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Examining the Relationship between Secondary Mathematics Teachers' Self-Efficacy, Attitudes, and Use of Technology to Support Communication and Mathematics Literacy

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Abstract

The rich language surrounding mathematical concepts often is reduced in many classrooms to a narrow process of memorizing isolated procedures with little context. This approach has proven to be detrimental to students' ability to understand mathematics at deeper levels and remain engaged with this content. The current generation of students values technology as a natural, and often preferred method, for communication. These preferences provide teachers a unique opportunity to extend mathematics communication beyond the classroom. This study sought to understand secondary mathematics teachers' use of communication technology and the relationship between variables that may contribute to a teacher's decision to integrate technology for this purpose. Using a descriptive quantitative approach, the research investigated the relationship between teachers' self-efficacy, attitudes, and the use of communication technology in secondary education mathematics classrooms. A total of 90 teachers in grades 7-12 participated. Results revealed a significant relationship between teachers' attitudes toward using technology for communication and personal self-efficacy ($p < .05$), yet few reported using technology in this way. An important recommendation from this study is to investigate why teachers who demonstrate key positive indicators for technology integration are not capitalizing on the potential that communication technology provides to cultivate mathematics communication and literacy.

Introduction

Communication and collaboration frequently are cited as key 21st century skills. Similarly, the presence of communication and collaboration in classroom environments has been regarded as an essential element of quality education for many years (Astleitner, 2005). Research shows, however, that this purposeful interaction in mathematics classrooms, although essential, is often neglected and replaced by approaches focusing only on the procedures of mathematics, vacant of context, communication, and the true essence of the mathematical concepts necessary to promote mathematics literacy (NCTM, 2000, 2009b). Ongoing communication in both written and verbal form is important in mathematics because it promotes students' ability to build the mathematics literacy skills which are necessary for improving overall mathematical understanding and performance (Thompson & Chappell, 2007; Turner, 2011; Wood, Jones, Stover, & Polly, 2011). This missing component to mathematics education is significant, because research also shows that an environment focused on individual work, drill, or practice does not allow students to experience or appreciate the connected and meaningful nature of mathematical concepts (Boaler, 2015). The result has left an abundance of students who struggle to achieve mathematical literacy or reach a level of self-efficacy and competence with this subject (OECD, 2012). Instead, students' perception of mathematics becomes limited to using numbers and mathematical processes in the absence of communication or conceptual understanding with little confidence, context, or purpose.

Recognizing the crucial role of communication in mathematics learning, the National Council of Teachers of Mathematics (NCTM) and the Common Core State Standard Initiative (CCSSO, 2010) included communication as an important standard of practice. Both documents outlined standards for teaching and learning mathematics and acknowledged that conversations about mathematics allowed students to explore concepts from a variety of perspectives as well as understand their own thinking more clearly (Adams, 2010; NCTM, 2009). Similarly, the International Baccalaureate curriculum describes the goal of learning mathematics across a continuum such that, "It is intended that students become competent users of the language of mathematics and begin to use it as a way

of thinking, as opposed to seeing mathematics as a series of facts and equations to be memorized” (IBO, 2015, p. 5). Despite these widely accepted perspectives for the inclusion of communication as an essential part of mathematical learning, many teachers overlook opportunities to incorporate communication and mathematics literacy building skills for students (Phillips et al., 2009; Seibert & Draper, 2008; Thompson & Chappell, 2007; Turner, 2011).

As teachers seek to promote mathematics literacy among their students through rich communication and collaborative approaches, methods and available strategies continue to grow. Technology has made a significant impact on the way in which teachers can successfully prepare students for the future (U.S. Department of Education, 2009; 2010), and has proven to be a preferred method for both learning and communicating with the current generation of students. The purpose of this study was to explore the use of communication technology by secondary mathematics teachers in the state of Pennsylvania in the United States of America. Specifically, the researcher examined the relationship between variables that may support or inhibit a teacher’s decision to integrate technology for this purpose. Similar to research conducted by Mustafina (2016), communication technology was defined as that which can be used in daily teaching practice. This is different from research that has examined mathematical software or programs designed for the purpose of specific concept exploration, practice, or calculation (Eddy & Patton, 2010; Samuels, 2010). Rather, communication technology in this study includes “devices created for the communication of information through wire-lines and wireless signals which allows users to search, access, store, transmit, and manipulate this information for facilitating or assisting the learning process” (Mustafina, 2016, p. 324; UNESCO, 2002). Such items may include a computer, the Internet, and mobile devices in conjunction with applications such as a learning management system, e-mail, blogs, online journals, discussion boards, or social networking tools.

Literature Review and Theoretical Framework

Communication Technology, Mathematics, and Today’s Learner

With advancements in technology and the push from industry to have a well-educated and highly specialized workforce, the importance of needing deeper understandings in mathematics and the integration of technology have reverberated throughout education (Barcelona, 2009; Proserpio & Gioia, 2007). With these developments came awareness that educating modern students must look different from instructional strategies once used. Proserpio and Gioia (2007) suggested that learning environments using technology were a natural extension for a generation of students embedded in devices. For these students, technology as a tool for learning is not merely convenient, but potentially a more appropriate modality to address the current trend of learning styles and preferences. This generation of students interacts with the world in a way that is more immediate, more technological, and more social than before (Proserpio & Gioia, 2007). For these reasons, educators must recognize the digital differences and accept that learning for many of these students must take place in a way that is more personal, meaningful, and distinctive to their interests and needs (Kiekel, 2007; Proserpio & Gioia, 2007). When contemplating 21st century needs such as communication and collaboration, Papp (2010) agreed that the opportunities made possible by technology provided not only a more effective way to reach students, but also the ability to foster a more collaborative, diverse, and communication rich atmosphere.

A multitude of communication technology tools available to teachers can provide effective and innovative ways to engage students who appear to prefer communication in this manner. Asynchronous discussion boards, for example, are one way that educators can provide opportunities for communication and interaction among students (Cox & Cox, 2008). Other researchers have recognized the increased opportunities to create mathematical discussions between teachers and students. Wentworth (2009), for example, explored using an online environment and argumentation as a tool to engage students in mathematical discourse. James (2011) examined the use of asynchronous discussion boards to promote active learning, stimulate motivation, and foster critical thinking among students. As mathematics communication is highlighted as an intended outcome for K-12 teachers, more classroom teachers may discover benefits of integrating communication technology into the learning environment for this intentional purpose.

Mathematics Literacy

The recommendation to make communication a continuous part of mathematics classrooms is not new, but has never been more necessary. When students learn to communicate mathematically, a deeper understanding occurs (NCTM, 2000) and this ability helps to create a mathematically literate individual. A precise definition of

mathematics literacy, however, is elusive. Pugalee (1999) described mathematics literacy using a model representing the outer circle processes as representation, manipulation, judging, and problem solving activities; whereas, the inner circle included communication, technology, and values to facilitate overall mathematics understanding. Common to all definitions of mathematics literacy is the requirement not merely to demonstrate an understanding of mathematical concepts, but to use mathematical ideas and communicate mathematical thoughts clearly (IB, 2015; Özgen & Bindak, 2011). In fact, Thompson and Chappell (2007) insisted that communication opportunities should exist regularly in the mathematics classroom because it was common for students to think they understood a new concept until required to explain their understanding to another. Without the opportunity to engage in this exchange, students may realize they not only lack sufficient understanding, but also the language skills to articulate their thoughts clearly.

The significant concern for mathematics literacy has steadily spread across the globe over recent years. In 2008, the National Mathematics Advisory Panel produced a report that claimed mathematical literacy, prowess, and ability had declined significantly (U.S. Department of Education, 2008). Similarly, the Programme for International Student Assessment (PISA) administered by OECD (2012) revealed ongoing concerns for mathematics literacy worldwide. Of the 64 countries that participated in the PISA, 39 showed either no improvement or a decline in mathematics performance. According to NCTM (2000, 2009), to be mathematically literate, an individual must develop fluency in the language of mathematics not only for expressing ideas clearly and persuasively, but also for challenging one's own thinking and reasoning.

Self-Efficacy and Social Learning Theory

Many factors affect a teacher's willingness to use technology as a tool for instruction. Teachers' attitudes towards technology (McFarlane et al., 1997) and self-efficacy play a significant role in their willingness to embrace new instructional methods and reform-based classroom strategies (Alsawaie & Alghazo, 2010; Philipp, 2007). A teacher's willingness to teach from a social cognitive and constructivist theoretical perspective is necessary because the use of communication technology relies heavily on these learning theories (Alsawaie & Alghazo, 2010; Li, 2003). The theoretical framework of social learning theory (Bandura, 1977) supports the need for the active construction of learning based on interaction and discussion with other members involved in the learning process. Similarly, the social constructivist perspective posited by Vygotsky (1978) promotes learning via discussion and interaction to allow students to create knowledge through peer reciprocal relationships. Bandura (1977) theorized that learning is a social process enhanced by social interaction and connection. These theories grounded this research study, and provided a lens through which the researcher could examine data.

Self-efficacy is foundational in Bandura's theory. According to Bandura (1995), an individual's attitudes, abilities, and cognitive skills comprise the self-system. These personal elements play a major role in how an individual perceives situations and responds to different scenarios (Bandura, 1995). Individuals with higher self-efficacy react to difficulties consistent with overcoming, rather than avoiding challenge (Bandura, 1986, 1997). A discussion of self-efficacy is important when considering the challenge of adopting technological advancements. Soon after Bandura published research related to self-efficacy, many studies followed and applied the concept of self-efficacy to attitudes toward technology. One study, in particular, stressed the connection between self-efficacy and technology integration (Becker, 2007). Becker revealed that a teacher's willingness to integrate various forms of technology into the curriculum depended on high self-efficacy.

Methodology

Using a quantitative method and a descriptive research design, this study explored the use of communication technology by secondary education mathematics teachers. More specifically, the researcher sought to understand relationship between the variables of teachers' attitudes toward technology, levels of self-efficacy, and the use of communication technology for mathematics. The participants for this study included public teachers in grades 7-12 in the northeastern region of the United States. A random sample of secondary mathematics teachers was invited to participate and complete the online survey measuring the variables of teacher efficacy, attitudes toward technology, and use of technology for communication in mathematics. The sample derived from a concentrated region in Pennsylvania and included only secondary mathematics teachers from 53 school districts that were in adjacent suburban or rural regions. The final sample size of those who completed the survey for the study was $n = 90$.

Data Collection and Instruments

The timing of data collection was mid January, which allowed newer teachers time to determine preferences for strategies discussed in this study. The survey for this research consisted of 50 items consolidated from three previously validated instruments to measure the variables of interest. These items were obtained from the USEIT teacher survey developed by Russel et al. (2007), the Technology Attitude Survey (TAS) developed by McFarlane, Green, and Hoffman (1997), and the Mathematics Teacher Efficacy Beliefs Instrument (MTEBI) developed by Enochs, Smith, and Huinker (2000). The MTEBI survey consisted of 21 items, 13 items on the Personal Mathematics Teaching Efficacy (PMTE) subscale and eight items on the Mathematics Teaching Outcome Expectancy (MTOE) subscale (Enochs et al., 2000). Respondents answered questions for the MTEBI portion using a five-point scale, ranging from 5- *strongly agree* to 1-*strongly disagree*. The TAS instrument consisted of 20 items with responses also on a Likert scale. This survey featured a seven-point scale, ranging from 1- *not true* to 7- *very true*. The context for the term technology was defined for participants as communication technologies to support learning in mathematics with an explanation of this distinction provided in the directions of the survey.

Each of the distinct survey instruments combined for this study had previously determined reliability factors using Cronbach's alpha. The MTEBI produced an alpha coefficient of 0.88 for the PMTE scale and an alpha coefficient of 0.75 for the MTOE scale (Enochs et al., 2000). McFarlane et al. (1997) indicated a Cronbach's alpha of 0.92 for the TAS. The USEIT survey included similar reliability measurements, resulting in the following alpha coefficients for each scale: a) teacher-directed student technology to use specific technology ($\alpha = 0.84$); b) teacher use of technology for preparation ($\alpha = 0.80$); c) teachers' professional use of email ($\alpha = 0.86$); d) teacher-directed students to use specific technology applications ($\alpha = 0.60$); and e) teacher-directed students to use technology to create products ($\alpha = 0.73$) (Russell et al., 2007). Each of these survey instruments maintained satisfactory levels of reliability for this study.

Data Analysis and Results

The purpose of this research was to explore the relationship between the variables of teachers' attitudes towards technology, levels of self-efficacy, and their use of communication technology for teaching mathematics. Three sub questions were created to deeper understand this relationship and included:

- i. What is the relationship between teachers' years of experience and the use of communication technology in mathematics classes?
- ii. What is the relationship between teachers' levels of self-efficacy and the use of communication technology in mathematics classes?
- iii. What is the relationship between teachers' levels of self-efficacy and their attitude toward the use of communication technology in mathematics classes?

Frequencies and percentages presented in table 1 summarize the demographic information for participants.

Table 2 summarizes descriptive statistics for the technology use, self-efficacy, and attitude toward use of technology scale scores. Smaller technology use scores indicate less use of communication technology for teaching mathematics. The minimum possible technology use score was 1.0, and the maximum possible score was 5.0, the average technology use score was below the median of 3.0, with an average (and *SD*) of 1.82 (.65) and a range of 1.0 to 3.6. The smallest possible attitude toward using technology score was 1.0 and the maximum possible was 7.0. Larger scores indicate a more positive attitude toward using technology. The teachers scored relatively high on attitude toward using technology, with an average (and *SD*) of 5.9 (.90) and a range of 2.9 to 7.0. Considering the personal mathematics teaching efficacy score had a possible range of 13 to 65, the sample of 90 teachers scored relatively high, with an average (and *SD*) of 56.9 (5.9) and a range of 34.7 to 65.

Because this research sought to understand the use of technology for the purpose of cultivating communication in mathematics class, select questions on the technology attitude instrument presented noteworthy information related to teachers' attitudes. Almost half of the participants (47.8%) indicated using their knowledge of technology for teaching and more than half (77.8 %) indicated that they "like using technology". Yet, in the context of capitalizing on technology for the purpose of cultivating mathematics communication, less than 25%

of teachers indicated using technology in this way, and more than half of those who did use technology did so less than once a week.

Table 1. Selected demographic characteristics by number and percentage

Demographic	n = 90	%
Gender		
Male	27	30.0
Female	63	70.0
Age (years)		
20-30	29	32.2
31-40	23	25.6
41-50	25	27.8
51-60	13	14.4
Education Level		
Bachelor's	13	14.4
Bachelor's plus	22	22.4
Master's	15	16.7
Master's plus	39	43.3
Doctorate	1	1.1
Total Experience (years)		
2 or less	7	7.8
3-5	18	20.0
6-10	20	22.2
11-15	14	15.6
More than 15	31	34.4

Data analysis for this study used the independent variables of years of teaching experience and level of teacher self-efficacy as determined by the demographic questions and the MTEBI survey, and the dependent variables of the use of technology and teacher's attitudes towards using technology for this purpose. The Pearson r calculation revealed the correlation between communication technology use and attitudes related to technology based on the teachers' years of experience and level of self-efficacy.

Table 2. Descriptive statistics

	n = 90	Mean	Std. Deviation	Minimum	Maximum
Technology Use ^a		1.8206	.65362	1.00	3.57
Attitude Toward Using Technology ^a		5.9425	.89894	2.90	7.00
Personal Mathematics Teaching Efficacy Belief ^b		56.9019	5.89583	34.67	65.00

a. Dependent variable; b. Independent variable

A one-way ANOVA test compared communication technology use and attitudes towards communication technology for mathematics class to the independent variables identified in the study. All levels of significance were set at $p = 0.05$.

Table 3. Descriptive statistics for the technology use score by years of teaching experience

How many years have you taught throughout your career?	N	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Less than 1 year to 2 years	7	7	0	1.9184	.53361	1.00	2.71
3-5 years	18	18	0	1.8095	.69642	1.00	3.57
6-10 years	20	20	0	1.7143	.56955	1.00	3.43
11-15 years	14	14	0	1.6837	.53797	1.00	2.57
More than 15 years	31	31	0	1.9355	.75668	1.00	3.57

Table 4 displays the results of the one-way ANOVA comparing general technology use with years of experience. Table 4 shows there was not a statistically significant difference in the average technology use score between the 5 groups, ($F = .55, p = .70$).

Research Question 1

What is the relationship between teachers' years of experience and the use of communication technology in mathematics class? Tables 4 presents the descriptive statistics, including mean and standard deviation, for the responses to technology use and years of experience.

Table 4. Analysis of variance to compare the average technology use score by years of teaching experience

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	.967	4	.242	.554	.696
Within Groups	37.056	85	.436		
Total	38.023	89			

Research Question 2

What is the relationship between teachers' levels of self-efficacy and the use of communication technology in mathematics class? Table 5 indicates there was not a statistically significant correlation between the technology use score and the self-efficacy score, ($r = .11, p = .31$).

Table 5. Pearson's correlation statistic for the technology use score versus the self-efficacy score

		Personal Mathematics Teaching Efficacy Belief
Technology Use	Pearson r	.109
	Correlation	
	p -value	.308
	n	90

Research Question 3

What is the relationship between teachers' levels of self-efficacy and their attitude toward the use of communication technology in mathematics class? The correlation coefficient indicated a statistically significant, moderately strong positive correlation between the attitude score and the self-efficacy score, ($r = .26, p = .012$).

As further exploration into the types of communication technology teachers may be using for this purpose and years of experience, Spearman's ρ was used to examine each of the seven items that make up the technology use score and years of experience as a teacher. A significant correlation was found between the number of years of experience as a teacher and forms of technology similar to Wikispaces used for communication in mathematics ($\rho = .24, p = .022$). None of the individual technology use survey questions were correlated with self-efficacy.

Results and Discussion

In this study, the data collected for determining teachers' self-efficacy was negatively skewed indicating a high level of self-efficacy among the participants, yet data also revealed a minimal use of technology for communication opportunities in mathematics. These findings contradict a study by Compeau and Higgins (1995) that revealed a strong relationship between self-efficacy and computer use. In related research, Tella (2011) found that mathematics teachers, in general, had high Internet self-efficacy and that using the Internet had the potential to drastically improve the way a teacher taught mathematics. Other researchers also found similar positive correlations between teachers' self-efficacy and the level of technology integration in classrooms (Hew & Brush, 2007), yet none of these studies isolated secondary level mathematics classrooms or the intention of the technology integration. The high level of self-efficacy demonstrated by data for this study and the alternately low level of technology integration indicates the possibility that more complex factors contribute to technology integration, specifically into mathematics classrooms.

Data collected for attitude toward technology and for teacher self-efficacy in this study indicated high teacher self-efficacy is directly correlated with more positive attitudes towards technology, yet actual implementation of technology to promote communication was low. Typically, teachers with higher self-efficacy have displayed

more positive attitudes towards technology integration into classrooms (Anderson, Groulx, & Maninger, 2011). Wang, Ertmer, and Newby (2004) reported that although “enhanced self-efficacy beliefs do not automatically translate into the actual use of technology among teachers, they are a necessary for technology integration” (p. 242). The consistent positive correlation lends the potential for the willingness of teachers to broaden current methodology, yet data revealed a gap exists between teacher attitudes and current practice in this study. Although researchers consistently report that self-efficacy is a strong indicator for receptivity to changing instructional practices (Tschannen-Moran & McMaster, 2009), there is a consistent and strong connection between teacher beliefs and their instructional methods. This study illuminates the need to continue to examine teacher beliefs as they relate to the most effective way to teach mathematics in order to support the level of understanding and application of concepts demanded by the 21st century environment.

This study found that although general use of communication technology was not related to years of experience, further analysis showed a significant relationship between years of experience and the use of one category of communication technology in mathematics classes. Specifically, teachers referenced the use of “WikiSpaces, or a tool similar in design”. According to Pappas (2013), Wikispaces is “a social writing platform that also acts as a classroom management tool” (p. 2). Various studies have been conducted examining the relationship between the general use of technology by classroom teachers and years of experiences. Within these studies, researchers discovered some conflicting results. While several research studies revealed a statistically significant relationship between technology integration and years of experiences (Russell, O'Dwyer, Bebell, & Tao, 2007), none of these studies focused exclusively on mathematics classes for the purpose generating and extending conversations about mathematics. Alternately, other studies have examined the use of discourse and communication in mathematics classes (Huang, & Normandia, 2009; Mendez, Sherin, & Louis, 2007); however, none of these researchers focused on using available communication technology to do so or teacher years of experience. Overwhelmingly, this sample indicated a low use of communication technology used for mathematics class. The technology use score had a possible range of 1 to 5, with the mean use for this study at 1.82 ($SD=.65$). Yet, participants revealed a relatively high positive attitude toward using technology for this purpose, with an attitude range of 2.9 to 7, and a mean of 5.9 ($SD =.9$). It stands to reason that these indicators may have translated into more creative uses of technology integration. These findings demonstrate that despite calls for mathematics teaching to include communication to promote mathematics literacy and a balance of understanding conceptual and procedural development, some teachers may be challenged to find methods that accomplish this task. Understanding the complexities that exist when integrating technology into mathematics teaching is important to consider because NCTM (2000) asserted that “technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning” (p. 24). Technology in mathematics education, however, was historically defined as a method to enhance graphics, drill, practice, and provide computation assistance. Other forms of technology integration into mathematics, such as communication technology, also can positively contribute to learning mathematics in ways that are significant for a generation of students who prefer different communication approaches. Modern students include the Net-gen, Generation Y, and V-Gen (Kiekel, 2007; Proserpio & Gioia, 2007), and many authors insist that these learners not only require different skills for future success, but also need education framed in a new paradigm of teaching and learning. This study also may highlight one problem in finding creative ways to bridge technology and communication in mathematics classes, which is the pervasive resistance or disbelief of mathematics teachers in the need to do so. From a literacy perspective, Shuard and Rothery (1984) demonstrated the increased complexity of learning the language of mathematics as opposed to everyday English. However, many mathematics teachers report the classroom is a place to develop skills, procedures, and ways to do mathematics, rather than cultivating conversations and discourse about how to think and communicate mathematically (Adams, 2010; Huang & Normandia, 2009; Phillips et al., 2009; Seibert & Draper, 2008).

This perception that mathematics is a fixed set of procedures and facts “excludes the more complex and less deterministic components of mathematical argument, discourse, and understanding” (Smith, 1996, p. 392). The exclusion of developing the language of mathematics may prevent students from becoming mathematically literate. The absence of meaningful mathematical conversations narrows students’ perspectives and limits their ability to deepen understanding, apply concepts, and use this knowledge in future unique situations (Boaler, 2015). The findings in this study indicate that the ability to use technology to cultivate mathematics communication and literacy may be overlooked.

Limitations

While purposive cluster sampling and small sample size may limit generalizability, demographics for this study were compared to a nationwide survey conducted by the U.S. Department of Education (Coppersmith, 2009)

and this examination revealed similar demographics to the 2008 School and Staffing Survey in the US. These similarities may increase the generalizability of this study. A second potential limitation may be Internet accessibility for more rural schools or technology available to teachers and students.

Conclusions and Recommendations

In a U.S. based national survey, Anderson et al. (2011) found that “the majority of school district administrators (60%) and principals (55%) reported that effective integration of instructional technology was extremely important to their core mission, whereas only 38% of teachers and future teachers reported similar views” (p. 321). The results of the current study highlight the need for continued exploration into several areas. First, it is essential to explore how are teachers using technology in meaningful ways to teach mathematics, keeping in mind the methods that are relevant and engaging to the current generation, as well as in support of best practice for teaching mathematics and achieving mathematics literacy. Overall, the participants in this study displayed high self-efficacy and attitudes towards using technology, yet little integration for the purpose of mathematical communication was apparent. This information is important for school leaders because a positive attitude toward technology supported with targeted professional development opportunities may help increase the level of technology integration and the overall achievement in mathematics. Effective technology integration into mathematics classrooms is recommended by leading organizations for mathematics teaching such as NCTM, and researchers found the integration of technology increases student engagement and motivation, as well facilitates a deeper understanding of mathematical concepts (James, 2011; Samuels, 2010; Wentworth, 2009). As technology access becomes more abundant, educators must realize the expanded potential of these tools. This study gives educational leaders a broader understanding of teacher perceptions and the factors relating to the use of technology, as well as informs teachers of the potentially unknown benefit of using communication technology to cultivate mathematics literacy.

Promoting social collaboration and technology-enhanced learning are necessary for contemporary learners who spend a majority of time surrounded by devices. Prensky (2001) discovered that a student in the Digital Native generation would have spent less than 5,000 hours of their lives reading, yet the amount of time using a form of technology will exceed 10,000 hours. Understanding that the use of these tools most familiar to today’s learners is essential to creating a successful educational experience and potentially deepen the learning of mathematics. In secondary mathematics education, teachers may have a limited perspective on the broader potential for using technology, so this research offers an expanded vision of a model for teaching mathematics that is consistent with the social process of discussion and collaboration essential for learning (Vygotsky, 1978). Consistent with the principles of social learning theorists, the teaching tools made available through communication technology not only allow students to collaborate and problem solve with peers, but also to experience the social and psychological connections that enhance learning. Further research into this intentional use for secondary mathematics classrooms may reveal positive results related to learning, motivation, and engagement.

Adams (2010) suggested, “learning mathematics is as much about learning language as about mathematical objects and relationship” (p. 371). Mathematics teachers and school leaders can reflect on this study to understand the gap that exists between the positive technology attitudes of mathematics teachers and the low integration of technology for communication and literacy building in mathematics classes. A substantial amount of research supports using technology to increase opportunities for communication, collaboration, reading, and writing, yet there is still a minimal amount of implementation taking place. This study challenges mathematics teachers to reflect on current pedagogy and student needs while recognizing that addressing these needs requires teachers to embrace a constructivist approach to learning along with technology integration. School leaders must support this paradigm shift by offering teachers the development necessary to change the current teaching and learning model in place.

Current technology offers many sophisticated and simple enhancements to the teaching and learning of mathematics. Gaps in mathematical understanding, however, reveal the inability of students to articulate, communicate, or reason mathematically (PISA, 2007). Research shows, contemporary students favor communication when using technology, whether by computers, social media, hand held devices, or instant messaging, and this study reinforces the need to explore the variables that may contribute to maximizing the learning potential for students in mathematics. The discrepancy revealed by this study between teachers’ attitudes towards technology and technology use deserve a deeper examination to determine why mathematics teachers are not integrating more communication technology into their mathematics practice and how teacher beliefs play into this shift. An important outcome of this study was a better understanding of the factors affecting the ways in which teachers use or do not use technology in mathematics classrooms, specifically to

support a critical missing piece to mathematics education -- communication. Prior to this study, little research existed on the way in which teachers use forms of communication technology to develop mathematics literacy and increased communication in a traditional classroom environment. This study offers an entry point for this discussion. Cathcart, Pothier, Vance, and Bezuk (2011) proposed that mathematics as a form of communication should influence the development of mathematics programs and teaching methodology over the next decade. Considering the persistent concentration on communication and reasoning in mathematics standards of practice, this focus on the integration of technology to facilitate mathematical communication and literacy is significant, relevant, and timely.

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