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# One-to-one iPad Technology in the Middle School Mathematics and Science Classrooms

**Sharon Grace Bixler**

## Abstract

Computer technology (CT) for student use is a popular avenue for school districts to pursue in their goal to attain higher academic achievement. The purpose of this study is to examine the use of iPads in a one-to-one setting, where every student has his own device 24/7, to determine the effects, if any, on academic achievement in the areas of mathematics and science. This comparison study used hierarchical linear modeling (HLM) to examine three middle schools in a private school district. Two of the schools have implemented a one-to-one iPad program with their sixth through eighth grades and the third school uses computers on limited occasions in the classroom and in a computer lab setting. The questions addressed were what effect, if any, do the implementation of a one-to-one iPad program and a teacher's perception of his use of constructivist teaching strategies have on student academic achievement in the mathematics and science middle school classrooms. The research showed that although the program helped promote the use of constructivist activities through the use of technology, the one-to-one iPad initiative had no effect on academic achievement in the middle school mathematics and science classrooms.

**Keywords:** One-to-one, iPad, mathematics, science, middle school.

## Introduction

Mobile devices, such as the iPad and other tablet-based devices, are the latest technology schools are looking toward for assistance in the teaching of the CCSSM and NGSS standards. There has been a substantial amount of research on computer technology in the areas of mathematics and science showing the benefits of its implementation in the classroom (Bayraktar, 2002; Li & Ma, 2010). However, according to Fisher, Lucas, and Galstyan (2013), "There is very little research involving the direct observation of the usage of iPads in the classroom" (p.166). Most of the iPad-focused research involves analyzing students' and teachers' perceptions of the benefits of iPads rather than measuring its effects on academic achievement. In order for school systems to justify the expense of incorporating mobile devices, such as the iPad, into their instruction, research needs to be conducted to determine the effect, if any, on students' learning.

The purpose of this study is to examine the use of iPads in a one-to-one setting, where every student has his own device 24/7, to determine the effects, if any, on academic achievement in the areas of mathematics and science. This research project examined three middle schools in a private school district. Two of the schools have implemented a one-to-one iPad program with their sixth through eighth grades and the third school uses computers in the classroom and in a computer lab setting on periodic occasions. Parents and schools have invested large amounts of money not only on the devices themselves but also on the schools' infrastructures to ensure adequate wireless Internet capabilities are in place to support multiple devices. The limitation of this study is that it is designed to provide an analysis of academic achievement for one specific private school district, thus the results are limited. However, its results may be used as a starting point for other districts grappling with determining the benefits of one-to-one iPad programs.

By determining the effects of the iPad program, the district will be able to see some of the results of the time and fiscal resources that have been dedicated to the program. Through the use of hierarchical linear modeling (HLM), the research examined the Measure of Academic Progress (MAP) scores obtained over two years from two schools that participated in a one-to-one iPad program and one school that used alternate forms of technology in instruction. A survey addressing the perceived use of constructivist strategies was administered to analyze if a teacher's perception of his use of constructivist strategies affects results.

## Method

This study addressed the following research questions:

1. What effect, if any, does implementation of a one-to-one iPad program have on student academic achievement in the mathematics and science middle school classrooms?
2. What effect, if any, does a teacher's perception of his or her use of a constructivist teaching style have on student academic achievement in the mathematics and science middle school classrooms?

### Research Design

The comparison study examined three schools and their technology use in the middle school mathematics and science classrooms over participants' $6^{th}$ and $7^{th}$ grade years. By collecting data at multiple time points over a two-year period, the project examined if a one-to-one iPad program significantly affected students' growth in mathematics and science academic achievement. This type of survey method does not allow for randomization of participants and was preferable for the study since random assignment of participants by the researcher was not possible.

Achievement test scores in mathematics and science were collected from all students. These scores measured academic achievement over the two-year period at up to six time points for each student. Participants were drawn from three schools. Two of the schools had implemented a one-to-one program where all middle school students had their own iPads for school and home use. The third school used computers on a limited basis in the classroom and in a computer lab at the school. The participants, both students and teachers, at the two one-to-one iPad schools were invited to complete surveys to determine the frequency, ease, and type of use of the iPads during instruction. The participants, both students and teachers, at the third school completed a survey addressing frequency, ease, and type of computer technology used at their school. A survey was administered to the teachers to determine teachers' perceptions of the use of constructivist teaching strategies during instruction. This survey was used to provide data for the second question of the project as to whether teachers' perceptions of their use of constructivist teaching strategies affected students' achievement scores.

For this project, the data was analyzed using a two-level hierarchical linear model (HLM) with a hierarchical structure of data with repeated measures nested within students. Raudenbush and Bryk (2002) explained that when using repeated measures, data is collected at different times and then nested within study participants (as cited in Woltman, Feldstain, MacKay, and Rocchi, 2012, p.52). SPSS, a statistical package for the social sciences, was used to prepare the data for the HLM software and to analyze the residual files to determine the top twenty-five students in regards to initial statuses and rates of growth.

### Population

The study examined the current $8^{th}$ grade students at three private middle schools. The researcher of this study was one of the mathematics teachers that participated in the study. The research site was a private school district located in the Southeast portion of the US. The three PreK-8 schools are all of similar size, ranging from approximately 400 to 530 students per school.

A total of 112 students served as the participants of the study that examined data from the 2013-2014 and 2014-2015 school years. If a student was not at the school for both years, he was removed from the study. Ten of the thirteen teachers (77%) of mathematics and science at the middle school level, one being the researcher, completed the survey addressing their perceptions of how frequently they use constructivist-teaching strategies in their classroom. The teachers and the students were invited to complete a survey identifying the frequency of use and the ways the iPads or other technology were implemented in instruction. Ten of the teachers (77%) chose to complete the survey as well as eighty-six (77%) of the students.

The students at the two iPad schools were part of a one-to-one initiative in which every student began using an iPad at the beginning of $6^{th}$ grade at school as well as at home. The two iPad schools had 29 students at one school and 50 students at another, for a total of 79 participants who used iPads in a one-to-one setting. The third school that did not use iPads had a total of 33 student participants. This was a convenience sampling since the students participating were chosen due to their school attendance choice.

In mathematics, the students covered the sixth and seventh grade Common Core State Standards for Mathematics (CCSSM, 2010) as well as various algebraic topics. None of the students were taking Geometry during the sixth or seventh grade years. In science, the students followed the Next Generation Science Standards (NGSS, 2013) by covering physical and life sciences in the sixth and seventh grades.

## Instrumentation and Reliability/Validity

### *NWEA MAP Test*

There were three types of instrumentation used in the research project. First, test scores from the Measure of Academic Progress (MAP), a computer adaptive test, developed by the Northwest Evaluation Association (NWEA), were used to measure students' growth by points on the RIT scale. The RIT scale score is based on the Rasch Unit scale that is an equal interval vertical scale. The MAP, through the use of computer-based adaptive assessment technology, measures individual student achievement, calculates student growth, and compares students' growth to other students (NWEA, 2013). Thorndike and Thorndike-Christ (2010) explained a computer-based adaptive test uses item response theory (IRT) as its basis, which "assumes the existence of a relatively unified underlying trait that determines an individual's ability to succeed with some particular type of cognitive task" (p.108). The trait can then be represented on a linear scale where people are placed in ordered sequence. Adaptive testing uses questions from a bank where each question has been assigned a difficulty level. It then adjusts the difficulty level of the test tasks to the student's ability. The test starts by giving a test question labeled at a 50% difficulty for the grade group and then raises or lowers the difficulty based on the student's response.

The study examined the mathematics and science MAP scores for the 2013-2014 and 2014-2015 school years of students who completed $6^{th}$ and $7^{th}$ grade during that time period. The MAP assessment is designed to measure students' achievement at multiple points during the school year. The testing window for the MAP to be administered is in the fall, winter, and spring giving up to six achievement scores for each student in each of the areas of mathematics and science over a two-year period.

### *NWEA MAP Test Reliability and Validity*

The NWEA (2004) used a combination of the test-retest and type of parallel forms to address reliability over time by analyzing Pearson correlations. Both types were administered over a seven to twelve month time span. Most coefficients were in the mid .80's to the low .90's with only two tests falling slightly below the acceptable .80 level. To determine the internal consistency of test items, the NWEA used the test characteristics; test information and RIT scale score, to calculate the marginal reliability coefficient. This resulted in consistency almost equal to coefficient alpha.

The NWEA (2004) addressed content validity by choosing test items that matched the content standards of the school district or state. It also took care to choose items that had a uniform distribution of difficulties. Two tests were given to students approximately two to three weeks apart and a Pearson correlation coefficient was used to determine the strength of correlation between the two tests with mid .80's considered a strong relationship.

### *Teacher Constructivist Strategies Survey*

Secondly, a teacher survey was administered that measured teaching styles. After not finding an appropriate survey, Henry (2003) created one designed to measure the use of constructivist and traditional teaching strategies. She used the survey to measure the correlation between constructivist teaching strategies and academic performance in the middle school. Henry found constructivist-teaching strategies did not have a significant effect on students' academic performance on the Florida Accountability scale. However, there was a positive correlation between the use of constructivist-teaching strategies and class size meaning the larger the class size the more frequent use of constructivist teaching strategies. Also, there was a negative correlation between constructivist teaching strategies and the number of behavior referrals per year indicating that the more constructivist teaching strategies were implemented in the classroom the less behavior referrals were submitted.

The Henry (2003) survey was administered to teacher participants in the present study to determine teachers' reported perceived use of constructivist teaching strategies in the classroom. The survey addressed three main topics- classroom management, teaching activities, and assessments. The questions identified with either constructivist or traditional teaching styles and asked participants to answer based on the Likert scale of 5 = Always, 4 = Frequently, 3 = Sometimes, 2 = Rarely, 1 = Never. The assignment of questions was as follows: 13 items addressing classroom management styles, 29 items addressing teaching activities, and 15 items addressing assessment strategies.

### *Teacher Constructivist Strategies Survey Reliability and Validity*

Henry (2003) created the survey by using "teacher forums, instructional strategy textbooks, the CRISS Manual (Santa, Havens, & Maycumber, 1998), the SHINES Manuel (Finger, 1999), the National Board Professional Teaching Standards (NBPTS, 2002) and reference books including Bruce Marlowe and Marilyn Page's *Creating and Sustaining a Constructivist Classroom* (Marlowe & Page, 1998)" (p.34). Henry addressed content validity by having a focus group of sixteen middle school teachers categorize individually and collectively each survey item as either constructive or traditional. Following that, five experts in the field of instructional strategies approved of the survey items and agreed the items were grouped in the correct categories of classroom management, teaching and learning activities, and assessment. A correlation analysis between scales was conducted to address construct validity. The analysis showed a positive correlation between traditional teaching style items and a negative correlation between traditional and constructivist styles, as well as constructivist items showing a positive correlation with other constructivist items. Henry (2003) addressed reliability by using Cronbach's Alpha to determine each item's association with other items. After deleting some items that detracted from internal consistency, all remaining items resulted in reliability estimates greater than or equal to an alpha of .60.

### *Teacher and Student Surveys of Technology Use*

Thirdly, the researcher created a survey that addressed the frequency of use, ease of use, and type of use of the technology, and their opinions of whether the use was beneficial to learning. The students were asked how often they used the technology in mathematics and science classes (daily, two to three times a week, once a week, one to three times a month, or rarely), how easy was it to use (very easy, somewhat easy, difficult, very difficult), and did they feel the technology helped them learn in mathematics and science classes (definitely helpful, helpful sometimes, helpful on rare occasions, not helpful at all). They were also asked what were the two most common ways the technology was used in the mathematics and science classrooms.

The teachers were asked how often they used the technology in their mathematics or science class for instructional purposes (daily, two to three times a week, once a week, one to three times a month, or rarely), how often the students used the technology in their classes (daily, two to three times a week, once a week, one to three times a month, or rarely), how easy was it to use (very easy, somewhat easy, difficult, very difficult), and did they feel the technology helped the students learn in mathematics and science classes (definitely helpful, helpful sometimes, helpful on rare occasions, not helpful at all). They were also asked what were the two most common ways the technology was used in their classrooms, how many years of experience they had and their current teaching certification and rank. In the state where the research was conducted, teachers are considered a Rank III with a bachelor's degree and teaching certificate, a Rank II with a master's degree, and a Rank I with 30 approved graduate or equivalent continuing education hours past a masters.

### *Research Design Reliability and Validity*

There are validity and reliability issues when using HLM and a comparison design. With a comparison design, groups are not randomly assigned, meaning there can be differences in how the students are allocated. Also, the characteristics of the setting may pose a threat. In this study, the settings are all small, private, suburban schools; thus generalizations to other school settings may not be appropriate (Creswell, 2009). When using HLM, there are steps to take when addressing validity. Group mean centering was not used since the groups do not differ dramatically. Another issue with validity is the small amount of participants involved in the study. To reach adequate power, HLM requires a large sample size (Woltman et al., 2012). To address assumptions in HLM, descriptive statistics were observed to identify any values that may be a potential problem. Level 1 residuals were checked for normal distribution (Anderson, 2012). With a population including 112 students and 10 teachers, validity is compromised. As a result, inferences drawn for this school district may not translate well to larger populations. HLM allows for the analysis of repeated measures to be nested within the students.

Following are the level one and level two variables used to analyze the MAP achievement test score data (Table 1).

**Level 1 Variables:** The MAP scores provided up to six measures of mathematics achievement and six measures of science achievement for each student that served as the continuous outcome variables for the study. In HLM, outcome variables are always at the first level of the hierarchy. Students were not eliminated if they did not have six scores since HLM allows for missing data at the first level (Woltman et al., 2012). MAP scores were entered using grand mean centering since MAP scores do not have a true zero point.

**Level 2 Variables:** The study was originally designed to use the student characteristics of attending or not attending one of the iPad schools, gender, and socioeconomic status (SES) as the level-two predictor variables. Socioeconomic status was determined by identifying those students who qualified for the national free or reduced lunch program. After identifying these students, there were only 6% of the participants who fell into this category so SES was removed from the list of student characteristics. The remaining predictor variables of iPad use and gender were treated as dichotomous variables.

Table 1. Variables for hierarchical levels

| Hierarchical Level | Hierarchical Level Description | Variables |
|---|---|---|
| Level-2 | Student Level | iPad use in a one-to-one setting<br>Gender |
| Level-1 | Repeated measures | MAP scores in mathematics and science over the students' 6th and 7th grade yrs. |

HLM was then used to determine if there was growth over time in mathematics and science academic achievement among students and whether student characteristics could predict academic growth. The level- 1 model (shown below) analyzed whether students varied significantly in their initial status and growth across six time points in mathematics and science achievement. The model for this portion of the analysis was as follows:

$Y_{ti} = \pi_{0i} + \pi_{1i}*(TIME_{ti}) + e_{ti}$
Within this model:
$Y_{ti}$ = *outcome (MAP scores)*
$t$ = *time*
$i$ = individual students
$\pi_{0i}$ = is the intercept, representing initial status
$\pi_{1i}*(TIME_{ti})$ = slope, in respect to time
$e_{ti}$ = the random effect of student $i$ with time $t$

After analyzing the level-1 model, the predictors of gender and iPad usage were introduced to determine their ability to predict growth in students' mathematics achievement. The model for this portion of the anaylsis was:
$Y_{ti} = \beta_{00} + \beta_{01}*SEX_i + \beta_{02}*IPAD\_USE_i + \beta_{10}*TIME_{ti} + r_{0i} + r_{1i}*TIME_{ti} + e_{ti}$

With this model: $\beta_{01}$, $\beta_{02}$, and $\beta_{10}$ serve as slopes for sex, iPad use, and time respectively along with $\beta_{00}$ serving as the intercept and the error terms listed for the model. A full model was not created for science since the null model showed students did not vary significantly in their growth in the science classroom. Upon completion of the HLM analysis, the survey responses of the teachers' perceptions of constructivist strategies and the student and teacher surveys addressing uses of the technology were examined using descriptive statistics to gather a broader picture of the learning environments that HLM could not provide.

## Analysis

The analysis for this study was conducted in three parts using the data from 112 students and 10 teachers from three different schools, two of which were part of a one-to-one iPad initiative (Table 2). First an HLM analysis was conducted to determine if iPad use had any effect on growth in points on the RIT scale for academic achievement in the area of mathematics over students' 6th and 7th grade years. Secondly, the same HLM analysis was conducted for students' growth in points in the area of science. Next, the teacher constructivist teaching strategies survey and student and teacher use of technology surveys were examined using descriptive statistics.

Table 2. Descriptive statistics of student and teacher participants

| | **Frequency** | **%** |
|---|---|---|
| School Participants | | |
| School A (iPad) | 29 | 25.9 |
| School B (iPad) | 50 | 44.6 |
| School C (Non-iPad) | 33 | 29.5 |
| Total iPad Users | 79 | 70.5 |
| Total non-iPad Users | 33 | 29.5 |
| | | |
| Student Gender | 52 | 46.4 |
| Female | 60 | 53.6 |
| Male | | |
| | | |
| Teacher Participants | 5 | 50.0 |
| School A (iPad) | 2 | 20.0 |
| School B (iPad) | 3 | 30.0 |
| School C (Non-iPad) | 7 | 70.0 |
| Total iPad Users | 3 | 30.0 |
| Total non-iPad Users | | |
| | | |
| Teacher Gender | 9 | 90.0 |
| Female | 1 | 10.0 |
| Male | | |

**Mathematics Achievement**

The first data set included 112 students with up to six mathematics achievement scores over the 2013-2014 and 2014-2015 school years. Scores were analyzed, first, to determine if students varied significantly in their initial statuses and growth in points. After using grand mean centering for the MAP test scores in mathematics, the level-1 model created by HLM was $MATH_{ti} = \pi_{0i} + \pi_{1i}*(TIME_{ti}) + e_{ti.}$

The null model (Table 3) showed students varied significantly in their initial statuses and their point growth across the six time points. There was a positive (0.32), although not strong, correlation between initial status and point growth indicating higher achieving students grew at a faster rate than the lower achieving students. The average initial status, being the fall score of the student's sixth grade year, for the population was 227.49 with an average 3.18 point growth from one time point to the next.

Table 3. Results of null model of mathematics achievement

| **Fixed Effect** | **Coefficient** | **SE** | **t-ratio** | **p-value** |
|---|---|---|---|---|
| Intercept (Initial MAP score) $\beta_{00}$ | 227.49 | 1.03 | 221.05 | <0.001 |
| For TIME slope, $\pi_1$ | | | | |
| Intercept 2, $\beta_{10}$ | 3.18 | 0.12 | 27.03 | <0.001 |
| | | | | |
| **Random Effect** | **Variance** | **d.f.** | **Chi-square** | **p-value** |
| Intercept 1, $r_0$ | 110.46 | 111 | 1439.49 | <0.001 |
| Time slope, $r_1$ | 0.57 | 111 | 174.01 | <0.001 |
| level-1, e | 17.40 | | | |

After showing there was significant growth, the predictor variables of iPad use in a one-to-one setting and gender were introduced into the analysis with results shown in table 4. Both iPad use and gender were dichotomously coded. The full analysis showed gender and iPad use were not significant in predicting growth.

After deleting predictors with the highest p-value, it was found all predictors remained insignificant when determining if they were capable of predicting the growth for students. The only significance was iPad use in relation to initial status. Those students who used the iPad had an average initial status of 5.21 points lower than those who did not use iPads. In regards to the first question of the study, it was found that iPad use in a one-to-one setting did not affect students' mathematics achievement for this study.

Table 4. Results of full model of mathematics achievement

| **Fixed Effect** | **Coefficient** | **SE** | **t-ratio** | **p-value** |
|---|---|---|---|---|
| Intercept, $\beta_{00}$ (Initial MAP score) | 232.04 | 2.23 | 104.14 | <0.001 |
| Sex, $\beta_0$ | -1.59 | 2.01 | -0.79 | 0.429 |
| iPad Use, $\beta_{02}$ | -5.40 | 2.25 | -2.40 | 0.018 |
| For TIME slope, $\pi_1$ | | | | |
| Intercept 2, $\beta_{10}$ | 3.23 | 0.25 | 12.86 | <0.001 |
| Sex, , $\beta_{11}$ | -0.02 | 0.24 | -0.10 | 0.925 |
| iPad Use, $\beta_{12}$ | -0.06 | 0.25 | -0.22 | 0.825 |
| | | | | |
| **Random Effect** | **Variance** | **d.f.** | **Chi-square** | **p-value** |
| Intercept 1, $r_0$ | 106.24 | 109 | 1367.38 | <0.001 |
| TIME slope, $r_1$ | 0.60 | 109 | 173.95 | <0.001 |
| level-1, $e$ | | | | |

**Science Achievement**

The second data set included the same 112 students with up to six science achievement scores over the 2013-2014 and 2014-2015 school years. Scores were analyzed, first, to determine if students varied significantly in their initial statuses and growth in points. After, using grand mean centering for the MAP test scores in science, and dichotomously coding gender and iPad use, the HLM analysis was first run without the predictors to analyze the null model, explained in the methodology.

The null model (Table 5) showed students varied significantly in their initial statuses but not in their growth across the time points measuring science achievement. There was a weak, negative correlation (-0.29) between initial status and growth indicating the gap between the high and low achieving students was narrowing. The average initial status was 213.27 with an average growth in points from one time point to the next of 1.42 points.

Table 5. Results of null model of science achievement

| **Fixed Effect** | **Coefficient** | **SE** | **t-ratio** | **p-value** |
|---|---|---|---|---|
| Intercept (Initial MAP score) $\beta_{00}$ | 213.27 | 0.78 | 272.22 | <0.001 |
| For TIME slope, $\pi_1$ | | | | |
| Intercept 2, $\beta_{10}$ | 1.42 | 0.12 | 11.74 | <0.001 |
| | | | | |
| **Random Effect** | **Variance** | **d.f.** | **Chi-square** | **p-value** |
| Intercept 1, $r_0$ | 54.17 | 111 | 509.19 | <0.001 |
| Time slope, $r_1$ | 0.07 | 111 | 115.52 | 0.365 |
| level-1, e | 22.68 | | | |

After determining growth was not significant for science achievement, a full model analysis introducing iPad use and gender was not conducted. As a result of there being no variance among students, iPad use was not a factor in students' growth in the middle school science classroom.

**Teacher Survey of Perceived Use of Constructivist Strategies**

The Henry (2003) survey was administered to the teachers to find their reported perceived use of constructivist strategies in the classroom. Ten of the thirteen teachers participated in the survey (77%). To determine the constructivist score, the mean was calculated using the responses to the questions addressing constructivist approaches to teaching. This analysis was similar to the study conducted by Henry comparing the frequency of constructivist strategies effect on academic performance, student social behavior, and relationship to class size as well as Koh' et al. (2014) study which analyzed the teachers' perceptions of constructivist-oriented TPACK in relation to teachers' age, gender, teaching experience, and teaching level. Although the study does not have enough teachers to provide a strong analysis, some interesting things emerged that would warrant another study with a larger sample size.

Table 6 below shows the descriptives and constructivist scores of the ten teachers who completed the constructivist strategies survey. A few things to note, the three teachers with the most experience had the lowest perceived use of constructivist teaching strategies. Also, in regards to education, three of the top four teachers had received a Rank I teaching certificate. In the state of the study, a Rank III signifies the teacher has a bachelors degree and a teaching certificate, a Rank II signifies the teacher has completed a masters in education, a Rank I signifies the teacher has completed 30 hours of approved graduate work or equivalent continuing education past the masters. A final interesting note is four of the top five constructivist strategy scores belonged to science teachers. The implications of these findings will be discussed in the following chapter.

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Table 6. Descriptive statistics for constructivist strategies survey

| | **Subject Taught** | **Yrs. Experience** | **Education** | **iPad school** | **Constructivist Score** |
|---|---|---|---|---|---|
| Teacher A | Science | 6 | Rank II | no | 3.58 |
| Teacher B | Science | 15 | Rank I | yes | 3.52 |
| Teacher C | Math | 9 | Rank I | yes | 3.45 |
| Teacher D | Science | 14 | Rank I | yes | 3.35 |
| Teacher E | Science | 11 | Rank II | yes | 3.32 |
| Teacher F | Math | 9 | Rank II | yes | 3.29 |
| Teacher G | Math | 3 | Rank III | no | 3.19 |
| Teacher H | Math | 34 | Rank II | no | 3.16 |
| Teacher I | Math | 20 | Rank II | yes | 2.90 |
| Teacher J | Science | 27 | Rank I | yes | 2.58 |

When broken down into the three categories of classroom management, teaching activities, and assessment, the weakest category for perceived use of constructivist teaching strategies falls in the area of assessment (Table 7). This included not only the type of assessment given but also the freedom given to students to choose their own form of assessment.

Table 7. Breakdown of the total score of constructivist teaching strategies

| | **Management** | **Teaching activities** | **Assessment** |
|---|---|---|---|
| Teacher A | 3.71 | 3.59 | 3.43 |
| Teacher B | 3.71 | 3.47 | 3.43 |
| Teacher C | 3.57 | 3.53 | 3.14 |
| Teacher D | 3.43 | 3.53 | 2.86 |
| Teacher E | 3.86 | 3.47 | 2.43 |
| Teacher F | 3.43 | 3.18 | 3.43 |
| Teacher G | 3.57 | 3.18 | 2.86 |
| Teacher H | 3.14 | 3.24 | 3.00 |
| Teacher I | 3.14 | 3.00 | 2.43 |
| Teacher J | 3.00 | 2.59 | 2.14 |

Overall, the teachers at the iPad schools had a mean perceived use of 3.20 with the non-iPad teachers reporting a mean perceived use of 3.31. A non-parametric U test was performed to determine if there was a significant difference between the teachers in the one-to-one iPad schools and those at the other school. It was found there was not a significant difference ($U=10$, $p=0.91$). The survey also had questions addressing traditional teaching strategies. Every teacher had a higher reported perceived score of traditional teaching strategies than their constructivist strategy score.

### Teacher Survey of Technology Use

The teachers also filled out a survey addressing the frequency of use for themselves and their students, how helpful they thought the technology was in assisting learning, and the ease of use of the technology. The mathematics teachers' and science teachers' data have been combined for this section into iPad users or non-iPad users to ensure anonymity of responses. With this survey, ten of the thirteen teachers (77%) participated.

Teachers were asked to report their technology use and that of their students as daily, two to three times a week, once a week, one to three times a month, or rarely. At the iPad schools, 100% reported students used the iPads either daily or two to three times a week. In contrast, 100% of the teachers at the non-iPad school reported students used a computer rarely. When using the iPads or computers for instruction, 100% of teachers at the iPad schools reported using iPads or computers either daily or two to three times a week. At the non-iPad school, 66% reported using a computer rarely and 33% reported using it once a week for instruction.

When reporting how teachers used the iPads or computers for instruction, there was no clear use that was mentioned more than others. The uses included to create tutorial videos, access edmodo website to share resources and communicate with students, search for appropriate apps, track behavior, and use Socrative, a formative assessment tool. The non-iPad teachers reported using computers to monitor students on Khan Academy, administer MAP tests, show YouTube videos, and search for instructional ideas. When reporting how the students were using the technology, iPad teachers reported the students used the iPads for ixl, edmodo for communication and resources, creating presentations, accessing online textbook, exploring animated models, taking notes, and using Socrative. The non-iPad teachers reported the students used computers for ixl, Khan Academy, and science research.

Along with their frequency, teachers also reported their opinions on whether using technology helped students learn in class. Teachers chose from the options of definitely helpful, helpful sometimes, helpful on rare occasions, or not helpful at all. Teachers also reported the ease of use by choosing very easy to use, somewhat easy, difficult, or very difficult. With helpfulness, 100% of iPad teachers reported the technology as definitely helpful and 100% of non-iPad teachers reported it as either definitely helpful or sometimes helpful. 100% of iPad teachers reported the iPads as very easy or somewhat easy. 66% of the non-iPad teachers reported the technology as somewhat easy and 33% as difficult to use.

### Student Survey of iPad Use

The students completed a survey addressing how frequently they used the iPads in their mathematics and science classes, whether the iPad technology was helpful in their learning process, and how easy it was to use the iPad. The iPad schools had 62 students (78%) participate in the survey. With frequency, students reported a strong use of the technology. The students were given the choices of daily, two to three times a week, once a week, one to three times a month, or rarely. In mathematics, 89% of the students responded they used the iPads either daily or two to three times a week. In science, 87% of the students responded they used the iPads either daily or two to three times a week.

Students reported they were using them for a variety of reasons. However, the most common uses in mathematics were for accessing their online textbook, completing problems on ixl, a tutorial based mathematics website, and using the iPad's calculator. The most common uses in science were to access their online textbooks, accessing edmodo, an online classroom designed for teachers and students to communicate about assignments, administer and complete assessments, and share documents, and searching the Internet for information.

Along with their frequency, students also reported their opinions on whether using the iPads helped them learn in class. Students chose from the options of definitely helpful, helpful sometimes, helpful on rare occasions, or not helpful at all. In mathematics, 94% of the students felt the technology was definitely or sometimes helpful in their learning. In science, 90% of the students reported they felt technology was definitely or sometimes helpful with assisting them in the learning process. With the iPads, the students reported the ease of use by choosing very easy to use, somewhat easy, difficult, or very difficult. With this topic, 100% of the students reported the iPads were either very easy or somewhat easy to use.

**Student Survey of Computer Use (Non-iPad School)**

The non-iPad school had 24 students (73%) participate in the survey. The students at the non-iPad school completed a survey addressing computer technology use in the mathematics and science classrooms. With frequency of use, students reported a low use of computer technology. The students were given the choices of daily, two to three times a week, once a week, one to three times a month, or rarely. In mathematics, none of the students reported daily use and only 8% of the students responded they used computer technology two to three times a week, in contrast to the iPad users' 89%. In science, 0% of the students responded they used technology either daily or two to three times a week, in contrast to the iPads users' 87%.

Students were using the computers for a variety of reasons. However, the most common uses in mathematics were accessing Khan Academy, a tutorial based website, and accessing other math related websites. The most common uses in science were using computers for research, most often specifically science fair research, and watching science-related content videos.

Along with their frequency, students also reported on whether using a computer helped them learn in class. Students chose from the options of definitely helpful, helpful sometimes, helpful on rare occasions, or not helpful at all. In mathematics, 84% of the students felt the technology was definitely or sometimes helpful in their learning. In science, 75% of the students reported they felt the computer was definitely or sometimes helpful with assisting them in the learning process. Surprisingly, although these students were not using technology with the same frequency as the iPad schools, they still felt it was a beneficial tool in the learning process of mathematics and science when they had the opportunity to utilize it. With technology, the students reported the ease of use by choosing very easy to use, somewhat easy, difficult, or very difficult. With this topic, 100% of the students reported the technology they used was either very easy or somewhat easy to use.

## Discussion

This project explored the effects of a one-to-one iPad initiative on the academic achievement of middle school students in mathematics and science. Using hierarchical linear modeling, the study determined whether the variables of iPad use in a one-to-one setting and gender could predict students' growth in academic achievement in mathematics and science. Descriptive statistics were used to examine teacher responses of a survey addressing perceptions of use of constructivist strategies in the classroom. Descriptive statistics were also used to examine student and teacher responses of a survey addressing frequency, types, and ease of use of technology. This chapter will expound upon the findings of the analysis for both mathematics and science. Limitations are also included as well as suggestions for further research needed of the topic that would assist those parties interested in implementing a one-to-one initiative in their school district.

**Mathematics and Science Achievement**

The mathematics and science MAP scores of the 112 students were analyzed to determine if the use of iPads in a one-to-one setting or gender had an effect on students' growth in academic achievement over their 6$^{th}$ and 7$^{th}$ grade years in mathematics and science. Kiger's et al. (2012) research has shown positive effects of using iPods in an elementary mathematics classroom on mathematics achievement when implemented over a 9-week period; however, in this research, iPads were shown to have no significant effect on mathematics achievement scores. This matches the research of Carr (2012) who found using iPads daily in a 5$^{th}$ grade mathematics classroom for 9 weeks had no impact, and Dunleavy and Heineche (2007) who found no significant effect of using laptops in a one-to-one middle school setting over a two year period on mathematics achievement. When using HLM to explore the science MAP scores, no variation among students' rates of growth was found so the intervention of iPads could not be analyzed. However, research has shown laptops in a one-to-one setting over a two year period were significant in increasing science achievement among middle school students (Dunleavy & Heineche, 2007). With conflicting findings, more research needs to be completed to determine what situations produce a significant impact on achievement.

Gender was not a significant predictor of academic achievement in the area of mathematics or science for this study. Hyde and Linn (2006) found no significant overall difference in boys' and girls' academic achievement in mathematics. For science, they found a small positive effect for boys, which has not changed over the past few years. However, they stressed the fact that with large sample sizes, such as in their study, increasingly small differences are detected and pointed out that the small effects lead to evidence of gender similarities instead of differences.

**Benefits of the One-to-one Classroom and iPads**

Although the use of iPads in this study was not shown to positively effect academic achievement in mathematics and science, there are other benefits to using technology in a one-to-one setting. Penuel (2006) stressed the importance of students being able to access technology 24/7 and with that ability comes an array of resources, communication opportunities, and fluency with technological tools. This study found students reported frequent use of the iPads, which was made possible by the implementation of the one-to-one initiative. Both teachers and students reported they felt the technology was helpful to students in their mathematics and science learning. This was apparent in the reports of iPad use by the teachers and the students as they utilized the devices multiple times a week in class. Overall, both teachers and students at the one-to-one schools felt the experience of being part of the iPad initiative had created a positive impact on the learning opportunities for the students. Oliver and Corn (2008) also found with their middle school one-to-one tablet initiative a high satisfaction rate among students in regards to the technology use at their school and significantly more frequent use of the technology in mathematics and science classes. Observations showed more project-based learning, teachers acting as coaches, and student-centered projects assigned.

Within this study, ixl, a mathematics website, provided teachers the opportunity to differentiate instruction by assigning students modules specific to their individualized needs. The online learning program offers “unlimited algorithmically generated questions, real-time analytical reports, and dynamic scoring to encourage mastery” (www.ixl.com, 2016). Teachers are able to pick from hundreds of topics aligned with the Common Core Standards for Mathematics that best fit an individual’s learning needs. Students are then able to self-monitor learning through the feedback and report options ixl provides. Milman et al. (2012) found in their study a one-to-one iPad initiative increased engagement of students and promoted an individualized learning experience at the elementary level. They found the increased engagement helped with attention issues, and teachers were taking on the role of facilitators and using the devices to differentiate their instruction in the classroom.

Students in this study also reported frequent use of the iPads to access edmodo, an online classroom website, designed to allow communication with teachers and peers, collaboration opportunities, assessment options and a digital platform for sharing resources. The educational website uses a social network format designed to be appropriate for the classroom. Students can share ideas with peers or teachers and receive feedback on their work through teacher-monitored posts. They are able to collaborate on group assignments outside of the classroom through the website as well as turn in assignments to allow for a more paperless learning environment. Heinrich’s (2012) study of a middle school one-to-one iPad initiative found students and teachers felt the program was positively impacting the learning and teaching in the school through its abilities to be used for communication among peers and teachers, to work more efficiently, create and deliver presentations, and share resources. When considering the device itself, iPads have been shown to increase collaboration and communication at the university level (Fisher et al., 2013). Fisher discovered the devices were able to change the classroom workspace into one that promoted the sharing of ideas as students were incorporating their iPads into almost all interactions with other students. Van Dusen and Otero (2012) also found iPads in the high school science classroom promoted collaboration and engagement. The iPads were used to assist students in their construction of knowledge, created excitement for learning that went beyond the class time, and promoted responsibility for their own learning.

However, using the devices frequently may not be enough to produce results in academic achievement. Research has shown computer technology is more effective when used in a constructivist classroom (Li & Ma, 2010) and the constructivist approach to learning has been shown to be an effective way of teaching (Ayaz & Sekeric, 2015; Kim, 2005; & Wu & Tsai, 2005). Ayaz’s and Sekeric’s (2015) meta-analysis was able to pinpoint some of the tactics used to create an effective constructivist-learning environment such as the use of the 5-E learning model in science and problem-based learning. This information allows school systems a glimpse into what is working as they develop ways to use technology to create an effective classroom. The first step toward that is to ensure teachers understand how and feel comfortable with their abilities to use technology to create a constructivist-oriented classroom.

**Teacher Survey of Constructivist Teaching Strategies**

The teachers completed a survey, by Henry (2003) addressing their perceived use of constructivist teaching strategies in the classroom. Although this study does not have enough teacher participants to provide a strong examination, some interesting information emerged that would warrant another study with a larger sample size. Koh et al. (2014) found in their study the teachers with the most teaching experience had a perceived lower score for constructivist-oriented technological pedagogical content knowledge (C-TPACK). In this study, the three teachers with the most experience had the lowest perceived use of constructivist teaching strategies. This may be due to these teachers beginning their careers in schools that had a more traditional focus to them. As new research-based methods are taught at our universities, more experienced teachers may have a harder time adapting to the new methods and resist changing the format they have always used. The study also found, in regards to amount of education, three of the top four teachers who reported the highest perceived use of constructivist teaching strategies had received the most formal education by reaching a Rank I certification (completed 30 hours past their masters degree). With more education, teachers have the opportunity to learn more current research based practices to incorporate into their classrooms.

Another finding was science teachers had four of the top five scores of perceived use of constructivist teaching strategies. Dunleavy and Heineche (2007) found the laptop initiative resulted in significant results for science but not for mathematics. They posed the question of whether science lends itself more readily to the implementation of technology than mathematics and whether it is easier to implement constructivist-teaching strategies in science due to the nature of its content. In this study, implementations of the iPad were similar with online textbooks and use of the edmodo classroom appearing on both lists of common uses in mathematics and science. However, some uses in science that were not on the mathematics list were accessing the web for information, which enabled students to view the most current content in the area of science, and the use of interactive models to promote understanding of concepts. When analyzing teachers C-TPACK, it’s important school administrators ensure teachers understand and feel comfortable implementing constructivist strategies that have been proven effective in their content areas. As teachers are developing their constructivist strategies, professional development that focuses on how to implement technology into specific content areas rather than broad applications of technology may enhance the training for teachers participating in one-to-one initiatives.

Henry (2003) broke the constructivist strategies questions into three categories- classroom management, teaching activities, and assessment. The lowest perceived scores for the teachers in this study were in the area of assessment. Koh et al. (2014) posed more experienced teachers might have a lower perceived C-TPACK as a result of spending more time in an exam driven school system. The fact teachers in this study rated themselves lowest in the area of using constructivist strategies for assessment may possibly be as a result of the system to which Koh et al. was referring in their study. As seen in the surveys of iPad use, the only reports of using them for assessments were in the area of mathematics, and it was only 13 of the 62 students that reported this type of use. More professional development in the area of utilizing iPads to administer constructivist forms of assessment would be beneficial to this specific school district. Sultan et al. (2011) pointed out one-to-one technology allows teachers opportunities to incorporate many different forms of assessment. Teachers need to be shown ways technology can promote more individualized assessments that incorporate a more constructivist approach. A final point of interest with the teacher survey is every teacher reported a higher mean score of perceived use of traditional strategies than of constructivist strategies. This shows that although there are constructivist-oriented activities occurring in the classroom, traditional methods are still prevalent- another reason to provide more professional development for teachers to help raise their C-TPACK.

**iPad Users Frequency of Use, Helpfulness, and Ease of Use**

One component of creating a successful one-to-one iPad initiative is ensuring they are actually being used in the classroom. Research has shown there is significantly more frequent use of technology in mathematics and science when a one-to-one program has been implemented (Oliver & Corn, 2008). Providing students and teachers with iPad technology does not guarantee it is being used during instruction. However, this study has shown they are using the devices. When asked about frequency of use, 89% of students reported they used the iPad either daily or at least two to three times a week in math class and 87% of students reported the same for science. Teachers were in agreement as 100% of both the mathematics and science teachers reported students used the devices either daily or at least two to three times a week.

Possible reasons the frequency use is high in this study is the ease of using the technology. 100% of the students and the teachers reported it as being either very easy or somewhat easy. The students also reported they felt the iPads were helpful in their learning; with 93% of the students reporting the devices were definitely helpful or sometimes helpful in mathematics and 90% the same for science, the students are seeing the benefits of using technology in school. All teachers, both mathematics and science, rated the iPads as definitely helpful to learning. This is an important statistic because if teachers do not feel the technology has merit they are not going to revise instruction to incorporate the devices into their lessons. Overbay et al. (2010) found teachers who reported a high level of constructivist practice also reported a high level of technology use. This is encouraging for this study since teachers in this school district have embraced the frequent use of iPads during instruction.

### Non-iPad Users Frequency of Use, Helpfulness, and Ease of Use

The frequency of use with non-iPad users differed dramatically from the one-to-one schools. In mathematics, no students at the non-iPad school reported daily use of technology and only 8% reported using it two to three times a week. In science, no students reported daily use or two to three times a week for their use of technology. The three teachers agreed with all reporting technology was rarely used in their classes. Surprisingly, though, the students' reports of helpfulness were positive. For instance, 83% of students felt the computers they used in mathematics class was either definitely helpful or sometimes helpful to them, and 75% of students felt it was definitely or sometimes helpful in science class. Also, 100% of the students stated the technology was very easy or somewhat easy to use.

The teachers at the non-iPad school had differing opinions of the technology. All three teachers chose differently for helpfulness- one choosing definitely, one choosing sometimes, and the last choosing helpful only on rare occasions. With ease of use, two teachers stated the technology was somewhat easy and one stated it was difficult to use. The teacher who stated it was difficult to use and only used it on rare occasions had one of the lowest perceived scores for implementing constructivist-teaching strategies in the classroom. However, the teacher felt it was definitely helpful for student learning when used. This emphasizes the need for appropriate professional development not only with how to use technology but also suggestions for more constructivist strategies to increase teachers' C-TPACK. This would be beneficial not just for teachers in the one-to-one schools but also the school that, although limited, does have access to some technology to be used during instruction.

Since the students felt the technology was helpful, this brings up the question of even if it were not a one-to-one school, would students bring their own devices if allowed. This is an option for schools that may have the infrastructure in place for wireless Internet capabilities but not a solid plan for a specific device. The opportunity to use technology in the classroom, even if they are not all the same devices, can have an impact on students' engagement, ability to access current content of the subject area, and encourage communication and collaboration.

### Types of iPad Use

With computer technology integration in mathematics, Li and Ma (2010) found in their meta-analysis the technology could be sorted into four types- tutorial, communication media, exploratory environment, and tools. However, their findings showed the type of technology use was not significant when analyzing the effects on mathematics achievement of students, but more importantly, it was significantly more beneficial in classrooms where the constructivist approach to learning was being practiced.

The question arises to whether the iPads in this study were being used to enhance a constructivist-learning environment. In mathematics, students reported multiple ways they used the iPads in class. However, the three most commonly reported uses were to access online textbooks, complete practice programs on a tutorial-based website, ixl, or use them as calculators. With online textbooks, an interactive component is present that is not available with traditional texts. For instance, the use of current data for real life application problems incorporated into lessons can promote authentic tasks for students. Calculators on an iPad can provide graphing options not available on standard calculators enabling students to explore concepts virtually. The website, ixl, offers practice in a multitude of topics in mathematics. An interactive component is provided that is not available when practicing problems on a worksheet. If a student misses a problem, he is provided with an instant solution and explanation of how to solve it correctly, allowing the opportunity to self-assess learning. It also has a tracking component where students can see the progress they've made and earn badges which can be an engaging way to motivate learning. This website is similar to Brown's (1998) assessment practice of observation checklists. She stated this type of use promotes a constructivist approach as it helps students track their learning and engage in planning how to improve their learning of the mathematical content.

In the area of science, Bayraktar (2002) found the most effective use of CAI was through simulations and the second most effective was tutorial. Neither one of these two formats were listed in the top three ways the schools were using the iPads. However, the most common options have the ability to provide students with a learning experience they could not have without the iPads.

In science, the three most common uses were accessing an online textbook, using an edmodo classroom, and accessing the web for information. As with math, the interactive textbooks can provide the most current information available. Online textbooks have interactive models for virtual exploration of science content. This is a huge benefit when our understanding of the world is changing daily. An edmodo classroom allows for communication between teacher and student or between students. It can offer peers a way to collaborate inside and outside of the classroom, an important part of the constructivist-learning environment. It also offers multiple assessment options- both formative and summative. Accessing the web for information is something students have been doing at home and in computer labs at school for some time. Penuel (2006) stated "24/7 access to computers makes it possible for students to access a wider array of resources to support learning, to communicate with peers and their teacher, to become fluent in their use of the technological tools of the 2st century workplace (p.332)". The one-to-one environment allows for easier access to that information aiding in the creation of a more efficient classroom. Overall, each of the uses of the iPads in the mathematics and science classes could promote a constructivist-learning environment for the students. Through their use, students were able to learn using the most current information for the subject areas and had the ability to collaborate with peers and self assess their learning process in and out of the classroom.

### Types of Computer Use (Non-iPad School)

With the non-iPad school, although students reported a lack of technology use, they still reported some common uses in the classroom. For mathematics, the most common use was the website, Khan Academy, and the second use was math-related websites. Khan Academy is a tutorial website that allows students to practice math problems, receive immediate feedback on their answer along with explanations of how to solve the problems, and links to tutorial videos if a student needs extra assistance. The websites were reported as different sites that allowed for the practice of math problems. In science, the most common use reported was conducting research using the Internet on science-related topics. The second was to watch science-specific content videos about topics they were learning. Both of these uses provided students with more current information than textbooks can provide.

Although this school environment was not using technology often, the choices of how they were using it added to their learning experience. The students reported they felt the use of technology aided in their learning in the mathematics and science classroom.

## Limitations

In a perfect research design, one would be able to conduct classroom observations and interviews to determine how the iPads were being used and the extent that constructivist teaching strategies were being used in the learning environment. Due to the researcher being a full time teacher, this was not possible so surveys were used instead to collect data from the participants. The qualitative data that observations and interviews provide would allow for more analysis of the teacher's impact and the technology impact on the student's learning. The surveys focused on the most common ways the technology was being implemented. However, observations could provide a bigger picture of the iPads' utilization in the classroom and interviews of both teachers and students would allow for a thorough discussion of technology use not observed through classroom visits.

There are also limitations to this study due to the small sample size. Only three schools were included in this study, equating to 112 student participants and 10 teacher participants. Also, the schools themselves are very similar to each other and only provide a glimpse into a small, private, suburban school district. Due to their low diversity and percentage of low socioeconomic students, findings will not translate well to the broader public school system.

Another limitation to having a small amount of teachers is the inability to analyze the teachers' information using HLM. With some students having more than one teacher over the two years in a content area and others having the same teacher, it was not feasible to look at more than the descriptive statistics to determine a broad look at what was occurring in the classroom. If the study had instead looked at growth over one year, it would have been easier to examine teacher characteristics. However, by examining growth over two years, the comparison study was made stronger by providing up to six time points for analysis. Also, due to the small number of teachers, some descriptors had to be addressed more broadly to protect anonymity of responses.

There were some limitations due to the nature of the surveys of technology use. Asking students to remember how much they have used the iPads over the past two years and the most common ways they have used them can be problematic. Some students may be remembering more of their $7^{th}$ grade years than their $6^{th}$ grade years. Also, surveys can only provide a snapshot of the learning environment. In order to find more detailed information of how constructivist strategies are being used in the classrooms and how the iPads are being used, a year long or more study involving multiple classroom observations would be extremely beneficial in providing a more in depth picture of the effects of a one-to-one iPad initiative on middle school mathematics and science classrooms.

## Implications and Suggestions for Further Research

Although research has shown through meta-analyses that technology can positively affect mathematics and science achievement (Bayraktar, 2002; Li & Ma, 2010), this study did not show a significant effect with the use of iPads in a one-to-one setting. Li's and Ma's (2010) analysis showed the most effective way to use technology was in a constructivist-learning environment. Some of the parameters of such an environment were reported in the one-to-one classrooms of this study. It is important, first, that the technology is actually being used. Overbay et al. (2010) found teachers who leaned toward a constructivist approach and thought the technology could be a useful tool for learning were more likely to report using the technology. In this study, teachers reported the use of constructivist teaching strategies and frequent use of iPads in the classroom. Teachers also indicated they felt the technology was beneficial for students to use. Students agreed with the teachers' reports of frequent use and stated they felt the iPads assisted them in learning content.

The types of uses of the iPad have also addressed the constructivist approach. For instance, the use of online textbooks, reported as one of the most common uses of the technology, enabled students to access more current information regarding content. ixl software provided students the opportunity to reflect on their work and receive instant feedback as they practiced. The use of edmodo, an online classroom, promoted communication within and outside the four walls of the classroom. The use of interactive computer models in science class allowed students to create an understanding of the material for themselves as they explored concepts virtually. Although, Li and Ma (2010) determined the type of use did not factor into whether technology had a positive effect on achievement, a constructivist approach did. All of these uses have merit in providing constructivist-learning opportunities in the one-to-one classroom. However, some of the most common uses were not content specific iPad uses. Interactive science apps that allowed for virtual exploration of topics and dynamic mathematics software such as Geogebra, were missing in the most commonly listed ways iPads were utilized.

Some other key components of a constructivist-learning environment were also missing from the schools. For instance, teachers reported their lowest perceived constructivist strategies scores in the area of assessment. Sultan et al. (2011) reported one-to-one technology could provide teachers the opportunity to use multiple forms of assessment, but that was not evident in the teachers' surveys of their teaching styles. Also, there were no references in the surveys that referred to the use of the iPads to complete projects designed to mirror real world situations or provide opportunities to learn through ill-structured domains, both important components of Constructivism. However, the survey asked for the most common uses so that is not to say these type of learning situations were not occurring in the classroom. More involved research analyzing the classrooms throughout the school year could address how much those constructivist strategies are incorporated into the learning environments.

Although some of the key components of a constructivist-learning environment were apparent in the study, significant effects on achievement by iPads were not found. Future research is needed to determine the best ways to attain that achievement with a one-to-one environment. A more in depth study of how the iPads are being used with a larger sample of schools would enable researchers to delve more deeply into how iPads are contributing to a constructivist environment and increased academic achievement. A larger sample size of teachers would be beneficial in order to examine individuals' teaching styles and their C-TPACK in relation to their effects on achievement scores.

One suggestion based on the teacher survey is the need for schools to provide professional development to assist teachers' in their implementation of technology into their instruction. Koh et al. (2014) found some teachers have a lower perceived C-TPACK than of other constructs that do not involve technology. It is important we are providing the training needed for our teachers to use the technology to its utmost potential. Within this study, teachers reported higher perceived uses of traditional strategies than constructivist strategies. This implies that although they are using technology and constructivist strategies, the traditional approach is still quite evident in the classroom.

## Conclusion

Choosing the iPad for a one-to-one initiative has many benefits such as portability, affordability, promotion of collaboration, and the ability to individualize learners' experiences (Melhuish & Falloon, 2010). This research study did not find a significant effect on achievement in the mathematics and science classroom. However, other benefits were evident for the students. Hoffman (2010) stated technology could assist in teaching students 21$^{st}$ century skills, including communication. The iPad schools displayed frequent use of the edmodo classroom, which can provide multiple opportunities for communication between peers and teachers. Heinrich (2012) mentioned the devices had a positive impact on learning as students and teachers reported regular use of the devices. Within this study, both the teachers and the students reported frequent use of the iPads as well as a positive response to the iPads being able to promote learning.

The schools in this research project have answered the charge by the U.S. Department of Education (2010) to use technology to provide engaging and powerful learning experiences for their students. Their classrooms are ones that use the iPads to meet the fifth standard for mathematical practice, use appropriate tools strategically, set forth by the Common Core State Standards for Mathematics (CCSSM, 2010). The Next Generation Science Standards (2013) recognizes the role technology can play in students' abilities to study the natural world. The science classes are able to use iPads to access online textbooks and Internet sites with the most current information for that purpose.

By the implementation of the iPads into activities that are constructivist-based, the schools have begun the process of producing a technology-based constructivist learning environment. The school district should be encouraged to continue its professional development offerings of how to incorporate technology appropriately to enhance instruction that uses a constructivist approach including applications specific to the content. With more training to develop a teacher's constructivist-oriented technological pedagogical content knowledge, the iPads could be used more effectively and thus possibly result in a positive effect on mathematics and science achievement in the future.

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