An Analysis of Integrating Graphing Technology While Teaching Graphs of Quadratic Functions

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Masters of Science

by

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An Analysis of Integrating Graphing Technology While Teaching Graphs of Quadratic Functions

Title of Item

math education, Quadratic Functions, iPad, Graphing, case stud

3 to 5 keywords or phrases to describe the item

Robert Stukes

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Robert Stukes 5/15/12

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Abstract:

Technology is continuously advancing and impacting all areas of modern life. Mathematics students come to classrooms familiar with various electronic devices and ways to apply them to find and utilize information. Educators should embrace these skills by incorporating interactive technologies into their pedagogies. Instructors on all levels are beginning to break through the rigidity of traditional teaching methods and beginning to explore alternatives which integrate the use of computer-based learning activities. The objective of this study is to investigate the effectiveness of using Apple iPad applications in the classroom to improve student's understanding of graphing quadratic functions. We compare the data collected from the case study to the results of the control group that was taught using a traditional lecture-based methodology to demonstrate significant improvement of understanding graphs by students who used iPad graphing technology during their learning process.

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A. Introduction

In this era of technological advancement, humans are constantly interacting with new forms of innovative devices. In the past, students' books and other written material were the basis for learning a new skill or finding information. However, in our current environment, students can simply execute Internet searches and find themselves reading Wikipedia articles or interactive text books, marginalizing the need for written media. Students consistently use the Internet and their computers, tablets, or smartphones to acquire the information they need (Loch & Donovan, 2006). Currently, in developed countries, people expect to immediately find information. For over two decades, teachers have attempted methods to integrate technology into their classrooms (Bennison & Goos 2010). However, instructors are hesitant to invest their time and money into digital methodologies because they are uncertain when a specific technological approach will be more effective than a traditional instruction method. Hence, technology-based learning activities need to be comparatively analyzed with regard to the specific subject matter, students' backgrounds, and specific topics (Bennison & Goos, 2010 and 2008).

The following questions are addressed in this paper: Do students' use of convenient and portable computer graphing applications foster improvement in their skills and understanding of the concept of graphing? Or, does this technology begin to harbor certain dependencies making students' progress inadequate in solving problems which are graphical in nature?

There are many educators in the field of mathematics who feel that incorporating technology is a necessity. Specifically, we advocate that tablets should be on the leading edge of this technological movement, due to their versatility, mobility, low cost, and intuitive nature (Galligan, Loch, McDonald, & Taylor, 2010). For these reasons, teachers may for the first time have the opportunity to supply every student a small computer to use in the classroom. The advantages of tablets have begun to overpower the downsides of costly and complicated personal computers in education. For instance, the risk of investments into software is minimized by the release of new and cheap applications which can simply be installed onto each tablet in a quick and synchronized manner. Instructors who use multiple rooms can now easily carry their technological supplies. Many students in developed countries are already familiar with tablet technology, since it is closely related to smartphone and multimedia technology that they utilize on a daily basis.

Incorporating advancements in technology to aid in instruction has long been explored in mathematics. The compass, protractor, abacus, slide rule, and calculator are all prime examples of technologies that have been accepted as beneficial tools in math education. While some of the above devices help to perform arithmetic operations, they do not teach arithmetic. Hence, the distinction between an interactive tool that is teaching and a teaching device is paramount when assessing the value of new technologies. Research shows that in the current environment educators should be making use of our significant technological advancements and continue to facilitate innovative teaching strategies in mathematics (Martin, 2008). The objective ofi this study is to evaluate whether allowing students to interactively manipulate graphs of quadratic functions, via the iPad graphing application, can improve their overall understanding of quadratic function graphs. While the iPad interactive software does not directly teach students how to graph quadratic functions, it does expedite the demonstration of key concepts through precise graphical examples and enables exploration and discovery of other useful algebraic representations. Students can investigate graphs through interactive manipulations and comparative analysis. While iPad graphing technology will never be a replacement for qualified human teachers, it will assist them with faster and more precise instruction.

B. Methodology and Assessment Procedure

The methodology employed for this thesis was a case study. The case study framework consists of four phases:

1.) Pre-test and survey

2.) iPad-based function graphing activity

3.) Post-test

4.) Data analysis

The first three study phases were conducted during consecutive class periods. Since during their typical learning activities students generally increase their knowledge of the topic, we expected an improvement on the post-test. For this reason, a control group was established to compare the improvement of skills and knowledge of participants in the case study and traditional groups. Ultimately, the goal was to assess both groups and determine if there was a significant advantage to the technique.

1. Description of the data collection [Appendix A1]

The initial student survey consisted of three parts:

1.) Demographics

2.) Technological experience

3.) Mathematical skill level

Participants first completed the demographic-oriented questionnaire. The demographic data collected included age, gender, grade level, major, first/second language(s), and preferred learning styles. Next, participants were queried about their previous experiences with Apple iPads and other related tablet or graphing technologies. Finally, each student was asked to self-evaluate their mathematical proficiencies in various areas. The purpose of this survey was to determine if there was any stratification of the respondents, and to identify possible outliers. An additional concern included possible bias in the study itself, which could be detected by correlations between survey and test data.

The pre-tests for each group consisted of two parts, graphing questions [Appendix B1] and conceptual questions [Appendix B2]. Each graphing problem included different canonical representations of quadratic functions: standard form, vertex form, and factored form. To eliminate computational errors, every function had integer coefficients, vertices had integer coordinates, and intercepts were integers. This allowed students to graph the functions using the provided representation of the function. Then, the students could transcribe additional representations of the functions via graphical interpretation or simple algebra without troublesome calculations. Students often decided to first algebraically manipulate the functions, and then use their preferred representation of the functions to graph them. The conceptual questions tested students' understanding of quadratic functions by asking them to describe certain situations either in a written response or with a quick sketch. Other conceptual questions were related to understanding of various precise definitions (for example, the quadratic formula). The pre-test was given during the last sixty minutes of a two-hour class period. It is important to note that the lecture preceding the pre-test was on the discriminant and roots of quadratic functions.

Following the pre-test, the function graphing activity was administered five days later at the end of the next class period. Students worked with iPads and the graphing application called Quick Graph. Participants were given a worksheet [Appendix C1 and C2] which stepped through graphing a given quadratic function as well as exploration and discovery of other useful algebraic representations of the function. During the iPad explorations, students worked to graphically identify the roots and vertex of the parabolas. The activity worksheet consisted of six questions and took about sixty minutes to complete. All work was performed individually; no group work was allowed. Students were required to stay for the entire sixty minutes and fill out the entire worksheet. It should be noted that at the beginning of the activity students were given a short lecture on the three main representations of quadratic functions: standard, vertex, and factored.

The post-test questions were similar to the ones on the pre-test, with slight changes. For example, the graphing questions had different integers as coefficients, roots, vertices, and intercepts, but the general representation of the quadratic functions were the same as on the pre-test [Appendix D1]. Also, some of the conceptual questions on the second page of the post-test were different from the pre-test, but they tested similar conceptual knowledge as the pre-test counterpart [Appendix D2]. In this study, the questions on the pre-test and post-test were matched for their content. Again, participants were asked to sketch a graphical representation of the situation being described in conjunction with their written response. It should be noted that the post-test was administered at the conclusion of a regular class session about applications of quadratic functions and the students were required to stay for the entire sixty minute period.

2. Description of the study and grading scheme

The participants in the study were all California State University Channel Islands Math 95, Intermediate Algebra, students. The control group was a different section of Math 95, which was given the same pre-test as the study group. The control group was taught how to graph quadratic functions using a traditional lecture-based method by their instructor. The lecture followed the assigned text book "Elementary and Intermediate Algebra: Concepts and Applications", by Bittinger, Ellenbogen, & Johnson, Chapter 11.6, "Quadratic Functions and

Their Graphs" and 11.7, "More about Graphing Quadratic Functions". After the lecture, the control group was given the same post-test as the study group.

Assessment of the pre-test and post-test was designed in such a way as to eliminate bias from the grading procedure by determining if individual aspects of the questions were either correct or incorrect. Therefore, a binary scale was used to grade pertinent aspects of each question. Each graphing question consisted of four parts:

1.) Correctness of graph

2.) Attempt to graph a corresponding parabola

3.) Correctness of the point(s) such as x-intercepts, coordinates of vertices, etc.

4.) Writing the function in at least one alternate representation

The conceptual questions were structured in a similar way. Each situational question was evaluated on a two point scale: correctness of written response, and any attempt to visualize the situation by sketching a diagram (making an *x-y* chart and graphing an example). Definition questions were assessed on a binary scale, for correct or incorrect answers. Given this assessment technique, analysis of the data was carefully segregated, and points carefully assigned. For example, the score for correctly graphing a quadratic function is not the same as a score for simply attempting to graph the function. Moreover, the score for a correct definition is not the same as the score for being able to perform the proper algebraic manipulations. For consistency, one person graded all tests in a uniform manner.

3. Description of statistical tools used

The purpose of this methodology and assessment procedure was to test for statistically significant improvement of student understanding after their participation in iPad graphing activities. An unpaired t-test was applied to evaluate if the improvement of case study participants is significantly greater than that of the control group. Results were compared and analyzed to demonstrate the potential benefits of implementing these iPad graphing activities in the classroom. Survey information was cross-referenced using correlation to support the findings in the explanation/reasoning behind the results.

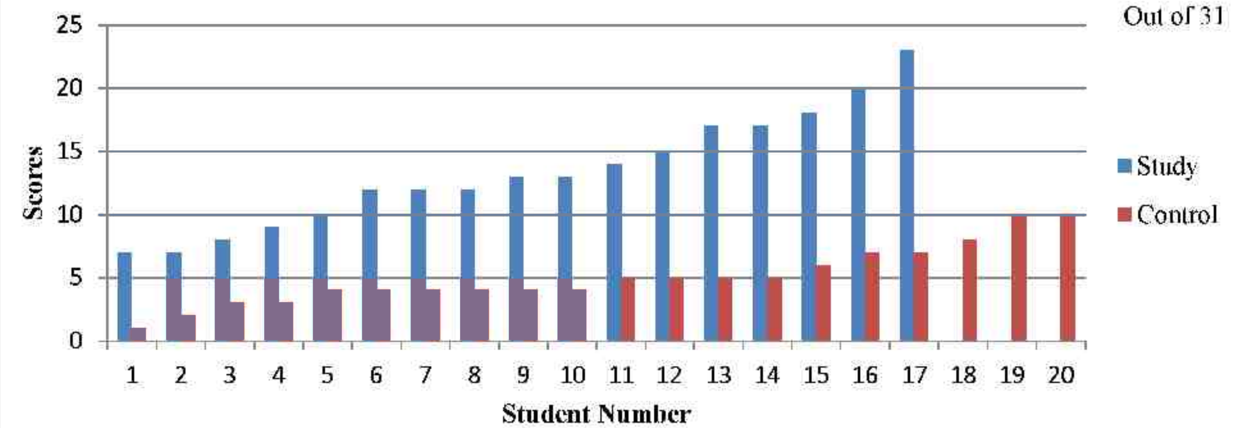
C. Data and Analysis

1. Total Scores

Initially, the goal of this study was to show whether or not using iPads (interactive approach) to teach graphing quadratic functions is a more effective instructional method then a lecture-based approach. Ideally, the study would begin with two compatible groups of students who each participated in different teaching methods for graphing quadratic functions. In an attempt to configure the study with the parameter of compatible groups, two groups of students (different section/teacher) in the same course (Math 95: Introduction to Algebra) at the same school (CSU Channel Islands) participated in the study. Since these students placement in Math 95 is based on a standardized Entry Level Mathematics assessment we have assumed that their general Algebra skills lie below a certain standard. Since the division into sections is quite random, we expected the groups to be roughly homogeneous.

Unfortunately, the data collected in this study showed that the two groups of students did not begin with equivalent skills in the graphing of quadratics functions. In fact, Figure 1 shows the case study group of students had significantly higher scores on the baseline pre-test given at the beginning of the study. Our original assumption that the average pre-test scores of the two groups would be statistically equivalent proved to be incorrect as the study group average was 13.4 points and the control group average was 5.1 points. With 99% confidence we can say that these groups are not similar. We must reject our initial hypothesis in favor of the alternative that the two groups' base knowledge levels were different. The study group having significantly better scores.

Figure 1: Pre-test Total Scores

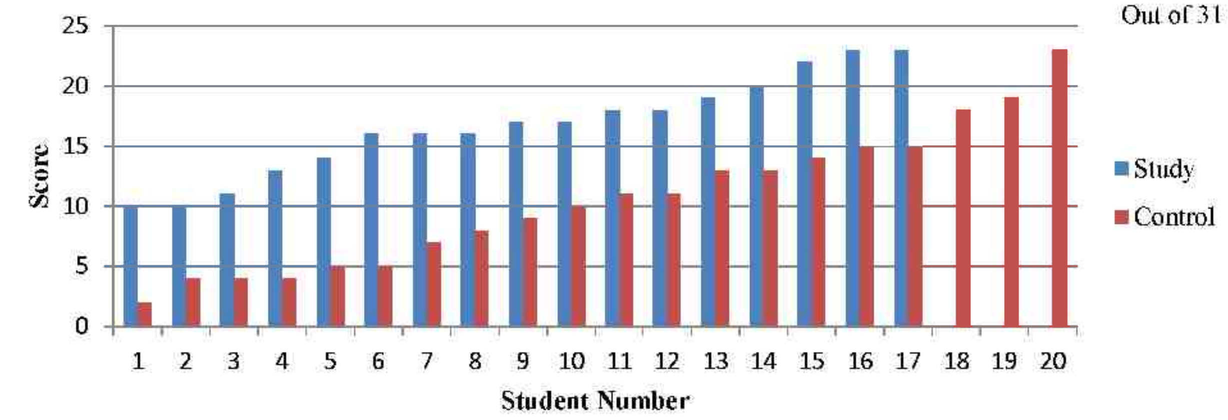


Note: The study group had only 17 participants (numbered 1-17), while the control group had 20.

There could be many reasons for this unusual situation. Since the study was conducted midway through the semester, students' knowledge may have begun to diverge. There was also a difference in the time of day that students had class, potentially effecting overall learning or concentration of students during the testing. Also, the two classes had different instructors; so teaching styles may have influenced student performance (for example, one of the instructors may have been more graphics-focused). This inconsistency in the pre-test scores affects our methodology and analysis of the data. Therefore we had to modify our data analysis; instead of directly comparing the total scores, we compared the total improvement scores (i.e. the post-test, pre-test difference) and compared the performance of the two groups on individual questions.

Notably, post-test results [Figure 2] like the pre-test showed that the study group's knowledge of graphing quadratic functions was still higher than the control group. In particular, the average score for the study group was 16.6 points and the control group was 10.5. Still, the statistical difference between the means of the two groups was significant.

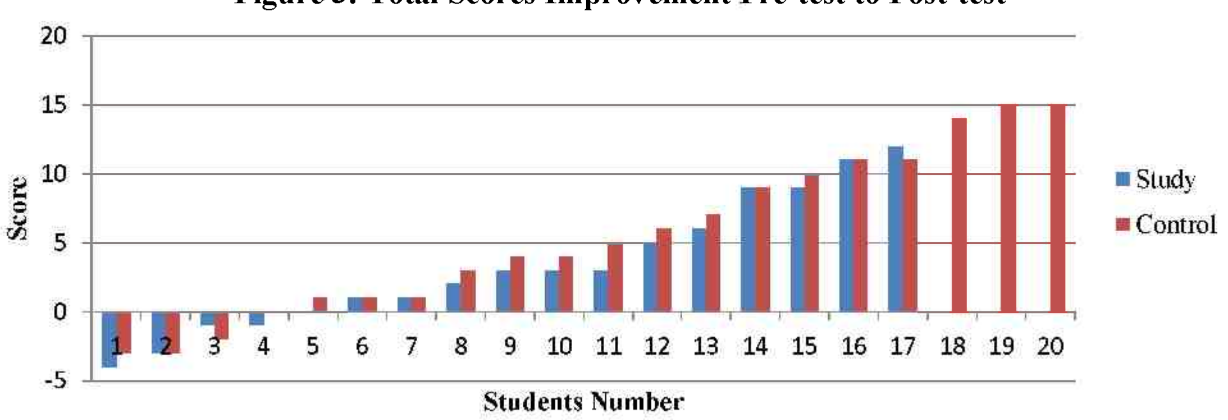
Figure 2: Post-test Total Scores



Note: The study group had only 17 participants (numbered 1-17), while the control group had 20.

Therefore, we consider overall student improvement [Figure 3]. The average improvement of the study group was 3.3 points and the control group was 5.5 points. After calculation of an unpaired t-test, we cannot reject the hypothesis that the two means are equal. Thus, we have evidence that overall improvement was similar in the two groups. Therefore, the iPad activities were at least as effective as traditional lectures. Note that with any assessment, as students get closer to a maximum score, it becomes increasingly difficult to continue to improve (the law of diminishing returns). In that respect, the average improvement in score can be misleading, since the control group had much more room to improve.

Figure 3: Total Scores Improvement Pre-test to Post-test



Note: The study group had only 17 participants (numbered 1-17), while the control group had 20.

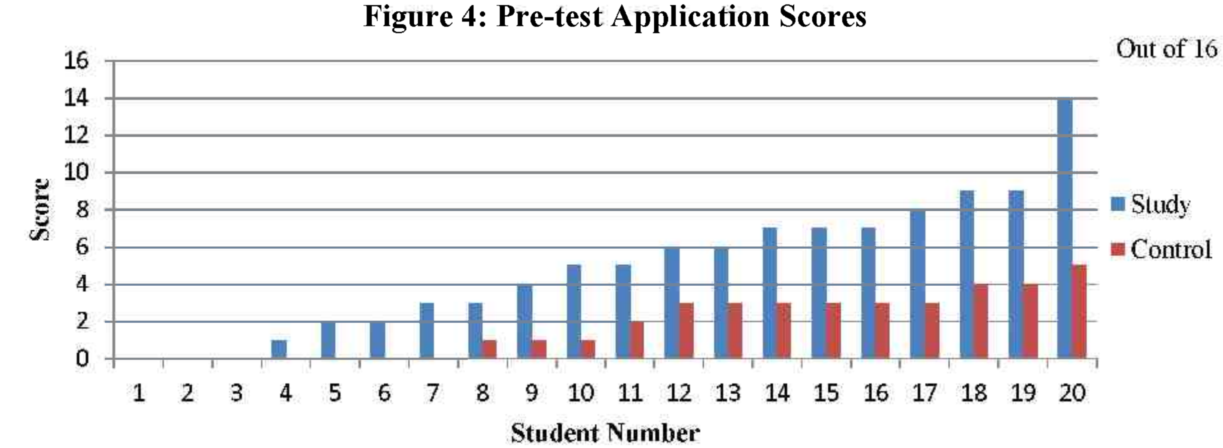
Since the two groups proved to be incompatible, we conducted the analysis on a question-by-question basis. To maintain a broader focus, related questions were grouped in order to demonstrate which specific areas of graphing quadratic functions were affected by the iPad graphing activity. The first grouping approach will split the data into two categories: application problems and conceptual problems.

2. Application Scores

Results from the application portion of the pre-test continue to follow the pattern which indicates that the study group must have had more previous knowledge with respect to the graphing of quadratic functions [Figure 4]. The mean score of the study group was 5.8 points, statistically higher than that of the control group's 1.8 points. Hence, in this category the groups were not compatible.

From this point forward, the analysis graphs will be represented with the study group participants shifted to the right, now numbered 4-20.

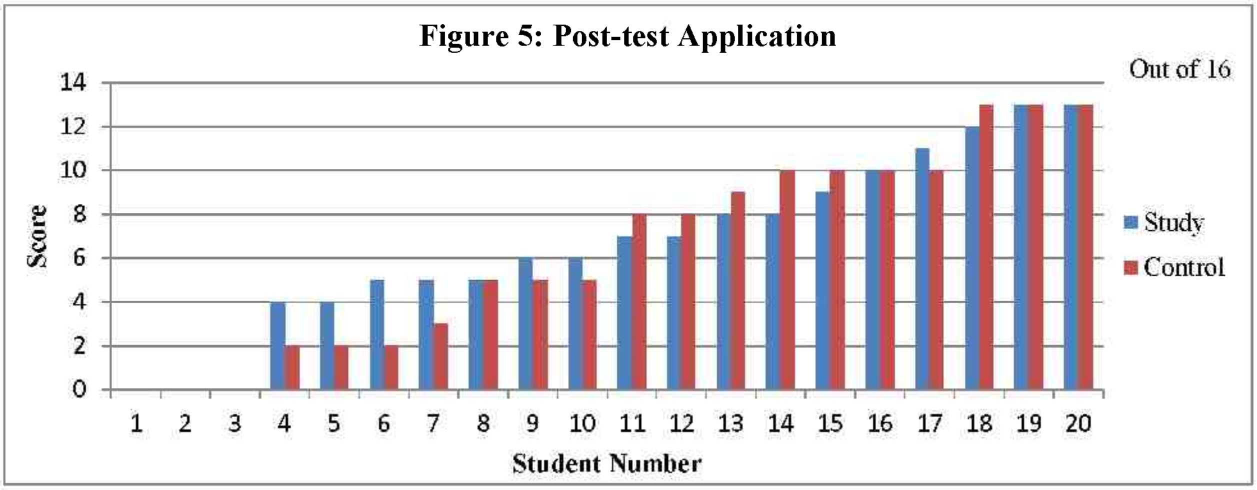
Figure 4: Pre-test Application Scores



Note: The study group had only 17 participants (numbered 4-20), while the control group had 20.

Remark: The control group had 7 participants who scored 0 points on the application pre-test.

For the post-test, the average of the study group continued to be higher than the average of the control group, but with nowhere near the same level of inequality. The study group's average grew to 7.8, where the control group closed the gap and achieved an average of 6.4. The data points trended to a leveling-out effect, central tendency is reflected in Figure 5.



Note: The study group had only 17 participants (numbered 4-20), while the control group had 20.

Remark: The control group had 3 participants who scored 0 point on the application post-test.

In this case, the control group had a far greater improvement from pre-test to post-test. The study group's improvement was minor however, their scores started at the higher level and their post-test scores ended up higher than the control groups scores. Figures 6 and 7 provide the percentage of correct and incorrect answers for the study group and control group respectively.

Figure: 6
Study Group Post-test Application

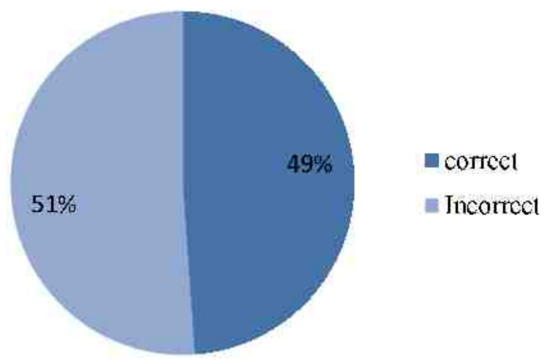
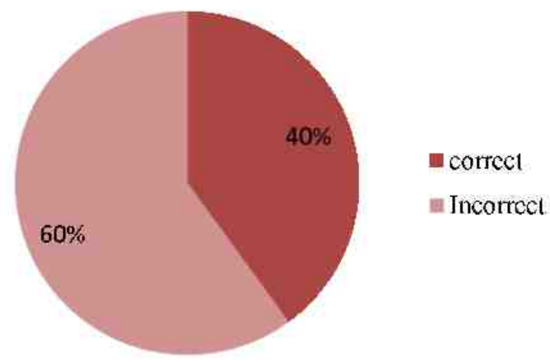


Figure: 7
Control Group Post-test Application

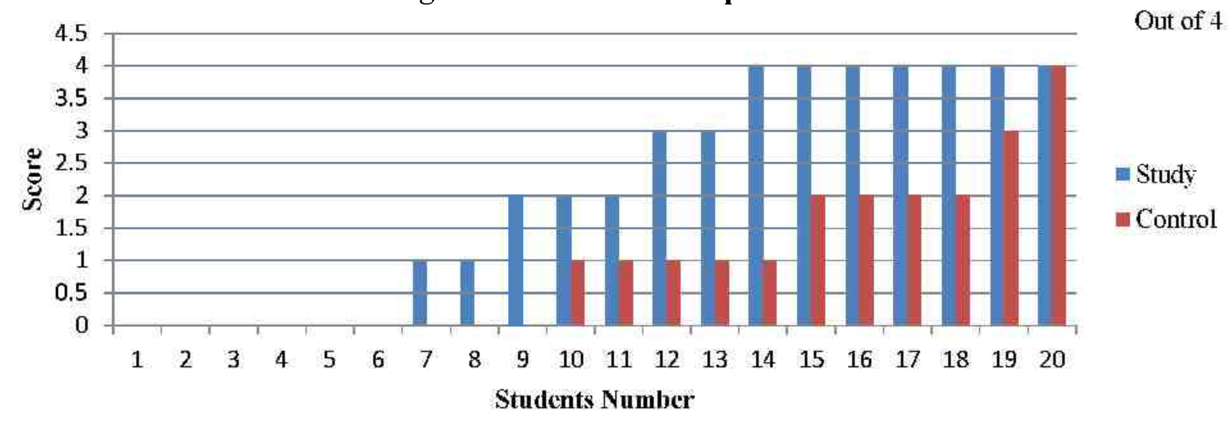


Again, we can conclude that the iPad activites were at least as effective as traditional lecture-based instuction.

3. Attempt Scores

Arguably, the most important aspect of the application portion of the test was simply students' attempts to graph the quadratic functions. Lowering students' affective filter and getting them to attempt problems is the first step to improvement. So, whether right or wrong, students were given at least one point for a reasonable attempt to graph a parabola. Looking at only the attempt scores in the pre-test data [Figure 8], we can compare students' confidence in their ability. On the pre-test, each student in the study group on average attempted 2.5 out of 4 graphing problems. In contrast, students in the control group attempted an average of 1 problem [Figure 8]. In fact, 45% of the control group did not attempt a single graphing problem. This is staggering in comparison to the less than 18% of the study group.

Figure 8: Pre-test Attempt Scores

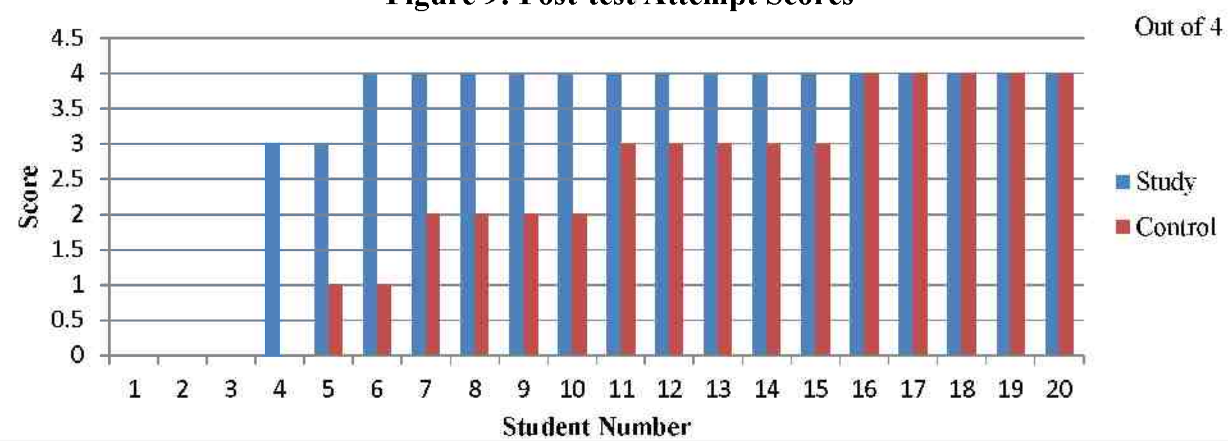


Note: The study group had only 17 participants (numbered 4-20), while the control group had 20.

Remark: 3 participants from the study group and 9 from the control group scored 0 points on the pre-test.

The post-test showed a considerable improvement from both groups, the study group's average attempts dramatically increased to 3.9 of 4 and the control group's average was 2.3 [Figure 9]. In the study group, 100% of participants attempted 3 or more problems. The control groups still had 4 participants, which is 20% who did not attempt a single problem.

Figure 9: Post-test Attempt Scores



Note: The study group had only 17 participants (numbered4-20), while the control group had 20.

Remark: 4 participants from the control group scored 0 points on the post-test.

Only 2 participants from the study group didn't attempt every problem, yet they still attempted 3 of 4. In stark contrast, the control group as a whole didn't attempt 39 of the 80 possible problems [Figure 10 and 11].

Figure 10:
Study Group Post-test Attempt

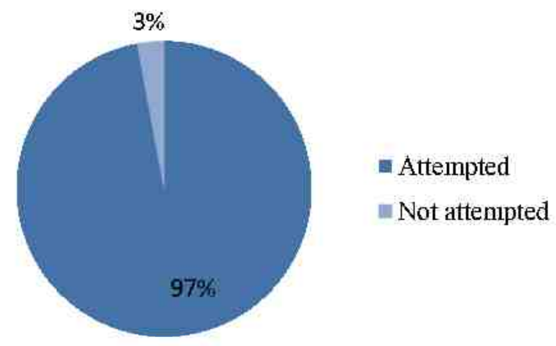
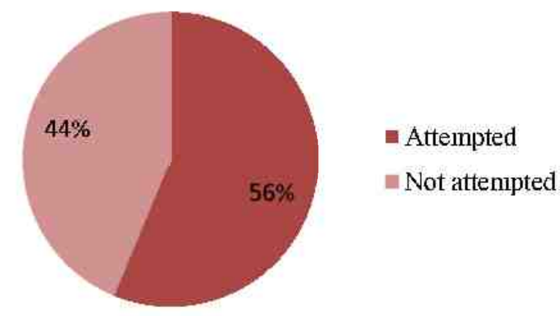


Figure 11:
Control Group Post-test Attempt

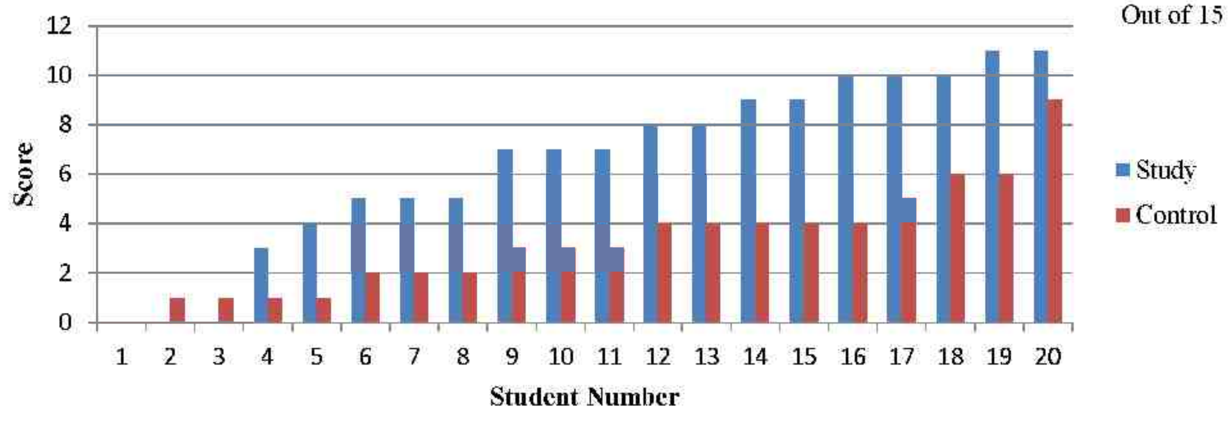


Therefore, we can definitely state that using iPads to explain graphing quadratic functions significantly improved students' self-confidence to try problem solving. In other words, having access to the iPad made the students at least curious about the graphing application

4. Conceptual Scores

The study group outperformed the control group on the conceptual questions as well. Pre-test averages were 7.6 points and 3.3 points, respectively [Figure 12]. An unpaired t-test confirmed the apparent significant difference in the means of the two groups.

Figure 12: Pre-test Conceptual Scores

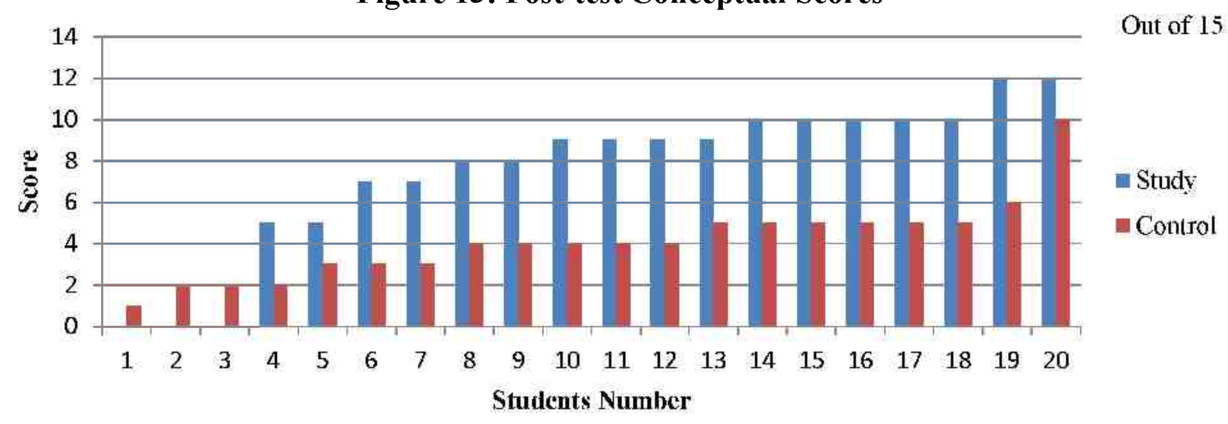


Note: The study group had only 17 participants (numbered 4-20), while the control group had 20.

Remark: 1 participant in the control group scored 0 on the pre-test.

Post-test results on the conceptual questions show the study group again outperforming the control group. The study group increased their average to 8.8 points, an average improvement of 1.2 points. The control group's average increased to 4.1 points, an average improvement of only 0.9 points [Figure 13]. An unpaired t-test shows a significant difference in the two means scores on the post-test, but we cannot conclude much as the groups were not shown to be homogeneous in their pre-test results.

Figure 13: Post-test Conceptual Scores

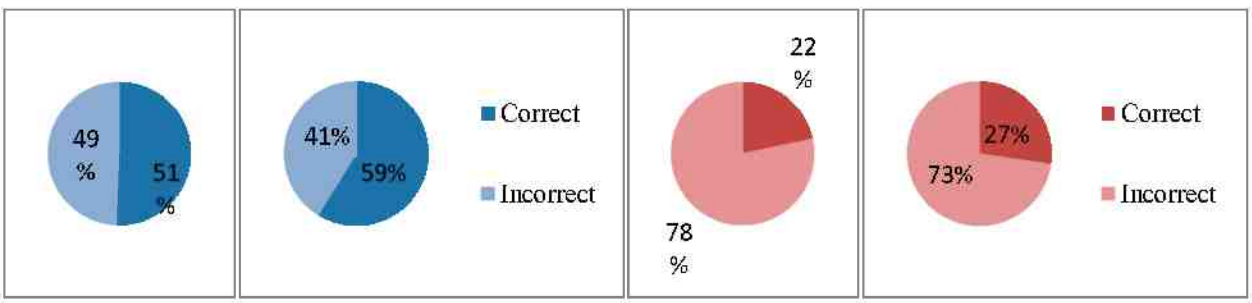


Note: The study group had only 17 participants (numbered 4-20), while the control group had 20

Another aspect to consider is the group improvements on the conceptual questions, 1.2 points and 0.9 points, respectively. An unpaired t-test suggests that there was no significant difference between the two groups average improvement. Figure 14 shows that the study group's cumulative conceptual score improved by 8 percent, where the control group's only improved by 5 percent. Considering the fact that the study group performed better on the pre-test and diminishing returns, then these results may warrant further investigation.

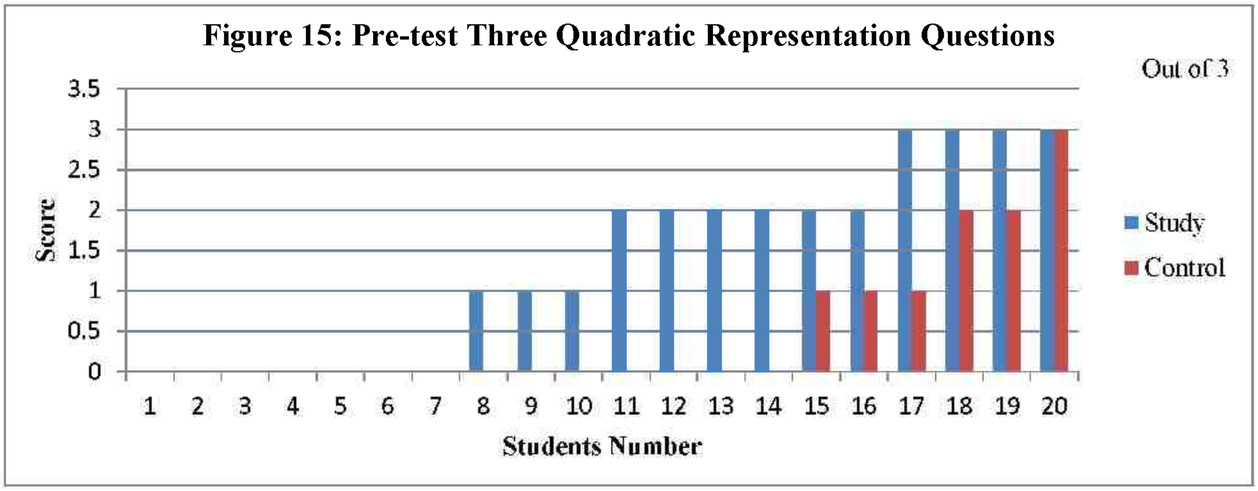
Figure 14: Conceptual Cumulative Percentages

Study Pre-test **Study Post-test** **Control Pre-test** **Control Post-test**



5. Quadratic Representation Scores

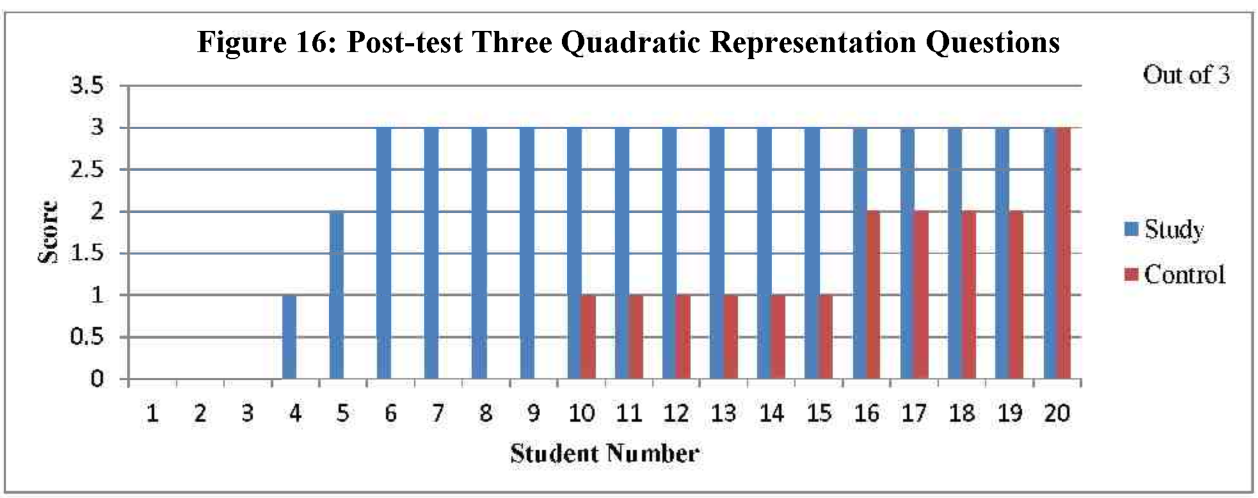
The differences in the scores between the study and control groups with respect to specific blocks of questions were quite telling, but also expected. The block consisted of three questions (at the top of the backside [Appendix B2 and D2] of the pre-test and post-test) asking students to write three commonly used generalized representations of a quadratic function: standard form, factored form, and vertex form. All participants from both the control and study groups had been taught these three representations before the experiment. Again, the pre-test results [Figure 15] still indicate that the study group had a significantly higher initial knowledge level.



Note: The study group had only 17 participants (numbered 4-20), while the control group had 20.

Remark: 4 participants from the study group and 14 from the control group scored 0 points on the pre-test.

Prior to taking the post-test, the study group did the iPad graphing activity worksheet [Appendix B1 and B2]. Since the activity focused on traversing the three quadratic representations via graphical interpretation; the study group had more exposure to and practice in identifying and applying the three representations. The control group knew these concepts through traditional teaching only. The results [Figure 16] of the post-test show a dramatic improvement in the study group's ability to identify the three main quadratic representations, a majority of them achieved perfection - 3 out of 3 graphical representations provided correctly.



Note: The study group had only 17 participants (numbered 4-20), while the control group had 20.

Remark: 9 participants from the control group scored 0 points on the post-test.

While both the study and control groups improved, the study group showed the largest improvement, averaging 1.24 points per participant. In contrast, the control group's improvement averaged 0.35 points per participant. The study group's mean improvement was statistically larger than that of the control group's mean improvement. Also, when we look at the total number of points that each group achieved collectively [Figure 17 and 18], the results are even more compelling. Clearly the study group understood the concept of different quadratic representations almost perfectly by the conclusion of the study.

Figure 17:
Study Group Post-test Quadratic Representation Questions

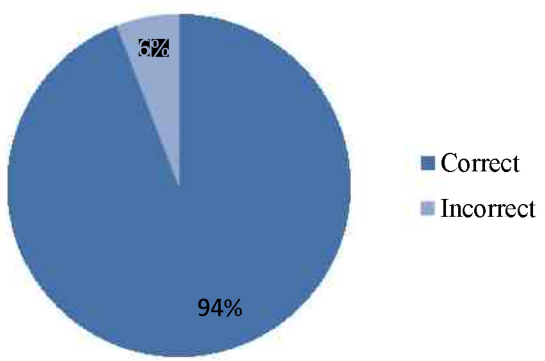
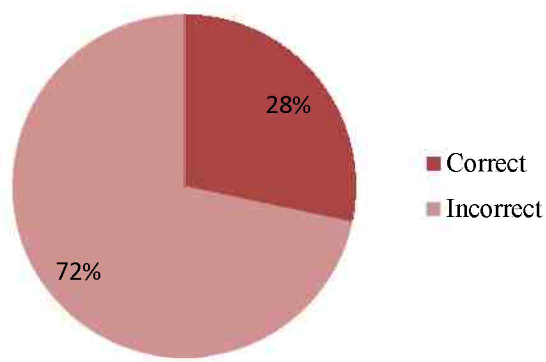


Figure 18:
Control Group Post-test Quadratic Representation Questions



Therefore, we can conclude that our iPad activities lead to mastering the representations of quadratic functions by almost all participants, an excellent result!

D. Results and Conclusions

Since the study group significantly outperformed the control group on the pre-test and post-test, the comparison of the results is not sufficiently relevant. There could be many reasons for this unexpected situation, but it seems likely that the study group had more preliminary knowledge of the graphs of quadratic functions. In future case studies, the post-test should be analyzed immediately to assure validity of the results. Ideally, the study group and control group will have the same teacher, as to control one more variable. However, by grouping similar questions and further analyzing individual questions, we can make several interesting observations based on our experience.

We expected the study group to improve on the application portion of the assessment because the graphing activity focused students' attention on the various representations of a quadratic function, and how those representation relate to graphing the vertex and intercepts of the parabola. However, it is interesting that the control group improved the most on the application portion focused specifically on graphing quadratic functions. It is possible that the traditional lecture method worked as well as the iPad activity. An important consideration is the fact that the iPad graphing activity increased students' self-confidence, which is evident by the fact that every student in the study group attempted nearly every application problem. This result alone warrants reason for further investigation into graphing technologies. Participation in the learning process is vital to improving students' understanding. Students who do not attempt problems will not learn from their experiences and never achieve mastery of the subject.

The unpaired t-test showed no significant difference between the means of the study group and control group's improvement of scores on the post-test. We would like to claim that is due to the initial significantly better performance of the study group, which was also performing better on every post-test or post-test that we have analyzed. The study group showed significant improvement on every test and subtest and nearly flawless mastery of quadratic representations. These results strongly suggest that the iPad graphing activities effectively influence the learning process.

Initially, the purpose of the study was to help students improve their practical ability to graph quadratic functions. This reasoning followed from the assumption that by using graphing technology, students could interpret the relationships between the representation of quadratic functions and the graphs, and then apply their knowledge to future problems. Remarkably, the iPad activity significantly improved the conceptual knowledge associated with graphing quadratic functions, and how to identify different quadratic representations associated with the vertex and intercepts of the parabola. The improvement of paper and pencil-based graphing was not as significant as we had expected.

In summary, this study suggests that the use of iPad graphing technology can be used to successfully peak student's interest and lower their affective filter. Further research is needed to study the long-term effects of this higher level of student participation. Most certainly, improved student participation would be welcome in almost any educational setting. The study also advocates that the iPad graphing activity aided students in the understanding and algebraic implementation of the three main representations of quadratic functions used in the graphing process. Based on this study, we recommend using iPad activities to introduce the idea of graphing quadratic functions, to improve base-level knowledge and to spark the interest of students in algebra classes. However, this study should be repeated on a larger scale with more classrooms participating to validate our interpretation of these results.

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Katrina Hammer – Collaborator

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G. Appendix

1. Demographic Survey

Student Informational

Name: ________________________ **Date:** ______________

Age: _____ **Gender:** _________ **Class:** F Soph J Sr

Major: _________________

Which ethnicity(s) you most often consider yourself: ___________________________________

Your primary language: _________________ Second languages? ________________________

What style of learning best fits you (visual, kinesthetic, auditory, other)? Multiple? Why?

____

____

Last Math Course taken: _________________________________ When? _________________

Have you ever used a graphing calculator? ____
(To graph)
Have you ever used an Apple product before? ____
(I-pod, MacBook,…)
Have you ever used an I-Pad before? ____

Rate your own skill level in the following categories on a scale from 0 to 5
(0-none 1-poor 3-average 5-excellent)

• The use of technology/computers	0	1	2	3	4	5
• Solving quadratic equations	0	1	2	3	4	5
• Graphing quadratic equations	0	1	2	3	4	5
• College algebra in general	0	1	2	3	4	5
• Math in general	0	1	2	3	4	5

Give an example of a quadratic function: ____

What shape is associated with a quadratic function? _________________________________

2a. Pre-test Graphing Questions

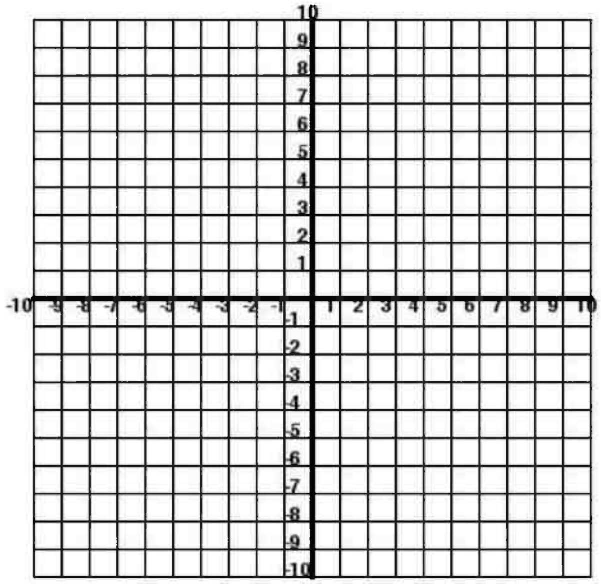
Quiz 1

Instructions: Graph the following functions and rewrite each function in at least two equivalent forms.

1. $(x+3)^2 - 4 = f(x)$

$=$

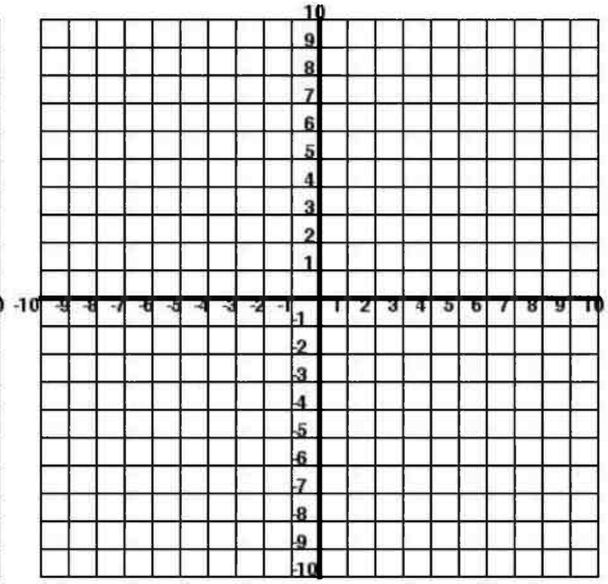
$=$



2. $(x+3)(x-3) = f(x)$

$=$

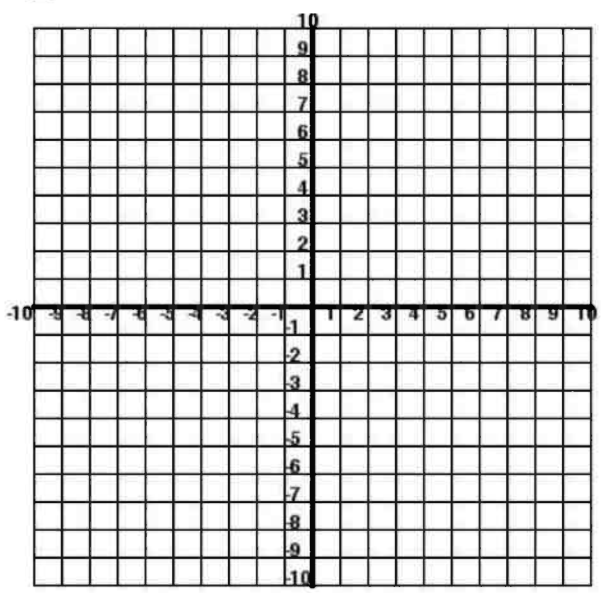
$=$



3. $x^2 - 6x + 5 = f(x)$

$=$

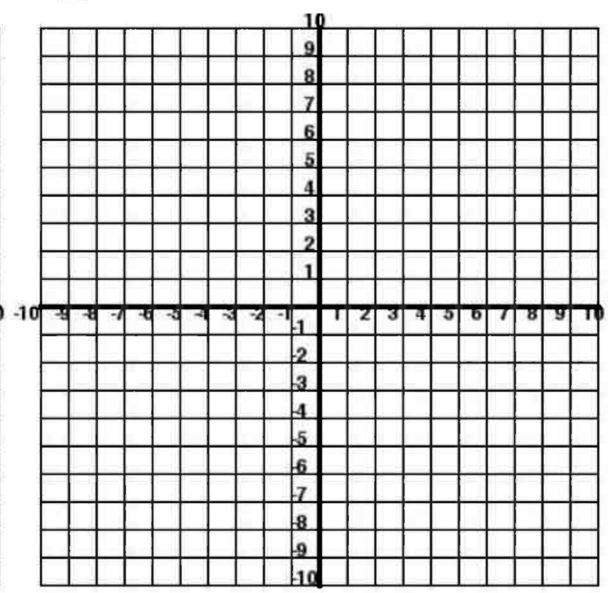
$=$



4. $2x^2 - 4x - 6 = f(x)$

$=$

$=$



2b. Pre-test Conceptual Questions

Write the three main generalized forms of quadratic functions:

Standard form ____

Factored form ____

Vertex form ____

Does $x^2 = 25$ mean that $x = 5$? Why or why not? Sketch the picture to the right.

____

Describe a case where a quadratic function has only one x-intercept. (Graphically or algebraically)

Sketch the picture to the right.

____

____

A quadratic function has no x-intercepts and opens upward. Which quadrant(s) must the graph lay?

Sketch the picture to the right.

____

____

Two quadratic functions have the same solutions. Are they the same functions? Explain.

Sketch the picture to the right.

____

____

A quadratic function has vertex $(-2, \frac{1}{3})$ and opens downward. What is the maximum of the function?

Sketch the picture to the right.

____

____

Name a visual property of the vertical line that passes through the vertex of a quadratic function?

____

Write the quadratic formula: ____

3a. Activity Worksheet Page 1

Graphing Worksheet

Quadratics

1. Graph the function $f(x) = x^2 - 6x + 5$ in the I-Pad graphing application
   Visually what are the x-intercepts of the graph?

   Write $x^2 - 6x + 5$ in factored form:

   Visually what is the vertex of the graph?

   Write $x^2 - 6x + 5$ in vertex form:

2. Graph the function $g(x) = -x^2 - 10x - 16$ in the I-Pad graphing application
   Visually what are the x-intercepts of the graph?

   Write $-x^2 - 10x - 16$ in factored form:

   Visually what is the vertex of the graph?

   Write $-x^2 - 10x - 16$ in vertex form:

3. Graph the function $h(x) = 3x^2 - 24x + 45$ in the I-Pad graphing application
   Visually what are the x-intercepts of the graph?

   Write $3x^2 - 24x + 45$ in factored form:

   Visually what is the vertex of the graph?

   Write $3x^2 - 24x + 45$ in vertex form:

3b. Activity Worksheet Page 2

4. Graph the function $k(x) = x^2 - 3x + \frac{5}{4}$ in the I-Pad graphing application
   Visually what are the x-intercepts of the graph?

   Write $x^2 - 3x + \frac{5}{4}$ in factored form:

   Visually what is the vertex of the graph?

   Write $x^2 - 3x + \frac{5}{4}$ in vertex form:

5. Graph the function $l(x) = \frac{1}{2}x^2 - 6x + 16$ in the I-Pad graphing application
   Visually what are the x-intercepts of the graph?

   Write $\frac{1}{2}x^2 - 6x + 16$ in factored form:

   Visually what is the vertex of the graph?

   Write $\frac{1}{2}x^2 - 6x + 16$ in vertex form:

6. Graph the function $m(x) = x^2 - 6x + 11$ in the I-Pad graphing application
   Visually what are the x-intercepts of the graph?

   Write $x^2 - 6x + 11$ in factored form: (complex factorization)

   Visually what is the vertex of the graph?

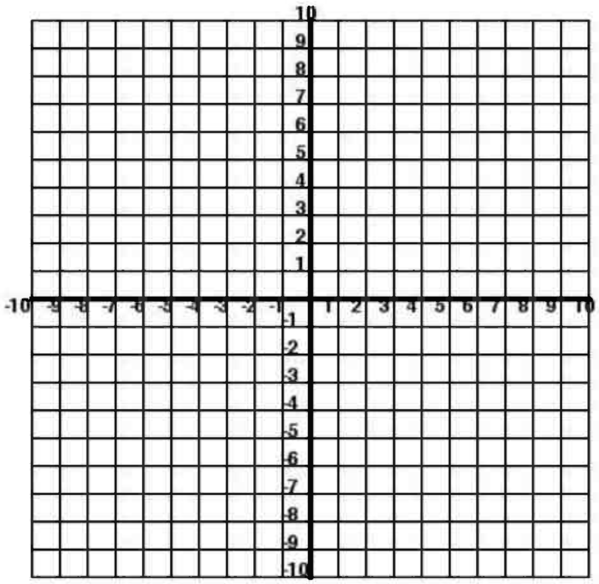
   Write $x^2 - 6x + 11$ in vertex form:

4a. Post-test Graphing Questions

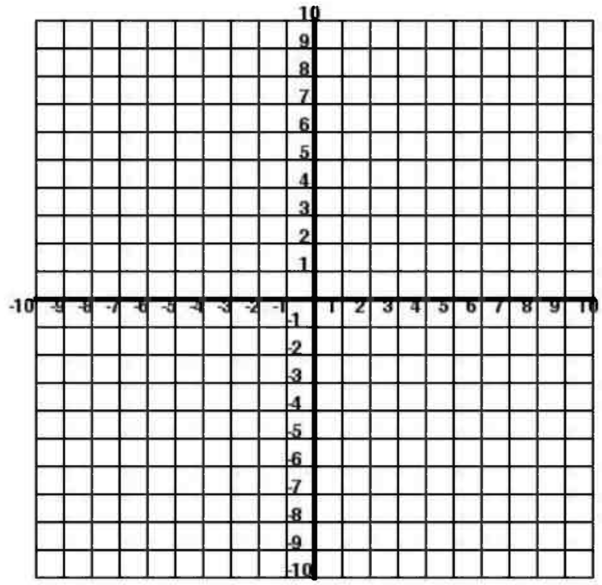
Quiz 2

Instructions: Graph the following functions and rewrite each function in at least two equivalent forms.

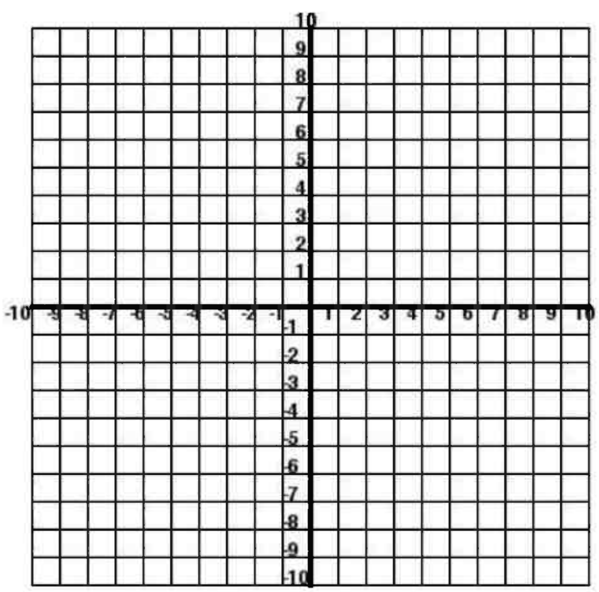
2. $(x+1)^2 - 4 = f(x)$
   $=$
   $=$



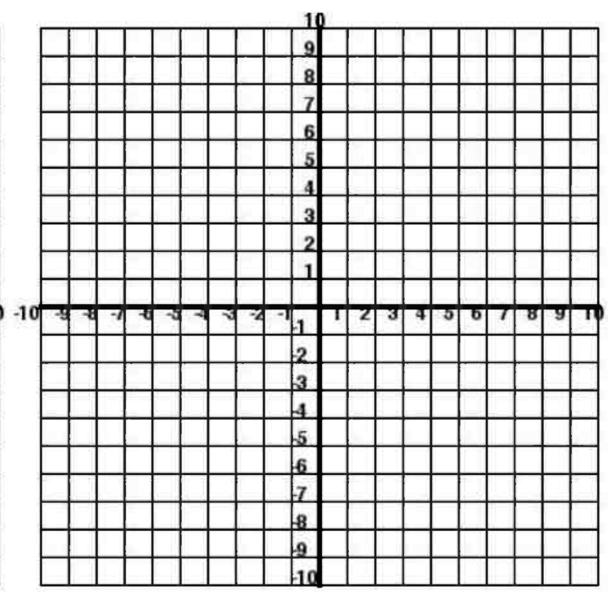
2. $(x+1)(x-5) = f(x)$
   $=$
   $=$



3. $x^2 - 8x + 12 = f(x)$
   $=$
   $=$



4. $2x^2 + 4x - 6 = f(x)$
   $=$
   $=$



4b. Post-test Conceptual Questions

Write the three main generalized forms of quadratic functions:

Standard form ____

Factored form ____

Vertex form ____

Does $x^2 = 36$ mean that $x = 6$? Why or why not? Sketch the picture to the right.

____

Describe a case where a quadratic function has only one x-intercept. (Graphically or algebraically)

Sketch the picture to the right.

____

____

A quadratic function has two x-intercepts and opens downward. Which quadrant(s) must the graph lay?

Sketch the picture to the right.

____

____

Give two different examples of a quadratic function whose solutions are $x = 5$ & $x = -2$.

Sketch the picture to the right.

____

____

How does one determine if quadratic functions have a minimum or maximum?

Sketch the picture to the right.

____

____

The vertical line that cuts a quadratic function into two symmetric halves passes through what special point on the parabola? ____

Write the quadratic formula: ____