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An Investigation of the Effect of Using Twitter by High School Mathematics Students Learning Linear Equations in Algebra 1

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AN INVESTIGATION OF THE EFFECT OF USING TWITTER BY HIGH SCHOOL MATHEMATICS STUDENTS LEARNING LINEAR EQUATIONS IN ALGEBRA 1

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Manuel Antonio Vilchez

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To: Dean Michael R. Heithaus
College of Arts, Sciences and Education

This dissertation, written by Manuel Antonio Vilchez, and entitled An Investigation of the Effect of Using Twitter by High School Mathematics Students Learning Linear Equations in Algebra 1, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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and Dean of the University Graduate School

Florida International University, 2016

DEDICATION

This dissertation is dedicated to two incredible women -- Marta L. Buitrago (my mother) and Celia J. Siezar (my grandmother).

DEDICACIÓN

Esta tesis está dedicada a dos mujeres increíbles -- Marta L. Buitrago (mi madre) y Celia J. Siezar (mi abuela).

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Kerouac once wrote, "One day I will find the right words, and they will be simple". This treatise represents my journey to find those words.

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There is never a penalty for asking. There is no shame in trying and not succeeding; however, there is shame in not trying at all. #TheEnd

ABSTRACT OF THE DISSERTATION

AN INVESTIGATION OF THE EFFECT OF USING TWITTER BY HIGH SCHOOL MATHEMATICS STUDENTS LEARNING LINEAR EQUATIONS IN ALGEBRA 1

by

Manuel Antonio Vilchez

Florida International University, 2016

Miami, Florida

Professor M. O. Thirunarayanan, Major Professor

The purpose of this quasi-experimental study was to investigate the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. This quasi-experimental study used ninth grade Algebra 1 classes that were learning linear equations for 18 school days.

First, the nonequivalent control group design, a pretest-posttest quasi-experimental design, was used in this quasi-experimental study. The research hypotheses were tested using a factorial analysis of covariance (ANCOVA) with the pretest on linear equations score as the covariate. The control group had three classes (n = 73) and the experimental group had three classes (n = 78). The experimental group received tweets on a daily basis as students learned linear equations. The tweets contained mathematical content, classroom logistics, or both. Lastly, the control group received the same information in class. The quantitative findings of this quasi-experimental study show that overall Twitter, content tweets, logistics tweets, and tweets containing both (content and logistics) did not have a statistically significant effect on the mean linear equations posttest score.

Second, this quasi-experimental study looked at students' performance on various subtopics throughout the unit. The ANCOVA showed that there were no statistically significant differences between the control group and the experimental groups in most of the quizzes. However, statistically significant differences were found in Quiz #2 and Quiz #4 among the logistics groups.

Third, the experimental group took a 10-item survey. The purpose of survey was to understand the students' opinion of using Twitter as they learned course content in Algebra 1. It can be concluded from the results of that survey that students had, for the most part, a positive attitude towards using Twitter as part of learning mathematics in high school.

In conclusion, the use of Twitter is not likely to show an increase in students' mean posttest linear equations score. However, the findings of the survey conducted after the study did show that the use of Twitter might be able to increase student motivation. The results of this quasi-experimental study made major contributions to the literature by investigating the effects of using Twitter in high school Algebra 1.

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CHAPTER I: INTRODUCTION

An increasing number of educators have applied some form of social media to their classroom instructional activities due to the popularity surrounding social media (Kassens-Noor, 2012). One of the findings derived from a study by Computer Discount Warehouse - Government division (CDW-G), the government division of a major technology provider, showed that 76% of students used social media for educational purposes (CDW-G, 2010). CDW-G's study conducted their study in May 2010 and it contained 1,004 participants comprised of high school students, faculty, and school district information technology personnel. The two aforementioned studies suggested that teachers could make good use of social media (e.g., Facebook, Twitter, blogs, and wikis) in order to discuss new ideas, implement best practices, share hyperlinks, and discuss research in the classroom (Cooke, 2012).

Salomon, Perkins, and Globerson wrote, "People have been making machines more 'intelligent.' Can machines make people more intelligent?" (1991, p. 2). This suggests that technology can be partner in the learning process (Goldman-Segall & Maxwell, 2003). In the past radio, telephone, and television have been utilized to learn at a distance with technology (Casey, 2008; Lease & Brown, 2009). The Internet, World Wide Web, and Web 2.0 present many more possible partnerships in learning. McLuhan famously wrote, "The medium is the message," implying that there is a relationship of mutual dependence between the channel that once uses to convey a message and what is being said (1964). Thus, effect of the message is amplified by how it is transmitted. In modern times one of the most powerful tools for conveying a message is Twitter.

If McLuhan’s rationale is correct, it follows that the tools one uses have a tremendous impact on understanding. Twitter is a fresh and unconventional tool that is immensely powerful because it has the potential to pique a student’s interest. A piqued interest when applied to educational content can be a great partner in the learning process. Twitter, unlike other education communication programs like Edmodo, is inherently more appealing to students thus providing an advantage in the education process. It follows that, students who are engaged and interesting by using this learning tool should be able to retain and recall for longer periods of time.

In this quasi-experimental study, the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1 was investigated. First, some researchers have used Twitter in other academic settings with some success; however, high school mathematics needs to be explored further. Second, there is a need to improve student success in Algebra 1 (Jacobson, 2000; Knuth, Stephens, McNeil, & Alibali, 2006; Moses & Cobb, 2001).

Background

Social networking websites can be traced back to the 1970s, but with rise of Web 2.0 technology various form of social networking websites have become extremely popular. These websites include, but are not limited to, MySpace, Facebook, LinkedIn, Tumblr, and Twitter. Most these platforms allow users to share audio files, hyperlinks, photos, and videos with other users (Kaplan & Haenlein, 2010).

The exponential growth in technology and rapid adoption of mobile devices has facilitated the adoption and usage of many forms of social media, which also includes Twitter. Fox, Zickuhr, and Smith (2009) concluded that users with mobile devices (e.g., iPhone, iPod Touch or iPad) are more likely to have a Twitter account. That study also indicated that 25% percent of all wireless Internet subscribers utilize Twitter (Fox et al., 2009).

Twitter was an important social medium for this quasi-experimental study due to the popularity among the younger generation. Kafka reported that worldwide 32.3% of Twitter users are between the ages of 15-24 globally. Other social networking websites such Facebook are popular among 18 to 54 year-olds, whereas LinkedIn is popular among the 25 to 65-year-old age group (2013).

Social media such as MySpace, Facebook, Tumblr, and Twitter have been used in educational settings (Cooke, 2012). For example, MySpace has been used for course papers and presentations in a course called Psychology of Women (Case & Hentges, 2010). Also, Facebook has been used to improve students' writing skills in a college English writing class (Shih, 2011). Likewise, Tumblr has been used for displaying ideas about art in a high school visual arts class (Napierala, 2011). Lastly, Blessing, Blessing, and Fleck (2012) and Everson, Gundlach, and Miller (2013) used Twitter to tweet about course content, Junco, Heiberger, and Loken (2011), about classroom logistics, and Van Vooren and Bess (2013) about both (course content and classroom logistics) have used Twitter in the classroom.

Twitter

Twitter is a free micro-blogging service, where one interacts with others by *following* them. The act of posting a message is called *tweeting*. Users have the capacity to spread messages of others through the act of *retweeting*. In 140-characters or less, users answer the fundamental question of: *What are you doing?* What a user can do with

140-characters or less runs is quite extensive. This includes, but is not limited to, asking questions and sharing one's thoughts (Dunlap & Lowenthal, 2009). Lastly, one can also post pictures, videos, share hyperlinks, and add a poll.

The popularity of Twitter has increased dramatically in a very short time period, as of mid-2009; Twitter had 41 million users (Kwak, Lee, Park, & Moon, 2010). According to Lunden (2012), Twitter had 500 million registered users and about 170 million active users. Twitter (2014) reported the following information about their product: It had 255 million monthly active users that send 500 million tweets per day. Of those millions of users, 78% of the active users are on mobile devices. Lastly, 77% of accounts are outside the U.S. due to the fact that Twitter supports over 35 languages.

However, neither Kwak et al. (2010) nor Lunden (2012) provide a breakdown of the ages for numbers they reported. The research that was conducted by other investigators did show that for the most part, Twitter users are between the ages of 18-44, with a median age of 31 (Fox, Zickuhr, & Smith, 2009). Yet, that statistic does not account for the users that are of school age. Nonetheless, those statistics are quickly changing because 11% of adults use Twitter and the majority of these users are young adults who are racially and ethnically diverse (Lenhart & Fox, 2009).

Furthermore, Kafka (2013) reported that, Twitter's users are disproportionally young and that Twitter is amidst a "youth movement." He went on to report that in the United States 0.6% of Twitter users are between 2-12 years old, 10.1% are 13-17 years old, and 18.2% are between 18-24 years old. Therefore, 28.3% of American Twitter users are between the ages of 13 and 24. Thus, we can conclude that youngsters are avid Twitter users.

Pew Internet Project's 2009 study revealed some interesting results. Pew analyzed data from a survey administered to 1,698 participants and the first finding showed that 19% of adults use Twitter or another service to update their status, in other words keep subscribers abreast of personal news one would like to share. Second, there was a significant different in the sex of those who use Twitter (17% men versus 21% women). Third, there was no significant difference in the race/ethnicity of the participants (19% White, 26% African American, and 18% Hispanic). Fourth, there was a significant difference in the age groups who used Twitter (18-29 year olds account for 33%, 30-49 year olds account for 22%, 50-64 years olds account for 9%, and 65 and over account for 4%). Fifth, there was no significant difference in the level of education among Twitter users (less than high school was 18%, high school diploma was 17%, some college was 21%, and college graduate was 21%). Lastly, there was no significant difference in the household income of Twitter users (less than $30,000 account for 22%, $30,000 to $49,999 account for 21%, $50,000 to $74,999 account for 20%, and $75,000 or more account for 20%; Fox et al., 2009).

Furthermore, the Pew Internet Project's 2009 study also found that 25% percent of all wireless Internet subscribers utilize Twitter (Fox et al., 2009). About a fourth of all tweets are direct messages to other users and the rest of the messages are broadcasted to all followers (Huberman, Romero & Wu, 2008). This is yet another way in which users have the ability to acquire up-to-date information about their friends, celebrities, and other news.

In previous studies, Twitter has been used in conjunction with libraries to promote exhibition, competitions, talks, seminars, workshops, tutorials, and training courses (Chu

& Du, 2013). Similarly, museums have used Twitter to link resources and create a dialogue to engage their followers (Osterman et al., 2012). Furthermore, Twitter has been used in higher education (Everson et al., 2013; Gao, Luo, & Zhang, 2012), elementary school (Waller, 2010), and middle school (Van Vooren & Bess, 2013) classrooms.

Distance Education

Historically speaking, distance education began with a correspondence course dating back to the 1800s. Since that time, distance education has taken on many forms. These modalities include, but are not limited to, radio, telephone, television, computer, satellite, and World Wide Web (Casey, 2008; Lease & Brown, 2009).

When the institution, instructor, and the learner are not occupying the same physical space, the learning that goes on is called distance education (Mielke, 1999). In a study by McKee (2010), distance education can be placed into five broad categories; correspondence education with printed materials, mixed media delivery, tele-learning, flexible learning, and lastly intelligent flexible learning. The use of social media for the purposes of learning falls squarely into this last category.

m-learning

Learning with the aid of mobile devices, or m-learning, is a new movement in education. However, m-learning can also be viewed as a subset of e-learning. The devices that can be used in m-learning include, but are not limited to, mobile phones, tablets, or laptops (Sharples & Beale, 2003).

Coupling mobile devices and education has been shown to be a successful marriage (Goh & Kinshuk, 2006). The capabilities of mobile devices are becoming increasingly sophisticated, but they do not need to be technologically advanced. The work by Stone, Briggs, and Smith (2002) and Cavus and Ibrahim (2009) show that the technology needed to communicate can be as simple as short message service (SMS).

Short Message Service

A SMS text message is akin to a Tweet because with both these mediums one can include plain text in the message that is being sent. However, an SMS is approximately 160 characters in length, which is slightly longer than a tweet by 20 characters. Thus, analogously the literature of using SMS needed to be explored.

For example, Cavus and Ibrahim (2009) implemented a system whereby they sent SMS text messages to students outside of classroom. The students who were involved in the Cavus and Ibrahim study did not reply to the texts they were receiving because an automated system was used in that the study and it was not designed to receive text messages (unidirectional messages). The results from that study showed that there was a significant difference between students' pretest and posttest after receiving SMS text messages for learning.

Also, Wang, Shen, Novak, and Pan (2009) used SMS text messages in a blended environment and concluded that participants became increasingly engaged in the learning process. Unlike the previous study, Wang et al. used SMS in the classroom and the instructor could receive text messages (bidirectional messages). However, this was contingent on the student being inclined to send the instructor a SMS text message.

In short, tweets are similar to SMS text messages. However, tweets are easier to keep track of, respond to, and can be viewed by others. The ability to view other tweets is particularly useful in following a conversation and a train of thought among users in an academic setting.

Algebra 1

Algebra 1 is an important course in secondary school mathematics. This course serves as the foundation for all other mathematics courses and it has often been referred to as a *gatekeeper* course (Jacobson, 2000; Knuth et al., 2006; Moses & Cobb, 2001). A student’s performance in Algebra 1 has a lasting effect on that student’s academic career. Nonetheless, many students struggle in this course to be successful (Knuth et al., 2006). Public school students fail mathematics more than any other subject (Jacobson, 2000). Moreover, a student who fails Algebra 1 is 4.1 more times likely to drop out than a student who does not (Orihuela, 2006).

Overall, 65.5% of students in urban schools fail first year algebra. Closer look reveals that 65% of Hispanics and 71% African American fail algebra compared to 36.5% of Whites (Confrey, 1998). The aforementioned statistics paint a very grim picture for what is happening in Algebra 1 courses across the nation. As a result, students look back on algebra, and mathematics in general, with high degree of disfavor (Steen, 1992). Nevertheless, every student needs to learn how to manipulate symbols, understand relationships between quantities, recognize patterns, and make generalizations (Williams & Molina, 1998). Thus, the need to improve student outcomes in Algebra 1 is imperative.

Theoretical Foundation

The theoretical foundation for this quasi-experimental study takes into consideration -- memory, the cognitive architecture, chunks of information, the information processing model, and cognitive load theory (CLT). Consistent with past research, the researcher is of the opinion that the brief messages, presented in parts, might have a lesser strain on the cognitive load of students, thus making the effects of the tweets stronger.

Memory. Memory is an essential to the learning process. It cultivates slowly before the age of 13, rapidly up to the age of 17, and reaches its peak at 25 (Rath, 2008). The multifaceted nature of memory and learning includes retention, recall, and recognition. Retention is facilitated and extended for a longer period of time if material is meaningful to the learner. Students can extend what they retain, recall, and recognize by being alert, interested, and maintaining an open dialogue with their peers (Rath, 2008).

Information can either be presented as a whole or in parts. Rath (2008) wrote, "children learn faster through 'part method' and adults with 'whole method'. Intelligent children learn better with the whole method and less intelligent with the part method" (p. 229). Rath (2008) findings on part and whole methods are supported by the work by Caple (1996). Capple's work concluded that working small chunks of information was more conducive to learning over larger chunks of information.

Cognitive architecture. As stated earlier, memory is an essential facet of the learning process. The cognitive architecture is composed of long-term and working memory (Sweller, 2004). The primary purpose of long-term memory is to store vast amounts of information. Working memory deals with maintaining information for a relatively short period of time and it also serves as a buffering mechanism for storing and processing complex information that can aid in the learning process (Baddeley, 1992).

Chunks of information. The number of chunks of information that the human mind can manage was originally thought to be 7±2 (Miller, 1956). Further research done in this area has suggested that it is closer to 4±1 chunks of information (Cowan, 2001).

In short, the minds' ability to work with a finite amount of information hovers around 4±1 chunks of information. Small chunks of information are what the human mind is accustomed to handling. This idea provides a foundation for the need to use Twitter and its 140-character limit per tweet. In this quasi-experimental study, a chunk of information was a tweet.

Information processing model. The chunks of information that are found in working memory are either positioned there from long-term memory or they enter working memory from two sensory channels -- acoustic and visual (Paivio, 1986). Written texts and images enter via visual sensory memory and then move to image base and pictorial model in working memory before finally being integrated into long-term memory (Mayer, 2003).

The information processing model is essential for understanding why Twitter is useful. Twitter has the capabilities to stimulate both channels in sensory memory. Tweets containing pictures or printed words will enter sensory memory via visual sensation. The selected images will become part of the image base and will be organized and integrated into long-term memory.

Cognitive load theory. Cognitive load theory offers an explanation as to why the creation of a schema can be facilitated or hindered (Sweller, 1988). The main components of cognitive load are intrinsic, extraneous, and germane (de Jong, 2010). Intrinsic cognitive load cannot be altered. However, extraneous cognitive load can be reduced through the use of adequate instructional design. As a result, information should be presented so that it does not tax the cognitive load of the learner (Chandler & Sweller, 1991).

Problem Statement

The use of Twitter in educational setting has been mostly limited to higher education and there are only a few studies that have applied Twitter to a K-12 setting (Gao et al., 2012). A review of the literature revealed that it has been used in a second grade class (Waller, 2010) and a middle school science class (Van Vooren & Bess, 2013). However, the bulk of the literature is descriptive, not experimental, in nature (Gao et al., 2012). Only three studies were located in the review of the literature that are experimental in nature (see Blessing et al., 2012; Junco et al., 2011; Van Vooren & Bess, 2013).

Enrollment in Algebra 1 is on the rise. However, the students enrolled in those classes are struggling to be successful. A student's success or shortcomings in Algebra 1 has long-lasting effects on the academic career of that high school student. The study was partially undertaken because of a need to improve student performance in Algebra 1.

The intersection of these two fields, Twitter and mathematics education, needs to be examined further. This quasi-experimental study primarily aimed to fill the gap in the literature related to social networking sites and mathematics education. The popularity of the Internet and Web 2.0 content, such as social networking sites, it is the right time to maximize the potential of using social networking sites in education with research. Thus far, a review of the literature did not reveal any studies that explored how Twitter affects high school mathematics students learning linear equations.

Purpose Statement

The purpose of this quasi-experimental study was to investigate the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. Since the majority of the literature on the use of Twitter is descriptive (e.g., anecdotal and opinions), it is imperative that empirical studies be conducted (Blessing et al., 2012).

Empirical studies are a form objective research where through experimentation; one can measure the relationship between independent and dependent variables. In an empirical study numerical data is collected from a sample that is representative of the population. It follows that the study can be easily replicated because it has careful design with clearly defined questions. In short, the need for this type of study is to fully understand the effect Twitter has on learning through a quantitative manner that can be measured by the use of statistics and statistical models (Babbie, 2007).

Thus, due to the lack of experimental and quasi-experimental studies in the literature it is important to conduct more quantitative studies in K-12 setting. In short, potential benefits of using Twitter in the classroom must be tested objectively in a controlled environment in order to determine whether there is a systematic difference between using Twitter and not using Twitter in an education setting.

The nonequivalent control group design was chosen because it is a vastly utilized quasi-experimental model in education. It is widely implemented and accounts for both a control group and an experimental group of students that may not be equivalent through the use of a covariate (Campbell & Stanley, 1963). As noted earlier, the need for quantitative research in this area is imperative in order to accurately gauge the effectiveness of using Twitter in the classroom.

Significance of the Study

The topic of this quasi-experimental study is important to educators who are searching for innovative methods to improve the high school mathematics students learning linear equations in Algebra 1. As a result, educators, policy makers, curriculum designers, instructional designers, student, and other stakeholders will benefit from this research.

Research Questions

This quasi-experimental study investigated the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. Based on the literature review conducted, there is a lack of quantitative research about the use of Twitter in secondary schools.

The research questions that were answered as the result of this quasi-experimental study are:

1. Is using Twitter more effective than giving content and logistics based information in class for solving Algebra 1 linear equations?
2. Is using mathematical content-based tweets more effective than giving the same content-based information in class for solving Algebra 1 linear equations?
3. Is using classroom logistics-based tweets more effective than giving the same logistics information in class for solving Algebra 1 linear equations?
4. Is using mathematical content-based and logistics-based tweets more effective than giving the same information in class for solving Algebra 1 linear equations?
5. Is there a relationship between students' attitudes towards Twitter and learning mathematics?

6. Do students who think that Twitter is a useful tool learn more than students who do not?

Research Hypotheses

The research hypotheses in null form for this quasi-experimental study are:

1. The mean of the number of correct answers in the posttest for the Twitter group (experimental group) will be significantly higher than the mean of the number of correct answers in the posttest of students received the messages in class (control group);
2. The mean of the number of correct answers in the posttest for the content-based tweets group (experimental group) will be significantly higher than the mean of the number of correct answers in the posttest of students received the messages in class (control group);
3. The mean of the number of correct answers in the posttest for the logistics-based tweets group (experimental group) will be significantly higher than the mean of the number of correct answers in the posttest of students received the messages in class (control group);
4. The mean of the number of correct answers in the posttest for the boty types of tweets group (experimental group) will be significantly higher than the mean of the number of correct answers in the posttest of students received the messages in class (control group);
5. There is no relationship between students' attitudes towards Twitter and performance on the various assessments;

6. There is no relationship between student perception and performance on the various assessments.

Identification of Variables

The independent variable used in this quasi-experimental study was the use of Twitter. The dependent variable in this quasi-experimental study was the individual posttest score on a test of on linear equations. The posttest score on linear equations was determined by the percent of questions answered correctly on a 20-item posttest on linear equations. The pretest on linear equations score was determined by the percent of questions answered correctly on a 20-item pretest on linear equations. This pretest score served as the covariate.

Throughout the unit, the groups were given four quizzes. Lesson quizzes were administered to measure student progress throughout the process. These mini-assessments allowed the teachers and the researcher to analyze subtopics that the participants showed success. Furthermore, it also informed the teachers and the researcher the subtopics the participants needed to improve upon. The quizzes were scored on a 4- or 5-point-scale. A score of zero was the minimum possible score and 4 or 5 were the maximum, a perfect score. Each item on the quizzes had equal weight. Lastly, these quizzes served as a safety measure for the experimental groups. Should any of the experimental groups performed noticeably worse than the control group of students the intervention would have ceased.

After experimental group students used Twitter as part of this quasi-experimental study, the Twitter group took a 10-item survey. The survey was intended to understand the students' opinion of using Twitter as they learned course content in Algebra 1. Given no other studies of this kind for Twitter, mathematics, algebra, linear equation, and high school level were found in the literature at the time of this quasi-experimental study bringing in qualitative information from surveys contributed to a better understanding of quantitative research information

Assumptions

The underlying assumptions of this quasi-experimental study are:

1. Students have a Twitter account or opened one for a class, either through http://www.twitter.com or a mobile device (i.e., smart phone or tablet).
2. Students are familiar with the basic functions of Twitter. In other words, students are able to tweet, reply to a tweet, retweet, favorite, and attach images to a tweet.
3. Since the School Board of Miami-Dade County Public Schools (M-DCPS), Superintendent of M-DCPS, the participating school, school newspaper, and school athletics department all have a Twitter account -- the use of Twitter in school is acceptable.

Delimitations

This quasi-experimental study has the following delimitations:

1. The Algebra 1 course is composed of ninth grade students. This particular course and grade level was chosen partially because it is the most homogeneous. Geometry, Algebra 2, and courses beyond are more likely to include mixed grade levels.
2. Even though linear equations are a recurring theme in high school mathematics, the present study was delimited to the study of linear equations in Algebra 1. Before this teaching tool is applied to other courses and grade levels it first needs to be determined if it is effective with Algebra 1 students. Students in high school are

exposed to linear equations in Algebra 1 (CPALMS, 2014a), Geometry (CPALMS, 2014d), Algebra 2 (CPALMS, 2014b), Pre-calculus (CPALMS, 2014e), Statistics (CPALMS, 2014f), and continue to work with them in Calculus (CPALMS, 2014c).

3. Three teachers took part in this quasi-experimental study based on their willingness to contribute. Thus, only those students in the participating teachers' classes were included in the data analysis of this quasi-experimental study.
4. The time period of fall 2015 was used. This is worth mentioning because the second semester (spring 2016) congested with copious amounts of state, district, and school mandate testing. This factor impedes the students' availability to continuously participate in the study.

List of Definitions

Chunk. Is "a collection of concepts that have strong associations to one another" (Cowan, 2001, p. 89).

Content learning. Knowledge or skill acquired by instruction or study of mathematics. The posttest score will measure the degree of how much was acquired.

Experimental mortality. Refers to, "differential loss of respondents from the comparison groups" (Campbell & Stanley, 1963, p. 5).

Follow. Means to "(subscribe to) people with whom they share similar interests, either about social hobbies or their professions" (Zhao & Rosson, 2009, p. 5).

Follower. Is "an individual who is not a friend of user A but 'follows' [the user's] updates" (Java, Song, Finn, & Tseng, 2006, p. 2).

Following. Is the act of subscribing to "update of people who post interesting tweets" (Cha, Haddadi, Benevenuto, & Gummandi, 2010, p. 3).

Hashtag. Can be defined as “a convention among Twitter users to create and follow a thread of discussion by prefixing a word with a ‘#’ character” (Kwak et al., 2010, p. 2).

Hispanic or Latino. It “refers to a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race” (Humes, Jones & Ramirez, 2011, p. 2).

History. Is, “the specific events occurring between the first and second measurement in addition to the experimental variable” (Campbell & Stanley, 1963, p. 5).

Instrumentation. That, “in which changes in calibration of measuring instrument or changes in the observers of scorers used may produce changes in the obtained measurement” (Campbell & Stanley, 1963, p. 5).

Maturation. It is the, “process within the respondents operating as a function of the passage of time per se” (Campbell & Stanley, 1963, p. 5).

Neomillennial generation. Those persons “being born after 1994” (Willems, 2008, p. 1104).

Nonequivalent control group design. Is a popular quasi-experimental design “that involves only two (nonequivalent) groups and two measurement waves, one a pretest and the other a posttest measured on the same instrument” (Cook & Shadish, 1994, p. 566)

Pretest-posttest. A type of quasi-experiment research design where, “the researcher measures the dependent variable before the intervention starts and after it is concluded” (Montero & León, 2007, p. 852).

Quasi experiments. Are those that, "include intervention designs in natural settings where is not possible to make random assignments or to control the order which the tasks are presented" (Montero & León, 2007, p. 852).

Retweet. Is a mechanism that allow "users [to] spread information of their choice beyond the reach of the original tweet's followers" and is always abbreviated as "RT" (Kwak et al., 2010, p. 1).

Selection-maturation interaction, etc. That "which in certain of the multiple-group quasi-experimental designs, such as Design 10 [nonequivalent control group design], is confounded with, i.e., might be mistaken for, the effect of the experimental variable" (Campbell & Stanley, 1963, p. 5).

Statistical regression. It is, "operating where groups have been selected on the basis of their extreme score" (Campbell & Stanley, 1963, p. 5).

Testing. It is, "the effect of taking a test upon the scores of a second testing" (Campbell & Stanley, 1963, p. 5).

Twitter. Is "a popular microblogging service" (Sakaki, Okazaki, & Matsuo, 2010, p. 1).

Tweet. A "text-based posts [that can contain] up to 140 characters in length" (Jansen, Zhang, Sobel, & Chowdury, 2009, p. 2172).

Web 2.0. There is no specific definition but it contains the following characteristics: "(a) services, not packaged software, with cost-effective scalability, (b) control over unique, hard-to-recreate data sources that get richer as more people use them, (c) trusting users as co-developers, (d) harnessing collective intelligence, (e) leveraging the long tail through customer self-service, (f) software above the level of a single device, (g) lightweight user interfaces, development models, and business models" (O' Reilly, 2007, pp. 36-37).

Summary

In short, the purpose of the present study was to investigate the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. Four of the research hypotheses were tested using a factorial analyses of covariance (ANCOVA) to determine whether there is (a) a difference in the mean posttest linear equations score for the Twitter group versus the mean posttest linear equations score for the control group of students, when adjusted for the pretest scores on linear equations, (b) a difference in the mean posttest linear equations score for the mathematical content group versus the mean posttest linear equations score for the control group of students, when adjusted for the pretest scores on linear equations, (c) a difference in the mean posttest linear equations score for the Twitter classroom logistics group versus the mean posttest linear equations score for the control group of students, when adjusted for the pretest scores on linear equations, and (d) a difference in the mean posttest linear equations score for the Twitter mathematical content and classroom logistics group versus the mean posttest linear equations score for the control group of students, when adjusted for the pretest scores on linear equations. Furthermore, an ANCOVA was used to determine if there is (a) a relationship between student's attitudes towards Twitter and their performance and (b) if there is a relationship between students' who think that Twitter is a useful tool and their performance. The next chapter sheds light on social networking sites, Twitter, theoretical framework, history of distance education, and national standards.

Organization of the Study

This quasi-experimental study is composed of five chapters. Chapter 1 has given a brief introduction to the problem at hand. The second chapter provides a review of the literature that is pertinent to the research problem. The third chapter presents the methodology of the study. The fourth chapter provides an analysis of the results. Finally, the fifth chapter will summarizes and provides some concluding remarks about the study.

CHAPTER II: LITERATURE REVIEW

This chapter reviews literature that was pertinent to the present study. The first section is a summary of social networking sites. The second section discusses distance education. The third section discusses pertinent literature on short message service. The fourth section presents Twitter, a social networking site. The fifth section discusses Twitter's potential in education. The sixth section provides a review of cognition and learning. The seventh section covers the standards of communication and technology in education. The eighth section covers Webb's Depth-of-Knowledge. The ninth section reviews literature relating to Algebra 1. The ninth section analyzes achievement and performance. The tenth section explores the wealth and income gap. Lastly, it concludes with an overview of the communication.

Social Networking Sites

Social networking sites have their origins dating back to the late 1970s. In 1979 Tom Truscott and Jim Ellis created *Usenet*. This platform was the precursor to the modern bulletin board system whereby users posted and read articles. Soon thereafter, Bruce and Susan Abelson created *Open Diary*, an online community that brought together those individuals who were interested in writing a diary. Since then, social networking sites (e.g., MySpace and Facebook) have become extremely popular because of the presence of the high-speed Internet access.

Social networking sites, like Facebook and Twitter, give users the ability to present themselves and share their thoughts through a medium that is media rich. Social networking sites differ from other sites in that users can create a personal profile and communicate with other users. These forms of communication include inviting others to join, sending e-mail, and instant messages. Lastly, users can share audios, hyperlinks, photos, and videos with other users (Kaplan & Haenlein, 2010).

An increasingly technological society coupled with students who are overly attached to mobile devices, calls for a shift on how social learning theory is applied to the classroom, both pedagogy and andragogy (Baird & Fisher, 2005). Social networking sites are both collaborative and interactive and thus conducive to the learning environment of students today (Baird & Fisher, 2005). It follows that Twitter, as a learning tool, has the potential to facilitate learning (Gao et al., 2012).

In summary, social networking sites can trace their genesis back to 1979 with the inception of *Usenet*. Society has become increasingly dependent and attached to mobile devices. Thus, new ideas about learning need to be explored. The creation and accessibility of high-speed Internet access has facilitated the development of Web 2.0 technology and in turn caused the proliferation of social networking sties. Since social networking sites (SNS) are exclusively online, as such, they can be treated as a form of distance education.

Distance Education

Distance education is not a new phenomenon. Its beginnings can be traced back to the 1800s. It was first applied to teaching stenography by receiving lesson through the mail. After that, the rapid changes in technology gave way to various forms of distance education. An education at a distance was possible through the use of radio, telephone, television, computer, satellite, and World Wide Web (Casey, 2008; Lease & Brown, 2009).

Every time a new form of technology emerged, education and communication soon followed (Peng, Su, Chou, & Tsai, 2009; Sharples, Taylor, & Vavoula, 2007). The latest form of technology and communication are social networking sites. The following section gives a brief overview of distance education and how it has been used in the past.

Distance Education Overview

Simply stated, in distance education the institution, the instructor, and the learner are physically separated by some geographic distance (Mielke, 1999). It can be viewed as either a way to deliver instruction or a style of instruction. However, with regards to the use of cell phones and social media in distance education, one can easily infer that distance education is a teaching style. This teaching style has found its place in education after decades of failed attempts. Hooper (2008) believes that even though prior educational technologies have failed in the past, the use of technology in the classroom should not be ignored.

A closer look reveals that mail, radio, telephone, television, computer, satellite, and World Wide Web can be defined as five generations of distance learning (McKee, 2010). The first generation is correspondence education with printed materials that are mailed to the learner. Education via printed material was incumbent on the learner's ability to be literate. The second generation involved mixed media delivery. This included combinations of prints, audiotapes, videotapes, computer-based, and interactive videos. The third generation consisted of tele-learning. This included audio-teleconferencing, video conferencing, audiographic communication, broadcast television, and radio. The fourth generation deals with flexible learning. Flexible learning can be described as interactive multimedia online, Internet access to World Wide Web resources, and computer-mediated communication. Lastly, the fifth generation is described as intelligent flexible learning.

The technologies in this last generation include interactive multimedia online tools, Internet based access to World Wide Web resources, computer-mediated communication, using automated response systems, campus access to institutional process, and resources. Social networks sites, which also include Twitter, and various other Web 2.0 applications, fall directly within the parameters of the fifth generation of distance learning.

Web 2.0

The 1990s marked the uncanny rise of the World Wide Web. Educators, politicians, and policy makers quickly embraced the learning potential of the Internet. On a national level, the political discourse offered promises that every classroom across the United States was going to have a computer with Internet access because it was a national priority. Above all else educators rapidly realized the effect this could have on the classroom. It follows that the wealth of information easily be accessible can be educational and social (Franklin & Peng, 2008).

Since the 1990s, the World Wide Web has evolved and has given rise to Web 2.0 content. Web 2.0 is radically different from the first generation of web content because it is geared towards user defined content and social networking sites (O' Reilly, 2007). Furthermore, the current generation of leaners (the Neomillennial Generation or the *always-on* generation) is radically different than those who came before them (Baird & Fisher, 2005; Belsey, 2005). This is because their expectations about how learning takes place and the tools that are being used to learn have changed.

Mobile Learning

The recent advances in mobile technology have paved the way for mobile learning, hereafter m-learning (DiGiano, et al, 2003). The literature review for this chapter found no consensus about the current state of m-learning. Some scholars (Goh & Kinshuk, 2006; Hoppe, Joiner, Milard, & Sharples, 2003) view m-learning as a subset of e-learning, while other scholars contend that m-learning is itself a new movement in learning (Hummel, Hlavacs, & Weissenböck, 2002; Keegan, 2002). This way of learning is still evolving thus making it fertile ground for research (Goh & Kinshuk, 2006).

The use of mobile devices for the purpose of educating is m-learning. According to Sharples and Beale (2003), a mobile device can be a mobile phone, tablet, or a laptop. The use of instructional games, classroom learning, laboratory learning, field trip learning, distance learning, informal learning, pedagogical learning, and teaching support have been used in conjunction with mobile devices (Goh & Kinshuk, 2006). Goh and Kinshuk stated that, “Mobile learning can be contained in a classroom and show to achieve good benefit” (2006, p. 2).

This new perspective of education and traditional schooling are at odds because traditional schooling does not incorporate the new capabilities that are emerging (Sharples, Taylor, & Vavoula, 2007). Even though mobile devices are becoming increasingly sophisticated the educational content does not have to be multimedia rich. The work by Stone, Briggs, and Smith (2002) and Cavus and Ibrahim (2009) show that the educational content can be as simple as short message service (SMS).

In summary, distance education began with idea that individuals can still learn while being geographically apart. The various generations of distance education coincide with the popularity of the state-of-the-art technology available at that time. Web 2.0 technology, high-speed Internet access, and mobile devices have opened a new set of possibilities for learning. Currently, a mobile device (i.e., iPhone, iPad, or iPod Touch) has the capacity to employ a wide array of multimedia formats. This new way of learning, known as m-learning, has shown some promise in assisting students learn new content.

Short Message Service

In a study conducted by Cavus and Ibrahim (2009) at the Near East University in Cyprus showed that SMS could be an effective learning tool. The Cavus and Ibrahim study involved 45 first-year students who received SMS text messages in regular intervals. The text messages were sent from a computer (MOLT system) to all of the participants' cellphones every 30 minutes between the hours of 9:00 AM to 5:00 PM. In total the participants received 16 messages per day for a period of 9 days. Therefore, as a result of being part of that study the participants received a grand total of 48 messages. The purpose of the text messages was to teach technical English words to students enrolled in the Computer Information Systems program at the university. The results from that study were promising because Cavus and Ibrahim (2009) reported that:

> MOLT system (M = 24.68, SD = 12.44), students had lower success rates than after using the MOLT system (M = 89.77, SD = 7.18). A paired sampled t-test based on pretest and posttest results has indicated a significant difference between the two tests (t = 32.29, p < 0.05) in favour of the posttest (p. 86)

Here one can see that the participants in that study were assessed twice, pre- and posttest. After the posttest was administered a paired sample t-test was conducted and the results showed a significant difference between the two tests. Even though the results of that study were promising the authors do highlight an important drawback to their study. There is a high price tag associated with sending a relatively large volume of text messages to sizeable group of students.

The study conducted by Wang, Shen, Novak, and Pan (2009) at Shanghai Jiaotong University in China also investigated the effect of using short text messages in a blended environment. As part of that study 178 participants answered a post-treatment survey. The survey revealed that:

> Students reported using their mobile phones in the following class-related activities:
> 1. discussing course content with classmates (85% of the participants);
> 2. asking classmates questions (54%);
> 3. asking the instructor or teaching assistant (TA) questions (90%);
> 4. answering questions from the instructor or TA (82%);
> 5. answering questions from classmates; and (52%)
> 6. exchanging ideas with classmates about the course material (38%). (p. 686)

Here the researchers observed that the participants in that study became increasingly engaged in the learning process which led to students being "behaviourlly, intellectually and emotionally involved in their learning goals" (p. 674). They attributed the success of the program to the student engagement. Unlike the previous generations of distance education where the learning tool was not interactive (e.g., watching TV), here students got involved and participated (Wang, Shen, Novak, and Pan, 2009).

In short, the literature of using SMS was explored because sending and receiving of an SMS is akin to a tweet. The aforementioned studies do have a commonality; they all make use of unidirectional messages to increase the learning of students and the messages were sent on a regular basis. The similarity because both mediums are text based. However, tweets can also contain text, pictures, and video and can be used on mobile devices or computers, making it more accessible.

Twitter

Twitter was introduced in mid-2006 at the beginning of the Web 2.0 movement. It quickly rose in popularity to become one of the top microblogging tools (Hughes & Palen, 2009; Jansen et al., 2009). It is a free microblogging service, where one interacts with others by *following* them. The act of posting a message is called *tweeting*. Users have the capacity to spread messages of others through the act of *retweeting*. In 140-characters or less, users answer the fundamental question of: *What are you doing?*

Table 1 illustrates the growth Twitter has seen from 2008 to the present (Jones, 2013). Based on the number of users, it can be concluded that Twitter is an immensely popular microblogging tool. One has to wonder, why is Twitter such a massively popular tool? A great deal of this has to do with the design elements associated with Twitter.

Table 1
Growth of Registered Twitter Users

Year	Number (in millions)
2008	6
2009	8
2010	26
2011	150
2012	500
2013	554.7

Twitter is sometimes referred to as microblogging. One of the characteristics of microblogging is that communication must be brief. More specifically, a tweet must be 140-characters or less. Users have used the 140-characters-or-less limit in many creative and diverse ways. This includes, but is not limited to, asking questions and sharing one's thoughts (Dunlap & Lowenthal, 2009). Twitter states that their mission is, “To give everyone the power to create and share ideas and information instantly, without barriers” (Twitter, 2014). Accordingly, for the Neomillennial Generation, Twitter is rapidly becoming the new *word of mouth* form of communication; this is demonstrated by the fact that millions of tweets are sent out every day (Baird & Fisher, 2005; Jansen et al., 2009). Since Twitter users are already asking questions and sharing their thoughts, then one has to ask: Is it possible to repurpose and adapt these practices to use Twitter as a tool for learning?

Another of the characteristics of microblogging is the pace and the frequency of exchange of information or spreading messages. Cha et al. (2010) highlighted that the value of the message being spread can be measured by how many times it is retweeted or is marked as favorite. Tweets can be sent from various common access protocols such as cell phones, e-mail, or the Web (Java et al., 2007). Microblogging differs from blogging in that the messages are shorter and appear at a faster pace. Microbloggers are eager to spread news and information while bloggers are not concerned with frequency and brevity (Java et al., 2007).

Social Networking Sites and Learning

Generating a sense of belonging and support might be possible with Twitter. Most social networking sites allow for the creation of groups or lists that are private. This is a useful feature because it creates a separation between what is content related and what is not. A study conducted by English and Duncan-Howell (2008) with pre-service students in higher education working in a private Facebook group showed that:

> Majority of posts were associated with affective communication such as group reinforcement, encouragement, and support which may suggest that the sense of community was strong in this group, but also that the key use of these types of online tools may lie more in the affective domain. (p. 600)

Even though the English and Duncan-Howell (2008) study dealt with pre-service teachers, the results show that if students are given the opportunity to interact outside of the classroom, they will do so and manage to interact about content related topics. It is entirely possible that social networking sites such as MySpace and Facebook can foster collaboration in class (Griffith & Liyanage, 2008). A study on the use of Flickr, a photo and video sharing website, in education showed "some level of cognitive engagement in the topic of collaboration as evidenced by the analysis of the descriptions and comments posted by students" (Lockyer & Patterson, 2008, p. 533). Lastly, a small survey conducted by Roblyer, McDaniel, Webb, Herman, and Witty, (2010) revealed that students are very much open to the idea of using social networking sites as part of their education. Roblyer et al. (2010) survey had 9 questions and was administered to 120 students and 62 faculty members at mid-sized southern university. Therefore, it is not unreasonable to assume that Twitter can achieve the same results.

Other Uses for Twitter

Cha et al. (2010) argued that one of Twitter's greatest strength is its influence on human behavior. While using Twitter one can influence many others through simple communication of ideas, gossip, and other updates (personal news). Twitter has been used to communicate during conferences (Reinhardt, Ebner, Beham & Costa, 2009), natural disasters (Hughes & Palen, 2009; Sakaki et al., 2010; Vieweg, Hughes, Starbird & Palen, 2010), political campaigns, and elections (Hughes & Palen, 2009; Tumasjan, Sprenger, Sandner & Welpe, 2010). Here we see that Twitter can be used in other settings, so it begs the question: Is it possible to use Twitter in the classroom?

In summary, Twitter was invented in 2006 and in a brief period of time it has become extremely popular. Twitter currently has hundreds of millions of users who are very diverse across all measureable demographics. The latest numbers show, that Twitter is currently very popular among young people. Twitter has been applied many setting and it is starting to be applied to education.

Twitter's Potential in Education

Dunlap and Lowenthal (2009) emphasized that learning does not occur in a vacuum. Part of the education process is rooted in some form of social interaction. If learning at a distance is to remain a viable option, it must contain some social aspects (Kuh, 1995). Dunlap and Lowenthal (2009) have suggested several uses for Twitter outside the classroom. The uses include, asking questions, seeking clarification, private messages in between cooperative group members, and sharing important news. In an era when tasks need to be completed in a timely manner, Twitter can help teachers and students communicate in the blink of an eye. The fact that both teachers and students, have to condense their thoughts to 140-characters or less, compels the user to state their questions or answers in a concise manner (Dunlap & Lowenthal, 2009).

The research, mentioned above, suggests that for this form of communication to be effective, several guidelines need to be in place. Students must have a clear understanding of how they are to participate in a class where Twitter is being used. Furthermore, the teacher needs to model how to effectively use Twitter. Lastly, both teachers and students must continuously be engaged in the lesson (Dunlap & Lowenthal, 2009). Twitter provides real-time, to the point, mobile, and cost effective information (Zhao & Rosson, 2009).

A review of the literature, for this chapter, suggests that there are no studies that implement Twitter in high school mathematics. The meta-analysis conducted by Gao et al. (2012) on microblogging in education found 21 peer-reviewed articles in major journals, three databases, Google Scholar, and snowball sampling from 2008-2011 (Table 2). The findings show great variability in terms of setting, topics, sample size, and duration of intervention.

First, the setting for these studies did not have a great deal of variance, 18 studies were used in higher education, one study was in a K-12 setting, and two studies were situated at conferences. Second, the topics covered included four papers on language, six on instructional design, three on new media, two on business, three on other topics, and three on topics that were not disclosed. Third, the sample size in some of these studies varied widely as well, with one study having a sample size less than 10, six studies with between 10 and 50 participants, two studies with a sample size from 51 to 100, six studies with a sample size greater than 150, and two studies with undisclosed sample sizes. Fourth, the duration of the intervention included two studies with less than 1 day, eight studies between 1 and 8 weeks, seven studies with nine to 15 weeks, two studies with over 15 weeks, and two studies with an unknown period of time. Of the 21 papers, the analysis showed that 20 of them used descriptive statistics, instead of inferential statistics. The descriptive data that were gathered included number of posts, number of tweets, and survey results. This meta-analysis highlights the need for further research in a K-12 setting, secondary school mathematics, with a larger sample size, and inferential in nature.

Table 2
Information About Studies of Twitter and Education

Author	Setting	Duration
Agherdien (2011)	Higher education	2 semesters
Antenos-Conforti (2009)	Higher education	14 weeks
Borau et al. (2009)	Higher education	7 weeks
Costa et al. (2008)	Higher education	1 weeks
de Waard et al. (2011)	Higher education	6 weeks
Dunlap and Lowenthal (2009)	Higher education	1 semester
Ebner (2009)	Higher education	2 lectures
Ebner and Schiefner (2008)	Higher education	8 weeks
Ebner et al. (2010)	Higher education	6 weeks
Elavsky et al. (2011)	Higher education	1 semester
Holotescu and Grosseck (2009)	Higher education	2 weeks
Junco et al. (2011)	Higher education	14 weeks
Kop (2011)	Higher education	1 semester
Kop et al. (2011)	Higher education	1 semester
Lowe and Laffey (2011)	Higher education	8 weeks
Perifanou (2009)	Higher education	N/A
Rinaldo et al. (2011)	Higher education	2 semesters
Waller (2010)	K-12	N/A
Wright (2010)	Higher education	7 weeks

Note. Adapted from "Tweeting for learning: A critical analysis of research on microblogging in education published in 2008–2011." by Gao et al., 2012.

Only one article was classified as experimental, written by Junco et al. (2011). Junco et al. (2011) used a sample size of 125 (70 participants in the experimental group and 55 participants in the control group of students) college students taking a seminar course for pre-health professionals for a period of 14 weeks. The second week students were exposed to an hour-long training seminar where they were coached on how to use Twitter. As part of this seminar students learned to sign-up for a Twitter account, send tweets, use hashtags, reply to tweets, and protect their privacy. Also, they were required to follow the Twitter account by the researchers and follow their fellow classmates. The tweets the participants received were designed to continue classroom discussion, allow students to ask question, discuss reading material, inform the class about campus events, provide support (personal and academic), create a learning community, organize the service learning project, and organize student groups. Based on what is described in the articles the tweets did not involve modeling but it did provide opportunities for cooperative learning. Furthermore, it does require that the student be more proactive about their education.

The students in the Junco et al. (2011) study were required to make two post and two replies. Also, tweet their reactions to a video and react to statements from the course readings. Lastly, they were required to discuss their service-learning project. Furthermore, there were two optional assignments. In the first assignment, the participants attended upper-level classes and tweet two questions to the discussion panel. In the second assignment, the participants tweeted about their reactions to shadowing a healthcare profession for a day.

The Junco et al. (2011) study tried to measure learning and engagement through by using Twitter. The engagement aspect was measured with a 19-item survey, National Survey of Student Engagement. Learning was measured analyzing final course grades, using a mixed effects ANOVA. The results of the ANOVA showed that students in the Twitter group had significantly higher level of engagement and higher grades than the control group of students. Junco et al. (2011) concluded that, “First piece of controlled experimental evidence that using Twitter in educationally relevant ways can increase student engagement and improve grades, and thus, that social media can be used as an educational tool to help students reach desired college outcomes” (p. 12).

The work by Gao et al., as mentioned previously, spans from 2008-2011 (2012). Since 2011 new literature has surfaced. The recent work of Everson et al. (2013) use various forms of social media, including Twitter, to teach an introductory statistics class for graduate students. The study involved 18 students in an introductory statistics class, of whom, 17 opened an account on Twitter. Students were not required to use Twitter but those who did receive extra credit. At the beginning of the assignment, Everson displayed exemplar tweets so that students understood the nature of the assignment. Each tweet was to be marked with the course number as the hashtag (i.e., #epsy5261). As part of the extra credit assignment they were asked to share hyperlinks, critiques, and ask questions. The purpose of sharing hyperlinks and posing questions was to demonstrate that they had read the article and reflected on the content of the article, as it related to statistics. Take for example, “Cows with names yield more milk than cows without names. Did they do a two-sample t-test? http://bit.ly/D3Wu #epsy5261” (p. 8). This example illustrates that Everson’s students are reading interesting articles, sharing them with others, reflecting on their education, and proposing questions about what they are learning in statistics with 140-characters or less using Twitter. Based on what is described in the articles the tweets did not involve modeling but it did provide opportunities for cooperative learning. Furthermore, it does require that the student be more proactive about their education.

Everson concluded the students enjoyed using Twitter as part of the course. This conclusion based on the conversations that were overheard throughout the duration of the assignment. It is not known whether students disliked using Twitter as part of the Everson et al. (2013) study. When Everson chose to replicate his study the following semester, over half the students hesitated to participate because they felt they could not express themselves well enough in 140-characters or less. From a qualitatively point-of-view, the results of the Everson et al. (2013) study are promising. However, Everson et al. (2013) offer no quantitative evidence that Twitter made a statistically significant difference in the learning outcomes of these 17 students.

The study conducted by Van Vooren and Bess (2013) examined the use of Twitter and student performance on the standardized tests in an eighth grade science class. The study involved two groups of students. The sample in the Van Vooren and Bess (2013) study involved 43 students who agreed to use Twitter and follow Bess (Sample A) and 43 students who did not want to use Twitter (Sample B). Both samples contained the same number of girls, boys, as well as, gifted and talented students. However, there was a slight difference between the numbers of English Language Learner (ELL), socioeconomic status (SES), and special education (SPED). In their study they made no effort to control for this difference among the groups.

The Twitter group received on average four or five tweets per week from Bess. These tweets were related to course material mentioned in class, assignments, homework, and reminders. Based on what is described in the articles the tweets did not involve modeling or cooperative learning. However, it does require that the student be more proactive about getting an education. Over the course of four weeks the participants took two publisher-developed tests assessing the California Science Standards.

The first assessment covered states of matter and the physical and chemical changes they undergo. On the first standardized curriculum test, the students who used Twitter got 77% of the answers correct. The group who did not use Twitter got 71% of the answers correct. Furthermore, the results of the first test were reported as the following:

> Sample t-test were; T = 1.9968, p = 0.02479, df = 73.0839. The statistical analysis suggests rejecting the null hypothesis at the 0.05 significance level. The statistical data suggested there is a correlation between the use of Twitter and students' performance on this particular standardized curriculum test. (p. 2)

The second assessment covered properties of matter, specifically physical, and chemical reactions. On the second standardized curriculum test, the students who used Twitter got 75% of the answers correct. The group who did not use Twitter got 67% of the answers correct. Additionally, the results for the second test were reported as the following:

> Sample t-test results are T = 2.1665, p = .01662, df = 80.4287. The statistical analysis suggests rejecting the null hypothesis at the 0.05 significance level. Statistically significant evidence led to a conclusion that the mean second test scores of those who used Twitter was greater than those who did not use Twitter. (p. 2)

In short, the Van Vooren and Bess (2013) study implies that there is a correlation between the using Twitter and the achievement of middle school science students (Van Vooren & Bess, 2013).

Blessing et al. (2012) conducted a study with undergraduate psychology students receiving about one tweet per day related to topics in psychology. The researchers wrote two sets of 84 tweets, six per chapter. One set of tweets was designed to be humorous and content related, while the other set of tweets were designed to be just humorous in nature. The researchers reported that overall the participants received about six to eight tweets per test. Based on what is described in the articles the tweets did not involve modeling or cooperative learning. However, it does require that the student be more proactive about education by reinforcing the main points of the content being taught.

The Blessing et al. study was conducted with 63 participants, 42 women and 21 men. The participants were randomly assigned to a group on the first day of class. Those students that were assigned to the Twitter group received instructions on how to use Twitter or how to receive and send tweets using Facebook. The researchers found that the student who received content-based tweets performed significantly better on the test items that were correlated to the content-based tweets. The researchers used an arsine transformation to analyze the test score percentages. Additionally, the results were reported as the following, "The humor-only group (M = 0.67, SD = 0.16) performed significantly worse than the course concept group (M = 0.74, SD = 0.12), $t(61) = 2.02$, $p = .048$, $d = 0.52$, on the target multiple-choice items" (p. 270). This analysis only focuses on the select test items; on the exam as a whole the researchers found no significant difference between the groups.

In the aforementioned study the researchers used the arcsine transformation (or angular transformation). In that transformation, $\theta = arcsin\sqrt{p}$, is used on data that is either a percent or proportion; where θ is an angle in radians and p is a proportion (Sokal & Rohlf, 1995). The following caveat is worth mentioning; researchers have argued that logistic regression should be used in its place (Shi, Sand Hu & Xiao, 2013; Wilson et al., 2013). The logistic regression was shown to improve residuals' normality, homogeneity, and independence (Wilson et al., 2013).

Even though this literature review found no studies that involve the use of Twitter in a high school science or mathematics class, there is some research that demonstrates that it can be used with some success (Junco et al., 2011; Van Vooren & Bess, 2013). Research has been conducted at the middle school and undergraduate levels, but there are no studies that show that it has been used in mathematics and other settings. As a result, there is a gap in the literature. This quasi-experimental study sought to fill that gap in the literature and perhaps open the door to future studies in science education and other secondary education fields.

In summary, the aforementioned studies suggest that Twitter could have the potential to be a powerful learning tool. The researchers report positive results when applying Twitter to education. Blessing et al. (2012) and Everson et al. (2013) used Twitter to tweet about course content. Junco et al. (2011) used Twitter to tweet about classroom logistics. Van Vooren and Bess (2013) used Twitter to tweet about both, course content and logistics. The majority of studies have focused on how Twitter can be used in higher education and the work tends to be descriptive in nature. However, there is a great deal of variance among the sample sizes, duration of the studies, and the disciplines to which it has been applied.

Cognition and Learning

As the theoretical foundation for this quasi-experimental study, cognitive architecture, chunks of information, information processing model, and cognitive load theory (CLT) was considered. A central feature of Twitter is its 140-character limit per tweet. Consistent with past research, the researcher was of the opinion that the brief messages, presented in parts, might have a lesser strain on the cognitive load of students, thus making the effects of the tweets stronger. The tweets in this quasi-experimental study included mathematical content, classroom logistics, or both.

The first subsection cognitive architecture will be discussed and how information moves through short-term memory before it goes to long-term memory. In the second subsection, chunks of information will be introduced. This provides a foundation for the understanding of information processing model and cognitive load theory. The model highlights the importance of how information goes through sensory memory to working memory, and finally long-term memory. This section is followed by a discussion of cognitive load theory (CLT) and how it informs the current study.

Cognitive Architecture

One of the most crucial functions of memory is its effect on learning. Sternberg and Williams (2010) wrote, "Memory is the active mental mechanism that enables people to retain and retrieve information" (p. 270). They stated that learning is relatively permanent change in behavior or thought process. Since learning cannot exist without memory, the cognitive architecture needs to be explored further.

The human cognitive architecture is composed of long-term memory and working memory (Sweller, 2004). Sweller (2004) goes on to say that, "Long-term memory consists of a large, relatively permanent store of information" (p. 11). Working memory is "a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning" (Baddeley, 1992, p. 556).

Information found in working memory arrives there by either being brought forth by long-term memory or through sensory system (e.g., vision, hearing, touch, taste, and smell). In contrast to the long-term memory, if information is not tied to an existing schema, it will only stay in working memory for a few seconds (Sweller, 2004). Working memory and long-term memory are essential components of the Information processing model of the human mind (See Figure 1).

Information Processing Model

The information processing model was significant to this quasi-experimental study because it deals with the way and the amount of information to be processed in the human mind. The model makes a distinction in the way by which information is processed through either the acoustic sensory or the visual sensory (Baddeley, 1998). More specifically, regulating these two sensory channels (acoustic and visual) facilitates the connections that are made about a single concept that is being represented (Paivio, 1986). However, there is a limit in the chunks of information that can be processed through working memory (Baddeley, 1998).

The information processing model has several components. First, there are three memory stores: sensory, working, and long-term memory. Also, there are five cognitive processes: selecting words, selecting images, organizing words, organizing images, and integrating. Lastly, there are two channels of knowledge: auditory-verbal channel and visual/pictorial channel (Mayer, 2003). Mayer wrote, “Printed words and pictures enter the cognitive system through the eyes, resulting in a short-lasting sensation in visual sensory memory. If the learner pays attention, parts of the sensation are transferred to visual working memory for further processing” (pp. 51-52). By applying the principals of the information processing model, if one can control the amount of information and the medium by which chunks of information enter, working memory can be controlled, and then short messages like tweets can have an effect on learning.

Further research has shown that the ability to hold information over extended periods of time is what distinguishes expert problem-solvers from novice problem-solvers because long-term memory has an effect on working memory (De Groot, 1965). Although De Groot (1965) study was conducted on chess players, it is inferred that all problem solving works in a similar manner because “learners must combine elements randomly and then determine which random combinations are useful in solving the problem” (Sweller, 2004, p. 14).

In short, the information processing model was discussed because the way information enters the human mind and effect learning are an essential for understanding why Twitter is useful. Twitter has the capabilities to stimulate both channels in Sensory Memory. As a result, the information processing model will have implications on this quasi-experimental study (See Figure 2). Tweets containing pictures or printed words will enter sensory memory via visual sensation. The selected images will become part of the image base and will be organized and integrated into long-term memory.

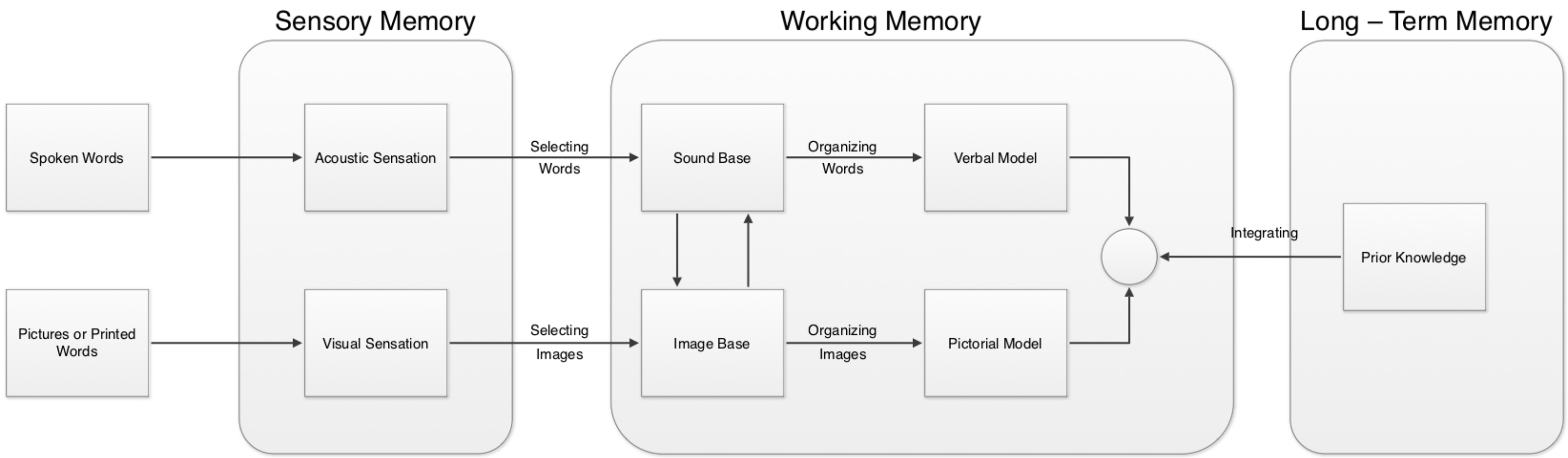

Figure 1. Information Processing Model on How the Human Mind Works. Reproduced from Mayer (2003).

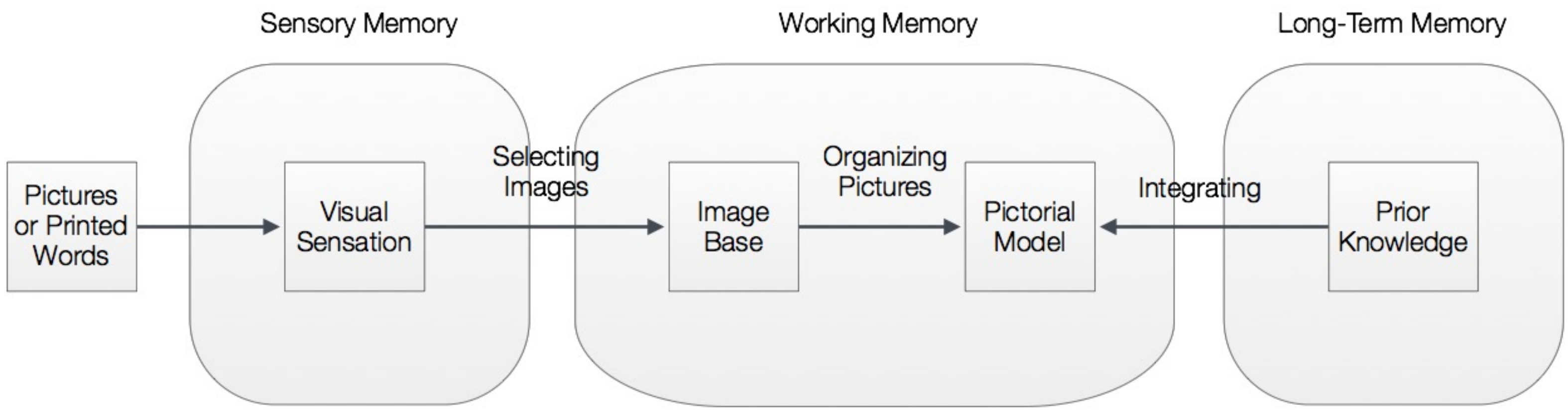

Figure 2. Application of the Information Processing Model to Twitter

Chunks of Information

The important role that short-term memory plays in education cannot be underscored, de Jong (2010) wrote, “Individual working memory performance correlates with cognitive abilities and academic achievement” (p. 106). Miller (1956) introduced the notion that a person’s attention span could only effectively process seven plus or minus two (7±2) chunks of information. Miller inferred that it is possible that memory can work very much the same way. To support this, Miller highlighted the research that has been conducted by Pollock (1952; 1953) using the recognition of various musical pitches. Pollock was meticulous in his research methods, but his findings are congruent to what Hayes (1952) had accomplished with binary digits, decimal digits, letters, letters and decimal digits, and monosyllabic words.

Even though Miller’s work was considered to be pivotal to the field of cognition and education, he was criticized by Cowan. The meta-analysis conducted Cowan (2001), concluded that Miller (1956) has overestimated the short-term memory (or working memory) capacity of the average adult. Based on his analysis, Cowan concluded that short-term memory could hold four plus or minus one (4±1) chunks of memory.

Cowan’s (2001) work implied that the average person can hold between three to five chunks of information in short-term memory. This number is not necessarily written in stone because some subjects had the capacity to only hold as low as two and others as high as six chunks of information in short-term memory. These sentiments are echoed by Sweller (2004), who first conceptualized cognitive load theory in 1988.

The work conducted by Caple (1996) suggests that working small manageable chunks of information was beneficial to students. The Caple study was conducted with

36 participants divided into two groups. One group of 18 participants received instruction that involved chunks followed by practice, while the second group of 18 participants received a large chuck of information without spaced practice. A pretest on "African American Scientist and Inventors" was administered and the results were used as the covariate for an ANCOVA test performed after the posttest. The ANCOVA was performed with $\alpha = .05$ as the significance level. The results show that there is a significant difference between the two groups in favor of the group that used small chunks of information and spaced practice (Caple, 1996).

In short, the minds' ability to work with a finite amount of information hovers around 4±1 chunks of information. Small chunks of information are what the human mind is accustomed to handling. This idea provides a foundation for the need to use Twitter and its 140-character limit per tweet. In this quasi-experimental study, a chunk of information is a tweet. The researcher is of the opinion that these small chunks of information will have a greater effect on learning because they are consistent with past research.

Cognitive Load Theory

First, the work conducted by Miller (1956) and others suggest that information is chunked in restricted amounts. Second, the work by Baddeley (1998) advocates the idea that information enters memory through different channels. Once the information has entered the mind it is essential to make sure that it is having a lasting effect. Sweller (1991) recommend that information "be presented in ways that do not impose a heavy extraneous cognitive load" (p. 295). Furthermore, they suggested, "Ideal formats for initial instruction should reduce extraneous cognitive load" (p. 296). Lastly, they mention that, “Isolating and eliminating redundant sources of information are preferable” (p. 330). Thus, the simple interface and 140-character limit that are common to Twitter are in line with past research.

Sweller (1988) first conceived of cognitive load theory while working on problem solving. His research suggests that heavy demands on the cognitive load hinder the ability to create schemas. He goes on to recommend that instruction and problem solving should not over burden the learner’s cognitive load. Instead, it should have the least amount of effect on the cognitive load as possible by proposing goal-free problems (1988, 1994).

The idea of cognitive load has been expanded to include three different parts: intrinsic, extraneous, and germane. Intrinsic cognitive load deals with the natural aspects of the material that is being presented. Extraneous cognitive load has to do the load that is affected by instructional tools used in instruction. Lastly, germane cognitive load deals with the load effected by learning new content (de Jong, 2010).

It is important to understand how the various parts of cognitive load influence instructional design. Sweller (1994) wrote, “Intrinsic cognitive load is fixed and cannot be reduced. On the other hand, extraneous cognitive load caused by inappropriate instructional designs can be reduced” (p. 308). Therefore, learning is impeded as the demand on extraneous cognitive load increases. Thus, one can infer that brief messages have a lesser strain on the cognitive load of students, thus making the effect of the message stronger.

Even though there were no articles located in the review of the literature about how to incorporate CLT and Twitter, there is some literature about multimedia instruction in education that offer some insight into how Twitter should be used in the present study. Mayer and Moreno (2003) suggested 9 techniques across 5 different scenarios to lessen cognitive load involving three processes. The three processes are essential processing, incidental processing, and representation holding. Essential processing refers to making sense of the information that is presented to the individual. Incidental processing involves additional information that is presented. Representation holding has to do with verbal or visual information in working memory.

First, when working with essential processing in the visual channel it is suggested that some information should be off-load from the visual channel to the auditory channel. They suggested that using spoken words over written text. Second, when working with essential processing in both, auditory, and visual channels, one should allow time amid bits of information. Information that is presented in small manageable chunks is preferred to one nonstop segment. Also, pre-training that involved knowing names and behaviors can assist in the transfer of information. Third, when working with essential and incidental processes one or both channels are overloaded due to extraneous material. It is suggested that weeding and signaling be used. Weeding involves removing of unimportant material. Signaling provides a prompt for how to process unimportant information. Fourth, when working with essential and incidental processes one or both channels are overloaded due to confusing material it is suggested that aligning and eliminating redundancy be used. Aligning involves incorporating printed words and graphics together to eradicate the need for scanning and thus, eliminating redundancy by not presenting the same information over identical channels. Lastly, when working with essential and representation holding it, is suggested that synchronizing and individualizing be employed. Synchronizing entails coordinating sight and sound to diminish the demand on working memory. Individualizing focuses on being able to maintain the appropriate mental image (Mayer & Moreno, 2003).

These theories work together and inform the study because one can conclude that too much information overloads the memory. Thus, this is why Twitter, which uses a small chunk of information, could be a beneficial learning tool in mathematics. In essence, Twitter does not cause cognitive overload. The aforementioned articles on SMS revealed that short text messages are able to help with memory retention and achievement. However, tweets can also contain text, pictures, and video. The information processing model states that pictures and printed words are a form of visual sensation that effect sensory memory. Then it moves to the image base in working memory. As per cognitive load theory, the chunks of information should not be greater than 4±1. Lastly, information is integrated with prior knowledge from long-term memory.

In summary, the cognitive architecture is composed of long- and short-term memory. The information that one can hold in short-term memory was once believed to be 7±2 chunks, but studies have showed that is closer to 4±1 chunks. The information processing model is composed of sensory memory, working memory, and long-term memory. Cognitive load theory states that the cognitive load is comprised of intrinsic cognitive load, extraneous cognitive load, and germane cognitive load.

Standards in Education

Instruction is not only influenced by a teacher's personal curriculum ideology and preferred practices, but also by the standards set by professional organizations. On a national-level The International Society for Technology in Education (ISTE) and National Council of Teachers of Mathematics (NCTM) have published standards for the classroom. ISTE has suggested exploring and experiential learning as key aspects of the learning process (ISTE, 2000; ISTE 2008). NCTM has also advice that technology can be used to help promote exploratory and inquiry learning in mathematics (NCTM, 2000). A closer look at the work by NCTM reveals that there are two major subdivisions to their overall philosophy.

National Council of Teachers of Mathematics

NCTM defines exploration and experiential learning within two major branches: The Content Standards and Process Standards. The Content Standards include Number and Operations, Algebra, Geometry, Measurement, and lastly Data Analysis and Probability. These standards outline the content that students are expected to know. The Process Standards include Problem Solving, Reasoning and Proof, Communication, Connections, and Representation. These standards map out how they believe students should be acquiring the knowledge prescribed in The Content Standards.

Two NTCM standards that merit consideration are Communication and Representation. First, the Communication Standard calls for students to develop the ability to share mathematical ideas with their classmates. NCTM goes on to recommend that students also critique the mathematical ideas of their classmates. It is further suggested that students use mathematically adequate vocabulary to express their thinking. Capraro and Joffrion have said, "Fostering mathematical communication typically does encouraging conceptual understanding of translating literal equations. Mathematics is a language of communication and tool for new discovery" (2006, p. 152). Second, the use of multiple representations to express mathematical ideas is important. NCTM explains that using graphics have traditionally been used as teaching tools and should continue to be used for their educational value.

Mathematics Florida Standards

In the past two decades, teachers in the State of Florida have had to become familiar with the following set of standards: The Sunshine Standards (SSS), The Next Generation of Sunshine State Standards (NGSSS), and Common Core State Standards Initiative (CCSSI). The CCSSI represents a change in the curricula of some states because it pools together, what the architects of the Common Core considered, to be the highest standards. As part of the standards, CCSSI chose to incorporate the NCTM process standards regarding problem solving, reasoning and proof, communication, representation, and connections (“Standards,” 2012).

On June 2, 2010, the Common Core standards in mathematics and language arts were announced (“FAQ,” 2012). Soon thereafter, many state boards of education voted to adopt those standards. Florida’s Board of Education adopted the Common Core Standards on July 27, 2010 (Florida Department of Education, 2010). However, in January 2014, Florida decided to modify the standards set forth by CCSSI. In February 18, 2014 the Florida State Board of Education adopted a set of new standards, Mathematics Florida Standards (MAFS), (Florida Department of Education, 2014). The MAFS are a renaming of the Common Core standards.

International Society for Technology in Education

The International Society for Technology in Education (ISTE) also has its own set of standards that teachers should follow. ISTE published National Educational

Technology Standards for Teachers (NETS-T) in order to improve student learning (ISTE, 2008). The NETS-T's second standard called for teachers to "design, develop, and evaluate authentic learning experiences and assessment incorporating contemporary tools and resources to maximize content learning in context and to develop the knowledge, skills, and attitudes" and "design or adapt relevant learning experiences that incorporate digital tools and resources to promote student learning and creativity" (2008, p. 1). Furthermore, NETS-T's third standard recommends that teachers, "Exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society" and "Communicate relevant information and ideas effectively to students, parents, and peers using a variety of digital age media and formats" (p. 1).

In summary, ISTE and NCTM are professional organizations at the national level that recommend the use of technology as a learning tool for students. However, NCTM is subject area specific and includes Content Standards and Process Standards. In the past few years, the state of Florida has implemented several standards. These standards include SSS, NGSSS, CCSSI, and MAFS.

Webb's Depth-of-Knowledge

Webb's Depth-of-Knowledge (DOK) is a four-level categorization scheme devised by Normal L. Webb at the Wisconsin Center for Education Research located at the University of Wisconsin-Madison in 2002. Recommendations for cognitive rigor in four content areas language arts (reading and writing), mathematics, science, and social studies were suggested (Webb, 2002). As part of this literature review only the mathematics DOK levels will be examined because the tweets that were sent out by the teachers as part of this quasi-experimental study used a number of the verbs identified by Webb in his DOK classification system.

Levels

Level 1 is the *recall and reproduction* level. This is the lowest level in Webb's DOK scheme. At this level the student is expected to recited information or perform simple tasks. Level 2 is the *skill/concept* level. This requires that the student go beyond rote behaviors and think about the problem. Level 3 is the *strategic thinking* level. Here the student must employ a higher level thinking that moves beyond the concrete and into the abstract. Level 4 is the *extended thinking* level. This is the highest level in Webb's DOK scheme. At this level the student is expect to do a substantial amount of thinking over long period of time (Webb, 2002).

Bloom versus Webb

Before one can compare the two major cognitive rigor schemes in the United States (Bloom and Webb) some background on the evolution of Bloom is necessary. Bloom et al. originally conceive a six-level classification system for cognitive rigor. These levels included knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956).

Bloom's Taxonomy was updated in 2000 and the levels were rebranded. The new six-level classification included remembering, understanding, applying, analyzing, evaluating, and creating. One of the most noticeable change from the old organization system to the new one was that the names of the classification went from being nouns to verbs (Perkins, 2008).

The most noticeable difference between Bloom's Taxonomy and Webb's DOK is that four levels instead of six. However, when compared these two systems are found to be similar. Remembering and understanding correspond to recall and reproduction. Applying resembles to skills and concepts. Also, analyzing parallels to strategic thinking. Lastly, evaluating and creating match to extended thinking (Palm Beach, n.d.).

Application of Webb's Depth-of-Knowledge

The Common Core uses Webb's DOK. Since Florida's MAFS is a rebranding of the Common Core they also inherit Webb's DOK. Subsequently, M-DCPS must abide by the Florida MAFS and course description, therefore it follows that the M-DCPS pacing guides also inherit Webb's DOK. As a result, the tweets that were used in this quasi-experimental study were structured around verbs commonly identified as being related to Webb's DOK.

Algebra

A few generations ago only a handful of students took algebra. Back then most high school students were only required to perform operations on positive rational numbers as part of their mathematics education (Capraro & Joffrion, 2003). The need for algebra as a graduation requirement is spreading (Chazan & Yerushalmy, 2003). Over simplistic and intellectually undemanding high school mathematics course are quickly being replaced with algebra and geometry (Usiskin, 1995). Currently, in the State of Florida a student needs 24 credits to graduate high school with a standard high school diploma. As part of these 24 credits a student must have four credits in mathematics. These four credits must include Algebra 1, Geometry, and their accompanying end-of-course exams. The remaining two credits must be composing of two credits at the level of Algebra 2 or higher (FLDOE, 2015). Courses that qualify as being at the Algebra 2 or higher include, but are not limited to, Pre-Calculus Honors, Probability and Statistics with Applications Honors, Calculus Honors, Mathematical Analysis and Trigonometry Honors, Advance Placement Statistics, Advance Placement Calculus, all Cambridge (AICE) mathematics courses, and all Dual Enrollment (DE) mathematics courses.

The need for algebra is quickly spreading like wildfire. Even though its application and usefulness are at times are less than obvious to students because teachers resort to teaching process over conceptual understanding (Capraro & Joffrion, 2003). There, of course, must be a balance between process and conceptual understanding (Ashlock, 2010) because algebra teaches students the ability to generalize, answer real-world problems, find relationship between quantities, and solve numerical problems (Usiskin, 1995).

To this day some students continue to struggle with algebra. The reason why students are still on this path has been at the center of much discussion. Some scholars argue that a student's shortcoming in algebra can be attributed to that student's conceptual understanding of the equal sign (Knuth et al., 2006). Furthermore, deficiencies in algebra can be attributed to misconception about symbols (sign of a number or operation), overgeneralization of rules, and misunderstanding of operations (Ashlock, 2010). Lastly, Usiskin identifies four major views on algebra: as study generalized arithmetic, problem solving procedures, relationship among quantities, and the study of structures (1988).

How to improve a student's understanding of algebra has been the topic of much debate. High school algebra has remained the same for quite some time. There are a great number of similarities in today's algebra book and those who have been around for close to 200 years. These resemblances include number systems, polynomials, first-degree equations, square roots, quadratics equations, and factoring. The aforementioned topics can be found in an algebra textbook translated by Charles Davies in 1846. The original sources for Davies' textbook was a French algebra book written by M. Bourdon (Dossey, 1998). Some scholars argue that algebra can be improved by increasing awareness throughout the K-12 curriculum (Kaput, 1998) or greater understanding in middle school (Capraro & Joffrion, 2003). Other scholars argue that improvements can be achieved if one increases the conceptual understanding of notation; such as the equal sign (Knuth et al., 2006), variables (Usiskin, 1998), or place a greater emphasis on the use of brackets (Hoch & Dreyfus, 2004). While others have called for a reduction of topics in order to increase emphasis on core topics so that one might move away from a curriculum that has been described as, *a mile wide and inch deep* (Phillips, 1998; Williams & Molina, 1998).

In a study by Kortering, de Bettencourt, and Braziel (2005) with 456 participants (410 general education students and 46 with a learning disability) at a southeastern U.S. high school in the fall of 2001 provided some insight into how one can improve instruction in algebra. The participants in that quasi-experimental study pointed out that assignments were too complex and preferred assignments were they are able to collaborate and socialize with their peers.

Achievement and Performance

Hispanics are the largest growing minority group in the United States (Kohler & Lazarín, 2007). Peterson, Woessmann, Hanushek, Lastra-Anadón (2011) analyzed

Programme for International Student Assessment (PISA) test results and found an achievement gap between White students and those of color, (which includes Hispanic students), in mathematics. Research indicates that technology, race, sex, and social economic status (SES) all play an important role in a child's education.

Achievement Gap by Race

In terms of student performance among the various ethnic and racial groups, studies have shown that there is a vast disparity between Whites (non-Hispanic), African Americans, Hispanics, Native American, and Asian students. Peterson et al. (2011) found the following:

> The percentage proficient in the United States varies considerably across students from different racial and ethnic backgrounds. While 42 percent of [W]hite students were identified as proficient in math, only 11 percent of African American students, 15 percent of Hispanic students, and 16 percent of Native Americans were so identified. Fifty percent of students with an ethnic background from Asia and the Pacific Islands, however, were proficient in math. (p. 9)

The results mentioned above were measured by the PISA test, a test administered to 15 year-old students in the United States and 65 countries around the world. This gap was derived from several factors such as: lack of applications of mathematics, their self-confidence to be successful in mathematics, ineffective teachers, teachers' empathy, the negative social perception about students who excel in mathematics, and an overall dislike of the subject because of past failure in the area. The gap in performance was not only racial/ethnic in nature, but also between sexes.

Achievement Gap by Sex

The current perception is that there exists an achievement gap between boys and girls in mathematical achievement, but the research (see below) on the subject was just slightly in favor of boys. One can analyze the performance of boys and girls in mathematics by using standardized test such as ACT, SAT, or National Assessment of Education Progress (NAEP). The NAEP test scores fall into one of three categories:

> **Basic** denotes partial mastery of the knowledge and skills that are fundamental for proficient work at each grade level. **Proficient** represents solid academic performance for each grade assessed. Students reaching this level have demonstrated competency over challenging subject matter, including subject-matter knowledge, application of such knowledge to real-world situations, and analytical skills appropriate to the subject matter. **Advanced** signifies superior performance. (Corbett et al.'s bold; Corbett, Hill, & Rose, 2008, p. 44)

National Center for Education Statistics (NCES), a division of the U.S. Department of Education, has been monitoring student achievement in mathematics, reading, and science for several decades. In the 20th century the NCES was responsible for monitoring student achievement in the Unites States beginning in 1969 by administering the NAEP. Ever since, the NAEP has continued to be administered every four years. The trend in score differences between boys and girls revealed that, "[t]he apparent difference between males' and females' average mathematics scores in 1999 was not statistically significant at any age" (Campbell, Hombo, & Mazzeo, 2000, p. 44). Given the fact that the data is over 10 years old, it warrants further investigation whether this assertion still holds true.

Research conducted by American Association of University Women (AAUW), a non-profit based in Washington, DC, reported that on the mathematics section of the SAT, boys are out preforming girls from 1994 to 2004. Corbett et al. (2008) explained that the, "[a]verage scores on the SAT-M improved for both girls and boys during this period. The sex gap remained fairly constant, however, with boys outscoring girls by 34 to 36 points" (p. 38). Similarly, boys also scored higher on the math and science sections of the ACT.

When AAUW analyzed the finding of NAEP, they found that there exists a slight achievement gap by sex between boy and girls. The gap that currently exist favors boys 13- and 17-years-olds but "no differences appeared in six of the nine years, and boys outscored girls in 1994, 1996, and 2004. Among 17-year-olds, boys outscored girls in eight of the nine tests" conducted between 1978 and 2004 (Corbett et al., 2008, p. 16). Here it was assumed that Corbett implied that there was no statistically significant difference between the groups.

Dee's analysis of the NCES report showed that 9-year-old students showed a "weakly significant" difference with a $p = .049$ (2007, p. 531). This illustrates that the only possible sex gap occurred when students were in elementary school. The same NCES report highlighted another important finding, "[f]or 9- and 13-year-olds, score differences favoring females in the 1970s have shifted to score differences favoring males in the 1990s" (Campbell et al., 2000, p. 44). Given the fact that the data is currently over 10 years old and that PISA only reports aggregate data about students in the United States performance compared to their international peers, this warrants an investigation whether today the pendulum has shifted the other way. Standardized testing represents only a small facet of a child's total education. A closer look at the microcosm does reveal some interesting information.

Performance Gap by Grades

At the primary, secondary, and tertiary levels women and girls earn better grades than men and boys (Duckworth & Seligman, 2006). The classroom grades, unlike the results of a standardized test, are the culmination of months of hard work versus a couple of hours devoted to one test. It has been suggested that the underlying reason why girls earn higher classroom grades can be attributed to self-discipline (Duckworth & Seligman, 2006). They go to say:

> Girls earned significantly higher final grades in Algebra I, English, and social studies than did boys. Girls also earned higher final grades in Algebra II, but because of the reduced sample size in the math subgroups, this difference did not reach statistical significance. (Duckworth & Seligman, 2006, p. 201)

The aforementioned study was commenced in the fall semester of 2002 and was concluded in the spring semester of 2003. It included a sample of 27 students (14 boys and 13 girls) enrolled in Algebra 2 and 111 students (47 boys and 66 girls) enrolled in Algebra 1. This sample was drawn, "from a socioeconomically and ethnically diverse magnet public school in a city in the northeast" (p. 200).

However, others have suggested that classroom grades are also a representation of several other variables. Grades are the final result of mastering content, meeting teacher expectations, appropriate mathematical disposition, and classroom behavior (Riegle-Crumb, 2006).

In short, there exist an achievement gap that is racial, which favors Asians and Whites. When one looks at sex, the achievement gap is not significant but it does favor boys over girls. In terms of academic performance, it favors girls over boys. This abbreviated review represents a small sample of larger body of work that supports the notion that there are differences by race/ethnicity and sex. Therefore, there is no need to explore if there are statistically significant differences among these students as part of this quasi-experimental study.

Wealth and Income Gap

The United States Department of Health and Human Services and The Census Bureau define poverty simply as the minimum income a family, or household, needs annually. For example, a family of four living in the contiguous 48 states or in the Washington, DC area was said to be poor if, collectively, they made less than $23,850 per annum (Federal Register, 2014). The Census Bureau publishes the poverty threshold every year because it needs to be adjusted annually for inflation.

Even though education is believed to be the key to social mobility, as the gap between the rich and the poor keeps widening, this premise is becoming less of a reality for most students in the United States. Policy, politics, and public relations are the variables that influence the education a student receives in the public school system. This is particularly hard on school age children, who are the most vulnerable. They are sentenced to unimaginable living conditions that are not of their own choosing. The residual effects of having been born into this life style follow them throughout their academic careers. This leads to the inability to master the necessary skills to succeed in school (McLoyd, 1998).

The majority of students who attend public schools are poor and those schools are ill equipped to prepare them to rise to the middle class. Thus, schools perpetuate poverty in American society through ill preparation. Currently, the United States is 29th in child poverty just ahead of Mexico (Alexander & Salmon, 2007). At any given time, it is estimated that somewhere from 11% to 15% of Americans are living in poverty. More specifically, this means that about 28%, or 1 in 4 children are living in relative poverty (Gardner, Tuchman & Hawkins, 2010).

In terms of numbers, nationwide, the majority of students living in poverty are White (non-Hispanic) but as a percentage, African Americans and Hispanic students are at the top (McLoyd, 1998). This illustrates that the United States has two major issues to combat, child poverty and education. Poverty and education do not exist in a vacuum and are not independent of one another. Since the Internet and the World Wide Web play such an important role in education of a student, the concerns about access to the Internet need to be addressed.

Wealth and the Technology Gap

It is easy to come to the conclusion that with poverty being a major issue in the United States, that the use of cellphone and Twitter should not merit consideration. Even though poverty is an issue that plagues young people today, the research conducted by Lenhart, Ling, Campbell, and Purcell (2010) indicates that despite this issue, cellphones are still prevalent and useful even among low-income teens.

Lenhart et al. (2010) conducted 800 telephone interviews of boys and girls ranging from 12 to 17 years of age. Their results show that, "Cell phones help bridge the digital divide by providing [I]nternet access to less privileged teens" (p. 4). They supported these finding by highlighting the fact that 59% of teens in households whose total income was under $30,000 have a cellphone. Among Hispanics, 68% percent of teens owned a cellphone and among African Americans, it was 75%. Of those teens whose age was between 14-17 years of age, 80% of them owned a cellphone. In short, this shows that the majority of teens have access to a cellphone.

Furthermore, "Teens from low-income households, particularly African-Americans, are much more likely than other teens to go online using a cell phone" with

“44% of black teens and 35% of Hispanic teens [who] use their cell phones to go online, compared with 21% of [W]hite teens” (Lenhart et al., 2010, p. 5). Meaning that, “21% of teens who do not otherwise go online say they access the [I]nternet on their cell phone” with “41% of teens from households earning less than $30,000 annually say they go online with their cell phone” (Lenhart et al., 2010, p. 5). Therefore, teens have access to the Internet. In short, even though there was an income gap, which shows that about 1 in 4 children are living in poverty, this does not prevent access to the Internet and owning a mobile device, such as a cellphone. This abbreviated review represents a small sample of larger body of work that supports the notion that there are differences by SES. Therefore, there was no need explore if there are statistically significant differences among these students as part of this quasi-experimental study.

Communication

Girls, unlike boys, to a greater extent have come to terms with communication and cellphones. For example, girls send 80 texts per day while boys only send and receive 30. Furthermore, about 86% of girls have used text messages to communication, while only 64% of boys engaged in this type of this behavior. Also, girls were more likely to text about school related matters than boys. Lastly, 76% of girls texted about school work versus only 64% boys who engaged in this type of activity (Lenhart et al., 2010). Therefore, girls communicate more often than boys do with their cellphones.

Summary

This chapter reviewed literature that was pertinent to the study. The review of the literature led to the formation of the research questions stated in Chapter 1 of the present study. Based on the review of current literature, it appears that there is a critical need for more empirical understanding of Twitter. Furthermore, there is an important need to improve student performance in Algebra 1. Lastly, no previous studies were found that explored the connection of using Twitter to improve mathematics education. Data gathered from this study will add to the body of literature about Twitter, Algebra 1, linear equations, and using Twitter in mathematics education. The next chapter will discuss the research design and the measures used in the present study to apply Twitter to Algebra 1.

CHAPTER III: METHODS

The purpose of this quasi-experimental study was to investigate the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. Since the majority of the literature on the use of Twitter is descriptive (e.g., anecdotal and opinions), it is imperative that empirical studies be conducted (Blessing et al., 2012). Thus, due to the lack of experimental and quasi-experimental studies in the literature it is important to conduct more quantitative studies in a K-12 setting. In short, potential benefits of using Twitter in the classroom must be tested objectively in a controlled environment in order to determine whether there is a systematic difference between using Twitter and not using Twitter in education settings.

Participants

The sample was drawn from the population of high school students in Algebra 1 at a major high school in south Florida. This is a convenience sample because the researcher was a faculty member at the high school where the sample was taken. This high school serves a predominantly Hispanic population that consists of approximately 4,200 students. Table 3 has school population breakdown of the high school.

Table 3
Ethnic/Racial Breakdown of the School Population as a Count

Race/ethnicity	Grade				Total
	9	10	11	12	
White	76	68	74	81	299
Black	27	15	21	27	90
Hispanic	949	950	855	947	3701
Asian	21	20	28	20	89
American-Indian	1	7	2	2	12
Multiracial	2	1	0	1	4
Total	1076	1061	980	1078	4195

The school population breakdown with respect to race and ethnicity can be found in Table 4. From the table below one can see that that the largest ethnic group of students was Hispanic. It follows, that the sample would also be predominantly Hispanic.

Table 4
Ethnic/Racial Breakdown of the School Population as a Percent

Race/ethnicity	Grade				Total
	9	10	11	12	
White	7.1	6.4	7.6	7.5	7.1
Black	2.5	1.4	2.1	2.5	2.1
Hispanic	88.2	89.5	87.2	87.8	88.2
Asian	2	1.9	2.9	1.9	2.1
American-Indian	0.1	0.7	0.2	0.2	0.3
Multiracial	0.2	0.1	0	0.1	0.1
Total	46.1	49.9	46.6	47.9	100

The male/female ratio of the population is shown on Table 5. The table shows that there are 4.8% more female students than male students. It follows, that the sample would also be predominantly female.

Table 5
Sex Breakdown of the School Population

	Grade				Total
	9	10	11	12	
Female Count	580	532	523	562	2197
Female Percent	53.9	50.1	53.4	52.1	52.4
Male Count	496	529	457	516	1998
Male Percent	46.1	49.9	46.6	47.9	47.6

In this school population, economically disadvantaged students account for 62.6% of the student body. A student that was considered economically disadvantage qualifies for free or reduced lunch ($0.40) as determined by The National School Lunch and Breakfast Programs administered by Miami-Dade County Public Schools (Table 6).

Table 6
Free and Reduced Lunch of the School Population

	Grade				Total
	9	10	11	12	
Free and Reduced Lunch Count	682	653	610	679	2624
Free and Reduced Lunch Percent	63.4	61.5	62.2	63	62.6

Lastly, the school population breakdown with respect students with disabilities (SWD), English language learners (ELL), and students who are part of the gifted program is shown in Table 7.

Table 7
Special Subgroups of the School Population

	Total	Percent
Gifted Count	780	18.6
ESE Count	412	9.8
ELL Count	283	6.7

Setting

The curricular focus of this quasi-experimental study was mathematics. From within the mathematics department the Algebra 1 course was used. Within the Algebra 1 course, the topic of linear equations was used. Furthermore, in this high school where the present study was conducted no teacher in the mathematics department had used Twitter for educational purposes. Lastly, the three teachers who agreed to participate were novice Twitter users.

As mentioned earlier, this quasi-experimental study had two groups of Algebra 1 students. These groups are determined by the school's master schedule. Building of the master schedule begins with articulation, whereby the middle schools that feed into the high school are made aware of the courses during the forthcoming school year. Then, the middle school students go through the subject selection process where they are given a list of required and elective courses to choose from. Based on teacher recommendation and academic interest, the middle school students select the course they might be enrolled in during the upcoming ninth grade year. Those students who are currently enrolled in high school and will be 10^{th}, 11^{th}, and 12^{th} grade students go through a similar process of selecting course based on academic interest and graduation requirements. The courses that both middle and high school students select are coded into a computer program and a schedule is build and at this point students are assigned randomly to class periods. The master schedule is built around optimizing the number of sections needed and logistics that taking into consideration several variables that include, but are not limited to -- high school graduation requirements, a student's remediation needs, student requests, teacher preference, teacher certifications, the Florida Virtual School (FLVS) graduation requirement, college/university dual enrollment availability, budget, retirement, reduction in force, teacher transfers, and teacher surplus.

Once a master schedule is generated it needs to be tweaked to make accommodations for singletons (single section courses such as Advanced Placement Statistics) and necessary corrections. These corrections may include a student's need for remediation courses, such as Intensive Reading and Intensive Mathematics. Lastly, the Florida Legislature passed into law Chapter 2003-391 (Florida's Class Size Reduction Amendment). This law sets a limit of 25 students per core class (English, math, and science) in a high school (FLDOE, 2013). However, this is not always the case. Schools that apply and received the designation of *school of choice* are exempt from this provision. A school of choice (choice school) is one that gives parents and students the opportunity to attend a school that in not within the assigned school boundaries. This choice is made available if the destination school has a magnet program, offers career academies, International Baccalaureate program or Cambridge Global Studies program. As a result, some of the subgroups in this quasi-experimental study had more than 25 participants.

Instrumentation

As part of this study several instruments were utilized. These instruments include a pre-treatment survey, pretest on linear equations, four quizzes, posttest on linear equations, a post-treatment survey, and Twitter. Each of these instruments will be discusses in the following subsections. Furthermore, the variables, safety, and the expert panel that was assembled to validate the pretest and posttest will also be discussed.

Tests

The students' understanding of linear equations was measured twice – once before the treatment (using the pretest) and once after the treatment (using the posttest). The format for both the pre- and posttest is the same, with only coefficients and the order of items changed. The questions on this test are written so that they correlate with the item specifications published by the State of Florida's Mathematics Florida Standards (MAFS). The instrument that was used to measure the students' understanding of linear equations before and after the treatment, is a teacher created test created so they meet the most current MAFS standards. The subtopics of the pre- and posttest included solving one-step equations, solving two-step equations, solving multi-step equations, solving equations with variables on both sides, solving literal equations, and solving proportions.

This posttest on linear equations is designed to measure Algebra 1 students' understanding of linear equations. The students had one class period, which is 90 minutes, to work on the posttest on linear equations. The posttest on linear equations consists of 20 free-response questions. Also, it assesses students' ability to solve literal equations. This includes rewriting and using equations and formulas. Furthermore, it also includes solving algebraic proportions by measuring the students' ability to solve and apply proportions. Lastly, real-world applications are tested (M-DCPS, 2013).

Expert panel. Two teachers were consulted and they were asked about the validity of the posttest on linear equations. To protect the anonymity of these two teachers, pseudonyms were used. Overall, each of the teachers that were consulted had over 15 years of teaching experience and several advanced degrees. Both of them have taught a wide range of courses in the public school system, which is an asset that contributes to their expertise in secondary school mathematics education.

"Mrs. Euler" was a veteran mathematics teacher with 16 years of teaching experience. She holds a Master of Science degree from a major university in the southeastern United States. Throughout her career she has taught courses ranging from Pre-Algebra to Advanced Placement (AP) Statistics and AP Computer Science. Outside of academia "Mrs. Euler" has extensive experience in operations research. She is currently a mathematics instructor teaching gifted and inclusion classes. After careful analysis of the posttest "Mrs. Euler" went on to say, "Posttest that was administered is consistent with the standards outlined by the State Department of Education referring to Topic III".

"Mrs. Newton" was veteran mathematics teacher with 24 years of teaching experience. She holds an Educational Specialist degree from a major university in the southeastern United States. Throughout her career she has taught courses ranging from

Pre-Algebra to Pre-Calculus. She is currently a mathematics instructor for the world renowned International Baccalaureate (IB) Programme. “Mrs. Newton” was asked to comment whether the posttest accurately measures the students understanding of linear equations. Based on her professional opinion the test, as it is, is valid. She went on to say, “This posttest reflects the standards in Algebra.”

Quizzes

Throughout the unit, the groups were given four quizzes. Lesson quizzes were administered to measure student progress throughout the process. These mini-assessments allowed the teachers and the researcher to analyze subtopics that the participants showed success. Furthermore, it also informed the teachers and the researcher the subtopics the participants needed to improve upon. The quizzes were scored on a 4- or 5-point-scale. A score of zero was the minimum possible score and 4 or 5 were the maximum, a perfect score. Each item on the quizzes had equal weight. Lastly, these quizzes served as a safety measure for the experimental groups. Should any of the experimental groups performed noticeably worse than the control group of students the intervention would have ceased.

Surveys

Before students begin to use Twitter as part of this quasi-experimental study, both groups took a 12-item survey. The survey is adapted from Lenhart et al. (2010) and was design to assess a student’s technology resources, the capabilities of their smartphones, and demographics (sex and race/ethnicity). Sex and race/ethnicity was used to describe the sample of participants.

After students use Twitter as part of this quasi-experimental study, the Twitter group took a 10-item survey. The survey was adapted from an instrument developed by Cavus and Ibrahim (2009). The purpose of the present study's instrument was to understand the students' opinion of using Twitter as they learned course content in Algebra 1. The instrument developed by Cavus and Ibrahim (2009) contained 24 questions and from that instrument questions 16 to 24 were unique to the MOLT system and could not be adapted to the present study. However, questions 1 to 15 of the Cavus and Ibrahim instrument were broad enough and written well enough so that changing the word MOLT to Twitter allowed the researcher of the present study to gauge the students' perception of using Twitter in the mathematics classroom.

Twitter

In this quasi-experimental study, the teachers who agreed to participate sent out the tweets. Furthermore, the students were instructed to share hyperlinks, critique, and ask questions in a concise manner. Cha et al. (2010) highlighted that the value of the message being spread can be measured by how many times it is retweeted or is marked as favorite. Therefore, students were instructed to mark any tweet that they find helpful as *favorite* or comment on why they did not find the tweet useful. Students learned to write mathematical notation in plain text. These include use of +, -, *, and / to denote addition, subtraction, multiplication, and division, respectfully.

In this quasi-experimental study, the content, format, and purpose of the tweets followed the past research presented in Chapter 2. The tweets that were sent by the teacher included course material mentioned in class, assignments, homework, and reminders (Van Vooren & Bess, 2013). The tweets were not limited to written text, they also included pictures of relevant diagrams and hyperlinks to instructional videos. These tweets were also used to inform the class about campus events (tutoring days), provide academic provide support (hyperlinks to helpful videos), and organize student groups (Junco et al., 2011). To foster collaboration outside of class (Griffith & Liyanage, 2008; Junco et al., 2011) students were encouraged to share hyperlinks and pose questions to demonstrate that they had read the sections in the textbook (Everson et al., 2013; Junco et al., 2011). To nurture an understanding of mathematics and further promote students to take an active role in learning the tweets containing mathematical content were infused with verbs that are associated with Webb's Taxonomy. Lastly, a positive tone was encouraged so as to promote social interaction (Dunlap &Lowenthal, 2009) in order to foster group reinforcement, encouragement, and support among peers (English & Duncan-Howell, 2008).

The content tweets that were used as part of this study communicated information about key concepts related to simplifying and solving linear equations in Algebra 1. For example, the teacher of the content group sent tweets that had the following information:

- "ICYMI [incase you missed it]: Adding property of equality. If A=B, Then A+C = B+C … Demonstrate this is true by creating a real world example."
- "You can use the properties of equality repeatedly to isolate a variable. Show how this idea can be applied to science."
- "In your own words, define equivalent equations."
- "Summarize what you would do to solve an equation with variable terms on both sides of the equal sign."

The logistics tweets that were used as part of this study communicated information about homework, tutoring, and other important reminders related to solving linear equations in Algebra 1. For example, the teacher of the logistics group sent tweets that had the following information:

- "Remember: Go to Study Buddy to get tutoring online."
- "Reminder: Free tutoring. Tuesdays and Thursdays. Algebra I and Geometry. Ms. XXX. Room 1234"
- "Test tomorrow!!! Study!"

The C+L tweets that were used as part of this study contained both of the aforementioned types of tweets. The respective control group of students heard the same messages mentioned above during class. Appendix A has the complete list of the tweets that were sent out to the control group and the experimental group by all three teachers.

The pacing guide published by the school district outlines the topics teachers are required to cover and the time frame in which to do so. The time frame of three and a half weeks (18 school days) is a slight extension of the 16 school days that the school district allocated for this topic. This time frame is similar to the Van Vooren and Bess (2013) study which also involved secondary public school students. The pacing guide that outlines the topics teachers are required to cover calls for schools that are on a 60-minute class period schedule to spend 16 school days learning linear equations in one variable. If a school is a 90-minute or 120-minute block schedule it is suggested that the school spend 8 days covering the same material. The 16 days includes both instruction and assessment. However, since this quasi-experimental study included a pretest and a posttest on linear equations and the extra school days were needed, thus it brought the total instructional days to 18 days (or approximately three and a half weeks). In short, the participants of this study had 90-minute block schedule classes and that the treatment concerned seven 90-minute lessons (Appendices A and C) that were conducted over a period of four weeks (Appendices D and E).

Variables

The independent variable used in this quasi-experimental study is the use of Twitter. The dependent variable used in this quasi-experimental study was the posttest score on a test of linear equations. The posttest score on linear equations was determined by the percent of questions answered correctly on a 20-item posttest on linear equations. The covariate used in this quasi-experimental study was the pretest score on a test of linear equations. The pretest on linear equations score was determined by the percent of questions answered correctly on a 20-item pretest on linear equations.

Safety

Anytime children are connected to the Internet, they are exposed to all kinds of threats. In this quasi-experimental study, these threats can include objectionable and inappropriate content that might be posted on Twitter. The number one priority of the researcher and teachers, who participated in this quasi-experimental study, is to keep students safe. In this study, both the participating teacher and the research monitored Twitter constantly for cyberbullying and netiquette.

To prevent students from being exposed to objectionable and inappropriate tweets, one has to maximize the useful features Twitter has to offer. First, and foremost, Twitter users have the possibility to mark their tweets as public or protected. Public tweets "are visible to anyone, whether or not they have a Twitter account" unlike protected tweets which are "only be visible to your approved Twitter followers" (Twitter, 2013a). Therefore, when a tweet is marked as protected it is made private from outsiders.

Consequently, this can be avoided by making a Twitter account private. In this study the participating teacher and the participating students used accounts that were protected.

Procedure

First, since the study called for the participation of human subjects, the Collaborative Institutional Training Initiative (CITI) Online IRB Training Course was completed in order to guarantee the ethical treatment of the human subjects. Second, the approval of the university Institutional Review Board (IRB) was sought. Third, the review type that was sought from the university IRB was *Exempt*. Fourth, student assent and parent consent forms were drafted. Fifth, an application proposal was submitted via Topaz Electronic Protocol Application System. Lastly, once the university has reviewed and approved the application, the approval of the school district where the participants were drawn from was sought.

Since the study involves working with adolescents the Miami-Dade County Public Schools (M-DCPS) Research Review Committee (RRC) was petitioned about conducted the study. First, the application and the supporting documents were filled out. These supporting documents include: full research prospectus, FIU IRB Approval, sample tweets, teacher consent form, parent consent form, child assent form, pre-treatment survey, and post-treatment survey. Lastly, as part of the M-DCPS RRC petition 30 minutes was requested for teacher training on a teacher planning day.

Furthermore, the school site administrator, principal, was informally approached about conducting the study. He was given a brief overview of the study, which would take place for the duration of about four weeks with three teachers and six class periods. The school principal at that time informally permitted the project to be implemented at his school. Once M-DPCS RRC approved the research study and their decision was given in writing, the M-DPCS RCC letter that was given was forwarded to the school principal for his records. When FIU IRB and M-DCPS RRC approved the research project, at the request of the dissertation committee chair, the researcher requested a formal letter of support from the school principal. At the request of dissertation committee chair, the M-DCPS RRC approval letter along with the school principal support letter was submitted to FIU IRB. The preexisting FIU IRB approval was amended and resubmitted. Finally, FIU IRB reapproved the project.

Once FIU IRB, M-DCPS RCC and the school principal sanctioned the research, Algebra 1 teachers were e-mailed and asked to participate. After three teachers agreed to participate the necessary materials were photocopied and provided to the participating teachers. These materials included guidelines on how to use Twitter in Algebra 1 class, student surveys, and copies of the parent consent and student assent.

The students in classes of the participating teachers received two letters to take home on a double-sided sheet of paper. The purpose of these two letters is to obtain student assent and parental consent. The teacher collected the signed letters and gave them to the researcher to maintain on file. At the request of the school principal photocopies of the student assent and parent consent letters were made for his records.

From the aforementioned school population, a sample of 151 students participated in this quasi-experimental study across six different class periods. The way that the classes are assembled in this high school is beyond the control of the researcher. The participants were not randomly selected, but rather randomly assigned to the class period from the population by the school's master schedule.

Based on random assignment by the master schedule, similar instructional pacing, and identical textbooks it is reasonable to assume that the groups are similar. Working with groups that are believed to be similar is congruent with the research of Campbell and Stanley (1963) on naturally assembled groups and choice of treatment. While it is expected that the groups have different means on pretest at the beginning of the experiment, this difference can be adjusted for with a covariate (Campbell & Stanley, 1963). However, the differences between the two groups of Algebra 1 students can be adjusted with a pretest on linear equations score as the covariate. The use of a covariate, the pretest on linear equations is necessary to measure learning gains (Campbell & Stanley, 1963).

As stated earlier, three teachers from the mathematics department were asked to participate. These three teachers were chosen based on their willingness to participate in the present study. Each teacher taught both an experimental and a control group classes. This quasi-experimental study employed six classes from a major high school in an urban area of south Florida (see Table 8). Group A (three classes, n = 73) was the control group (CG) and Group B (three classes, n = 78) was the experimental group (EG) of students. The teacher determined the assignment of the control and experimental treatments.

Table 8
Teacher Assignment of Control and Experimental Group

Teacher 1	Teacher 2	Teacher 3
Content CG (n = 20)	Logistics CG (n = 30)	C+L CG (n = 23)
Content EG (n = 25)	Logistics EG (n = 24)	C+L EG (n = 29)

Group B (three classes, n = 78) was required to open a free Twitter account. Group A (three classes, n = 73) received the same messages as Group B, over the same time period, as the students cover the same Algebra 1 content. However, Group A (three classes, $n = 73$), received the messages as part of the notes in class and Group B, via Twitter. Since the messages were related to course content there was no opportunity for the teacher to forget to mention the message. The Twitter Timeline is very much like a running list of notes one might take during class. The similarity between these two mediums allows for an appropriate comparison. Lastly, students were expected to pay attention and take notes during class.

Prior to the beginning of each session, the researcher provided the three participating teachers with the message they were to say during the lesson. These messages were then sent to the Group B via Twitter at the end of the day. It was essential that both groups receive the same message because if the message and classroom instruction are similar and if course content is equal, while controlling for the covariate, then a statistically significant difference in the adjusted mean linear equation posttest scores of the experimental and control groups can be attributed to the use of Twitter.

The tweets used by Group B were sent from a protected Twitter account. Twitter users have the option to make their tweets public or protected. Public tweets “are visible to anyone, whether or not they have a Twitter account” unlike protected tweets which are “only be visible to your approved Twitter followers” (Twitter, 2013a). Therefore, by having the experimental group’s tweets protected the participants did not have the ability to retweet the messages sent by the teacher. If participants in the experimental group cannot retweet, it impedes the ability to expose the messages to their friends, including those subjects that are in the control group of students. Unlike the messages sent by the participating teacher, other messages in the Twitterverse cannot be controlled and thus, subjects in the experimental group were exposed to tweets that were educational and non-educational in nature.

Teacher Preparation and Information

"Mrs. Leibniz", the teacher of the content group, was a veteran mathematics teacher with 26 years of teaching experience. She holds a Master of Science degree in Computer Science Education from a major university in the southeastern United States. Throughout her career she has taught a wide array of courses at the secondary level. She has taught Algebra 1 (regular, honors, and gifted), Geometry (regular, honors, and gifted), Algebra 2 (regular, honors, and gifted), Advanced Topics in Mathematics, and Programming in BASIC (an acronym for Beginner's All-purpose Symbolic Code) at the high school level. Prior to this quasi-experimental study, she had never used Twitter. Her use of social media was limited to Facebook and Instagram.

"Mrs. Riemann", the teacher of the logistics group, was a veteran mathematics teacher with 15 years of teaching experience. She holds a Master of Science degree in Mathematics Education from a major university in the southeastern United States. Throughout her career she has taught a wide array of courses at the secondary level. These courses include middle school (junior high) sixth, seventh, and eight grade annual mathematics courses. Also, she has taught Algebra 1, Geometry, Algebra 2, and SAT Prep courses at the high school level. Prior to quasi-experimental, she has never used Twitter. Her use of social media is limited to only the use of Facebook.

"Mrs. Gauss", the teacher of the content plus logistics (C+L) group, was a mathematics teacher with 8 years of teaching experience. She holds a Bachelors degree from a major university in the southeastern United States. Throughout her career she has taught a wide array of courses at the secondary level. These courses include Algebra 1, Geometry, Algebra 2, Algebra with Financial Application, and Chemistry. Prior to this quasi-experimental study, she has never used Twitter, but has used other forms of social media (MySpace, Facebook, and Instagram).

The three teachers that agreed to participate were given a 30-minute preparation session during a teaching planning day. As part of this session the teachers were given a tutorial on how to use Twitter. This session included an introduction to Twitter, the character limit, the ability to posting text, links, photos, and videos. The teachers were advised that they did not have to use their real picture as their profile picture.

Other topics of discussion included the experimental design, why I was conducting the experiment, duration of the study, how the tweets fit into the pacing that has been predetermined by the school district, what they will be tweeting, and their role in encouraging students to take an active role in using Twitter. The participating teachers were asked to encourage students to mark any tweet that they find helpful as *favorite*, comment on why they did not find the tweet useful, share videos, or critique Khan Academy videos. Also, as part of this session the teachers decided which class was going to be designated the control group and which class was going to be designated the experimental group of students. Lastly, the teachers were instructed to tweet in the mornings after they had taught the lesson to the experimental group class.

Design

The nonequivalent control group design, a pretest-posttest quasi-experimental design, was used in this quasi-experimental study. This design is one of the most widely utilized designs in educational settings (Campbell & Stanley, 1963) and in social research, not just education research (Trochim, 2006). When applied to an educational setting, groups might refer to classrooms or schools that are believed to be similar (Trochim, 2006).

First and foremost, this design accounts for initial differences that might exist in both the control group and the experimental group of students (Campbell & Stanley, 1963). Second, it uses intact group that are believed to be similar (Trochim, 2006). Third, it does not interrupt the preexisting assignment of the participants (Dimitrov & Rumrill, 2003).

The use of the nonequivalent control group design has its strengths and weakness. The strengths of the design are that it controls for history, maturation, testing, instrumentation, selection, and experimental mortality. These six factors are an important source of internal validity (Campbell & Stanley, 1963).

However, some weaknesses need to be acknowledged. Statistical regression is a weakness of the design and that the interaction between selection and maturation, etc. is a cause for concern (Campbell & Stanley, 1963). Trochim, and others (see Cook & Shadish, 1994; Dimitrov & Rumrill, 2003), raised the same concerns about the validity of this design and offered the following word of caution, “Under the worst circumstances, this can lead us to conclude that our program didn’t make a difference when in fact it did, or that it did make a difference when in fact it didn’t” (Trochim, 2006, p. 1). Some scholars argue that due do the lack of random assignment of the participants one cannot guarantee that the groups are in fact comparable (Cook & Shadish, 1994; Trochim, 2006).

To improve the internal validity of the design it has been suggested that one use multiple group comparisons (Cook & Shadish, 1994). The nonequivalent control group design displays a weakness in the area of external validity due to the interaction of testing and treatment. Lastly, other possible concerns arise in the areas of interaction of selection and treatment as well reactive arrangements (Campbell & Stanley, 1963).

This quasi-experimental study had two groups of Algebra 1 students: Group A (three classes, n = 73) was the control group and Group B (three classes, n = 78) was the experimental group of students (see Table 9).

Table 9
The Experimental Design

	Pretest	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Posttest
Content CG	O					O
Content EG	O	X_1O	X_2O	X_3O	X_4O	O
Logistics CG	O					O
Logistics EG	O	X_1O	X_2O	X_3O	X_4O	O
C+L CG	O					O
C+L EG	O	X_1O	X_2O	X_3O	X_4O	O

Note. O denotes a measurement and X indicates the exposure to the treatment.

It is possible that the two groups of Algebra 1 students were not equivalent (e.g., mathematical ability) but the nonequivalent control group design accounts for that. The central feature of this experimental design is that it takes into account that the control group and the experimental group of students which may not have be equivalent in ability prior to the treatment. The uses of a covariate, for this quasi-experimental study it was the mean pretest score on linear equations, was necessary to measure any statistically significant differences between mean posttest score of the control group versus the mean posttest score of the experimental group (Campbell & Stanley, 1963).

Data Analysis

First this section covers data source that were used in this quasi-experimental study. Second, this section discusses the variables that were used in this experiment.

Furthermore, it discusses the statistical treatments that were performed to answer the research questions.

Data Source

Prior to the beginning of the unit, both the control and experimental groups were given the same pretest on linear equations. The pretest on linear equations score was used as the covariate in the statistical analysis. Throughout the unit the groups were given four quizzes. At the end of the unit, both groups were given the same posttest on linear equations.

Statistical Treatment

A pre- and posttest was administered to both groups for each teacher and their performance was analyzed using Statistical Package for Social Sciences (SPSS) version 22 GradPack. To analyze pretest-posttest data one can use an analysis of variance (ANOVA) on the gained scores, analysis of covariance (ANCOVA), ANOVA on residual scores, or a repeated measures ANOVA (Dimitrov & Rumrill, 2003).

The six hypotheses were tested using a factorial ANCOVA. The process of analyzing the data followed the guidelines provided by Green and Salkind (2011). The ANCOVA was conducted with the pretest on linear equations score as the covariate. The dependent variable used in this quasi-experimental study was the posttest score on a test of linear equations. The independent variables were the use of Twitter (Twitter versus non-Twitter), use of Twitter for content, use of Twitter for logistics, and use of Twitter for both. In this quasi-experimental study, the significance level was set to $\alpha = .05$ because this level minimizes the chances of making a Type I error.

Covariance. DeGroot states the following about covariance, "Let X and Y be random variables having a specified joint distribution; and let $E(X) = \mu_X$, $E(Y) = \mu_Y$, $Var(X) = \sigma_X^2$, and $Var(Y) = \sigma_Y^2$. The *covariance of X and Y*, which is denoted by $Cov(X, Y)$, is defined as follows: $Cov(X, Y) = E[(X - \mu_X)(Y - \mu_Y)]$" (1989, p. 214). A covariance is used to reduce the error and eliminate systematic bias (Dimitrov & Rumrill, 2003). In this quasi-experimental study, the pretest on linear equations score was used as the covariate.

ANCOVA. The ANCOVA was chosen based on the recommendation of Dimitrov and Rumrill (2003). They stated that, "ANCOVA should be the preferred method of analysis of pretest-posttest data" because it reduced error variance (p. 164). Hinkle, Wiersma, and Jurs (2003) share a similar opinion about the use of the ANCOVA:

> Statistical control, used when experimental control is difficult, if not impossible, can be achieved by measuring one or more variables in addition to the independent variables of primary interest and by controlling the variation attributed to these variables through statistical analysis rather than through research design. The analytic procedure employed in this statistical control is analysis of covariance. (p. 496)

Moreover, they wrote, "A second application of ANCOVA: when using intact groups of subjects. Such an application is used when treatments *can* be randomly assigned to groups, but subjects *cannot* be randomly assigned to treatment groups" (p. 498). Furthermore, they stated that, "When intact groups are used, ANCOVA can be used to partially adjust for the preexisting differences among the groups" (p. 498). Lastly, they stated that, "Using ANCOVA, the researcher can increase the precision of the research by partitioning out the variation attributed to the covariate, which results in a smaller error variance" (p. 498).

Dixon and Massey also shared a similar opinion on the ANCOVA. They stated that:

> If the second variable represents an actual measurement or score for each individual (rather than a category), we can again test the effect of the first variable separately from the effect of the second variables. The method of analysis called the *analysis of covariance*. The second variable is referred to as a *control variable*. (Dixon & Massey, 1983, p. 256)

Moreover, they cite the following application of the ANCOVA to education:

> In an experiment designed to study the results of a program to increase the spelling ability of four classes of students, we measure the spelling ability Y of each student at the end of the program and introduce the original spelling ability X for each student as a control variable. We may student the differences in the effectiveness for the four classes with the use of the Y variable "controlled," or "adjusted" for the X variable" (Dixon & Massey, 1983, p. 257).

Lastly, this statistical test can be extended to include multiple observations (Dixon & Massey, 1983).

It was anticipated that there would be a difference in the mean posttest linear equations score for Twitter group versus the mean posttest linear equations score for control group of students, when adjusted for the pretest on linear equations scores. It is also anticipated that there would be difference in the mean posttest linear equations score for mathematical content group, classroom logistics group and C+L group versus the mean posttest linear equation score of their respective control groups, when adjusted for the pretest on linear equations scores.

General linear models. Two models were developed to understand the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. The two models that were constructed were general linear models. Rutherford (2001) wrote:

> The experimental design GLM (general linear model) may be compared with the equivalent regression equation,
>
> $Y_i = \beta_0 + \beta_1 X_{i,1} + \beta_2 X_{i,2} + \beta_3 X_{i,3} + \beta_4 X_{i,4} + \beta_5 X_{i,5} + \beta_6 X_{i,6} + \beta_7 X_{i,7} + \beta_8 X_{i,8} + \beta_9 X_{i,9} + \varepsilon_1$.
>
> Where Y_i represents the ith dependednt variable score (not the ith subject), $\beta_0$is a constant $\beta_1$is the regression coefficient for the predictor variable X_2. However, in repeated measures design, the subjects providing the repeated measures also are represented. The *N* levels of the subject factor as represented by $(N - 1)$ variables. Therefore, the eight levels (i.e., subjects) are represented by the first seven variables (X_1 to X_7). Similarly, the p levels of the experimental conditions are represented by $(p - 1)$ variables. Therefore, the three experimental conditions are represented by the last two variables ($X_{8,}X_9$). Again, the random variable $\varepsilon_1$represents the error. (p. 74)

Based on the writing of Rutherford (2001), it follows that the Twitter, content, logistics, and C+L treatment groups had the following GLM:

$$Y_{posttest} = \beta_7 + \beta_8 X_{twitter} + \beta_9 X_{pretest} + \varepsilon_2$$

$$Y_{posttest} = \beta_0 + \beta_1 X_{content} + 0 + 0 + \beta_4 X_{pretest} + \varepsilon_1$$

$$Y_{posttest} = \beta_0 + 0 + \beta_2 X_{logistics} + 0 + \beta_4 X_{pretest} + \varepsilon_1$$

$$Y_{posttest} = \beta_0 + \beta_1 X_{content} + \beta_2 X_{logistics} + \beta_3 X_{C+L} + \beta_4 X_{pretest} + \varepsilon_1$$

The control group of students had the following GLM:

$$Y_{posttest} = \beta_0 + 0 + 0 + 0 + \beta_4 X_{pretest} + \varepsilon_1$$

These models were used in assessing the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1.

Summary

In short, this chapter outlined the methodology that was used in this quasi-experimental study. This quasi-experimental study used a high school ninth grade Algebra 1 class that was learning linear equations for three and a half weeks (18 school days). A pretest and posttest on linear equations was used to accurately measure the effect on learning. The pretest and posttest on linear equations was given to both an experimental and a control group of students by using the nonequivalent control group design. The results were analyzed using Statistical Package for Social Sciences (SPSS) version 22 GradPack. To determine if there is an effect of using Twitter by high school mathematics students learning linear equations in Algebra 1 a factorial ANCOVA was utilized with the pretest on linear equations score as the covariate.

CHAPTER IV: RESULTS

This chapter includes the results of this quasi-experimental study. The purpose of this quasi-experimental study was to determine whether using Twitter by high school mathematics students learning linear equations in Algebra 1 was more effective than getting the information in class. The demographic information about the participants in the sample, analysis of the pre-treatment survey, analysis of the pretest, analysis of the intermediate quizzes, analysis of the posttest, results of testing the research hypotheses, and analysis of the post-treatment survey are presented in this chapter.

Demographics of the Sample

The demographic information presented here will be divided into three subsections: all participants, control group of students, and experimental group of students. The sample consisted of 151 participants; approximately half of them were girls ($n = 72$) and the rest were boys ($n = 69$) with 10 missing cases. Table 10 shows the frequencies and percentages for race/ethnicity status. Approximately 78.8% of the participants were Hispanic, and the remaining participants were distributed across White (7.9%), Multiracial (3.3%), Black (1.3%), and Asian/Pacific Islander (1.3%). The majority of the participants in the sample, very much like the students in the setting of the school who were in 10^{th} through 12^{th} grade, were Hispanic.

The control group of students had twice as many White (non-Hispanic) students than the experimental group of students. Both the control and the experimental group of students had an equal number of Black (non-Hispanic) students. Also, both the control and the experimental group of students had no students who identified themselves as Native American or Other. However, the experimental group of students had more Asian students than the control group of students. Furthermore, both the control and experimental group of students had very similar number of Hispanic, Multiracial, and missing cases.

Table 10
Race/Ethnicity Frequencies and Percentages of the Sample

Category	Frequency	Percentage
White (non-Hispanic)	12	7.9
Black (non-Hispanic)	2	1.3
Hispanic	119	78.8
Asian/Pacific Islander	2	1.3
Native American	0	0
Multiracial	5	3.3
Other	0	0
Missing	11	7.3

Control Group Demographics

The demographic information present here, and in the subsequent subsections, are derived from the last two questions of the survey the pre-treatment survey. The participants were asked to identify their sex and race/ethnicity. The missing cases presented here, and in the following parts, are the result of the participants not wishing to answer the sex and race/ethnicity questions on the pre-treatment survey.

The control group of students consisted of 73 participants; approximately 58.9% of them were girls (n = 43) and the rest were boys (n = 24) with 6 missing cases. Table 11 shows the frequencies and percentages for race/ethnicity status. Approximately 82.2% of the participants were Hispanic, and the remaining participants were distributed across White (5.5%), Multiracial (2.7%), and Black (1.4%). The majority of the participants in the control group of students, very much like the entire school population, were Hispanic.

Table 11
Race/Ethnicity Frequencies and Percentages of the Control Group

Category	Frequency	Percentage
White (non-Hispanic)	4	5.5
Black (non-Hispanic)	1	1.4
Hispanic	60	82.2
Asian/Pacific Islander	0	0
Native American	0	0
Multiracial	2	2.7
Other	0	0
Missing	6	8.2

Experimental Group Demographics

The experimental group of students consisted of 78 participants; approximately half of them were boys (n = 45) and the rest were girls (n = 29) with 4 missing cases. Table 12 shows the frequencies and percentages for race/ethnicity status. Approximately 75.6% of the experimental group participants were Hispanic, and the remaining experimental group participants were distributed across White (10.3%), Multiracial (3.8%), Asian/Pacific Islander (2.6%), and Black (1.3%). The majority of the participants in the experimental group sample, very much like the entire school population, were Hispanic.

Table 12
Race/Ethnicity Frequencies and Percentages of the Experimental Group

Category	Frequency	Percentage
White (non-Hispanic)	8	10.3
Black (non-Hispanic)	1	1.3
Hispanic	59	75.6
Asian/Pacific Islander	2	2.6
Native American	0	0
Multiracial	3	3.8
Other	0	0
Missing	5	6.4

Pre-Treatment Survey

The pre-treatment survey information presented here will be divided into three subsections: all participants, control group of students, and experimental group of students. Twitter is Internet based and tweets can contain text and embedded graphics and videos. A phones' ability to send and receive the aforementioned was germane to the study. Technology capabilities can impede the students from sending and receiving tweets. Furthermore, Twitter sends emails about tips (for novices) and updates of what happened since one last logged in. Hence, a small survey was created to understand the students' technology resources and the capabilities of the students' smartphones. The survey consisted of 12 items, of which 10 questions were related to technology. The last two questions of the survey asked students to identify their sex and race/ethnicity.

In this study the difference between control group and the experimental as far as technology access was very similar. The experimental group had 0.5% more smartphone ownership than the control group. The experimental group had 7.3% more tablets than the control group. The experimental group had 7.1% more laptop computers than the control group. Lastly, the experimental group had 4.5% more desktop computers than the control group.

All Participants

Table 13 shows the frequencies and percentages for the technology that was available to the participants in the sample. Approximately 88.7% of the participants owned a smartphone (e.g., Blackberry, iPhone or Samsung Galaxy). Additionally, the remaining participants that owned a tablet (e.g., iPad or Samsung Tab) comprised 70.9%, laptop (72.2%), and desktop (51.7%). In short, the participants owned at least one device that could have allowed them to tweet and view the tweets.

In this quasi-experimental study, sample was drawn from a school population that was 88.2% Hispanic. A SPSS crosstab of race/ethnic and smartphone was conducted and revealed that 76.16% of the participants were Hispanic and owned a cellphone. Lenhart et al. (2010) researched concluded that 68% of Hispanics teens owned a cellphone. The present study's finding was consistent with Lenhart et al. (2010).

Table 13
Technology Frequencies and Percentages for All Participants

Category	Yes - Frequency (%)	No - Frequency (%)	Missing - Frequency (%)
Smartphone	134 (88.7)	6 (4.0)	11 (7.3)
Tablet	107 (70.9)	34 (22.5)	10 (6.6)
Laptop	109 (72.2)	29 (19.2)	13 (8.6)
Desktop	78 (51.7)	63 (41.7)	10 (6.6)

Table 14 shows the frequencies and percentages for the smartphone technology capabilities that were available to sample of participants. Approximately 88.7% of the participants had cellphones with the capabilities to send or receive text messages. Furthermore, the participants who were able to send or receive e-mail (89.4%), take pictures (88.7%), send or receive pictures (88.1%), record video (88.7%), and send or receive videos (88.1%).

Table 14
Technology Capabilities Frequencies and Percentages for All Participants

Category	Yes - Frequency (%)	No - Frequency (%)	Missing - Frequency (%)
Send/Receive Text	134 (88.7)	7 (4.6)	10 (6.6)
Send/Receive E-mail	135 (89.4)	6 (4.0)	10 (6.6)
Take Pictures	134 (88.7)	7 (4.6)	10 (6.6)
Send/Receive Pictures	133 (88.1)	8 (5.3)	10 (6.6)
Record Video	134 (88.7)	7 (4.6)	10 (6.6)
Send/Receive Videos	133 (88.1)	8 (5.3)	10 (6.6)

Based on the self-reported information provided by the participants in this quasi-experimental study we can infer that technology was not a barrier that impeded the participants' ability to send or receive tweets. The majority (88.7%) of the participants owned a smartphone with multimedia capabilities. This is important because, tweets can have four pictures or a video embedded.

Other Combinations

Table 13 suggests that participants owned at least one device that granted them access to Twitter. Since the survey inquired about owning a smartphone, tablet, laptop computer, or desktop computer it follows that other combinations exist. Hereafter, a combination is defined as $C = \frac{n!}{k!(n-k)!}$.

It is possible that participants owned two devices creating a maximum of six combinations. The possible combinations are {smartphone and tablet}, {smartphone and laptop}, {smartphone and desktop}, {tablet and laptop}, {tablet and desktop}, and {laptop and desktop}. Table 15 shows the frequencies and percentages for these combinations in the sample of participants. In short, the participants had at least two devices that could have allowed them to tweet and view the tweets.

It is possible that participants owned three devices creating a maximum of four combinations. The possible combinations are {smartphone, tablet, and laptop}, {smartphone, tablet, and desktop}, {smartphone, laptop and desktop}, and {tablet, laptop, and desktop}. Table 15 shows the frequencies and percentages for these combinations in the sample of participants. In short, the participants had at least three devices that could have allowed them to tweet and view the tweets

It is possible that participants owned all four devices creating a maximum of one combination. The one possible combination is {smartphone, tablet, laptop, and desktop}. Table 15 shows the frequencies and percentages for these combinations in the sample of participants. In short, the participants had all four devices that could have allowed them to tweet and view the tweets. An SPSS crosstab with two layers was conducted and produced finding of Table 15.

Table 15
Other Combinations in Technology for All Participants

Category	Yes - Frequency	Yes - Percent
Smartphone and Tablet	103	68.21
Smartphone and Laptop	104	68.87
Smartphone and Desktop	76	50.33
Tablet and Laptop	84	55.63
Tablet and Desktop	59	39.07
Laptop and Desktop	54	35.76
Smartphone, Tablet, and Laptop	82	54.30
Smartphone, Tablet, and Desktop	58	38.41
Smartphone, Laptop, and Desktop	52	34.44
Tablet, Laptop, and Desktop	43	28.48
Smartphone, Tablet, Laptop, and Desktop	42	27.81

Control Group

Table 16 shows the frequencies and percentages for the technology that was available to the participants in the control group. Approximately 89% of the participants owned a smartphone (e.g., Blackberry, iPhone or Samsung Galaxy). Additionally, the remaining participants that owned a tablet (e.g., iPad or Samsung Tab) were 67.1%, laptop (68.5%), and desktop (49.3%).

Table 16
Technology Frequencies and Percentages for Control Group

Category	Yes - Frequency (%)	No - Frequency (%)	Missing - Frequency (%)
Smartphone	65 (89.0)	1 (1.4)	7 (9.6)
Tablet	49 (67.1)	18 (24.7)	6 (8.2)
Laptop	50 (68.5)	14 (19.2)	9 (12.3)
Desktop	36 (49.3)	31 (42.5)	6 (8.2)

Table 17 shows the frequencies and percentages for the smartphone technology capabilities that were available to sample of participants. Approximately 87.7% of the participants had the capabilities send or receive text messages. Furthermore, the participants that were able to send or receive e-mail (90.4%), take pictures (89%), send or receive pictures (89%), record video (89%), and send or receive videos (89%).

Table 17
Technology Capabilities Frequencies and Percentages for Control Group

Category	Yes - Frequency (%)	No - Frequency (%)	Missing - Frequency (%)
Send/Receive Text	64 (87.7)	3 (4.1)	6 (8.2)
Send/Receive E-mail	66 (90.4)	1 (1.4)	6 (8.2)
Take Pictures	65 (89.0)	2 (2.7)	6 (8.2)
Send/Receive Pictures	65 (89.0)	2 (2.7)	6 (8.2)
Record Video	65 (89.0)	2 (2.7)	6 (8.2)
Send/Receive Videos	65 (89.0)	2 (2.7)	6 (8.2)

Based on the self-reported information provided by the participants of control group of students in this quasi-experimental study we can infer that technology was not a barrier that impeded the participants' ability to send or receive tweets. The majority (89%) of the control group participants owned a smartphone with multimedia capabilities. This is important because, tweets can have four pictures or a video embedded.

The results of the pre-treatment survey on the hardware that was available to the control group and experimental group of participants show that the technology that was available to both of them are somewhat similar. Furthermore, the results of the technology capabilities available to the control group and experimental group of participants show that they are very similar. As a result, whether the master schedule placed the student in the control group or the experimental group, it would not have affected the results of the study because the descriptive statistics are similar.

Experimental Group

Table 18 shows the frequencies and percentages for the technology that was available to the participants in the experimental group. Approximately 88.5% of the experimental group participants owned a smartphone (e.g., Blackberry, iPhone or Samsung Galaxy). Additionally, the remaining experimental group participants that owned a tablet (e.g., iPad or Samsung Tab) were 74.4%, laptop (75.6%), and desktop (53.6%).

Table 18
Technology Frequencies and Percentages for Experimental Group

Category	Yes - Frequency (%)	No - Frequency (%)	Missing - Frequency (%)
Smartphone	69 (88.5)	5 (6.4)	4 (5.1)
Tablet	58 (74.4)	16 (20.5)	4 (5.1)
Laptop	59 (75.6)	15 (19.2)	4 (5.1)
Desktop	42 (53.8)	32 (41.0)	4 (5.1)

Table 19 shows the frequencies and percentages for the smartphone technology capabilities that were available to experimental group of participants. Approximately 89.7% of the experimental group of participants had the capabilities send or receive text messages. Furthermore, the participants that were able to send or receive e-mail (88.5%), take pictures (88.5%), send or receive pictures (87.2%), record video (88.5%), and send or receive videos (87.2%).

Table 19
Technology Capabilities Frequencies and Percentages for Experimental Group

Category	Yes - Frequency (%)	No- Frequency (%)	Missing - Frequency (%)
Send/Receive Text	70 (89.7)	4 (5.1)	4 (5.1)
Send/Receive E-mail	69 (88.5)	5 (6.4)	4 (5.1)
Take Pictures	69 (88.5)	5 (6.4)	4 (5.1)
Send/Receive Pictures	68 (87.2)	6 (7.7)	4 (5.1)
Record Video	69 (88.5)	5 (6.4)	4 (5.1)
Send/Receive Videos	68 (87.2)	6 (7.7)	4 (5.1)

Based on the self-reported information provided by the participants of the experimental group in this quasi-experimental study we can infer that technology was not a barrier that impeded the participants' ability to send or receive tweets. The majority (88.5%) of the participants owned a smartphone with multimedia capabilities. This is important because, tweets can have four pictures or a video embedded. Since the 74.4% experimental group participants that owned a tablet, 75.6% owned a laptop, and 53.6% owned a desktop. It follows that the remaining 11.5% of the participants in the experimental group had access to the tweets even though they could not access to them through their cellphone.

Pretest

The pretest information presented here will be divided into two subsections: by group and subgroup. The students' understanding of linear equations was measured twice - once before the treatment (using the pretest) and once after the treatment (using the posttest). The format for both the pre- and posttest was the same, with only coefficients and the order of items changed. The subtopics of the pre- and posttest included solving one-step equations, solving two-step equations, solving multi-step equations, solving equations with variables on both sides, literal equations, and solving proportions. The pretest was scored on a 20 point-scale. A score of zero was the minimum possible and a score of 20 was the maximum, a perfect score. Each item on the pretest had equal weight.

Group

Table 20 presents the means and standard deviations of the pretest. The mean and the standard deviation of the control group were lower than the experimental group. The control group performance was lower than the experimental group (*M* = 3.8164, *SD* = 4.711).

Table 20
Descriptive Statistics for the Pretest Scores by Group

Group Type	Mean	*SD*	*N*	Missing
All Participants	3.3706	4.563	145	6
Control	2.9059	4.389	71	2
Experimental	3.8164	4.711	74	4

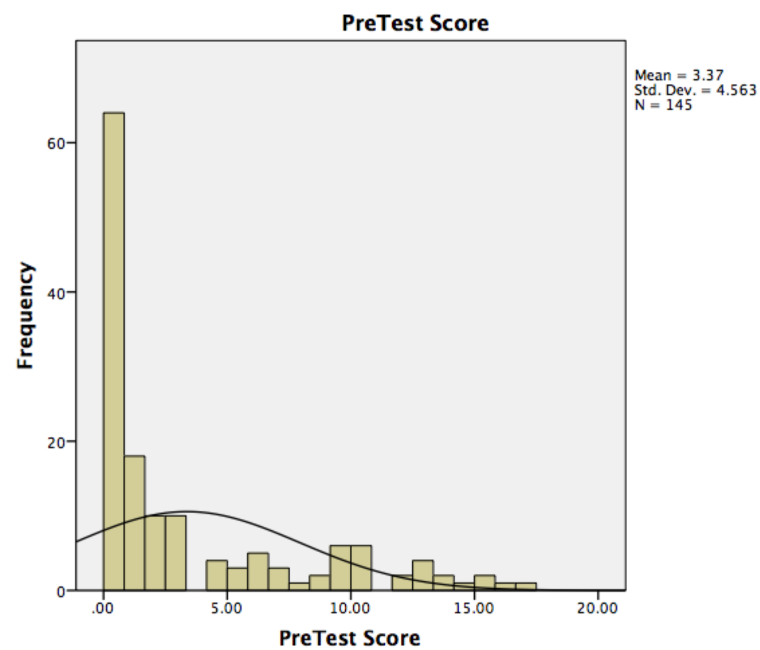

Figure 3. Histogram of the Sample's Pretest Scores.

Subgroup

Table 21 presents the means and standard deviations of the pretest. The content control group performance was slightly higher than the content experimental group (*M* = 1.2146, *SD* = 1.848). The logistics control group performance was lower than the logistics experimental group (*M* = 10.3386, *SD* = 2.84). The C+L control group performance was higher than the C+L experimental group (*M* = .9218, *SD* = 1.203).

One can see that in Table 21 that the logistics experimental and control groups mean scores on the pretest was much higher than the other groups. The participants for the logistics experimental and logistics control were students in an Algebra 1 Honors class. It was expected that the groups have different means on pretest at the beginning of the experiment and based on this data it did occur.

Table 21
Descriptive Statistics for the Pretest Scores by Subgroups

Group Type	Mean	*SD*	*N*	Missing
Content Control	1.5356	1.484	18	2
Content Experimental	1.2146	1.848	24	1
Logistics Control	4.8847	5.871	30	0
Logistics Experimental	10.3386	2.84	22	2
C+L Control	1.3974	2.212	23	0
C+L Experimental	.9218	1.203	28	1
Total			145	6

A one-way analysis of variance (ANOVA) was conducted to determine if there was a significant difference between content control group and the content experimental group on the mean pretest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANOVA was not significant $F(1, 40) = .366$ with $p = .549$. Therefore, there was no significant difference between content control group and content experimental group on the mean pretest score.

A one-way ANOVA was conducted to determine if there was a significant difference between logistics control group and the logistics experimental group on the mean pretest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANOVA was significant $F(1, 50) = 16.148$ with $p = <.001$. Therefore, there was a significant difference between logistics control group and logistics experimental group in favor of the experimental group.

A one-way ANOVA was conducted to determine if there was a significant difference between C+L control group and the C+L experimental group on the mean pretest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANOVA was not significant $F(1, 49) = .954$ with $p = .333$. Therefore, there was no significant difference between C+L control group and C+L experimental group.

Quizzes

The quizzes information presented here will be divided into four subsections: Quiz #1, Quiz #2, Quiz #2, and Quiz #4. Throughout the unit, the groups were given four quizzes. Lesson quizzes were administered to measure student progress throughout the process. These mini-assessments allowed the teachers and the researcher to analyze subtopics that the participants showed success. Furthermore, it also informed the teachers and the researcher the subtopics the participants needed to improve upon. The quizzes were scored on a 4- or 5-point-scale. A score of zero was the minimum possible score and 4 or 5 were the maximum, a perfect score. Each item on the quizzes had equal weight. Lastly, these quizzes served as a safety measure for the experimental groups. Should any of the experimental groups performed noticeably worse than the control group the intervention would have ceased.

Quiz #1 Scores by Group

The subtopic of Quiz #1 was solving two-step equations. This quiz was scored on a 4 point-scale. A score of zero was the minimum possible score and 4 were the maximum, a perfect score. Each item on the quizzes had equal weight.

Results by group. Table 22 presents the means and standard deviations of the Quiz #1. The mean and the standard deviation of the control group were slightly lower than the experimental group. The control group performance was slightly lower than the experimental group (*M* = 2.8836, *SD* = 1.186).

Table 22
Descriptive Statistics for Quiz #1 by Group

Group Type	Mean	*SD*	*N*	Missing
All Participants	2.8356	1.108	146	5
Control	2.7877	1.03	73	0
Experimental	2.8836	1.186	73	5

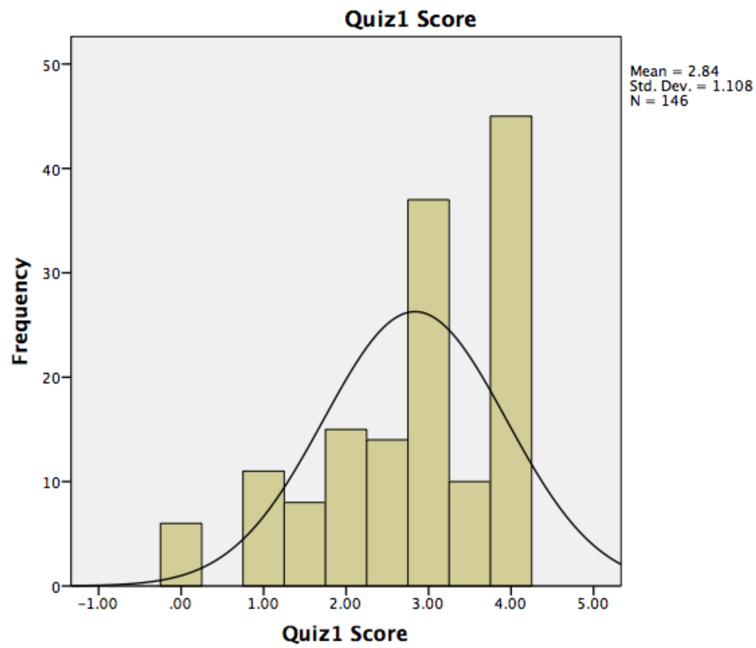

Figure 4. Histogram of the Sample's Quiz #1 Scores.

Results by subgroup. Table 23 presents the means and standard deviations of the Quiz #1. The mean and the standard deviations of the content groups were relatively similar. The content control group performance was slightly lower than the content experimental group (*M* = 2.9318, *SD* = 1.266). The logistics control group performance was lower than the logistics experimental group (*M* = 3.3864, *SD* = .999). The C+L control group performance was slightly lower than the C+L experimental group (*M* = 2.4655, *SD* = 1.133).

Table 23

Descriptive Statistics for Quiz #1 by Subgroup

Group Type	Mean	*SD*	*N*	Missing
Content Control	2.9250	.73	20	0
Content Experimental	2.9318	1.266	22	3
Logistics Control	3.0167	.905	30	0
Logistics Experimental	3.3864	.999	22	2
C+L Control	2.3696	1.29	23	0
C+L Experimental	2.4655	1.133	29	0
Total			146	5

A one-way ANCOVA was conducted to determine if there was a significant difference between content control group and the content experimental group on the mean Quiz #1 score. The independent variable was the Quiz #1 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 36) = .133$ with $p = .717$. Therefore, there was no significant difference between content control group and content experimental group.

A one-way ANCOVA was conducted to determine if there was a significant difference between logistics control group and the logistics experimental group on the mean Quiz #1 score. The independent variable was the Quiz #1 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was significant $F(1, 49) = .358$ with $p = .552$. Therefore, there was no significant difference between logistics control group and logistics experimental group.

A one-way ANCOVA was conducted to determine if there was a significant difference between C+L control group and the C+L experimental group on the mean Quiz #1 score. The independent variable was the Quiz #1 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 48) = .106$ with $p = .747$. Therefore, there was no significant difference between C+L control group and C+L experimental group.

Quiz #2 Scores by Group

The subtopic of Quiz #2 was solving multi-step equations. This quiz was scored on a 5 point-scale. A score of zero was the minimum possible score and 5 were the maximum, a perfect score. Each item on the quizzes had equal weight.

Results by group. Table 24 presents the means and standard deviations of the Quiz #2. The mean control group was lower than the experimental group, but the standard deviation was higher. The control group performance was slightly lower than the experimental group (*M* = 3.1308, *SD* = 1.415).

Table 24
Descriptive Statistics for Quiz #2 by Group

Group Type	Mean	*SD*	*N*	Missing
All Participants	2.9361	1.46	133	18
Control	2.7500	1.488	68	5
Experimental	3.1308	1.415	65	13

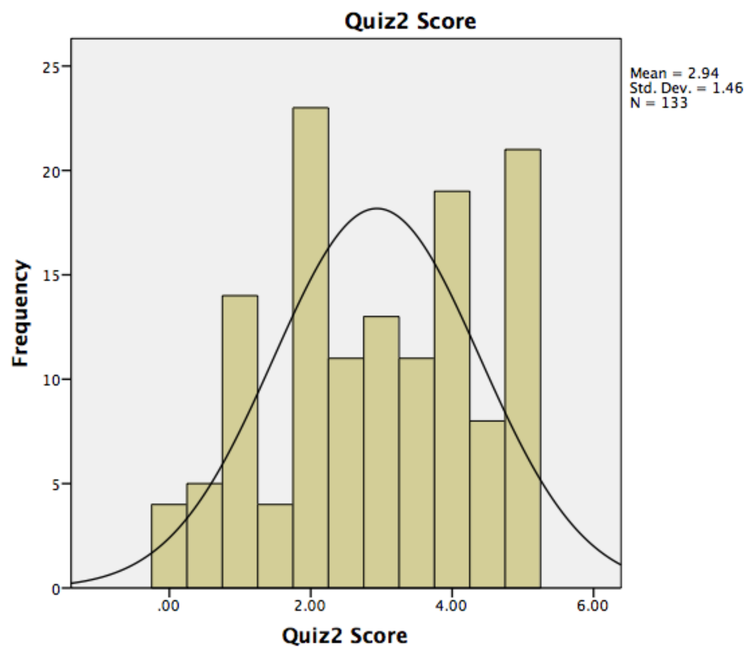

Figure 5. Histogram of the Sample's Quiz #2 Scores.

Results by subgroup. Table 25 presents the means and standard deviations of the Quiz #2. The content control group performance was slightly lower than the content experimental group (M = 3.3947, SD = 1.339). The logistics control group performance was higher than the logistics experimental group (M = 3.5714, SD = 1.19). The C+L control group performance was slightly lower than the C+L experimental group (M = 2.5600, SD = 1.356).

Table 25
Descriptive Statistics for Quiz #2 by Subgroup

Group Type	Mean	*SD*	*N*	Missing
Content Control	2.5278	1.169	18	2
Content Experimental	3.3947	1.339	19	6
Logistics Control	3.7143	1.19	28	2
Logistics Experimental	3.5714	1.381	21	3
C+L Control	1.7045	1.306	22	1
C+L Experimental	2.5600	1.356	25	4
Total			133	18

A one-way ANCOVA was conducted to determine if there was a significant difference between content control group and the content experimental group on the mean Quiz #2 score. The independent variable was the Quiz #2 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 31) = 2.802$ with $p = .104$. Therefore, there was no significant difference between content control group and content experimental group.

A one-way ANCOVA was conducted to determine if there was a significant difference between logistics control group and the logistics experimental group on the mean Quiz #2 score. The independent variable was the Quiz #2 score and the dependent variable was the group assignment (control or experimental). The significance level was set to α = .05 because this level minimized the chances of making a Type I error. The ANCOVA was significant $F(1, 46) = 5.940$ with $p = .019$. Therefore, there was significant difference between logistics control group and logistics experimental group in favor of the control group.

A one-way ANCOVA was conducted to determine if there was a significant difference between C+L control group and the C+L experimental group on the mean Quiz #2 score. The independent variable was the Quiz #2 score and the dependent variable was the group assignment (control or experimental). The significance level was set to α = .05 because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 43) = 3.736$ with $p = .060$. Therefore, there was no significant difference between C+L control group and C+L experimental group.

Quiz #3 Scores by Group

The subtopic of Quiz #3 was solving equations with variables on both sides. This quiz was scored on a 4 point-scale. A score of zero was the minimum possible score and 4 were the maximum, a perfect score. Each item on the quizzes had equal weight.

Results by group. Table 26 presents the means and standard deviations of the Quiz #3. The mean of the control group was lower than the experimental group, but the standard deviation was higher. The control group performance was slightly lower than the experimental group ($M = 2.0317$, $SD = .971$).

Table 26
Descriptive Statistics for Quiz #3 by Group

Group Type	Mean	*SD*	*N*	Missing
All Participants	1.9427	1.068	131	20
Control	1.8603	1.152	68	5
Experimental	2.0317	.971	63	15

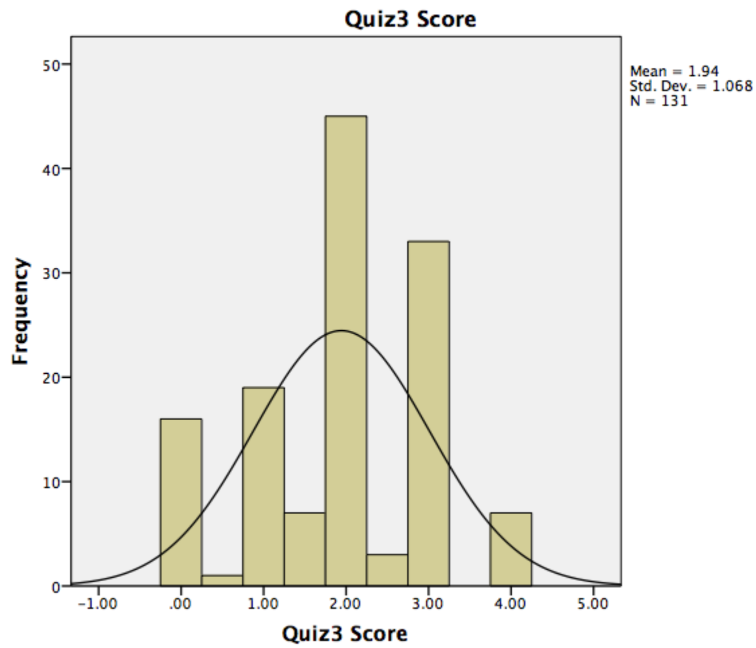

Figure 6. Histogram of the Sample's Quiz #3 Scores.

Results by subgroup. Table 27 presents the means and standard deviations of the Quiz #3. The content control group performance was slightly lower than the content experimental group (*M* = 2.000, *SD* = 1.043). The logistics control group performance was lower than the logistics experimental group (*M* = 2.4286, *SD* = .939). The C+L control group performance was slightly lower than the C+L experimental group (*M* = 1.7083, *SD* = .846).

Table 27
Descriptive Statistics for Quiz #3 by Subgroup

Group Type	Mean	*SD*	*N*	Missing
Content Control	1.5000	1.061	17	3
Content Experimental	2.0000	1.043	18	7
Logistics Control	2.3103	1.145	29	1
Logistics Experimental	2.4286	.939	21	3
C+L Control	1.5455	1.068	22	1
C+L Experimental	1.7083	.846	24	5
Total			131	20

A one-way ANCOVA was conducted to determine if there was a significant difference between content control group and the content experimental group on the mean Quiz #3 score. The independent variable was the Quiz #3 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 29) = .912$ with $p = .347$. Therefore, there was no significant difference between content control group and content experimental group.

A one-way ANCOVA was conducted to determine if there was a significant difference between logistics control group and the logistics experimental group on the mean Quiz #3 score. The independent variable was the Quiz #3 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was significant $F(1, 47) = .393$ with $p = .534$. Therefore, there was no significant difference between logistics control group and logistics experimental group.

A one-way ANCOVA was conducted to determine if there was a significant difference between C+L control group and the C+L experimental group on the mean Quiz #3 score. The independent variable was the Quiz #3 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 42) = .641$ with $p = .428$. Therefore, there was no significant difference between C+L control group and C+L experimental group.

Quiz #4 Scores by Group

The subtopic of Quiz #4 was solving literal equations. Table 28 presents the means and standard deviations of the Quiz #4. This quiz was scored on a 4 point-scale. A score of zero was the minimum possible score and 4 were the maximum, a perfect score. Each item on the quizzes had equal weight.

Results by group. Table 28 presents the means and standard deviations of the Quiz #4. The mean of the control group was lower than the experimental group, but the standard deviation was higher. The control group performance was lower than the experimental group (*M* = 1.9216, *SD* = 1.293).

Table 28
Descriptive Statistics for Quiz #4 by Group

Group Type	Mean	*SD*	*N*	Missing
All Participants	1.8776	1.297	136	15
Control	1.8309	1.309	66	7
Experimental	1.9216	1.293	70	8

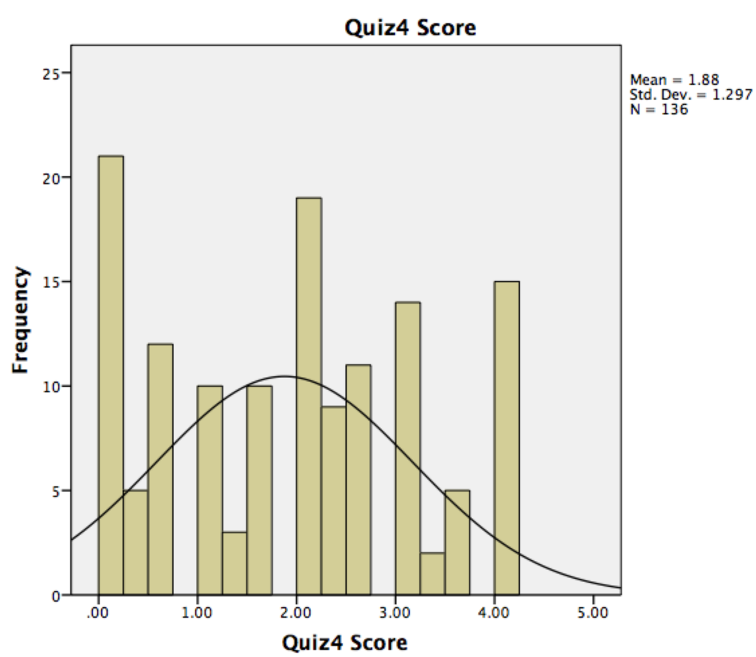

Figure 7. Histogram of the Sample's Quiz #4 Scores.

Results by subgroup. Table 29 presents the means and standard deviations of the Quiz #4. The content control group performance was lower than the content experimental group (*M* = 2.0310, *SD* = 1.466). The logistics control group performance was slightly lower than the logistics experimental group (*M* = 1.6041, *SD* = 1.058). The mean and the standard deviations of the C+L groups were relatively similar. The C+L control group performance was slightly lower than the C+L experimental group (*M* = 2.0929, *SD* = 1.329).

Table 29
Descriptive Statistics for Quiz #4 by Subgroup

Group Type	Mean	*SD*	*N*	Missing
Content Control	1.9582	1.492	17	3
Content Experimental	2.0310	1.466	20	5
Logistics Control	1.5873	1.28	26	4
Logistics Experimental	1.6041	1.058	22	2
C+L Control	2.0122	1.212	23	0
C+L Experimental	2.0929	1.329	28	1
Total			136	15

A one-way ANCOVA was conducted to determine if there was a significant difference between content control group and the content experimental group on the mean Quiz #4 score. The independent variable was the Quiz #4 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 31) = .050$ with $p = .824$. Therefore, there was no significant difference between content control group and content experimental group.

A one-way ANCOVA was conducted to determine if there was a significant difference between logistics control group and the logistics experimental group on the mean Quiz #4 score. The independent variable was the Quiz #4 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was significant $F(1, 45) = 7.819$ with $p = .008$. Therefore, there was a significant difference between logistics control group and logistics experimental group in favor of the experimental group.

A one-way ANCOVA was conducted to determine if there was a significant difference between C+L control group and the C+L experimental group on the mean Quiz #4 score. The independent variable was the Quiz #4 score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 47) = .062$ with $p = .805$. Therefore, there was no significant difference between C+L control group and C+L experimental group.

In short, the experimental group's mean score on the quiz was higher than the control group's mean score on Quiz #1, Quiz #2, Quiz #3, and Quiz #4. While the mean scores of the experimental group were higher than the control group, most of the one-way ANCOVAs were not significant. The only two exceptions were on Quiz #2 and Quiz #4.

Posttest

The posttest information here will be divided into two subsections: by group and subgroup. The students' understanding of linear equations was measured twice - once before the treatment (using the pretest) and once after the treatment (using the posttest). The format for both the pre- and posttest was the same, with only coefficients and the order of items changed. The subtopics of the pre- and posttest included solving one-step equations, solving two-step equations, solving multi-step equations, solving equations with variables on both sides, literal equations, and solving proportions. The pretest was scored on a 20 point-scale. A score of zero was the minimum possible score and 20 were the maximum, a perfect score. Each item on the posttest had equal weight. The pretest and the posttest were separated by 16 days.

Table 30 presents the means and standard deviations of the pretest. The mean and the standard deviation of the control group were lower than the experimental group. The control group performance was lower than the experimental group (M = 6.9649, SD = 4.639).

Table 30
Descriptive Statistics for the Posttest by Group

Group Type	Mean	*SD*	*N*	Missing
All Participants	6.7686	4.403	141	10
Control	6.5518	4.15	67	6
Experimental	6.9649	4.639	74	4

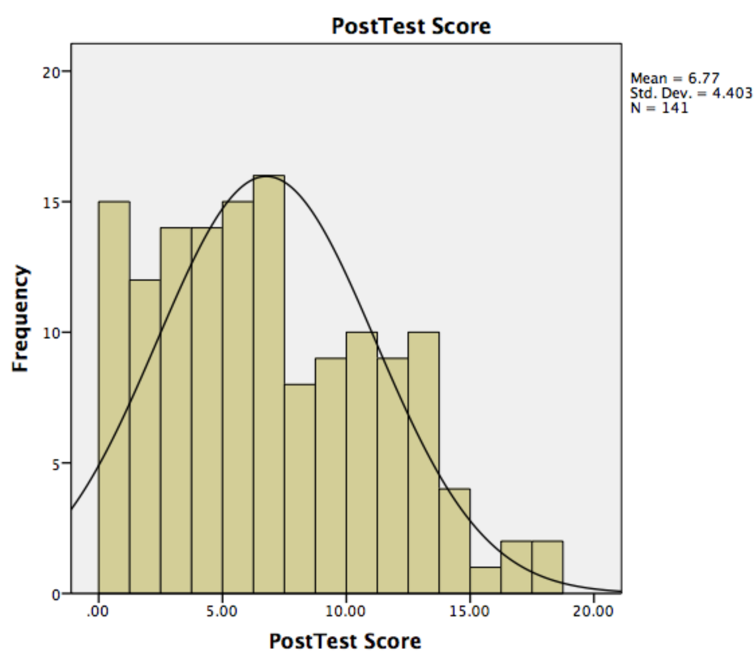

Figure 8. Histogram of the Sample’s Posttest Scores.

Table 31 presents the means and standard deviations of the pretest. The content control group performance was lower than the content experimental group (*M* = 6.4575, *SD* = 4.325). The logistics control group performance was slightly lower than the logistics experimental group (*M* = 11.6652, *SD* = 3.348). The C+L control group performance was slightly higher than the C+L experimental group (*M* = 3.9810, *SD* = 2.594).

Table 31
Descriptive Statistics for the Posttest by Subgroup

Group Type	Mean	*SD*	*N*	Missing
Content Control	5.1933	2.948	18	2
Content Experimental	6.4575	4.325	24	1
Logistics Control	8.7962	4.191	26	4
Logistics Experimental	11.6652	3.348	21	3
C+L Control	5.0778	3.907	23	0
C+L Experimental	3.9810	2.594	29	0
Total			141	10

Figure 9 shows the means of pretest and the posttest by subgroups. The content control mean increased from *M* = 1.5356 to *M* = 5.1933. The content experimental increased from *M* = 1.2146 to *M* = 6.4575. The logistics control mean increased from *M* = 4.8847 to *M* = 8.7962. The logistics experimental mean increased from *M* = 10.3386 to *M* = 11.6652. The C+L control mean increased from *M* = 1.3974 to *M* = 5.0778. The C+L experimental mean increased from *M* = .9218 to *M* = 3.9810.

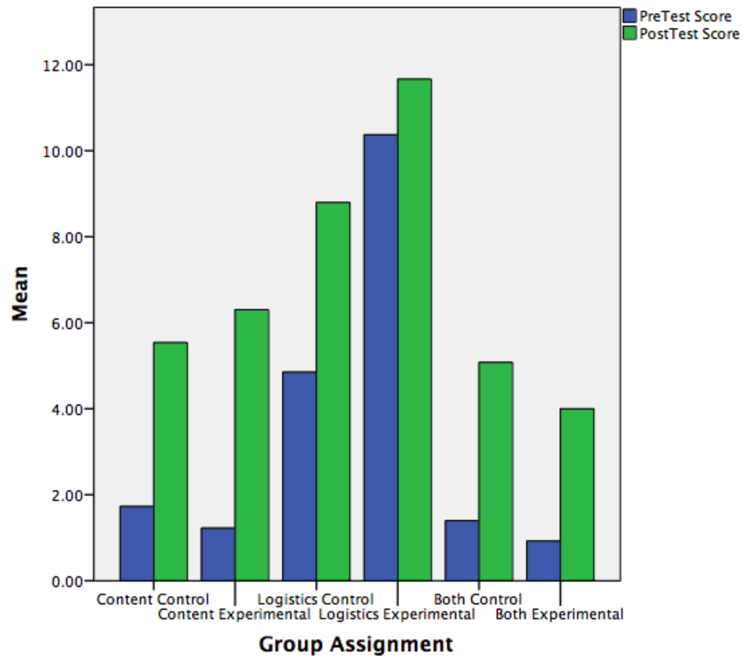

Figure 9. Bar Graph of the Subgroups Pretest Versus Posttest Scores.

Test of the Hypotheses

In total 151 students participated in this quasi-experimental study. The control group had 73 participants in total. Within that group the content control group had 20 participants, the logistics control group had 30 participants, and the C+L control group had 23 participants. The experimental group had 78 participants in total. Within that group the content experimental group had 25 participants, the logistics experimental group had 24 participants, and the C+L experimental group had 29 participants.

From a school population of 4195 students Krejcie and Morgan (1970) suggest that a sample size of 380 is needed. The school where the study was conducted had 1076 freshmen (ninth graders), applying Krejcie and Morgan's (1970) suggestion implies that one needs between 278 and 285 participants. A sample size of 278 across six classrooms suggests that each classroom needs to contain at least 46 participants. Using a sample size of 380 across six classrooms suggest that each classroom needs to contain at least 63 participants. In this educational setting this condition could not be met. The largest group of participants (logistics control) contained 30 volunteers out of 39 possible volunteers.

The ANCOVA has four underlying assumptions. First, the dependent variable is normally distributed. Second, the variances of the dependent variable are equal to 1. Third, the observations represent random and independent samples from the population. Lastly, homogeneity-of-slopes (parallelism) of the covariate and dependent variable is assumed (Green & Salkind, 2011; Hinkle, Wiersma, & Jurs, 2003).

One of the most important underlying assumptions of many statistical tests is the assumption that data is normally distributed. One can gauge the degree of normality through graphical, numerical, and formal test methods. The formal tests include Shapiro-Wilk test, Kolmogorov-Smirnov test, Lilliefors test, and Anderson-Darling test. Razali and Wah (2011) used the Monte Carlo simulation then concluded that the Shapiro-Wilk test was the most powerful test for assessing normality. In this study, the assumption of normality was tested using the Shapiro-Wilk test.

Normally Distributed Assumption

Table 32 illustrates that Shapiro-Wilk test for normality was used to determine if the observed distribution is normally distributed. The null hypothesis for this test assumes that the observed distribution fits the normal distribution. The alternative hypothesis for this test assumes the observed distribution does not fit the normal distribution. In this test, should the results be significant, one can conclude that the distribution is not normally distributed (Shapiro & Wilk, 1965).

Table 32
Shapiro-Wilk Test for Normality on Posttest Scores

Statistic	*df*	Sig.
.963	137	.001

In this quasi-experimental study Shapiro-Wilk test for normality was applied to the posttest on linear equations score. For this test, the significance level was set to α = .05. A Type I error occurs when one rejects a true null hypothesis (Hinkle, Wiersma, & Jurs, 2003). As a result, one rejects the null hypothesis at the α = .05 significance level since the value of the Shapiro-Wilk test statistic is less than the critical value. One can conclude that the observed distribution is not normally distributed.

Even though the normality assumption has not been observed, the ANCOVA is a powerful statistical test. To some extent, the ANCOVA allows the violation of the normality assumption to be present. The work conducted by Levy (1980) stated, "That ANCOVA is robust with respect to dual violations of the assumptions of equal regression and normality of distribution" (p. 835). Levy went on to conclude that, "ANCOVA appears to be robust to violations of the assumption of normality whether group sizes are equal or not" (Levy, 1980, p. 840). The last two columns of Table 31 show that group sizes are not equal.

Furthermore, Glass, Peckham, and Sanders (1972) reviewed the literature pertaining to robustness of the ANOVA and ANCOVA. They analyzed the work of several researchers and concluded that, "These results indicate that the analysis of covariance, in the balance layout, is robust with respect to non-normality" (p. 275). Lastly, Blair's (1981) critique of Glass et al. (1972) argued that education data is hardly ever normally distributed and non-parametric tests such as Wilcoxon's rank-sum test should strongly be considered. In short, even though the normality assumption has not been met the ANCOVA is powerful enough to account for non-normality.

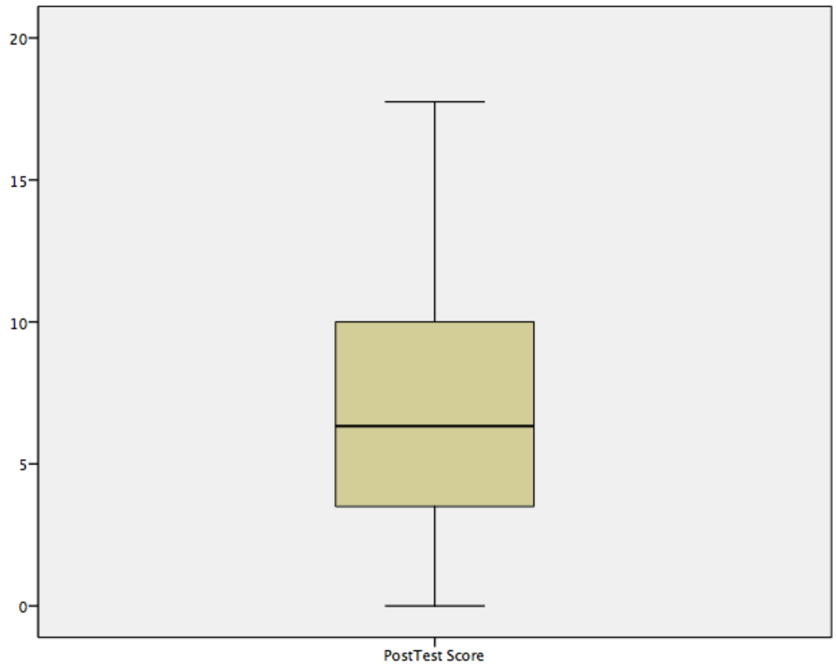

Figure 10. Boxplot of the Twitter Group Posttest Scores.

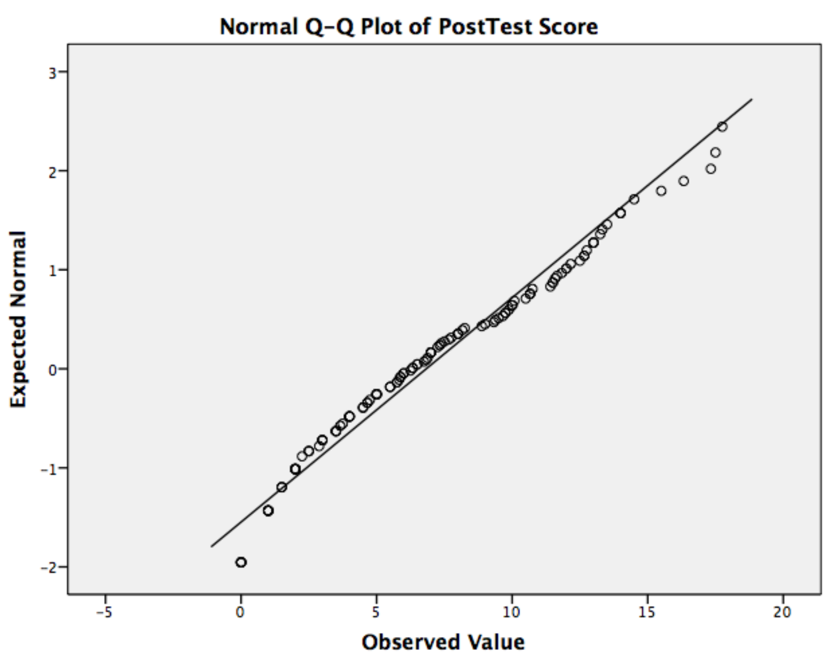

Figure 11. Normal Q-Q Plot of the Twitter Group Posttest Scores.

Equality-of-Variance Assumption (Homoscedasticity)

Table 33 illustrates that Levene's test of equality of variance was used to determine if variance between two samples are equal. The null hypothesis for this test states that population variances are equal. In other words, $H_0: \sigma_1^2 = \sigma_2^2$. The alternative hypothesis for this test assumes that variance of the samples from where the population was drawn from are not equal. In other words, $H_a: \sigma_1^2 \neq \sigma_2^2$ (Hinkle, Wiersma, & Jurs, 2003). In this test, should the results be significant, one can conclude that at least one of the variances is not equal (Green & Salkind, 2011). The work conducted by Box (1954a, 1954b) about ANOVA and ANCOVA concluded that, "Inequality of variance does not seriously affect the test" (1954a, p. 290).

Table 33

Levene's Test of Equality of Variance on Posttest Scores

F	*df1*	*df2*	Sig.
3.788	3	133	.012

In this quasi-experimental study Levene's test for equality of variance was applied to the posttest on linear equations score. For this test, the significance level was set to $\alpha = .05$. As a result, one rejects the null hypothesis at the $\alpha = .05$ significance level since the value of the Levene test statistic is less than the critical value. One can conclude that the variances are not equal.

ANCOVA

A factorial ANCOVA was conducted and results are presented in Table 34. The independent variable, use of Twitter and the dependent variable was the posttest score on a test on linear equations and the covariate was the score on a pretest on linear equations. An analysis evaluating the homogeneity-of-slopes assumption indicated that the relationship between the covariate and the dependent variable did not differ significantly as a function of one of the independent variables. $F(1, 131) = .667$, $MSE = 7.599$, $p = .415$, partial $\eta^2 = .005$, possibly due to a lack of power.

Table 34
Summary ANCOVA for Posttest

Source	*SS*	*df*	*MS*	*F*	Sig.	Partial Eta Squared
Corrected Model	1156.232	4	289.058	25.531	<.001	.436
Intercept	1391.735	1	1391.735	122.923	<.001	.482
Pretest	432.858	1	432.858	38.232	>.001	.225
Content	19.712	1	19.712	1.741	.189	.013
Logistics	7.907	1	7.907	.698	.405	.005
Content*Logistics	52.757	1	52.757	4.660	.033	.034
Error	1494.501	132	11.322			
Total	9045.458	137				
Corrected Total	2650.733	136				

The means of the posttest scores on a test on linear equations adjusted for initial differences across the three Twitter groups. The content by logistic group had the largest adjusted mean (*M* = 52.757), the content group had a smaller adjusted mean (*M* = 19.712), and the logistics group had the smallest adjusted mean (*M* = 7.907).

The estimated marginal means of the posttest were computed. Table 35 shows the results of those calculations.

Table 35
Content by Logistics Tweets Estimated Marginal Means of the Posttest

				95% Confidence Interval	
Content Tweet	Logistics Tweets	Mean	Std. Error	Lower Bound	Upper Bound
Yes	Yes	5.295	.670	3.970	6.619
	No	7.438	.725	6.003	8.873
No	Yes	7.897	.954	6.010	9.785
	No	6.936	.419	6.106	7.765

From Table 35, it follows that the content, logistics, and C+L treatment groups had the following GLM:

$$Y_{posttest} = \beta_0 + \beta_1 X_{content} + \beta_2 X_{logistics} + \beta_3 X_{C+L} + \beta_4 X_{pretest} + \varepsilon_1 =$$

$$\beta_0 + \beta_1 X_{content} + 0 + 0 + \beta_4 X_{pretest} + \varepsilon_1 = 7.438$$

$$Y_{posttest} = \beta_0 + \beta_1 X_{content} + \beta_2 X_{logistics} + \beta_3 X_{C+L} + \beta_4 X_{pretest} + \varepsilon_1 =$$

$$\beta_0 + 0 + \beta_2 X_{logistics} + 0 + \beta_4 X_{pretest} + \varepsilon_1 = 7.897$$

$$Y_{posttest} = \beta_0 + \beta_1 X_{content} + \beta_2 X_{logistics} + \beta_3 X_{C+L} + \beta_4 X_{pretest} + \varepsilon_1 =$$

$$\beta_0 + \beta_1 X_{content} + \beta_2 X_{logistics} + \beta_3 X_{C+L} + \beta_4 X_{pretest} + \varepsilon_1 = 5.295$$

The control groups had the following GLM:

$$Y_{posttest} = \beta_0 + \beta_1 X_{content} + \beta_2 X_{logistics} + \beta_3 X_{C+L} + \beta_4 X_{pretest} + \varepsilon_1 =$$

$$\beta_0 + 0 + 0 + 0 + \beta_4 X_{pretest} + \varepsilon_1 = 6.936$$

First, Figure 11 is a graphical representation of the data that we see on Table 35. The green point on the left represents content-yes and logistics-no $M = 7.438$. The green point the right represents content-no and logistics-no $M = 6.936$. Similarly, the blue point on the left represents content-yes and logistics-yes $M = 5.295$. Lastly, the blue point on the right represents content-no and logistics-yes $M = 7.897$.

Second, the posttest score was lower for the C+L experimental group when compared to the control experimental group. The posttest score was lower for the C+L control group when compared to the logistics experimental group. The figure suggests the participants responded differently to the types of tweets.

Lastly, Figure 12 shows a profile plot of the Twitter groups. The figure displays the estimated marginal means of the posttest scores separated out by groups. One can see that the line segments cross, this is an indication that an interaction between content and logistics for the posttest scores does exist. In other words, we do not have a significant main effect for content and logistics. One can conclude there is an interaction between the two independent variables.

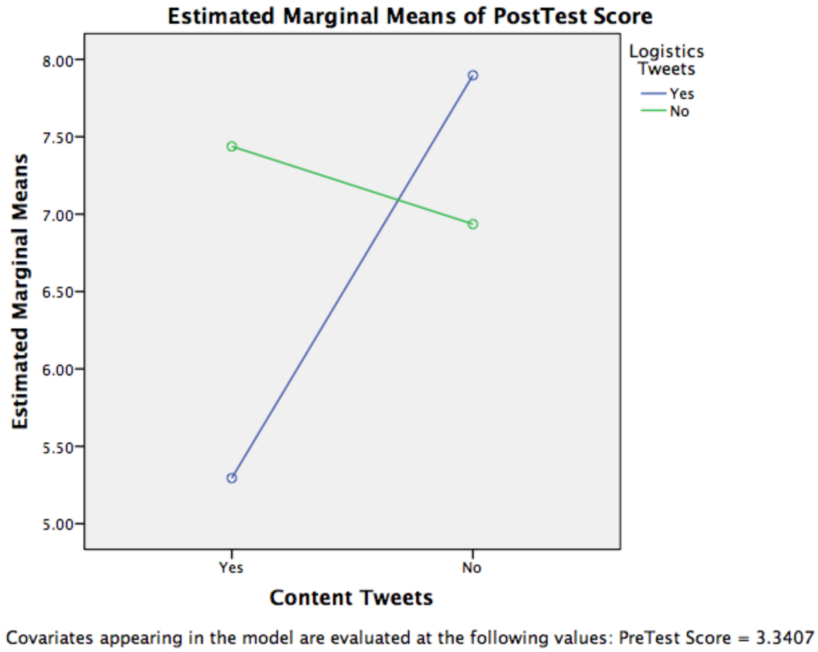

Figure 12. Profile Plot of the Twitter Groups Posttest Scores.

Effect Size

The effect size (η^2) indicates the proportion of variance in the dependent variable accounted for by the independent variables. The value for η^2 ranges from 0 to 1. Common partial η^2classifications include .01 is considered small .06 is medium, and .14 is large (Green & Salkind, 2011). In content group η^2 = .013, which is considered small. In the logistics group η^2 = .005, which is considered small. For the C+L group η^2 = .034, which is considered small.

When one looks at the effect of the covariate, the pretest, one can see that it is statistically significant (p = <.001). It has a statistically significant effect on the posttest score. It accounts for (η^2 = .225) 22.5% of the variance in the outcomes. The pretest was a good covariate; it does have a strong effect on the posttest.

Results for Research Question #1

Is using Twitter more effective than giving content and logistics based information in class for solving Algebra 1 linear equations? This hypothesis was tested using a one-way ANCOVA. The ANCOVA was conducted with the pretest on linear equations score as the covariate and compared the control groups versus the experimental groups. For this hypothesis, the significance level was set to α = .05. Table 36 illustrates that there was not a significant effect on the posttest that can be attributed to tweets, $F(1,134) = .216$, $p = .643$.

Table 36
Question 1 Summary ANCOVA for Posttest

Source	*SS*	*df*	*MS*	*F*	Sig.	Partial Eta Squared
Corrected Model	1078.120	2	539.060	45.933	<.001	.407
Intercept	2020.703	1	2020.703	172.181	<.001	.562
Pretest	1075.197	1	1075.197	91.616	>.001	.406
Twitter	2.540	1	2.540	.216	.643	.002
Error	1572.613	134	11.736			
Total	9045.458	137				
Corrected Total	2650.733	136				

Results for Research Question #2

Is using mathematical content-based tweets more effective than giving the same content-based information in class for solving Algebra 1 linear equations? This hypothesis was tested using a two-way (factorial) ANCOVA. The ANCOVA was conducted with the pretest on linear equations score as the covariate. For this hypothesis, the significance level was set to α = .05. Based on the results presented in Table 34, that there was not a significant effect on the posttest that can be attributed to content-based tweets, $F(1, 132) = 1.741$, $p = .189$.

A one-way ANCOVA was conducted for further analysis of this research questions. The independent variable was content-based tweets, the dependent variable was posttest scores, and the covariate was the pretest scores. A preliminary analysis evaluating the homogeneity-of-slopes assumption indicated that the relationship between the covariate and the dependent variable did not differ significantly as a function of the independent variable, $F(1,35) = .702$, $MSE = 13.670$, $p = .408$, partial $\eta^2 = .020$. Table 37 shows that the ANCOVA was not significant $F(1,36) = .860$, $MSE = 13.557$, $p = .360$. The strength of the relationship between content-based tweets and posttest scores was very weak, as assessed by a $\eta^2 = .023$.

Table 37
Question 2 Summary ANCOVA for Posttest

Source	*SS*	*df*	*MS*	*F*	Sig.	Partial Eta Squared
Corrected Model	61.254	2	30.627	2.259	.119	.112
Intercept	514.078	1	514.078	37.920	<.001	.513
Pretest	55.718	1	55.718	4.110	.050	.102
Content	11.657	1	11.657	.860	.360	.023
Error	488.051	36	13.557			
Total	1948.269	39				
Corrected Total	549.305	38				

Results for Research Question #3

Is using classroom logistics-based tweets more effective than giving the same logistics information in class for solving Algebra 1 linear equations? This hypothesis was tested using a two-way (factorial) ANCOVA. The ANCOVA was conducted with the pretest on linear equations score as the covariate. For this hypothesis, the significance level was set to $\alpha = .05$. Based on the results presented in Table 34, that there was not a significant effect on the posttest that can be attributed to logistics-based tweets, $F(1, 132) = .698$, $p = .405$.

A one-way ANCOVA was conducted for further analysis of this research questions. The independent variable was logistic-based tweets, the dependent variable was posttest scores, and the covariate was the pretest scores. A preliminary analysis evaluating the homogeneity-of-slopes assumption indicated that the relationship between the covariate and the dependent variable did not differ significantly as a function of the independent variable, $F(1,43) = .760$, $MSE = 10.962$, $p = .388$, partial $\eta^2 = .017$. Table 38 shows that the ANCOVA was not significant $F(1,44) = .279$, $MSE = 10.902$, $p = .600$. The strength of the relationship between logistic-based tweets and posttest scores was very weak, as assessed by a $\eta^2 = .006$.

Table 38
Question 3 Summary ANCOVA for Posttest

Source	*SS*	*df*	*MS*	*F*	Sig.	Partial Eta Squared
Corrected Model	279.171	2	139.586	12.803	<.001	.368
Intercept	666.991	1	666.991	61.180	<.001	.582
Pretest	183.544	1	183.544	16.836	>.001	.277
Logistics	3.046	1	3.046	.279	.600	.006
Error	479.695	44	10.902			
Total	5532.553	47				
Corrected Total	758.866	46				

Results for Research Question #4

Is using mathematical content-based and logistics-based tweets more effective than giving the same information in class for solving Algebra 1 linear equations? This hypothesis was tested using a two-way (factorial) ANCOVA. The ANCOVA was conducted with the pretest on linear equations score as the covariate. For this hypothesis, the significance level was set to $\alpha = .05$. Based on the results presented in Table 34, that there was a significant interaction on the posttest that can be attributed to content-based and logistics-based tweets, $F(1, 132) = 4.660$, $p = .033$.

A one-way ANCOVA was conducted for further analysis of this research questions. The independent variable was logistic-based tweets, the dependent variable was posttest scores, and the covariate was the pretest scores. A preliminary analysis evaluating the homogeneity-of-slopes assumption indicated that the relationship between the covariate and the dependent variable did not differ significantly as a function of the independent variable, $F(1,48) = .139$, $MSE = 9.604$, $p = .711$, partial $\eta^2 = .003$. Table 39 shows that the ANCOVA was not significant $F(1,48) = .743$, $MSE = 9.485$, $p = .393$. The strength of the relationship between logistic-based tweets and posttest scores was very weak, as assessed by a $\eta^2 = .015$.

Table 39

Question 4 Summary ANCOVA for Posttest

Source	*SS*	*df*	*MS*	*F*	Sig.	Partial Eta Squared
Corrected Model	279.171	2	41.717	4.398	.018	.155
Intercept	666.991	1	484.012	51.029	<.001	.515
Pretest	183.544	1	68.716	7.245	.010	.131
C+L	3.046	1	7.043	.743	.393	.015
Error	479.695	48	9.485			
Total	5532.553	51				
Corrected Total	758.866	50				

Post-Treatment Survey

After experimental group of students used Twitter as part of this quasi-experimental study, the Twitter group took a 10-item survey. The survey was intended to understand the students' opinion of using Twitter as they learned course content in Algebra 1. Given no other studies of this kind for Twitter, mathematics, algebra, linear equation, and high school level were found in the literature at the time of this quasi-experimental study bringing in qualitative information from surveys contributed to a better understanding of quantitative research information. See Appendix E for the full set of questions that the participants were asked to answer.

Table 40 shows the frequencies and percentages from self-reported responses of the sample of participants. Overall, the data in Table 40 shows that the mode on most of the questions was "Agree". The two exceptions to this occurred at question 6 and question 8. Question 6 asked the participants if, "Using Twitter has motivated [them] to learn mathematics" and Question 8 asked the participants if, "The use of Twitter would have been more effective if the teacher would have replied to [their] tweets".

Table 40
Students' Opinion About Using Twitter for Complete Sample (N = 78)

Survey Item	Strongly Agree - Frequency (Percent)	Agree - Frequency (Percent)	Disagree - Frequency (Percent)	Strongly Disagree - Frequency (Percent)	Missing Frequency (Percent)
Questions 1	10 (12.8)	42 (53.8)	13 (16.7)	7 (9.0)	6 (7.7)
Questions 2	9 (11.5)	44 (56.4)	13 (16.7)	4 (5.1)	8 (10.3)
Questions 3	8 (10.3)	31 (39.7)	20 (25.6)	11 (14.1)	8 (10.3)
Questions 4	18 (23.1)	32 (41.0)	13 (16.7)	9 (11.5)	6 (7.7)
Questions 5	7 (9.0)	31 (39.7)	23 (29.5)	10 (12.8)	7 (9.0)
Questions 6	3 (3.8)	24 (30.8)	29 (37.2)	14 (17.9)	8 (10.3)
Questions 7	9 (11.5)	30 (38.5)	24 (30.8)	8 (10.3)	7 (9.0)
Questions 8	17 (21.8)	17 (21.8)	28 (35.9)	9 (11.5)	7 (9.0)
Questions 9	17 (21.8)	34 (43.6)	13 (16.7)	7 (9.0)	7 (9.0)
Questions 10	14 (17.9)	32 (41.0)	17 (21.8)	8 (10.3)	7 (9.0)

Table 41 shows the frequencies and percentages from self-reported responses of the content experimental group. Overall, the data in Table 41 shows that the mode for half of the question was “Agree”. The four exceptions occurred at questions 3, 5, 6, and 8. The participants were evenly split (11 to 11) on question 7. Question 3 asked the participants if, “[They] can easily remember the tweets [they] received” and Question 5 asked the participants if, “With the help of Twitter [they] learned a great deal”. Question 6 asked the participants if, “Using Twitter has motivated [them] to learn mathematics” and Question 8 asked the participants if, “The use of Twitter would have been more effective if the teacher would have replied to [their] tweets”.

Table 41
Students' Opinion About Using Twitter for Content Group (*N* = 25)

Survey Item	Strongly Agree - Frequency (Percent)	Agree - Frequency (Percent)	Disagree - Frequency (Percent)	Strongly Disagree - Frequency (Percent)	Missing Frequency (Percent)
Questions 1	3 (12.0)	11 (44.0)	5 (20.0)	3 (12.0)	3 (12.0)
Questions 2	4 (16.0)	13 (52.0)	3 (12.0)	1 (4.0)	4 (16.0)
Questions 3	4 (16.0)	6 (24.0)	7 (28.0)	5 (20.0)	3 (12.0)
Questions 4	5 (20.0)	11 (44.0)	4 (16.0)	2 (8.0)	3 (12.0)
Questions 5	4 (16.0)	6 (24.0)	8 (32.0)	4 (16.0)	3 (12.0)
Questions 6	2 (8.0)	5 (20.0)	9 (36.0)	6 (24.0)	3 (12.0)
Questions 7	3 (12.0)	8 (32.0)	7 (28.0)	4 (16.0)	3 (12.0)
Questions 8	5 (20.0)	2 (8.0)	11 (44.0)	4 (16.0)	3 (12.0)
Questions 9	6 (24.0)	9 (36.0)	5 (20.0)	2 (8.0)	3 (12.0)
Questions 10	4 (16.0)	8 (32.0)	6 (24.0)	4 (16.0)	3 (12.0)

Table 42 shows the frequencies and percentages from self-reported responses of the logistic experimental group. Overall, the data in Table 42 shows that the mode for each of the question was “Agree”. The two exceptions occurred at question 4 and question 8. Question 4 was bimodal, with “Strongly Agree” and “Agree” both receiving seven responses. Question 8 asked the participants if, “The use of Twitter would have been more effective if the teacher would have replied to [their] tweets”.

Table 42
Students' Opinion About Using Twitter for Logistics Group (*N* = 24)

Survey Item	Strongly Agree - Frequency (Percent)	Agree - Frequency (Percent)	Disagree - Frequency (Percent)	Strongly Disagree - Frequency (Percent)	Missing Frequency (Percent)
Questions 1	4 (16.7)	13 (54.2)	1 (4.2)	3 (12.5)	3 (12.5)
Questions 2	2 (8.3)	13 (54.2)	2 (8.3)	3 (12.5)	4 (16.7)
Questions 3	3 (12.5)	9 (37.5)	4 (16.7)	4 (16.7)	4 (16.7)
Questions 4	7 (29.2)	7 (29.2)	2 (8.3)	5 (20.8)	3 (12.5)
Questions 5	0 (0)	11 (45.8)	4 (16.7)	5 (20.8)	4 (16.7)
Questions 6	0 (0)	10 (41.7)	5 (20.8)	5 (20.8)	4 (16.7)
Questions 7	3 (12.5)	10 (41.7)	3 (12.5)	4 (16.7)	4 (16.7)
Questions 8	10 (41.7)	3 (12.5)	4 (16.7)	3 (12.5)	4 (16.7)
Questions 9	7 (29.2)	8 (33.3)	2 (8.3)	3 (12.5)	4 (16.7)
Questions 10	5 (20.8)	10 (41.7)	2 (8.3)	3 (12.5)	4 (16.7)

Table 43 shows the frequencies and percentages from self-reported responses of the C+L experimental group. Overall, the data in Table 43 shows that the mode on most of the questions was "Agree". The three exceptions to this question 6, question 7, and question 8. Question 6 asked the participants if, "Using Twitter has motivated [them] to learn mathematics," Question 7 asked the participants if, "Twitter has allowed [them] to keep with the lesson during their leisure time," and Question 8 asked the participants if, "The use of Twitter would have been more effective if the teacher would have replied to [their] tweets".

Table 43
Students' Opinion About Using Twitter for C+L Group (*N* = 29)

Survey Item	Strongly Agree - Frequency (Percent)	Agree - Frequency (Percent)	Disagree - Frequency (Percent)	Strongly Disagree - Frequency (Percent)	Missing Frequency (Percent)
Questions 1	3 (10.3)	18 (62.1)	7 (24.1)	1 (3.4)	0 (0.0)
Questions 2	3 (10.3)	18 (62.1)	8 (27.6)	0 (0.0)	0 (0.0)
Questions 3	1 (3.4)	16 (55.2)	9 (31.0)	2 (6.9)	1 (3.4)
Questions 4	6 (20.7)	14 (48.3)	7 (24.1)	2 (6.9)	0 (0.0)
Questions 5	3 (10.3)	14 (48.3)	11 (37.9)	1 (3.4)	0 (0.0)
Questions 6	1 (3.4)	9 (31.0)	15 (51.7)	3 (10.3)	1 (3.4)
Questions 7	3 (10.3)	12 (41.4)	14 (48.3)	0 (0.0)	0 (0.0)
Questions 8	2 (6.9)	12 (41.4)	13 (44.8)	2 (6.9)	0 (0.0)
Questions 9	4 (13.8)	17 (58.6)	6 (20.7)	2 (6.9)	0 (0.0)
Questions 10	5 (17.2)	14 (48.3)	9 (31.0)	1 (3.4)	0 (0.0)

Results for Research Question #5

Is there a relationship between students' attitudes towards Twitter and learning mathematics? This hypothesis was analyzed using descriptive statistics. Further analyses were conducted using a one-way ANOVA and ANCOVA. The results show that there was no significant difference in mean pretest, Quiz #1, Quiz #2, Quiz #3, Quiz #4, and posttest score between those students who agreed with question 10 on the post-treatment survey and those students who disagreed with the question.

The results of question 10 on the post-treatment survey showed that 58.9% of the participants (32.1% strongly disagreed or disagreed) who used Twitter strongly agreed or agreed that they could easily remember the tweets that they received. The following table shows a comparison of the means. In Table 44 the dependent variables were the pre-test, all the quizzes, and the posttest. The independent variable is their response to question 10 on the post-treatment survey.

Table 44
Comparison of Performance Means by Learning with Twitter Question

Question 3	Statistic	Pretest	Quiz #1	Quiz #2	Quiz #3	Quiz #4	Posttest
Agree	Mean	4.5402	2.9130	3.3452	1.9302	2.00	7.4102
	SD	5.17339	1.20326	1.33201	1.03844	1.341	5.02532
	n	44	46	42	43	45	46
Disagree	Mean	2.3792	2.9545	2.4737	2.1176	1.85	6.1880
	SD	3.21289	1.01076	1.36904	.69663	1.172	3.76067
	n	25	22	19	17	21	25

A one-way ANOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 10 on the mean pretest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANOVA was not significant $F(1, 67) = 3.567$ with $p = .063$. Therefore, there was no significant difference in mean linear equations pretest score between those students who agreed with question 10 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 10 on the mean Quiz #1 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 63) = .132$ with $p = .718$. Therefore, there was no significant difference on the mean Quiz #1 score between those students who agreed with question 10 on the post-treatment survey and those students who disagreed with the question on the post-treatment survey.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 10 on the mean Quiz #2 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was significant $F(1, 56) = 3.657$ with $p = .061$. Therefore, there was no significant difference in the mean Quiz #2 score between those students who agreed with question 10 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 10 on the mean Quiz #3 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 55) = 1.214$ with $p = .275$. Therefore, there was no significant difference on mean Quiz #3 score between those students who agreed with question 10 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 10 on the mean Quiz #4 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The

ANCOVA was not significant $F(1, 61) = .240$ with $p = .626$. Therefore, there was no significant difference in mean Quiz #4 score between those students who agreed with question 10 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 10 on the mean posttest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 66) = .122$ with $p = .728$. Therefore, there was no significant difference in mean linear equation posttest score between those students who agreed with question 10 on the post-treatment survey and those students who disagreed with the question.

Results for Research Question #6

Do students who think that Twitter is a useful tool learn more than students who do not? This hypothesis was analyzed using descriptive statistics. Further analyses were conducted using a one-way ANOVA and ANCOVA. The results show that there was no significant difference in mean pretest, Quiz #1, Quiz #2, Quiz #3, Quiz #4, and posttest score between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question.

The results of question 5 on the post-treatment survey showed that 48.7% of the participants (42.3% strongly disagreed or disagreed) who used Twitter strongly agreed or agreed that they learned a great deal while using Twitter. The following table shows a comparison of the means. In Table 45 below the dependent variables were the pre-test, all the quizzes, and the posttest. The independent variable is their response to question 3 on the post-treatment survey.

Table 45
Comparison of Performance Means by Learned a Great Deal Question

Question 3	Statistic	Pretest	Quiz #1	Quiz #2	Quiz #3	Quiz #4	Posttest
Agree	Mean	4.0076	2.9079	3.3429	1.9857	2.04	6.9434
	SD	5.02660	1.21841	1.28207	1.01811	1.336	5.05924
	n	37	38	35	35	37	38
Disagree	Mean	3.4678	2.9500	2.7115	1.9800	1.84	7.0218
	SD	4.24432	1.04510	1.47765	.87178	1.223	4.15664
	n	32	30	26	25	29	33

A one-way ANOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 5 on the mean pretest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANOVA was not significant $F(1, 67) = .228$ with $p = .634$. Therefore, there was no significant difference in the mean linear equation pretest score between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 5 on the mean Quiz #1 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 63) = .286$ with $p = .595$. Therefore, there was no significant difference in the mean Quiz #1 score between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 5 on the mean Quiz #2 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 56) = 3.043$ with $p = .087$. Therefore, there was no significant difference in the mean Quiz #2 score between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 5 on mean Quiz #3 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 55) = .015$ with $p = .903$. Therefore, there was no significant difference in the mean Quiz #3 score between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 5 on the mean Quiz #4 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 61) = .105$ with $p = .747$. Therefore, there was no significant difference in the mean Quiz #4 score between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 5 on the mean posttest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 66) = .118$ with $p = .732$. Therefore, there was no significant difference between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question.

Summary

This chapter presented the results of this quasi-experimental study. The demographic information about the participants in the sample, analysis of the pre-treatment survey, analysis of the pretest, analysis of the intermediate quizzes, analysis of the posttest, analysis of the post-treatment survey, and research hypotheses was presented in this chapter.

The six hypotheses were tested using various one-way and two-way ANCOVAs. The ANCOVA was conducted with the pretest on linear equations score as the covariate. The dependent variable used in this quasi-experimental study was the posttest score on a test of linear equations. The independent variables were the use of Twitter (Twitter versus non-Twitter), use of Twitter for content, use of Twitter for logistics, and use of Twitter for both. The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error.

A one-way ANOVA was utilized to determine if there were any statistically significant differences in the pretest. The results of the ANOVA showed that the logistic experimental group had a significantly higher mean pretest test score than its control group.

Also the one-way ANCOVAs showed that there were no statistically significant differences between the control group and the experimental groups in most of the quizzes. However, statistically significant differences were found in Quiz #2 and Quiz #4 among the logistics groups. The logistic control group performed significantly higher on Quiz #2 and the logistics experimental group performed significantly higher on Quiz #4.

The one-way and two-way ANCOVAs showed that there were no significant differences among the different treatment levels hypothesized in research questions 1 through 4. Lastly, the one-way ANOVAs and ANCOVAs showed that there were no significant differences in student attitudes towards Twitter and the learning of mathematics (research questions 5 and 6).

The following chapter will discuss the results reported in this chapter as well as suggest practical implications, limitations of the study, and offer recommendations for future research.

CHAPTER V: DISCUSSION

This chapter restates the problem and summarizes the study. Also it will provide a summary and discussion of the results. Furthermore, it will suggest practical implications, and offer recommendations for future research. Finally, the chapter closes with concluding remarks.

Restatement of the Problem

The use of Twitter in educational setting has been mostly limited to higher education and there are only a few studies that apply Twitter to a K-12 setting (Gao et al., 2012). A review of the literature revealed that it has been used in a second grade class (Waller, 2010) and a middle school science class (Van Vooren & Bess, 2013). However, the bulk of the literature is descriptive, and not experimental, in nature (Gao et al., 2012).

More than ever before students are taking Algebra 1 as part of their high school experience because of its fundamental role as a high school graduation requirement. Even though more students are taking Algebra 1, student success has been lackluster. A student’s performance in this pivotal course has enduring effects for the student. To an extent, this study was undertaken because of a need to improve student performance in Algebra 1.

The intersection of these two fields, Twitter and mathematics education, needs to be examined further. This quasi-experimental study was undertaken to help fill the gap in the literature related to social networking sites and mathematics education.

Summary of the Study

This pretest-posttest quasi-experimental study investigated the effect of using Twitter by high school mathematics students in Algebra 1 as they learned linear equations. As part of this study the nonequivalent control group design was utilized. To test the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1 a factorial ANCOVA was applied. In this study the covariate was the pretest scores. The research questions that were answered as the result of this quasi-experimental study are:

1. Is using Twitter more effective than giving content and logistics based information in class for solving Algebra 1 linear equations?
2. Is using mathematical content-based tweets more effective than giving the same content-based information in class for solving Algebra 1 linear equations?
3. Is using classroom logistics-based tweets more effective than giving the same logistics information in class for solving Algebra 1 linear equations?
4. Is using mathematical content-based and logistics-based tweets more effective than giving the same information in class for solving Algebra 1 linear equations?
5. Is there a relationship between students' attitudes towards Twitter and learning mathematics?
6. Do students who think that Twitter is a useful tool learn more than students who do not?

Discussion of the Results

Based on the results of the factorial ANCOVAs and one-way ANCOVAs given in Chapter 4, one can conclude that there were no statistically significant differences between the experimental and control groups. The following subsections summarize the results and provide a brief discusses for each research question. Furthermore, other topics that are germane to discussion are also discussed.

Summary and Discussion of Results for Research Question #1

The results of the ANCOVA indicated no statistically significant difference in the mean linear equation posttest scores between the experimental group (those students who used Twitter) and the control group (those students who did not use Twitter). This suggests that any group difference in the increase in students' mean linear equations posttest score may be due to chance.

The results of the ANCOVA contradict hypothesis 1, which postulated that the group that uses Twitter would do better than the control group. This finding is inconsistent with Dunlap and Lowenthal's (2009) descriptive study in higher education suggestions that Twitter should be used outside the classroom.

Summary and Discussion of Results for Research Question #2

The results of the ANCOVA indicated no statistically significant difference in the mean linear equation posttest scores between the experimental group (that received content-based tweets) and the control group (who did not receive content-based tweets). This suggests that any group difference in the increase in students' mean linear equation posttest score may be due to chance.

The results of the ANCOVA contradict hypothesis 2, which postulated that the group that receives content-based tweets would do better than the control group. This finding contradicts the conclusion reached by Blessing et al.'s (2012) experimental study in higher education and Everson et al.'s (2013) descriptive study in higher education of tweeting about course content. Blessing et al. (2012) and Everson et al. (2013) concluded that students who received tweets about course content performed better than those who did not.

Summary and Discussion of Results for Research Question #3

The results of the ANCOVA indicated no statistically significant difference in the mean linear equation posttest scores between the experimental group (that received logistics-based tweets) and the control group (who did not receive logistics-based tweets). This suggests that any group difference in the increase in students' mean linear equations posttest score may be due to chance.

The results of the ANCOVA contradict hypothesis 3, which postulated that the group that receives logistics based tweets would do better than the control group. This finding is not consistent with Junco et al.'s (2011) experimental study in higher education of tweeting about classroom logistics. Junco et al. (2011) concluded that students who received tweets about classroom logistics performed better than those who did not.

Summary and Discussion of Results for Research Question #4

The results of the ANCOVA indicated no statistically significant difference in the mean linear equation posttest scores between the experimental group that received both types of tweets and the control group who did not receive any tweets. This suggests that any group difference in the increase in students' mean linear equation posttest score may be due to chance.

The results of the ANCOVA contradict hypothesis 4, which postulated that the group that receives both types of tweets would do better than the control group. This finding is not consistent with Van Vooren and Bess' (2013) experimental study in junior high of tweeting about both. Van Vooren and Bess (2013) concluded that students who received tweets about both performed better than those students who did not.

Summary and Discussion of Results for Research Question #5

One can conclude from the information presented in Table 44 that those students who reported that they found Twitter to be very effective did show an increase in performance when compared to the control group of students. It was only on Quiz #1 (solving two-step equations) and Quiz #3 (solving equations with variables on both sides) that the students who disagreed with the question on the post-treatment survey performed higher than those who agreed with the question on the post-treatment survey.

The results of the ANOVA and ANCOVA determined that there was no significant difference in the mean assessment scores between those who agreed and who disagreed with question 10 and how they performed on the various assessments. The results of the ANCOVA are consistent with hypothesis 5, which postulated that there is no relationship between students' attitudes towards Twitter and performance on the various assessments.

Summary and Discussion of Results for Research Question #6

One can conclude from the information presented in Table 45 that those students who reported that they learned a great deal with Twitter did show an increase in performance when compared to the control group of students. It was only on Quiz #1 (solving two-step equations) and the posttest that the students who disagreed with the question on the post-treatment survey performed higher than those who agreed with the question on the post-treatment survey.

The results of the ANOVA and ANCOVA determined that there was no significant difference in the mean assessment scores between those who agreed and who disagreed with question 5 and how they performed on the various assessments. The results of the ANOVA are consistent with hypothesis 6, which postulated that there is no relationship between student perception and performance on the various assessments.

Summary and Discussion of the Tweets

First, the lack of statistical significance could possibly be attributed to the types of tweets that were sent out to the participants. The State of Florida adopted the Common Core standards and then quickly replaced them with MAFS. The MAFS were simply a rebranding of the Common Core standards. The cognitive rigor scheme that is associated with both standards is Webb's DOK, not Bloom's Taxonomy. The tweets used verbs commonly associated with both Webb's DOK and Bloom's Taxonomy. It is entirely possible that the students were not accustomed to using of these verbs in mathematics. Also, it is possible that the cognitive academic language of the tweets was too obscure for ninth graders. Lastly, these two things taken together might have further contributed to further confusion among the participants.

Second, based on view rates it entirely possible that the lack significance can be attributed to the types of tweets that were used. These include that students did not completely understand what they were suppose to do when they replied to a tweet. Throughout the many drafts of the tweets every attempt was made to make sure that the content of the tweets were grammatically correct and the instructions were very clear; however, it is possible due the wording was awkward and the participants did not understand the tweets.

Third, because the tweets might have been too abstract it could have caused the participants to spend a great deal of thinking about the tweet. Thus, taxing the cognitive load of the participants. Extended time on task might have discouraged some participants from contributing. A future study could reverse the style of the content tweets. For example, instead of asking the student to create an example one can present an example and ask the student what property is illustrated in the example. Another possibility can be that the student is presented with an example and based on that example have the student create another example that is similar.

In short, the tweets might have been too confusing, abstract, or awkward. Moving forward one possible remedy to this problem is admin slips. Admit slip, very much like the exit slip, serves as form of formative assessment. The student can fill out an admit slip prior to or at the beginning of class. On the admit slip the student will be asked to explain in his or her own words to interpret the meaning of the tweet. This serves, as a perfect opportunity to address any concerns about what is it about the tweet that they found to be confusing, abstract, or awkward. Also, if the student understood the tweet that student could propose an original tweet that could be used in a later class or provide an alternative tweet to the one they sent the night before.

Moving forward, similar studies involving Twitter and mathematics education will need to rephrase the tweets found in Appendix A. A tweet was used in this study was, "ICYMI [in case you missed it]: Subtraction property of equality. If A = B, Then A - C = B - C … Apply this to a real world example." Twitter allows users to attach up to four pictures in a tweet. This could be rephrased and retooled in the following manner, "Take and submit a couple of pictures of you demonstrating how you use the Subtraction Property of Equality in your daily life." The pre-treatment survey should that 89% of the control group participants had cellphones that had the capabilities to take pictures. The experimental group had a similar statistic with 88.5% of the participants having a cellphone that had the capacity to take pictures. The over 10% of participants who did not have this ability to take pictures on their cellphones could partake in this assignment by searching for a pictures on the Internet that illustrates the point they were trying to communicate.

The following tweet was used in this study, “Write a plan to solve a two-step equation. Explain why you think your plan is appropriate.” Using Twitter’s 30-second video limit one can also do the following to revamp this tweet, “Be creative and make a short video explaining how to solve two-step equations.” The pre-treatment survey should that 89% of the control group participants had cellphones that had the capabilities to record video. The experimental group had a similar statistic with 88.5% of the participants having a cellphone that had the capacity to record video. The over 10% of participants who did not have this ability to record video on their cellphones could contribute in this assignment by searching for a pictures on the Internet and make a short video, using Microsoft Windows Movie Maker or Apple iMovie, that illustrates the point they were trying to communicate.

The following tweet was used in this study, “You can undo order of operations to solve an equation. First, addition and subtraction. Then, multiplication and division. Is this correct?” To revamp this tweet one can use Twitter’s new poll feature. Here the teacher can ask students to weigh in what the answer could be. Twitter’s new poll feature can serve as a form of formative assessment. The teacher can then come back the next and address any misconceptions that may be lingering. The pre-treatment survey showed that overwhelmingly most participants had the technology to access the tweets. Those students who did not have a device that granted them access to the tweets could join the discussion asking the teacher what s/he will be tweeting about and submitting admit slip at the beginning of the following class.

Summary and Discussion of Participation

First, throughout the study the students were instructed to share hyperlinks, critique, and ask questions in a concise manner. However, very few of the 78 participants (content = 25, logistics = 24, and C+L = 29) in the experimental group did the tasks as instructed. Twitter defines an impression as the number of times a tweet appeared in a user's timeline. Based on the Twitter analytics tool the researcher observed that the average of the impression for the tweets across all groups was 27.06 views.

The sum of the impression for the content experimental group was 567. The average of the impressions for the content experimental group was 22.68. This suggests that the content experimental group participants saw the tweets on the their timeline .91 times, average impression divided by number of participants in the sample.

The sum of the impression for the logistics experimental group was 412. The average of the impressions for the logistics experimental group was 45.78. This suggests that the logistics experimental group participants saw the tweets on the their timeline 1.91 times, average impression divided by number of participants in the sample.

The sum of the impression for the C+L experimental group was 915. The average of the impressions for the C+L experimental group was 25.42. This suggests that the C+L experimental group participants saw the tweets on the their timeline .88 times, average impression divided by number of participants in the sample.

It follows that the group was with the lowest impression rate was the C+L experimental group and the group with the highest impression was the logistics experimental group. Therefore, one can conclude that the participants just viewed the tweets and probably did not give them too much thought. A similar behavior, whereby the students passively participated in a study, was also identified in the work of Gao, Luo, and Zhang (2012). Thus, future studies must find a way to incorporate behaviorist techniques to somehow compel students to actively participate in the replying to tweets.

The separation between work life and home life has been disappearing because of the rise of technology. As a result the welfare of the individual is compromised (Desrochers & Sargent, 2004). Extending this idea to students and schools, it is entirely possibly that social media and technology are beginning to blur the lines between these distinct areas of students' lives. As results, students might not want to integrate these two areas with social media.

Second, it is also possible that they found the use of Twitter enjoyable but did not find the tweets enjoyable and did not want to reply to the tweets even though they were explicitly instructed to reply to the tweets. Rephrasing the tweets so that they may have a broader appeal to high school freshmen is something future researchers might want to take into consideration.

Lastly, in the age of accountability onus probability needs to be placed on both parties. For the student, this means that the student must reply to the tweets. The quantity and quality of the reply tweets must be acceptable for the student to receive an acceptable assignment grade as part of the course. For the teacher, this means setting up a grading system or a token economy that reflects mastery of the content in the curriculum. Lastly, the content in the tweets needs to be reinforced. It is possible, that the tweets were sent, as per the protocol outlined in Chapter 3 of the present study, but they did not get discussed the following class period. Bringing the online discussion into the classroom to clear up misconceptions might contribute to greater participation and a possible statistical significance in the results.

Summary and Discussion of Cognitive Load Theory

As part of the theoretical framework for this quasi-experimental study cognitive load theory (CLT) was explored. It was suggested that Twitter's central feature, its 140-character limit per tweet, would help the learner remember information. Furthermore, it was inferred that using tweets was consistent with past research and thus the brief messages might have a lesser strain on the cognitive load of students, thus making the effects of the tweets stronger.

The results of question 3 on the post-treatment survey showed that 50% of the participants (31% strongly disagreed or disagreed) who used Twitter strongly agreed or agreed that they could easily remember the tweets that they received. The following table shows a comparison of the means. In Table 46 below the dependent variables were the pre-test, all the quizzes, and the posttest. The independent variable is their response to question 3 on the post-treatment survey.

Table 46
Comparison of Performance Means by Remember Tweets Question

Question 3	Statistic	Pretest	Quiz #1	Quiz #2	Quiz #3	Quiz #4	Posttest
Agree	Mean	4.0967	2.8846	3.1714	1.8750	2.0608	6.5779
	SD	4.93115	1.22722	1.50461	1.02382	1.36754	4.94649
	n	39	39	35	36	37	39
Disagree	Mean	3.3959	3.0179	2.9423	2.1458	1.8550	7.6139
	SD	4.36359	1.02272	1.24360	.82724	1.17338	4.22558
	n	29	28	26	24	28	31

One can conclude from the information presented in Table 46 that even though students reported that they were able to remember what was being tweeted this did not translate into an increase in student performance. It was only on the pretest, Quiz #2 (solving multi-step equations), and Quiz #4 (solving literal equations) that the students who agreed with the question on the post-treatment survey performed higher than those who disagreed with the question on the post-treatment survey.

Further analyses were conducted using a one-way ANOVA and ANCOVA. The results show that there was no significant difference in mean pretest, Quiz #1, Quiz #2, Quiz #3, and Quiz #4 score between those students who agreed with question 5 on the post-treatment survey and those students who disagreed with the question. The only statistically significant difference between the two means that was discovered was with the posttest.

A one-way ANOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 3 on the mean pretest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANOVA was not significant $F(1, 66) = .370$ with $p = .545$. Therefore, there was no significant difference in the mean linear equation pretest between those students who agreed with question 3 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 3 on the mean Quiz #1 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 62) = .437$ with $p = .511$. Therefore, there was no significant difference in the mean Quiz #1 score between those students who agreed with question 3 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 3 on the mean Quiz #2 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 56) = .582$ with $p = .449$. Therefore, there was no significant difference in the mean Quiz #2 score between those students who agreed with question 3 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 3 on the mean Quiz #3 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 55) = 1.756$ with $p = .191$. Therefore, there was no significant difference in the mean Quiz #3 score between those students who agreed with question 3 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 3 on the mean Quiz #4 score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 60) = .353$ with $p = .555$. Therefore, there was no significant difference in mean Quiz #4 score between those students who agreed with question 3 on the post-treatment survey and those students who disagreed with the question.

A one-way ANCOVA was conducted to determine if there was a significant difference between those who agreed and who disagreed with question 3 on the mean linear equation posttest score. The independent variable was the pretest score and the dependent variable was the group assignment (control or experimental). The significance level was set to $\alpha = .05$ because this level minimized the chances of making a Type I error. The ANCOVA was not significant $F(1, 65) = 3.999$ with $p = .050$. Therefore, there was a significant difference in mean linear equations posttest score between those students who agreed with question 3 on the post-treatment survey and those students who disagreed with the question.

Summary and Discussion of the Absence of Statistical Significance

First, a review of the Shapiro-Wilk test for normality ($SW = .963$, $df = 137$, $p = .001$) suggested that normality was not a reasonable assumption. Many statistical tests, including the ANOVA and ANCOVA, are designed for data that is normally distributed. However, the ANCOVA is a vigorous test and it is robust enough to handle non-normality (Levy, 1980). Therefore, one can rule out non-normality as an underlying cause for the lack significance.

Also, the lack of statistically significant differences might have to do with Twitter not being an appropriate intervention for a school population that is not very diverse. Fox et al. (2009) found that race/ethnic breakdown of Twitter users were as follows: 19% White, 26% African American, and 18% Hispanic. The sample used as part this dissertation study was not similar to the global descriptive statistic. A much more diverse school population might yield different results. Based on the literature reviewed in Chapter 2 of the present study, the work of Van Vooren and Bess (2013) produces statistically significant results. The student sample in the Van Vooren and Bess study was 66% White (non-Hispanic) and 20% Hispanic. The present study had a sample that was 5.5% White (non-Hispanic) and 82.2% Hispanic.

It was suggested that using Twitter outside of the classroom could be considered a form of distance education. The research conducted by Russell (1999) showed that time after time studies involving distance education produced no significant differences in student outcomes. As part of his work Russell reviewed 355 papers, articles, and research studies dating back to 1928 (Phipps and Merisotis, 1999) and from those sources he concluded the use of distance education is just as effective as face-to-face classroom instruction.

Phipps and Merisotis' (1999) critique of the work conducted by Russell also found that the vast majority of the literature on distance education produced outcomes that were comparable traditional classroom instruction. However, they go to say that some of the sources reviewed by Russell did not control for extraneous variables, they lack of random assignment of the participants, and the reliability and validity of the instruments that was used in the original sources were debatable. Their only critique of Russell's work was that the 355 sources reviewed might have been included works that were accidently counted more than once.

Summary and Discussion of the Experimental Design

First, the nonequivalent control group design, a pretest-posttest quasi-experimental design, was used in this quasi-experimental study. This design is an improvement on the posttest only design with nonequivalent groups. The posttest only is the simplest and least effective of the quasi-experimental designs. The nonequivalent control group design is open selection bias because the participants were not randomly assigned to a group. Therefore, anyone attempting to generalize the results to other groups should do so with some caution.

Second, the present study did not incorporate all the features Twitter had to offer. The tweets that were sent out were unidirectional. If the teacher and students were engaged in a dialogue by replying to each other's tweets this has the potention clear up any misunderstanding with the tweets. As a result, this might cause a reduction in extraneous cognitive load of the student. Furthermore, asking students to submit pictures and video as part of using Twitter can improve the students' experience of utilizing Twitter in mathematics class. Lastly, the present study did not incorporate the poll feature in Twitter because it was not a feature that was available at the time the study was undertaken.

Practical Implications

The topic of this quasi-experimental study is important to educators who are searching for innovative methods to improve learning linear equations by high school students in Algebra 1. As a result, educators, policy makers, curriculum designers, instructional designers, student, and other stakeholders will benefit from this research because "the role of technology in the teaching and learning of algebra and how technology can enhance the development of algebraic reasoning and conceptual understanding" is a top priority (National Research Council, 1998).

In this section practical implication are extrapolated from the self-reported responses given by the experimental group on the post-treatment survey. The post-treatment survey had a 4-point Likert scale with values that included -- Strongly Agree, Agree, Disagree, and Strongly Disagree.

Educators and Students

Kafka suggested (2013) Twitter is very popular among young people. Steen's analysis (1992) implied that students had an unfavorable view of mathematics. One has to wonder if there is a way to change this view among students. Question #1 on the post-treatment survey asked the participants if they found the use of Twitter in math class to be enjoyable. The most common response to this post-treatment survey question was "Agree" (53.8%). Here 66.6% of the participants said that they agree or strongly agreed with this sentiment versus 25.7% of the participants who disagreed or strongly disagreed. It is within the realm of possibility that some of the panache associated with Twitter is inducing a favorable view of the intersection between Twitter and learning Algebra 1.

Question 2 on the post-treatment survey asked students if they think that their classmates, who used Twitter in this math class are happy about it. The most popular response to this post-treatment survey question was “Agree” (56.4%). For this item 67.9% of the students said that they agree or strongly agreed with the statement versus 21.8% of the participants who disagreed or strongly disagreed. Based on these findings educators can use Twitter to engage students in Algebra class.

Chandler and Sweller (1991) suggested that information should be presented in such a way that it does not tax the cognitive load of the learner. Question 3 on the post-treatment survey asked participants if they can easily remember the tweets that that they received. The most prevalent response to this item was “Agree”. Here 39.7% of the participants agree with this statement and 10.3% strongly agreed. When combined 50.0% of the experimental group were in agreement versus 39.7% of the participants who disagreed or strongly disagreed. This finding suggest that tweets might not over tax the cognitive load of student and an educator can use this method to not overwhelm the student.

Self-fulfilling prophecy is vital to student success. Question 5 on the post-treatment survey asked students if with the help of Twitter did they learn a great deal. Here 39.7% of the participants agree with the sentiment and 9.0% strongly agreed. When combined 48.7% of the experimental group were in agreement versus 42.3% of the participants who disagreed or strongly disagreed. To some extent, educators who are looking for ways to bolster student confidence can use this tool to help their students’ confidence.

Policy Makers, Curriculum, and Instructional Designers

The NETS-T's second standard called for teachers to incorporate contemporary learning tools as part of their repertoire (ISTE, 2008). Question 4 on the post-treatment survey asked the students if they would like to continue using Twitter in math class. Here the most frequent response was "Agree" (41%). Here 64.1% (total percentages) of the students agreed or strongly agreed with the statement versus 28.2% who either disagreed or strongly disagreed. From this finding policy makers can encourage teachers to use unconventional tools in their classroom.

NCTM has identified mathematical disposition as a factor that merits consideration (NCTM, 2000). Question 6 on the post-treatment survey asked the students if using Twitter has motivated them to learn mathematics. The most frequently occurring response to this item was "Disagree" (37.2%). Here 55.1% of the participants disagreed or strongly disagreed with the statement versus 34.6% who agreed or strongly agreed. As a result of this policymakers need to try other methods to increase the mathematical disposition of students.

Thornton and Houser concluded that most of the students who received the foreign-language messages typically read the messages when they were able to concentrate fully on learning (2005). Question 7 on the post-treatment survey asked participants if Twitter allowed them to keep up with the class because they did not pay attention in class. The most common response was "Agree" (38.5%). Here 50.0% of the participants agreed or strongly agreed with the statement versus 41.1% of the participants who disagreed or strongly disagreed. This suggests that curriculum and instructional designers can recommend that teachers use this tool to help students keep up with the material. In a similar manner to the direct instruction flashcards system, it is possible that tweets can be used to help students study.

Limitations

In this quasi-experimental study, the focus was sending tweets to high school students in Algebra 1. The purpose of this quasi-experimental study was to investigate the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. However, there are other factors that can affect learning such as, the learning style of the student and the student's disposition towards using social networking sites in the classroom.

This quasi-experimental study had the following limitations:

1. Partial generalizability of the results. The sample used was predominantly composed of Hispanic students. The results might only be generalizable to similar groups of ninth grade students in Algebra 1.
2. This represents only a small sample from the population of students in M-DCPS. It is worth mentioning that the district population of M-DCPS is very diverse. M-DCPS is the "fourth largest school district in the United States, comprised of 392 schools, 345, 000 students … District students speak 56 different languages and represent 160 countries" (M-DCPS, 2015, p.1).
3. Teaching style of the three teachers selected. Even though all three teachers used the same pacing guide published by the school district that outlines the topics teachers are required to cover and same textbook, no three teachers teach exactly the same.

4. Setting of the study. The students are part of groups and were not selected randomly. However, they were assigned randomly to the class period by the school's master schedule. The teacher determined the assignment of the control and experimental treatments.
5. The size of the sample. The work conducted by Krejcie and Morgan (1970) stated that a sample of 278 to 285 participants is needed from a school population 4,000 students.

The quantitative impact that a teacher has on student performance and achievement is limited. Nye, Konstantopoulos, and Hedges (2004) conducted a four-year experimental study where students and teachers were randomly assigned to classes within the same school. The learning gains achieved by students were not affected by class size, the teacher's years of service, or the teacher holding a graduate degree.

As part of the present study, the three teachers who participated did so based on their willingness to partake, thus no effort could be made to control for the teacher effect. The C+L group had 23 participants in the control group and 29 in the experimental group. As part of the present study two teachers had master's degrees and one bachelor's degree with 26, 15, and eight years of teaching experience. The content group had 20 participants in the control group and 25 in the experimental group. The logistics group had 30 participants in the control group and 24 in the experimental group. The work of Nye, Konstantopoulos, and Hedges (2004) suggests that the impact of the teacher on the present study would not have been significant.

In conclusion, even though there are some limitations, this quasi-experimental study contributed to the knowledge base on social networking sites and mathematics education.

Future research on other ethnic groups needs to be explored with a large sample allowing for generalizability to all ninth grade Algebra 1 students. Furthermore, future research can also focus on other age groups and grade levels in a K-12 setting. Lastly, research on science education and other fields will need to be conducted.

Recommendations for Future Research

Question 8 on the post-treatment survey asked the participants if using Twitter would have been more effective if the teacher would have replied to their tweets. The most popular response was "Disagree". Here 38.5% of the participants shared this sentiment. However, in the Wang, Shen, Novak, and Pan (2009) study messages were bidirectional and it concluded that students became more engaged. Based on the findings of Wang et al. (2009) it is hypothesized that bidirectional tweets might have a greater impact on student performance outcomes and mathematical disposition. Thus, a separate study on bidirectional tweets merits consideration.

Furthermore, it was suggested earlier that the tweets used as part of this study might have been too confusing, abstract, and awkward. The use of bidirectional tweets in future studies might help increase students' understanding of what is being asked of them. Take for example, "You can use the properties of equality repeatedly to isolate a variable. Show how this idea can be applied to science." If a student replies to a tweet and states that there is some confusion about how to apply this concept, the teacher can immediately reply and offer some suggestions. As possible reply could be, "Example, Newton's Law of Motion is F = m*a. To solve for 'a"' you can use The Division Property of Equality and divide both sides by 'm'."

This quasi-experimental study was designed to advance the understanding of the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. Based on the results of the ANCOVA and the post-treatment survey the following suggestions for future research are proposed:

1. Future research could include assessing the effects of using bidirectional tweets by high school mathematics students learning linear equations in Algebra 1.
2. Future research could include the assessment of the effects of using Twitter in classrooms were students are given grades based on the quantity and quality of material they post on Twitter.
3. After the present study was conducted, Twitter implemented a survey feature to its user interface. This new features opens a new set of possibilities that need to be explored.

Conclusion

First, this quasi-experimental study attempted to understand the effects of using Twitter by high school mathematics students learning linear equations in Algebra 1. This work provides a beginning into understanding the use of social media in secondary mathematics education. In this quasi-experimental study, the researcher determined that overall, Twitter, content tweets, logistics tweets, and tweets containing both (content and logistics) did not have a statistically significant effect on the mean posttest linear equations score.

Second, this quasi-experimental study looked at students' performance on various subtopics throughout the unit. These subtopics were measured by four lesson quizzes. The ANCOVA showed that there were no statistically significant differences between the control group and the experimental groups in most of the quizzes. However, statistically significant differences were found in Quiz #2 and Quiz #4 among the logistics groups. The logistic control group performed significantly higher on Quiz #2 and the logistics experimental group performed significantly higher on Quiz #4.

Third, this quasi-experimental study looked at students' attitudes towards the use of Twitter as part of learning mathematics in high school. It can be concluded that students have, for the most part, a positive attitude towards using Twitter as part of learning mathematics in high school. Based on the self-reported information provided by the participants of this quasi-experimental study in the post-treatment survey (Question 9) the researcher can infer that most students would like to use Twitter in their next mathematics class. Lastly, the post-treatment survey (Question 10) also suggests that the majority of the participants found learning to be very effective.

Ultimately, there was no statistically significance difference between the adjusted posttest linear equation score of the control and experimental groups. In spite of this, it can be concluded from the results of post-treatment survey that students had, for the most part, a positive attitude towards using Twitter as part of learning mathematics in high school. Thus, it could be used in the modern-day mathematics classroom as a means to increase student motivation.

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APPENDICES

APPENDIX A
SAMPLE TWEETS

90-Minute Block #2: Tweets about Solving One-Step Equations		
Mathematical Content	Classroom Logistics	C+L
ICYMI: Adding property of equality If A = B, Then A + C = B + C … Demonstrate this is true by creating a real world example.		ICYMI: Adding property of equality If A = B, Then A + C = B + C … Demonstrate this is true by creating a real world example.
ICYMI: Subtraction property of equality If A = B, Then A - C = B - C … Apply this to a real world example.		ICYMI: Subtraction property of equality If A = B, Then A - C = B - C … Apply this to a real world example.
ICYMI: Division property of equality If a = b, Then a/c = b/c … Identify a real world situation where this might be true.		ICYMI: Division property of equality If a = b, Then a/c = b/c … Identify a real world situation where this might be true.
ICYMI: Multiplication property of equality If a = b, Then (a)(c) = (b)(c) … Name a real world situation where this might be true.		ICYMI: Multiplication property of equality If a = b, Then (a)(c) = (b)(c) … Name a real world situation where this might be true.
	Remember: Go to Study Buddy to get tutoring online	Remember: Go to Study Buddy to get tutoring online
	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234

90-Minute Block #3: Tweets Solving Two-Step Equations		
Mathematical Content	Classroom Logistics	C+L
You can use the properties of equality repeatedly to isolate a variable. Show how this idea can be applied to science.		You can use the properties of equality repeatedly to isolate a variable. Show how this idea can be applied to science.
Write a plan to solve a two-step equation. Explain why you think your plan is appropriate.		Write a plan to solve a two-step equation. Explain why your think your plan is appropriate.
You can undo order of operations to solve an equation. First, addition and subtraction. Then, multiplication and division. Is this correct?		You can undo order of operations to solve an equation. First, addition and subtraction. Then, multiplication and division. Is this correct?
Devise a plan to eliminate a fraction from an equation.		Devise a plan to eliminate a fraction from an equation.
Watch some of these videos to prepare for a quiz soon. http://www.khanacademy.org/math/algebra/solving-linear-equations-and-inequalities …		Watch some of these videos to prepare for a quiz soon. http://www.khanacademy.org/math/algebra/solving-linear-equations-and-inequalities …
Discuss what you like or do not like about Khan Academy videos.		Discuss what you like or do not like about Khan Academy videos.
	Remember: Go to Study Buddy to get tutoring online	Remember: Go to Study Buddy to get tutoring online
	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234

90-Minute Block #4: Tweets Solving Multi-Step Equations		
Mathematical Content	Classroom Logistics	C+L
In your own words, define equivalent equations.		In your own words, define equivalent equations.
Develop a plan for solving multi-step equations.		Develop a plan for solving multi-step equations.
I know that not everyone is a fan of Khan Academy. Please share an instructional video you found helpful. Explain why you found it helpful.		I know that not everyone is a fan of Khan Academy. Please share an instructional video you found helpful. Explain why you found it helpful.
The properties of equality and real numbers can be used repeatedly to isolate the variable. Illustrate that this is true.		The properties of equality and real numbers can be used repeatedly to isolate the variable. Illustrate that this is true.
Choose an instructional video you found helpful. Describe why other might find it helpful.		Choose an instructional video you found helpful. Describe why other might find it helpful.
	Remember: Go to Study Buddy to get tutoring online	Remember: Go to Study Buddy to get tutoring online
	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234

90-Minute Block #5: Tweets Solving Equations with Variables on Both Sides		
Mathematical Content	Classroom Logistics	C+L
Summarize what you would do to solve an equation with variable terms on both sides of the equal sign.		Summarize what you would do to solve an equation with variable terms on both sides of the equal sign.
Describe what you would do to solve an equation with parentheses on both sides of the equal sign.		Describe what you would do to solve an equation with parentheses on both sides of the equal sign.
Outline the necessary steps to solve an equation with parenthesis.		Outline the necessary steps to solve an equation with parenthesis.
Recommend an instructional video you found helpful. Express why the might think it is useful.		Recommend an instructional video you found helpful. Express why the might think it is useful.
	Remember: Go to Study Buddy to get tutoring online	Remember: Go to Study Buddy to get tutoring online
	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234

90-Minute Block #6: Tweets Literal Equations and Formulas		
Mathematical Content	Classroom Logistics	C+L
In your own words, state the definition of a literal equation		In your own words, state the definition of a literal equation
Justify how you would select the appropriate formula to use in a word problem.		Justify how you would select the appropriate formula to use in a word problem.
Our chapter test is coming up. Summarize a concept you feel is important.		Our chapter test is coming up. Summarize a concept you feel is important.
	Remember: Go to Study Buddy to get tutoring online	Remember: Go to Study Buddy to get tutoring online
	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234

90-Minute Block #7: Tweets on Solving Proportions		
Mathematical Content	Classroom Logistics	C+L
Proportions have many applications in the real-world. Apply this concept to a real world example.		Proportions have many applications in the real-world. Apply this concept to a real world example.
	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234	Reminder: Free tutoring Tuesdays and Thursdays Algebra I and Geometry Ms. XXX Room 1234

90-Minute Block #8: Tweets on Review of Solving Equations		
Mathematical Content	Classroom Logistics	C+L
	Test tomorrow!!! Study!	Test tomorrow!!! Study!

APPENDIX B
FLORIDA STANDARDS

MAFS.912.A-CED.1.1 - Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational, absolute, and exponential functions.

MAFS.912.A-CED.1.3 - Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context.

MAFS.912.A-CED.1.4 - Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.

MAFS.912.A-REI.1.1 - Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

MAFS.912.A-REI.2.3 - Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

APPENDIX C
PACING

90-Minute Block #1:
Pretest on linear equations (20 free-response questions)
Pre-treatment survey (12 questions)

90-Minute Block #2:
Solving One-Step Equations (lesson)

90-Minute Block #3:
Solving Two-Step Equations (lesson)

90-Minute Block #4:
Quiz #1 - Solving Two-Step Equations (4 free-response questions)
Solving Multi-Step Equations (lesson)

90-Minute Block #5:
Quiz #2 - Solving Multi-Step Equations (5 free-response questions)
Solving Equations with Variables on Both Sides (lesson)

90-Minute Block #6:
Quiz #3 - Solving Equations with Variables on Both Sides (4 free-response questions)
Literal Equations and Formulas (lesson)

90-Minute Block #7:
Quiz #4 - Solving Literal Equations (4 free-response questions)
Solving Proportions (lesson)

90-Minute Block #8:
Review of Solving Equations (lesson)

90-Minute Block #9:
Posttest on linear equations (20 free-response questions)
Post-treatment survey (10 questions)

APPENDIX D
TEACHER CONSENT TO PARTICIPATE IN A RESEARCH STUDY

TEACHER CONSENT TO PARTICIPATE IN A RESEARCH STUDY

An Investigation of the Effect of Using Twitter by High School Mathematics Students Learning of Linear Equations in Algebra 1.

Dear [Name of Teacher],

We would like for you to be in a research study we are doing. A research study is a way to learn information about something. We would like to find out more about the effect of using Twitter by high school mathematics students learning of linear equations in Algebra 1. If you agree to participate in this study, you will be one of three teachers in this research study. Furthermore, if you agree to participate in this study, your students will be a few out of 300 students (in six classes) in this research study.

Your participation will require you to open a free Twitter account, for education purposes only. If you participate in this study, we will ask you to do the following things: You will send tweets on a daily basis for a period of four weeks as your students learn linear equations. Lastly, you will administer a two short surveys -- 12-item survey to your students before using Twitter and 10-item survey after using Twitter.

There are no risks or benefits for being involved in this study. There are no known alternatives available to you other than not taking part in this study. The records of this study will be kept private and will be protected by the researchers. You do not have to be in this study if you don't want to and you can quit the study at any time. No one will get mad at you if you decide you don't want to participate.

If you have any questions about the research study you may contact Dr. M. O. Thirunarayanan at Florida International University, 305-348-2085, thiru@fiu.edu. If you would like to talk with someone about your rights of being a participant in this research study, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

Sincerely,

Manny Vilchez

APPENDIX E
PARENTAL CONSENT TO PARTICIPATE IN A RESEARCH STUDY

FIU | FLORIDA INTERNATIONAL UNIVERSITY

PARENTAL CONSENT TO PARTICIPATE IN A RESEARCH STUDY

An Investigation of the Effect of Using Twitter by High School Mathematics Students Learning Linear Equations in Algebra.

You are being asked to give your permission for your child to be in a research study. The purpose of this study is to investigate the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. If you agree to allow your child to participate in this study, he/she will be one of about 300 students (in six classes) in this research study.

Your child's participation will require him/her to open a free Twitter account, for education purposes only. If your child participates in this study, we will ask your child to do the following things: Receive tweets on a daily basis for a period of four weeks as students learn linear equations. Lastly, a survey short 12-item survey will be administered before using Twitter and 10-item survey after using Twitter.

There are no risks or benefits for being involved in this study. There are no known alternatives available to your child other than not taking part in this study. However, any significant new findings developed during the course of the research that may relate to your child's willingness to continue participation will be provided to you.

The records of this study will be kept private and will be protected to the fullest extent provided by law. In any sort of report we might publish, we will not include any information that will make it possible to identify your child as a subject. Research records will be stored securely and only the researcher team will have access to the records. However, authorized University or other agents who will be bound by the same provisions of confidentiality may review your child's records for audit purposes.

Your child's participation in this study is voluntary. Your child is free to participate in the study or withdraw his/her consent at any time during the study. Your child's withdrawal or lack of participation will not affect any benefits to which he/she is otherwise entitled. The investigator reserves the right to remove your child from the study without your consent at such time that they feel it is in the best interest.

If you have any questions about the purpose, procedures, or any other issues relating to this research study you may contact Dr. M. O. Thirunarayanan at Florida International University, 305-348-2085, thiru@fiu.edu. If you would like to talk with someone about your child's rights of being a subject in this research study or about ethical issues with this research study, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

I have read the information in this consent form and agree to allow my child to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. I understand that I am entitled to a copy of this form after it has been read and signed.

________________________________	__________________
Signature of Parent/Guardian	Date
________________________________	________________________________
Printed Name of Parent/ Guardian	Printed Name of Child Participant
________________________________	__________________
Signature of Person Obtaining Consent	Date

APPENDIX F
CHILD ASSENT TO PARTICIPATE IN A RESEARCH STUDY

CHILD ASSENT TO PARTICIPATE IN A RESEARCH STUDY

An Investigation of the Effect of Using Twitter by High School Mathematics Students Learning Linear Equations in Algebra.

We would like for you to be in a research study we are doing. A research study is a way to learn information about something. We would like to find out more about the effect of using Twitter by high school mathematics students learning linear equations in Algebra 1. If you agree to participate in this study, you will be one of about 300 students (in six classes) in this research study.

Your participation will require you to open a free Twitter account, for education purposes only. If you participate in this study, we will ask you to do the following things: You will receive tweets on a daily basis for a period of four weeks as you learn linear equations. Lastly, a survey short 12-item survey will be administered before using Twitter and 10-item survey after using Twitter.

There are no risks or benefits for being involved in this study. There are no known alternatives available to you other than not taking part in this study. The records of this study will be kept private and will be protected by the researchers. You do not have to be in this study if you don't want to and you can quit the study at any time. No one will get mad at you if you decide you don't want to participate.

If you have any questions about the research study you may contact Dr. M. O. Thirunarayanan at Florida International University, 305-348-2085, thiru@fiu.edu. If you would like to talk with someone about your rights of being a participant in this research study, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

This research study has been explained to me and I agree to be in this study.

___________________________________ ___________________
Signature of Child Participant Date

____
Printed Name of Child Participant

_________________________________ ___________________
Signature of Person Obtaining Consent Date

APPENDIX G
STUDENT SURVEYS

Pre-Treatment Survey

Technology

1. Do you own a smartphone (For example: Blackberry, iPhone or Samsung Galaxy)?
   a. Yes   b. No

2. Do you own a tablet (iPad or Samsung Tab)?
   a. Yes   b. No

3. Do you own a laptop computer?
   a. Yes   b. No

4. Do you own a desktop computer?
   a. Yes   b. No

Technology Capabilities

5. Is your smartphone able to send or receive <u>text messages</u>?
   a. Yes   b. No

6. Is your smartphone able to send or receive <u>e-mail</u>?
   a. Yes   b. No

7. Is your smartphone able to <u>take pictures</u>?
   a. Yes   b. No

8. Is your smartphone able to send or receive <u>pictures</u>?
   a. Yes   b. No

9. Is your smartphone able to <u>record video</u>?
   a. Yes   b. No

10. Is your smartphone able to send or receive <u>videos</u>?
    a. Yes   b. No

Demographic

11. Sex
    a. Female   b. Male

12. Race/Ethnicity
    a. White (non-Hispanic)   b. Black (non-Hispanic)   c. Hispanic
    c. Asian/Pacific Islander   d. Native American   e. Multiracial
    f. Other

Post-Treatment Survey

General Instructions: Please read each question carefully and answer all questions honestly. After you complete the survey, please check to make sure that you have answered all questions before you return the survey. The purpose of this survey is to obtain your thoughts of using Twitter in the mathematics class. There are no correct or wrong answers, only your answers.

Instructions: For questions 1 through 10 please circle one response to each question, based on the following scale:

1 = Strongly Agree 2 = Agree 3 = Disagree 4 = Strongly Disagree

1.	I found the use of Twitter in math class to be enjoyable.	1	2	3	4
2.	I think all my classmates who used Twitter in this math class are happy about it.	1	2	3	4
3.	I can easily remember the tweets that I received.	1	2	3	4
4.	I would like to continue using Twitter in this math class.	1	2	3	4
5.	With the help of Twitter I learned a great deal.	1	2	3	4
6.	Using Twitter has motivated me to learn mathematics.	1	2	3	4
7.	Because at times I do not pay attention in class, Twitter has allowed me to keep up with the lesson during my leisure time.	1	2	3	4
8.	The use of Twitter would have been more effective if the teacher would have replied to my tweets.	1	2	3	4
9.	I would like to use Twitter in my next math class.	1	2	3	4
10.	I found learning with Twitter very effective.	1	2	3	4

VITA

MANUEL ANTONIO VILCHEZ

	Born, Managua, Nicaragua
1999-2001	Associate in Arts, Pre-Bachelor of the Arts Miami Dade Community College Miami, Florida, USA
2002-2004	Bachelor of Science, Mathematics Education Florida International University Miami, Florida, USA
2005-Present	Mathematics Teacher Miami-Dade County Public Schools Miami, Florida, USA
2008-2010	Master of Science, Curriculum and Instruction Florida International University Miami, Florida, USA
2010-2013	Education Specialist, Curriculum and Instruction Florida International University Miami, Florida, USA
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PUBLICATIONS AND PRESENTATIONS

Thirunarayanan, M. O., Vilchez, M., Abreu, L., Ledesma, C., & Lopez, S. (2010). A survey of video game players in a public, urban, research university. *Educational Media International*, *47*(4), 321-337.

Thirunarayanan, M. O., Vilchez, M., Abreu, L., Ledesma, C., & Lopez, S. (2010, April). *A Survey of Video Gamers in a Public, Urban, Research University*. Paper presented at the meeting of the International Conference on College Teaching and Learning, Ponte Vedra, FL.

Vilchez, M., & Thirunarayanan, M. O. (2011). Cheating in online courses: A qualitative study. *International Journal of Instructional Technology and Distance Learning*, *8*(1), 49-60.

Thirunarayanan, M. O., & Vilchez, M. (2011, April). *Cheating in Online Courses: A Qualitative Study*. Paper presented at the meeting of the International Conference on College Teaching and Learning, Ponte Vedra, FL.

Thirunarayanan, M. O., & Vilchez, M. (2012). Why do they consider themselves to be 'gamers'?: The 7es of being gamers. *Journal of Information Systems Technology & Planning*, *5*(12), 80-86.

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