.

Fall Semester Grades

Descriptive statistics for the Fall Semester grades are presented in Table 8 a) for all teachers and b) for Teacher A.

Place Table 8 here

To examine the interrelationships between the independent variables, a 2 (type of technology: experimental vs. control group) × 3 (student level: F vs. R vs. A) analysis of variance (ANOVA) was conducted on Fall Semester grades. The analysis revealed a main effect for Type of Technology ($F(1, 919.49) = 5.65$ $p < .001$), with the experimental group performing significantly higher than the control group. A two-way interaction (Type of Technology × Student Level) was also significant ($F(2, 1114.18) = 6.84$, $p < .001$). A one way ANOVA and then post hoc Scheffe tests revealed that there was a significant difference only between Level F experimental and control groups ($p < .05$). Levels R and A didn't differ significantly between experimental and control group.

A one-way ANOVA on Fall Semester grades for Teacher A revealed main effect for Student Level ($F(2, 1477.67) = 7.212$, $p < 0.005$). Post hoc Sheffe tests indicated that Level R students in the experimental group performed as well as Level F students in the control group. Both these groups performed significantly higher than Level A students in the control group ($p < .01$).

Supplemental analysis was performed on Race. 101 students in experimental group and 166 students in control group reported their races. A 2 (type of technology: experimental vs. control) × 4 (Black vs. Hispanic vs. White vs. Asian) ANOVA was conducted to determine whether Race had any interaction with Type of Technology. The descriptive statistics for midyear assessment on Race are shown in Table 9.

Place Table 9 here

The analysis revealed no main effect for Race or interaction of the two variables, Race and Type of Technology. This analysis indicates that there were no significant differences in performance among students of different races.

Supplemental analysis was also performed on Gender. To examine the interrelationships between independent variables, a 2 (type of technology: experimental vs. control group) × 2 (Gender: male vs. female) analysis of variance (ANOVA) was conducted on fall semester grades. Descriptive statistics for midyear assessment on gender are presented in Table 10.

Place Table 10 here

The analysis yielded a main effect for Gender ($F(1, 1368) = 7.11$ $p < .008$) with the female students performing significantly better than the males. Finally, a two-way interaction (Type of Technology × Gender) was also significant ($F(1, 888) = 4.63$, $p < .03$). The analysis of interactions shows that the females in the experimental group ($M = 72.11$) performed significantly better than all other groups i.e., the males in the experimental group (M = 63.62), the females in the control group (M = 63.07), and the males in the control group (M = 62.17).

Spring Semester Grades

Descriptive statistics for the Spring Semester grades are presented in Table 11 a) for all teachers and b) for Teacher A.

Place Table 11 here

A 2×3 ANOVA was conducted on the students' spring semester grades. The analysis revealed a main effect for Type of Technology ($F(1, 933.12) = 6.07$ $p < .05$) with the experimental group performing significantly higher than the control group, only at Level F. Lastly, a two-way interaction (Type of Technology × Student Level) was not significant.

A one-way ANOVA on Spring Semester grades for Teacher A revealed a main effect for Student Level ($F(2, 1037.54) = 8.437$, $p< 0.005$). Post hoc Sheffe tests indicated Spring Semester grades parallel those of the Fall Semester in that students in Level R in the experimental group performed as well as students in Level F in the control group, and both these groups performed significantly higher than students in Level A in the control group ($p< .05$).

Supplemental analysis revealed no main effect on group × race. The interrelationships between group and gender were examined with 2 (type of technology: experimental vs. control group) × 2 (Gender: male vs. female) analysis of variance (ANOVA). Descriptive statistics for Spring Semester grades on gender are presented in Table 12.

Place Table 12 here

The analysis yielded a main effect for Gender ($F(1, 1111.92) = 7.11$ $p< .05$) with the female students performing significantly better than the males in the experimental group only. Finally, a two-way interaction (Type of Technology × Gender) was not significant.

NYS Regents Algebra Exam Scores

A 2×3 ANOVA was conducted on the students' Regents scores. The analysis revealed no main effect for Type of Technology with the experimental group (M = 59.68, SD = 12.02, N = 92) outperforming the control group only by about three points (M = 56.99, SD = 12.75, N = 92). No main effect was revealed for Student Level either. A one-way ANOVA for Teacher A also revealed no difference by group or course level (see Table 13 for Descriptive Statistics a) for all teachers, and b) for Teacher A).

Place Table 13 here

Supplemental analyses of Regents scores did not reveal significant differences among students of different races or gender. Although on all previous assessments girls outperformed boys, Regents scores actually revealed almost identical scores. More specifically, girls had a mean of 58.32 (SD = 11.97, N = 133) and boys had a mean of 58.27 (SD = 10.88, N = 89).

NYS Regents Algebra Exam Passing Rates

The comparison of the passing rates on NYS Regents exams revealed that about 10% more students in the experimental group passed the exam compared to the control group (see Table 14 a). More specifically, the experimental group had higher passing rates on all course levels with 6% difference at Level F, 20% difference at Level R, and less than 1% difference at Level A. Similar results were observed for the students of Teacher A (see Table 14b), with 10% more students passing the NYS Regents exam in the experimental group compared to the control group.

Place Table 14 here

Analysis of passing rates by race revealed that the experimental group had higher passing rates from the control group for each racial group, with about 16% higher passing rate for Blacks, 7% for Hispanics, 14% for Whites, and 23% for Asians. Overall Hispanics, Whites, and Asians in the experimental group had the highest passing rate (50%), and control group Blacks had the lowest passing rate (22.4%) (see Table 15).

Gender analysis yielded 15% higher passing rates for girls and 7% higher passing rates for boys in the experimental group compared to the control group. Overall, girls had significantly higher passing rates than boys in the experimental group, but the passing rate was the same for girls and boys in the control group (see Table 16).

Conclusions and Discussion

Research has established that students who are taught using various technological devices achieve higher scores in mathematics than those who are taught without them (e.g. Ellington, 2005; Heller, Curtis, Jaffe, & Verboncoeur, 2005; Khoju, Jaciw & Miller, 2005). The present study compared the effectiveness of a new generation of technology with an existing one. In particular, the students in an experimental group received algebra instruction with the new TI-Nspire handhelds, while those in a control group received instruction through TI-84 graphing calculators – an existing technology. In our study teacher participants both in the experimental and the control group were not just asked to use technology but in addition received year-long professional development. In a recent article on assessing the impact of teacher professional development, Desimone (2009 p. 192) states: “Finally, we need more work that links professional development and changes in teaching practice to student achievement.” In our case the changes in teaching practice came about through the incorporation of a new technology supported by professional development, the focus being on the effective use of new or existing technology for teaching and learning algebra. We now turn to the discussion of student achievement as measured by our dependent variables.

Student Achievement

The results were as follows: (1) The midyear assessment scores indicated that the experimental group did significantly better than the control group, except for students at Level A. (2) Fall and Spring Semester grades were significantly higher only for students in Level F of the experimental group. (3) There were no significant differences between the control and experimental groups or between different levels in the Regents exam scores. However, the passing rates on Regents exam were higher for all student levels in the experimental group.

Our results indicate that the TI-Nspire technology had a different impact on the performance of students of different achievement levels. The higher achieving students who used TI-Nspire performed significantly better on school/teacher made assessments. This could be explained by the fact that higher achieving students are capable of working with the high demand cognitive tasks offered by TI-Nspire technology. Lower achieving students on the other hand, are still struggling with basic skills and concepts that could be targeted equally by graphing calculator and TI-Nspire technology. The lack of significant difference between student scores on the NYS Regents exam is consistent with research on large scale assessments (e.g., Stancavage, Shepard, McLaughlin, Holtzman, Blankenship, Zhang, 2009). However, analysis of passing rates demonstrated that more students at all achievement levels receive passing scores when taught with TI-Nspire technology, thus showing that ultimately this technology does affect lower achieving students as well.

The supplemental analyses performed on the students of Teacher A – the only teacher who taught both experimental and control groups – allowed us to analyze the effects of type of instruction while controlling for teacher effects. The results of such analyses indicated that lower achieving students taught with TI-Nspire technology could achieve the same level of performance as higher achieving students with TI-84 graphing calculator at school and teacher-created assessments. Otherwise the results on the NYS Regents scores and passing rates for Teacher A were consistent with the whole group.

Discussion on Race

The final research question examined whether there were any race differences in student achievement. Results indicated that there were no significant differences among races (Hispanic, Black, White, Asian) in any of the assessments. However, the passing rates on the NYS Regents exams were higher for each race in the experimental group compared to the control group. These results are promising as they suggest that inquiry-based instruction with technology that allows for dynamic and interactive explorations could engage underrepresented groups of students in learning mathematics and possibly reduce the achievement gap. These findings do not confirm any of the existing literature, in which the academic achievement gap, particularly the mathematics achievement gap, between Black students and their White counterparts has been well documented (Strutchens, Lubienski, McGraw, & Westbrook, 2004; U.S. Department of Education, 2003). Although mathematics educators know that the achievement gap exists, we do not fully understand the complexities of why it exists. Such an analysis is beyond the scope of the present study. Many educators have attempted to find methods to assist teachers in eliminating the race gap. One suggested method is to present class work that is challenging but not so difficult that it lies outside an individual's ability (Gonzales, Blanton, & Williams, 2002). We can only speculate as to why in the present study the teachers of our students were able to eliminate race differences when teaching Integrated Algebra with technology.

Discussion on Gender

Next, gender differences in student achievement as a result of the technology were examined. The results on gender were as follows: midyear assessment, Fall and Spring Semester grades, indicated that girls significantly outperformed boys in the experimental group, but not in the control. Only the Regents scores indicated no significant differences between the performances of girls and boys, although the girls in the experimental group had much higher passing rates than the boys. Thus in the experimental group girls did significantly better than boys and in the control group boys and girls did equally well. This result raises a question of whether the interactive technology environment provides girls with higher motivation and time-on task than boys. Research on gender differences as a result of using technology has yielded mixed results. The National Center for Educational Statistics signature report, "The Nation's Report," (National Center for Education Statistics, 2001, p. 144) provides data indicating that frequent use at the eighth grade level – but not at the fourth grade level – is associated with greater mathematics achievement for both girls and boys. The superior performance of girls over boys when a particular technology is used needs further examination.

Limitations

The quasi-experimental design of this study was such that strong causal inferences are not warranted because students were not randomly assigned to classes and classes were not randomly assigned to teachers. Research findings suggest that teachers who volunteer to participate in the experimental condition are probably motivated to change and try something new (Supovitz & Zeif, 2000). Further, there is evidence that the most qualified teachers are the ones who seek out professional development with effective features such as content focus (Desimone, Smith, & Ueno, 2006). In our study we controlled for teacher effects such as teacher age and teacher experience by running regression analyses and finding that these were not significant factors. We did not, however, control for teacher motivation and attitudes.

Additional comparison of student performance for Teacher A --the teacher who taught with both technologies--reaffirmed this conclusion.

Another limitation of our study was that we worked in a Title I school which has high mobility and dropout rates among the students. This led to about 30% data lost for each assessment, and the possibility of under-representation of low achievers who often are more mobile and have higher dropout rates than their peers. Analysis of the data showed that different students were absent each time an assessment was administered. Collecting data only on those students who were present at each assessment reduces the sample size to a too small sample for the multi-level analysis. The fact that on average all students had the same attendance, and thus were exposed to about the same amount of instruction, provides a basis for comparison of the scores of a whole group on *each* assessment.

Implications and Future research

Teachers need to stay informed about the features and effectiveness of new technology. TI-Nspire technology was chosen for the experimental group because it represents an advance in the capabilities of a low-cost personal computing device. It is reliable, easy-to-use, and supports a broad range of instructional models and advanced modes of assessment for teaching mathematics. Furthermore its use is permitted on state tests. The two new capabilities that TI-Nspire™ incorporates are: a) *The ability to display multiple representations which are connected and in a single plane.* That is, the multiple representation capability dynamically links graphical curves, axes, equations, and tables in simultaneous displays, such that a change in one representation is transmitted to the others. This feature allows teachers to design new tasks for their students to address the NCTM standards focusing on connections between algebraic and geometric representations, on inquiry-based approaches to teaching and learning mathematics, etc. b) *The ability to document content.* This document-based content system comprises an organized presentation of multiple screens of mathematics, which can be saved, shared, annotated, and revisited, giving teachers new ways of assessing their students' understanding of mathematics and technology.

The present study compared the effects of two types of technology on student achievement while providing the same type of professional development to the teachers using either. Future studies should look closer at the effects of professional development as part of the overall model that leads to improved student achievement.

Another important question that this study raised is what the learning curve is for the students at different levels of performance. Future studies should analyze if there is a predictable pattern to the students' learning curve. It may even be possible to design teacher scaffolding to accelerate the learning curve. It may be that the degree and type of scaffolding students need changes according to their skill and knowledge profile. It may be that there is a skill hierarchy for mastery of TI-Nspire in classroom instruction. Research on these issues will allow us to refine the professional development system supporting TI-Nspire in scalable, sustainable ways.

TI-Nspire has the ability to capture a progression of documents which may represent stages in a student's thinking about a problem-solving task. It also has the ability to support free-form answer entries using alphanumeric and algebraic notation. Further studies could explore how to exploit these capabilities for formative and summative assessment, with particular attention to deep understanding (of connected, contextualized concepts and principles) and "doing real work" (ill-structured problem solving) in mathematics.

References

Bannasch, S. (1999). The electronic curator: Using a handheld computer at the Exploratorium. Concord Consortium Newsletter. Retrieved August 10, 2003 from http://www.concord.org/library/1999fall/electronic-curator.html.

Cole, H., & Stanton, D. (2003). Designing mobile technologies to support co-present collaboration. *Personal and Ubiquitous Computing, 7*, 365-371.

Curtis, M. (2005). The rise of the handheld computer in schools. *Media and Methods, 41*(6), 14.

Danesh, A., Inkpen, K., Lau, E, Shu, K., & Booth, K. (2001). Geney: Designing a collaborative activity for the Palm handheld computer. Proceedings of CHI, Conference on Human Factors in Computing Systems. Seattle: WA.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181-199.

Desimonone, L. M., Smith, T., & Ueno, K (2006). Are teachers who need sustained, content-focused professional development getting it? An administrator's dilemma. *Educational Administration Quarterly*, *42*(2), 179-215.

Ellington, A. J. (2003). A meta-analysis of the effects of calculators on students' achievement and attitude levels in precollege mathematics classes. *Journal for Research in Mathematics Education*. *34*(5), 433-463.

Fleener, M. J. (1995). A survey of mathematics teachers' attitudes about calculators: The impact of philosophical orientation. *Journal of Computers in Mathematics and Science Teaching, 14*, 481-498.

Gonzales, P. M., Blanton, H., & Williams, K. J. (2002). The effects of stereotype threat and double-minority status on the test performance of Latino women. *Personality & Social Psychology Bulletin*, *28*, 659–670.

Heller, J. L., Curtis, D. A., Jaffe, R., & Verboncoeur, C. J. (2005). *Impact of handheld graphing calculator use on student achievement in Algebra 1*. Oakland, CA: Heller Research Associates.

Inkpen, K. (2001). Designing handheld technologies for kids. Proceedings of CHI, Conference on Human Factors in Computing Systems. Seattle: WA.

Kastberg, S., & Leatham, K. (2005). Research on graphing calculators at the secondary level: Implications for mathematics teacher education. *Contemporary Issues in Technology and Teacher Education, 5*(1), 25-37.

Khoju, M., Jaciw, A., & Miller, G. I. (2005). *Effectiveness of graphing calculators in K-12 mathematics achievement: A systematic review*. Palo Alto, CA: Empirical Education, Inc.

Author (2003a). Connecting Mathematics with Science: Experiments for Precalculus. Emeryville, CA: Key Curriculum Press.

Author (2003b). Connecting Mathematics and Science: Experiments for Calculus. Emeryville, CA: Key Curriculum Press.

Mandryk, R. L., Inkpen, K. M., Bilezkjian, M., Klemmer, S. R., & Landay, J. A. (2001). Supporting children's collaboration across handheld computers. Proceedings of CHI, Conference on Human Factors in Computing Systems. Seattle: WA.

National Center for Education Statistics. (2001). *The nation's report card: Mathematics 2000.* (No. NCES 2001-571). Washington, DC: U.S. Department of Education.

Niess, M. (2001). A Model for Integrating Technology in Preservice Science and Mathematics Content-Specific Teacher Preparation, *School Science and Mathematics, 101*(2), 102-109.

Roschelle, J. (2003). Unlocking the learning value of wireless mobile devices. *Journal of Computer Assisted Learning, 19*(3), 260-272.

Roschelle, J. & Pea, R. (2002). A walk on the WILD side: How wireless handhelds may change computer-supported collaborative learning. *International Journal of Cognition and Technology, 1*(1), 145-272.

Roth, J. (2002). Patterns of mobile interaction. *Personal and Ubiquitous Computing, 6*, 282-289.

Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers and Education, 34*, 177-193.

Soloway, E., Norris, E., Blumenfeld, P., Fishman, B., Krajcik, J., & Marx, R. (2001). Log on education: Handheld devices are ready-at-hand. *Communications of the ACM, 44*(6), 15-20.

Stancavage, F., Shepard, L., McLaughlin, D., Holtzman, D., Blankenship, C., & Zhang, Y. (2009). Sensitivity of NAEP to the effects of reform-based teaching and learning in middle school mathematics. In *NAEP Validity Studies*.

Strutchens, M. E., Lubienski, S. T., McGraw, R., & Westbrook, S. K. (2004). NAEP findings regarding race and ethnicity: Students' performance, school experiences, and attitudes and beliefs, and family influences. In P. Kloosterman & F. K. Lester (Eds.), *Results and interpretations of the 1990 through 2000 mathematics Assessment of the national assessment of education progress* (pp. 269-304). Reston, VA: National Council of Teachers of Mathematics.

Supovitz, J. A., & Zeif, S. G. (2000). Why they stay away. *Journal of Staff Development*, *21*(4), 24-28.

Thomas, J. A., & Cooper, S. B. (2000). Teaching technology: A new opportunity for pioneers in teacher education. *Journal of Computing in Teacher Education*, *17*(1), 13-19.

Tinker, R. (1996). The whole world in their hands. Washington, DC: Department of Education. http://www.ed.gov/Technology/Futures/tinker.html

Tinker, R., & Krajcik, J. (Eds.). (2001). Portable Technologies: Science Learning in Context. New York: Kluwer Academic/Plenum Publishers.

U.S. Department of Education. (2003). *Status and Trends in the Education of Blacks.* (NCES 2003-034), by K. Hoffman & C. Llagas. Project Officer: T. D. Snyder. Washington, DC: National Center for Education Statistics. Retrieved July, 17, 2006, from http://nces.ed.gov/pubs2003/2003034.pdf

Vahey, P., & Crawford, V. (2002). Palm Education Pioneers Program: Final evaluation report. Menlo Park, CA: SRI International.

van't Hooft, M., Diaz, S., & Swan, K. (2004). Examining the potential of handheld computers: Findings from the Ohio PEP project. *Journal of Educational Computing Research, 30*(4), 295-312.

Wolf, M. A. (2007). A Guiding Hand. *The Journal of Higher Education, 34*(7), 12-13.

Figure 1. Screen shots of students' explorations in the TI-Nspire document developed by the teachers.

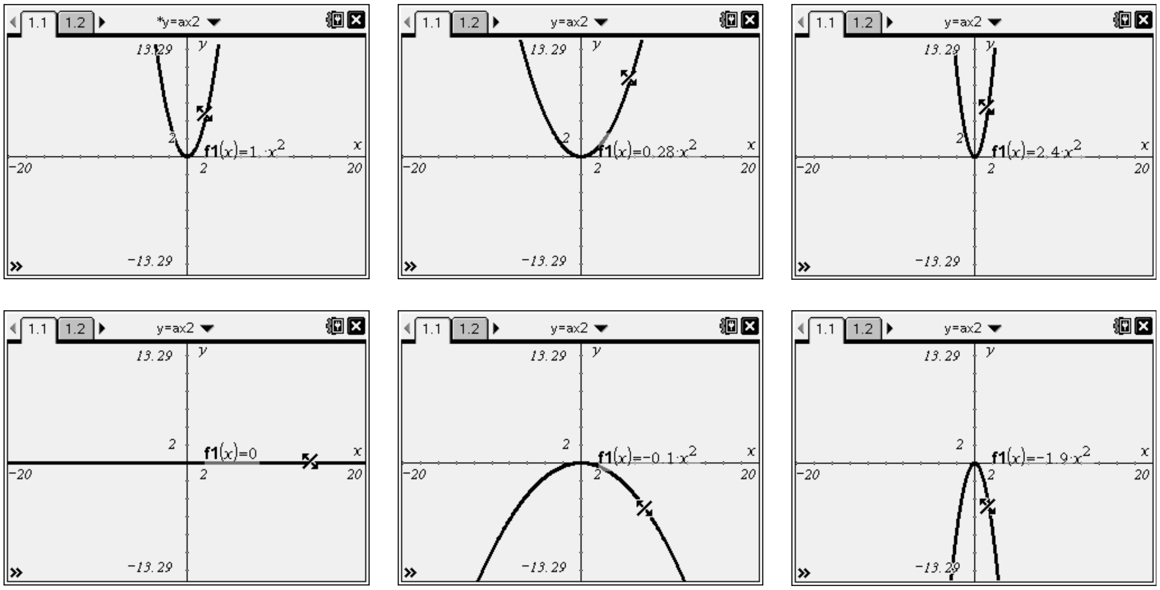

Table 1: Composition of Experimental and Control Groups by Course Level, Race and Gender.

		Experimental Group	Control Group	Total
Level	Level F	32%	26%	29%
	Level A	48%	17%	37%
	Level R	20%	57%	34%
Race	African American	36%	49%	40.5%
	Hispanic	37%	35%	36%
	White	12%	12%	18.5%
	Asian or Pacific Islander	5%	9%	5%
Gender	Male	43%	45%	43.5%
	Female	57%	55%	56.5%

Table 2: Demographics for Teachers in the Experimental Group (at the end of the 2007-2008 academic year).

Gender	Age	Teaching Experience (years)	Total sections taught	Number of experimental sections
*F	23	1	5	1
F	26	3	5	2
F	30	10	2	1
M	37	13	1	1

*Teacher A

Table 3: Demographics for Teachers in the Control Group (at the end of the 2007-2008 academic year).

Gender	Age	Teaching Experience (years)	Total sections taught	Number of control sections
*F	23	1	5	2
M	30	2	5	1
F	25	1	5	4
F	36	8	5	1

*Teacher A

Table 4. Number of Assessed Students for each Dependent Variable.

	Initial enrollment	Baseline assessment	Midyear assessment	Fall semester grades	Spring semester grades	NYS Math Regents
Control	197	134	133	178	171	147
Experimental	131	95	98	105	107	92

Table 5. Descriptive Statistics for Baseline Assessment Scores.

a) By race

	RACE				
	African American	Hispanic	White, not Hispanic	Asian or Pacific	Total
Experimental Group	M = 49.83 SD = 19.848 N = 41	M = 49.63 SD = 15.099 N = 32	M = 60.60 SD = 23.651 N = 10	M = 48.25 SD = 23.215 N = 4	M = 50.92
Control Group	M = 46.88 SD = 21.623 N = 40	M = 52.50 SD = 23.883 N = 40	M = 47.75 SD = 26.702 N = 24	M = 49.55 SD = 26.151 N = 11	M = 48.48
Total	M = 48.37	M = 51.22	M = 51.53	M = 49.20	M = 49.98

b) By gender

	GENDER		
	Male	Female	Total
Experimental Group	M = 49.45 SD = 17.904 N = 42	M = 52.29 SD = 19.787 N= 45	M = 50.92
Control Group	M = 52.90 SD = 23.782 N = 48	M = 46.67 SD = 23.599 N = 67	M = 49.27
Total	M = 51.29	M = 48.93	M = 49.98

Table 6: Descriptive Statistics for Midyear Assessment. Group × Course Level.

a) For all teachers

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group	M = 74.76 SD = 13.14 N = 25	M = 49.26 SD = 17.30 N= 58	M = 52.60 SD = 12.17 N = 15	M = 56.28
Control Group	M = 63.87 SD = 19.21 N = 54	M = 39.00 SD = 26.37 N = 34	M = 54.96 SD = 19.74 N = 45	M = 54.50
Total	M =69.31	M = 44.13	M = 53.78	

b) For Teacher A.

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group		M = 49.86 SD = 16.67 N= 21		M = 49.86
Control Group	M = 62.56 SD = 13.42 N = 9		M = 53.93 SD = 22.16 N = 14	M = 57.30

Table 7: Descriptive Statistics for Midyear Assessment Scores. Group × Gender.

	GENDER		
	Male	Female	Total
Experimental Group	M = 50.45 SD = 16.580 N = 44	M = 61.13 SD = 19.966 N= 52	M = 56.24
Control Group	M = 54.16 SD = 24.068 N = 57	M = 55.33 SD = 23.160 N = 70	M = 54.80
Total	M = 52.54	M = 57.80	M = 55.42

Table 8: Descriptive Statistics for Fall Semester Grades. Group × Student Level.

a) For all Teachers

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group	M = 79.63 SD = 11.23 N = 27	M = 65.70 SD = 11.92 N= 60	M = 58.06 SD = 5.19 N = 18	M = 67.97
Control Group	M = 70.93 SD = 14.00 N = 56	M = 66.19 SD = 11.89 N = 36	M = 57.41 SD =13.46 N = 86	M = 64.35
Total	M = 75.28	M = 65.95	M = 64.17	

b) For Teacher A.

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group		M = 68.52 SD = 10.75 N= 21		M = 68.52
Control Group	M = 69.31 SD = 15.24 N = 12		M = 55.38 SD =15.90 N = 32	M = 59.20

Table 9: Descriptive Statistics for Fall Semester Grades. Group × Race.

	RACE				
	African American	Hispanic	White, not Hispanic	Asian or Pacific	Total
Experimental Group	M = 69.39 SD = 13.597 N = 49	M = 65.63 SD = 10.749 N = 35	M = 70.50 SD = 15.139 N = 12	M = 71.60 SD = 18.649 N = 5	M = 68.33
Control Group	M = 61.66 SD = 13.246 N = 59	M = 61.54 SD = 15.429 N = 61	M = 64.51 SD = 15.933 N = 37	M = 69.67 SD = 10.062 N = 9	M = 62.69
Total	M = 65.17	M = 63.03	M = 65.98	M = 70.36	

Table 10: Descriptive Statistics for Fall Semester Grades. Group × Gender.

	GENDER		
	Male	Female	Total
Experimental Group	M = 63.62 SD = 10.86 N = 45	M = 72.11 SD = 13.59 N= 56	M = 67.87
Control Group	M = 62.17 SD = 14.5 N = 71	M = 63.07 SD = 14.7 N = 95	M = 62.62
Total	M = 62.73	M = 66.42	M = 64.57

Table 11: Descriptive Statistics for Spring Semester Grades.

a) For all teachers

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group	M = 73.96 SD = 14.61 N = 23	M = 62.88 SD = 11.90 N= 66	M = 59.72 SD = 8.13 N = 18	M = 64.73
Control Group	M = 67.08 SD = 13.00 N = 50	M = 61.89 SD = 11.32 N = 44	M = 55.00 SD =13.09 N = 77	M = 60.30
Total	M = 70.52	M = 62.39	M = 57.39	

b) For Teacher A

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group		M = 62.17 SD = 10.53 N= 23		M = 62.17
Control Group	M = 69.57 SD = 12.90 N = 7		M = 52.70 SD =11.10 N = 27	M = 56.18
Total	M = 69.57	M = 62.17	M = 52.70	

c)

Table 12: Descriptive Statistics for Spring Semester Grades. Group × Gender.

	GENDER		
	Male	Female	Total
Experimental Group	M = 62.00 SD = 10.58 N = 43	M = 68.38 SD = 14.18 N= 53	M = 65.52
Control Group	M = 59.75 SD = 13.80 N = 65	M = 62.15 SD = 13.82 N = 85	M = 61.11
Total	M = 60.65	M = 64.54	M = 62.83

d) Table 13: Descriptive Statistics for NYS Regents Exam. Group × Level.

a) For all teachers

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group	M = 62.6 SD = 9.17 N = 25	M = 59.14 SD = 13.30 N= 56	M = 55.82 SD = 10.05 N = 11	M = 59.19
Control Group	M = 59.21 SD = 13.01 N = 53	M = 55.97 SD = 11.71 N = 38	M = 55.57 SD = 13.10 N = 56	M = 56.92
Total	M = 60.29	M = 57.86	M = 55.61	

b) For Teacher A

	STUDENT LEVEL			
	Level F	Level R	Level A	Total
Experimental Group		M = 61.14 SD = 9.90 N= 22		M = 61.14
Control Group	M = 59.67 SD = 9.90 N = 9		M = 53.14 SD = 16.38 N = 22	M = 55.03
Total	M = 59.67	M = 61.14	M = 53.14	

Table 14. Passing Rates on NYS Regents Exams (Type of Technology x Course Level).

a) For all teachers

	Student Level			
	Level F	Level R	Level A	Total
Experimental (N = 92)				
% within course level	56%	41.1%	27.3%	
% of total	15.2%	25%	3.3%	43.5%
Control (N = 147)				
% within course level	50.9%	21.1%	26.8%	
% of total	18.4%	5.4%	10.2%	34%

b) For Teacher A

	Student Level			
	Level F	Level R	Level A	Total
Experimental (N = 22)				
% within course level		45.5%		
% of total		45.5%		45.5%
Control (N = 31)				
% within course level	66.7%		22.7%	
% of total	19,4%		16.1%	35.5%

Table 15. Passing Rates on NYS Regents Exams (Type of Technology x Race).

	Race				
	Black	Hispanic	White	Asian	Total
Experimental (N = 111)					
% within race	38.1%	50%	50%	50%	
% of total	19%	15.5%	7.1%	2.4%	44%
Control (N = 138)					
% within race	22.4%	42.6%	35.5%	27.3%	
% of total	8.0%	14.5%	8.0%	2.2%	32.6%

Table 16. Passing Rates on NYS Regents Exams (Type of Technology x Gender).

	Gender		
	Male	Female	Total
Experimental (N = 111)			
% within gender	38.9%	47.9%	
% of total	16.7%	27.4%	44%
Control (N = 138)			
% within gender	32.1%	32.9%	
% of total	18.4%	20.3%	32.6%