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Extending mathematic learning beyond the classroom through online discussion and reflection

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Extending mathematic learning beyond the classroom through online discussion and reflection

Abstract

This review explores the research (2002-2015) focusing on the use of writing in the high school mathematics classroom incorporating blogs and online discussion. Thirty articles were identified and analyzed which provided information on how writing in the math classroom was developed and carried out. The research found that extending the mathematical learning through writing creates a sense of community among students, allows student reflection and application, and helps students gain a deeper understanding of a mathematical concept. Implications of the research and suggestions for future research are discussed.

**Extending Mathematic Learning Beyond the Classroom
through Online Discussion and Reflection**

A Graduate Review

Submitted to the

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Master of Arts

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Abstract

This review explores the research (2002-2015) focusing on the use of writing in the high school mathematics classroom incorporating blogs and online discussion. Thirty articles were identified and analyzed which provided information on how writing in the math classroom was developed and carried out. The research found that extending the mathematical learning through writing creates a sense of community among students, allows student reflection and application, and helps students gain a deeper understanding of a mathematical concept. Implications of the research and suggestions for future research are discussed.

Table of Contents

Abstract 3

Methodology 7

Analysis and Discussion 9

 Effects of Using Blogging and Online Discussion 9

 Student Reflection and Problem Solving 15

 Challenges That Affect Teacher Use 20

Conclusions and Recommendations 24

 Effects of Using Blogging and Online Discussion 25

 Student Reflection and Problem Solving 26

 Challenges That Affect Teacher Use 27

 Recommendations 28

 Final Conclusion Remarks 31

References 32

Extending Mathematical Learning Beyond the Classroom
through Online Discussion and Reflection

While looking over test scores from her twenty-two Algebra II students, Mrs. Urbanek began to wonder why her students were not able to apply what they had learned about right triangle trigonometry to story problems. The students had shown that they understood the process of solving right triangles, but when it came to applying it to real life problems, they were not as successful. She began to think about new strategies to incorporate into her classroom in order to help students understand the meaning behind the mathematics, and how to apply it in different situations. She started incorporating writing into her classroom through blogs and discussion forums to help students process the mathematics they were learning, learn from their peers' ideas, and apply the mathematics to various applications.

Writing is not typically something students think of doing in a mathematics classroom. Incorporating writing into the math classroom provides students with another way of demonstrating their understanding of a topic. At times students may understand a concept, however they may not have memorized the exact process to solve a problem. Through the use of writing, the students can then show what they know. By incorporating collaborative writing into the curriculum, teachers can give students new opportunities to learn from each other and gain a deeper understanding of a topic.

Writing in the classroom can be introduced to students through Web 2.0 tools. These are tools designed to emphasize user-generated content, usability, and interoperability. Teachers can use tools such as blogs, discussion forums or chat rooms to provide students with a new way to learn from each other. Hsu, Ching and Graboski (2014) say, "Blogging

has a positive impact on learning. Additional benefits occurred when they are used to sharing learning progress with peers, and when students are able to read peer blogs as well” (p.750). The purpose of this review is to find reasoning for teachers to incorporate writing into the math classroom through blogging and discussion forums/threads.

This review is important for teachers today because many secondary schools are implementing 1:1 initiatives where students have access to computers at all times. With the new generation of students, teachers continuously look for new ways of engaging students and teaching them how to learn using the technology available. Burns says that journaling (blogging) gives students a record of their learning experiences (2004). As math is a language all it’s own, teachers can help their students better use, read, and understand math by teaching them the content through writing (Phillips, Bardsley, Bach, & Gibb-Brown, 2009, p.467). By incorporating writing through the use of technology into the mathematics classroom, teachers can help students gain an understanding of what they are learning, from multiple resources. Cooper (2012) states:

The Principles and Standards for School Mathematics (National Council of Teachers of Mathematics 2000) recommends that written communication be encouraged because it leads to reflection, clarification of ideas, and a greater depth of understanding into the many processes involved in mathematics. This depth of understanding is crucial for students to be able to properly justify their own work and analyze the work of others. (p.80)

This review will address the following questions:

1. What are the effects of using online discussion and blogging to incorporate writing in

the math classroom?

2. How does integration of reflection through writing in the math classroom affect problem solving abilities and application of content among students?
3. What challenges affect teacher use of integrating technology that incorporates writing in a math classroom?

This review may help teachers determine effective practices of using technology within their mathematics classrooms. The results of this review can provide teachers with research-based evidence about implementing writing in the mathematics classroom through blogging, discussion forums, and/or chat rooms.

Methodology

Sources for this review were found by searching in *Google Scholar* and *ERIC (EBSCOhost)* databases. These databases were chosen because of their credibility in educational research. Specific descriptors were used to locate peer-reviewed articles within these databases. The descriptors included *writing in math*, *collaboration in math*, *blogging in math*, *reflection in math* and *writing in high school math*. The *writing in math* descriptor provided 470 results. The *collaboration in math* descriptor resulted in 32 results. The *blogging in math* descriptor resulted in one article. The *reflection in math* descriptor provided 16 results, and the *writing in high school math* descriptor resulted in one article. To discover other articles, the snowball research process was used. This process examines the references of identified articles which led to additional resources.

Another criteria is the research methodology, which included qualitative research, quantitative research, action research, mixed method research studies and literature reviews,

all that related to writing in a high school math classroom. The references were chosen if they included a search term listed above, were peer-reviewed articles by credible authors, and were written in the twenty-first century. These sources were also discovered using credible research databases that are well known in educational research. The articles chosen were required to integrate some type of online collaboration tool that encouraged students to write in the math classroom such as discussion boards and/or blogs. Searching for research studies in the secondary math classroom resulted in few studies. Therefore, I extended my research to all ages from elementary to college as long as the studies focused on incorporating writing in math or teaching math in an online setting and therefore met the criteria.

Once the articles were selected, each was analyzed in depth. The first step was to read the abstract to find key terms that applied to this literature review. Terms listed earlier were required in order for the article to be included in this review. Each article was read thoroughly with key points noted in order to reference later. Any common trends among articles were noted and coded throughout the research process. Factual information such as participant information, sample size, methods of research process and findings were organized to compare to one another. After choosing 30 articles to answer the research questions, each article was labeled with this information and sorted by research question. The articles were then sorted by theme; blogging, online discussion, and teaching methods. After this, 30 articles were organized, analyzed, and synthesized in order by common research findings. The following is the analysis and discussion of the findings from these articles.

Analysis and Discussion

The empirical studies included in this literature review focused on integrating writing into a mathematics classroom. Cooper (2012) pointed out “It is apparent that chats, forums, and blogs are not only useful tools for the mathematics classroom but also, truly, best practice as well” (2012, p.81). Three major themes emerged from this review: 1) The effects from incorporating writing in the math classroom through online discussion and blogging; 2) How integrating reflection through writing in the math classroom affect problem solving abilities and application of content among students; and 3) The challenges integrating writing in the math classroom that affect teacher use. These themes are discussed in the following three sections.

Effects of Using Blogging and Online Discussion

The first theme is about the effects of using online blogging and online discussion. There were eighteen empirical studies found on the two topics, eleven discussed blogging in the classroom, three discussed using online discussions for learning and four discussed various forms of writing in the math classroom through journals, blogs and/or discussion. In addition to the studies, there were twelve peer-reviewed articles that discussed the introduction of writing in mathematics through blogging, online discussions and various other methods (Cooper, 2012; Hirsch, 2005; Hsu, Ching & Grabowski, 2014; Groth, 2008; Spector, 2005).

The age range of the studies identified varied from elementary students to preservice teachers. These studies mainly focused on integrating blogging and/or journal writing into the mathematics classroom, as well as online discussion. These two effective uses of

technology will be discussed respectively.

Blogging. “Blogs are simple online journals primarily used to support communication in the form of presentation, and they provide a great tool for class interaction. Blogs are easy to set up... (and) are organized by time like a journal” (Driscoll, 2007, p. 10). Blogs, also known as weblogs, are used in classrooms in various ways. Some are used as a way for students to share information they have learned. Other strategies use them to communicate with each other about a topic, while others use them to engage the students. According to Althausser and Jones (2012), blogs provide three functions related to teaching: 1) Support classroom management, 2) Provide methods of collaboration, and 3) Provide opportunities to engage in online discussions (p.4340). Blogs also give students an individual voice and help teachers and students keep track of their ideas over time (Hirsch, 2005).

The analysis of the studies indicates that some of the studies focused on the earlier adoption of blogging. For example, in an early study about blogging, MacBride and Luchmann’s study (2008) conducted a case study where they explored the intent, use and perceived value of a high school blog. They chose the blog of a high school Pre-Calculus teacher, Mr. K, as it provided various examples of ways to use a blog in the classroom. His blog included student posts, student reflections, enrichment challenge problems, chat boxes, sharing of resources, digital stories, instructions to conduct an online class, and comments from students. In the study, the researchers discovered that Mr. K chose to use blogs in order to “1) increase collaborative learning and nurture a community of learners; 2) create a student-centered learning environment; 3) provide a place for reflection; and 4) provide enrichment to the class” (p.175). Both the researchers, and Mr. K , found that blogs gave

students the opportunity to ask questions of the teacher, as well as each other, draw conclusions, and learn from each other. It was found that students also enjoyed the use of blogs in the math classroom because it created discussion in and out of the classroom. This study was valuable and cited by another author, Vasseur, who found that, "This ability to take time and reflect and learn from others is paramount in Web 2.0 applications. In this sense, students are truly focusing on their education and learning from one another" (2008, p.9). The blog gave the more reserved students in a typical classroom setting a voice through the scribe posts and reflections.

In addition to MacBride and Luchmann's (2008) study about using blogging in high school, McGrail and McGrail (2014) used blogs in an elementary classroom to help students make connections with each other and the content being studied. Throughout the study, students occasionally were given writing prompts, and at times were given choice in their writing topics. Students had conversations through the blog with their readers about math and other subject areas. Through their findings, they reported one student that connected with Mr. K, the same teacher mentioned previously in MacBride & Luchmann's study. Mr. K conversed with the student through the blog about his post. He helped the student reflect on his post, asked him questions, and helped further his learning of the math content. The researchers reported that it filled the student with, "a wave of excitement, inspiration, and aspiration" (p.10). This demonstrated how, through blogs, students can collaborate with their peers as well as many others throughout the world (p.12). This also showed how the using blogs can help further student understanding of mathematical content. The readers and commenters on the blogs augmented the students' understanding of topics or encouraged

them to find more information about these ideas. When teachers integrate the use of chat rooms, forums, and blog posts from other people, whether it is students or teachers, it allows the student to gain guidance from someone other than the classroom teacher, and it can happen at any time. The student no longer needs to wait to ask questions in class, synchronously. They now have the opportunity to learn from others asynchronously (Quealy, 2014, p.3).

Similarly, Greer and Reed's study (2008) of a small upper-level Bates College mathematics class showed how the using blogs created an interaction between students. The professor, Meredith, had set up the class to include blogging where students responded to questions based on the reading, as well as comment on and grade each other's posts. She used this to ensure students had "a valid understanding of the exercise even though they were grading papers that might have been done in very different ways" (p.143). Blogging provides not only the students with information about math, but also teachers with information about the students' understanding. Meredith stated, "I thought I had a much better connection to how much students understood and what they needed to spend more time on" (p.146). Similar to Mr. K's blog mentioned earlier, the researchers found that, "The blog was also a different way of communicating with students, so I was able to get some insight into the thoughts of students who were very quiet during class" (p.146).

Online Discussion. Another tool that has been adopted is the on-line discussion forum. "Online discussion allows asynchronous exchanges and permits one-to-one and one-to-many interactions. Students exhibit motivation, learn independently, and transfer and apply knowledge to real-life situations" (Kramarski & Mizrachi, 2006, p.219). Online

discussions are used to engage students in dialogue with each other and with the teacher in order to gain a deeper understanding of a concept. Online discussions can be held using discussion forums and/or an online chatroom, synchronously or asynchronously. "Chat rooms allow students to conduct real-time discourse in short bursts, whereas forums promote discussion at different times over the duration of the assignment" (Graham & Hodgson, 2008, p.25).

An action research study by Graham and Hodgson (2008) involved a multi-ethnic high school in suburban Washington, D.C. The students who were observed were enrolled in Geometry and Algebra II classes. The students in these classes were introduced to online discussions through Moodle, a course management system. The teacher would create an online discussion that focused on math specific vocabulary and concepts in order to encourage students to use the vocabulary they are learning and construct their understanding of said vocabulary. To participate in the chat, students were asked to interpret portions of their textbook or notes into terms that make sense to them. Through the use of the online discussion, "Students help each other develop an understanding of the math by reading and reacting to discussion posts" (p.25). Not only did this provide the students with a chance to learn from each other, it gave the teacher the opportunity to analyze the online interactions among the students. The online discussion can be reviewed by the teacher to learn about each individual student's understanding, and guide any future instruction. By comparing the performance of these two classes with students taught in a traditional classroom, the results indicated that the online discussions positively affected the students learning. The researchers also found that online discussions can work for any discipline, whether it be

math, science, English, or history. According to Graham and Hodgson, “Electronic discussion boards facilitate rich discussions about course content and broad participation by our increasingly diverse learners. They add new, effective tools to the teacher’s instructional toolkit” (p.27).

Not only can the online discussions happen in the classroom synchronously, but also outside of class, asynchronously. Through the use of course management systems like Blackboard, Moodle, and Schoology, teachers can provide online forums where students can create posts whenever they would like. Roth McDuffie and Slavit (2002) chose to implement online discussions in each of their Methods of Teaching Elementary Mathematics classrooms at Washington State University. They did this in order to provide pre-service teachers with an opportunity to see how an online discussion can provide reflection for students. Both classes met once a week for three hours. Throughout the course, students were able to create their own discussion threads, comment on each other’s discussion boards, and respond to threads that were started by the teacher. Roth McDuffie and Slavit used the online discussion to extend any ideas that were presented during weekly in-class discussions. Both classes used the online discussion boards as reflections of the students’ own experiences in the classroom as pre-service teachers, as well as reviews of the readings and discussions in class. Both, once again, found that the online discussions supported individual reflection. “We found that participating in an online discussion facilitated reflection...while providing the additional benefit of sharing their reflections with others” (p.452). One other benefit found, similar to Mr. K who used blogging, was that online discussions enhanced classroom discussions. By providing a forum for student dialogue online, the researchers found that

students were willing to discuss in class as well because they felt as if a sense of community had been built already among the students in the class. This allowed for more student voices to be heard through written reflection.

Student Reflection and Problem Solving

In addition to allowing the students to have their voice through blogging and online discussions, students use writing in the math classroom to reflect and problem solve by using online tools.

When you write, you learn. Writing allows you to have a deeper connection to the subject you are trying to learn. Simply going through the motions in mathematics will leave you unsuccessful and ineffective. This is why writing- especially in mathematics, is so crucial to being successful. The connections students make while writing in mathematics classes make for critical thinking, developmentally sound, and more productive learners. (Quealy, 2014, p.1)

This quote describes the importance discovered about integrating writing in the math classroom. Incorporating writing in the classroom can help students reflect on what they are learning and make connections to the real world.

Similar to the Roth McDuffie and Slavit study (2002) of pre-service teachers, Flores and Brittain (2003) also implemented writing in a mathematics methods course with pre-service teachers in order to provide them with an experience that may influence their future classrooms. They stated that the pre-service teachers' writing throughout the course helped the students organize their thoughts and questions, and it allowed them to reflect on what they had done. The pre-service teachers saw the progress they made and the understanding

they gained first hand, and could later implement writing in their own classrooms. By doing this on their own and seeing the results, their reflections taught them how to better help students in their future careers. This echoed what Hsu, Ching, and Grabowski (2014) concluded: “When blogs serve as learning logs, they provide a space for learners to express their observations and perspectives, and make connections between their experiences and what they learn” (p. 749).

Other studies used more vigorous research methodology to investigate the effect of on-line discussion. For example, in an experimental design study by Olson and Johnson (2012), students in four grade-8 mathematics classes were given the opportunity to create a learning log to incorporate writing into the mathematics class. Students were split into two groups: Group A was given instruction in journal writing and Group B was not. Students were given a pre- and post-test to determine if the learning log assisted in improving student achievement. The learning logs provided students with various open-ended questions to describe their thinking. The researchers found that this provided students with a deeper understanding of the material presented. The study also provided students with an opportunity to assess each other, which helped start, “a valuable conversation where students took the role of the teacher and explained to each other what was needed to fully meet expectations in completing the journal entries” (p.195). Once again this study confirmed the above mentioned finding that the writing helped students make connections and provide fellow students with suggestions to develop their thinking and apply it.

Using writing does not only benefit the students in the regular classroom but also the students with special needs. Baxter, Woodward, and Olson (2005) had similar findings in

their research of middle school math students. Through their research, they observed special education students to see if the use of journal writing in the math classroom helped the teacher understand more of the students' conceptual comprehension. They explained that many of these students do not participate often in class, yet through their writing in the journal were able to explain and demonstrate their understanding. The use of communication in the math classroom is essential for these students to learn the content. The writing "will forge connections with students who typically drift or run rapidly away from mathematics. Writing offers a means for students to relate mathematical ideas to their own lives" (p.132).

Much like other studies mentioned, in Nichols' action research study (2012) of students in grades 3, 4, and 5, blogging was used to explore the level of engagement in the writing process in homeroom classrooms, as well as math, science and technology labs. Students responded to teacher prompted questions and posts through comments. They commented on each other's blogs throughout the school year, much like other studies mentioned above. Teachers demonstrated how to setup a blog, explained the use of the blog in class, and monitored student progression through the administrative dashboard. Throughout the study, Nichols reported on students' ability to write properly for their grade level, as well as the number of students who liked to write. Nichols stated, "I was also surprised to find that many students really enjoy blogging and are very motivated by the comments of their peers" (p.172). Through this opportunity to write in classrooms, where writing is not typically incorporated, Nichols' reports, "It is exciting to report that the 5th grade state mandated test scores improved by 50% at the end of this school year as well, which can be attributed in part to this action research project" (p.172). By providing the

opportunity for students to learn through writing or blogging, as the previous studies have done, teachers gave students a deeper understanding of the mathematical concepts, and at the same time created a classroom climate that benefited students. Burns (2004) says, "Writing in math....provides a way for students to reflect on their own learning and to explore, extend and cement their ideas about the mathematics they study" (p.30).

In a recent study, Beavers, Fox, Young, Bellows and Kahn's study (2015) of fifth grade students found similar findings as well. In their action research project, they incorporated students' journal writing in the math classroom to research students' thinking processes and skills. They found that having students journal had a positive effect on student motivation and an increase in conceptual understanding. Even though students were not initially interested in journaling in the math classroom, they later shared that the writing did help them reflect and think more deeply about problems (p. 26). Similar to earlier studies, these researchers also found that, over time, student responses to the journal prompts became more organized, the explanations and processes were more detailed and efficient, and the solutions provided were correct more often. They explained that the writing allowed students to think about the mathematical investigation, engage in collaborative thinking, communicate with other students, and be accountable for their learning. "Math journals help students comprehend the idea that math is all around them, not just a subject that must be acquired within a school setting" (p.27).

Interestingly enough, throughout the research process only two studies were found that disagreed with all of the others. In Haidet's study (2010) of eighth grade math students she found, much like others, that students, for the most part, seemed to enjoy writing the blog

posts. They were engaged in their writing and most students completed their blog assignments, when they didn't typically do so when it came to traditional math homework. However, in her findings, she stated that unfortunately the blogging did not seem to help raise student test scores, nor did it create the sense of math community among her students. Some found that they had conversations with each other about what they wrote in their blog post, but that was the extent of it. There were factors that hindered the results at times, such as access to computers. She did state however that even though test scores did not rise, her students did have a better understanding of the math they were learning and the blogging helped them think through a problem solving process, and provided a new opportunity to learn in the math classroom.

Comparable to Haidet's study (2010), Mathews study (2009) of middle school students using the Talking Math, Blogging Math curriculum, also found the use of blogs benefited students in their mathematical understanding of concepts and the proper use of mathematical terminology. Students were well versed in the proper terminology in their explanatory proofs after using this curriculum and blog posts. She stated, however, that her students did not create a sense of community as others have described. Once again, limited technology use and students not familiar with blogging and asynchronous discussion taking place caused issues to arise. The limited use of technology is an issue teachers must be aware of in order to integrate writing in the math classroom through the use of either blogs or online discussion.

Santos and Semana (2015) also found in their qualitative study that the eighth grade students they researched began using proper terminology in their expository writing in the

math classroom. Throughout this study, the teacher had three different writing tasks for students to perform. The tasks involved: a) writing for reflection, b) writing for problem solving skills, and c) writing for application and justification. After students performed the first task, the teacher was intentional in providing feedback to students about their mathematical writing. Then, when the students submitted future writings, the researchers found that the students were able to interpret supporting documents that had been provided and they were able to elaborate more in their explanations using mathematical vocabulary. The researchers shared that the intentionality of the teacher may "...support the students' writing, ... in order to stimulate the development of mathematical communication and a deeper understanding of mathematical ideas" (p.84). This leads to the next discussion of how writing integration affects teachers.

Challenges That Affect Teacher Use

The previous studies and articles have explained how writing in the math classroom has impacted student learning. While many of these studies show the student benefits of integrating writing in the math classroom, this may not always be an easy task for the teacher to implement. Many of the studies mentioned earlier shared implications of how integrating writing in the math classroom will effect teacher preparation. O'Kelley (2013) found in her qualitative study of preservice mathematics teachers that it is beneficial for future teachers to experience writing in the math classroom before they will actually use it in their own, however, they need to understand how to guide that experience. "Essentially, we are laying the groundwork for them (the students) to have favorable experiences with writing in mathematics" (p.24). The following are ways teachers can create that experience.

Teachers must be aware of certain aspects of providing an online learning experience for students. Beavers et al.'s study (2015) recommends before implementing the idea of writing in the math classroom, teachers should conduct interviews to determine student motivation levels and attitudes toward writing in math (p.28). This gives the teacher an insight into the students' thought process throughout the implementation of writing in the math classroom.

The teacher must also be aware of how they grade the online conversations. It is important for teachers to use the online conversations, either through blog posts or online discussions, as a formative assessment. If students are concerned about being graded for writing a certain way, the discussions may not be as focused on the learning, and become more focused on pleasing the teacher to earn a certain grade (Groth, 2008, p.426). Flores and Britain's study (2003) of pre-service math teachers also shared that the study helped the prospective teachers organize their thoughts in a logical sequence even if they did not come up with the most efficient strategy. The pre-service teachers explained how the writing helped eliminate some of the anxiety many math students have to find the correct answer that the teacher is expecting (p.117).

A key piece to this process is making the writing process a collaboration among students. Research suggests that peer review is an integral piece for students to learn from one another. Eaton & Wade (2014) explain how to effectively and efficiently do this in their study. They share that the first time the teacher introduces peer review, the teacher must explain why they are doing it (p.532). Students need to buy in to the process and understand the end goal before they participate. They must also understand that writing is a process

itself and they may need to revise and edit their responses after discussing with their peers. The teacher must also provide examples of responses for students, such as questions, for their peers. In order to provide constructive feedback and to create a dialogue, students must understand that the peer review is to assist them in their own learning as well as their peer's learning. The more they discuss, the deeper the understanding could be.

Oftentimes in mathematics, student responses include mathematical notation that not all programs or websites provide as text options. Therefore, the teacher needs to be aware that the question prompts provided do not require any use of mathematical symbols (Smith, Torres-Ayala, and Heindel, 2008). In their study of online math instructors, they discovered that instructors had the most challenge presenting material to students online, as well as evaluating student knowledge due to the challenge of using math notation and diagrams in the online environment (p.77). The teachers must be aware of any technological issues that may arise, but also allow students to explain their reasoning and process of a problem instead of demonstrating it as they would on paper.

One other focus for teachers is to revisit how to cite and reference the work of others. McGrail and McGrail (2014) found that their students lacked the ability to do this. Not only is it important when writing a research paper, but any time students borrow from others, they must cite their work. Throughout students learning of digital citizenship, they must learn the "responsibility of blogging and ethical use of works by others" (2014, p.14).

Last but not least, the most common factor teachers need to attend to in their classrooms is the amount of time it takes to implement writing in their classrooms. Many of the studies found for this literature review stated something about the amount of time it takes

to effectively integrate writing in the math classroom. Both the teacher and student invest their time towards implementation. The teacher designs the instruction, guides students, and responds to their posts. The students invest time outside of class to develop their understanding and share with others. The amount of time the students invest, however, is considerably less than the teacher (Spector, 2005, p.23). Whether the teacher chooses to integrate online discussion or blogging into the classroom, it will take time to read through each of the posts and participate in a dialogue with the students, either synchronously or asynchronously. Smith and Ferguson warn teachers that the increase in motivation for students may be worthy of all of the work it takes to implement asynchronous discussion, however the turn-around time to answer them can be too slow for students who struggle in math. Baxter et al. (2005), on the other hand, stated that, "The additional time needed to read the journals was offset by important benefits" (p.132). No matter how much extra time it takes to implement writing into the math classroom, the amount of knowledge the teacher gains about his/her students is worth it.

Seto and Meel (2006) agree with this sentiment. In their qualitative study of a college algebra classroom, the teacher used various writing assignments in the classroom to gain insight to student understanding. Her assignments varied in the length and time it took for student response as well as, time it took her to provide feedback. She had three types of writing assignments throughout the course: (a) mathematical biographies; (b) impromptu writing prompts; and (c) e-mail journals. Each of these opportunities for students to write provided her with information about student understanding, however each of them took time. The biographies were lengthy for students to complete, and for her to read through and

provide feedback, however she found them to be beneficial for her to understand more about the student and their learning. The impromptu writing prompts were shorter in length and her responses could be quicker as well, but both types of writing assignments provided the teacher with information about the student and their understanding.

Not only does it take time to read through the posts, but the amount of curriculum teachers have to present to students throughout the school year does not allow for much extra time in the pacing of the year. Teachers often need to think of new ways to present the learning and decide what the best practice is that will be most beneficial to student learning.

Conclusions and Recommendations

Clearly the 21st century learner is not the same learner seen in the classroom in the last fifty years. Students can now get information in mere seconds for anything they want to know about. In the math classroom, students often want to know how to apply the mathematics they are learning, and often do not understand why they are doing a process to solve a problem, besides the fact that the teacher told them to do it, of course. The studies in this review show consistent evidence that by incorporating writing into the mathematics curriculum, teachers have the opportunity to help students find answers to these issues (Flores & Brittain, 2003; Olson & Johnson, 2012; Nichols, 2012; Baxter et al., 2005). Many of the studies state that having students reflect on their learning through writing and make connections throughout the content gives students a better understanding of the content being learned (Flores & Brittain, 2003; Olson & Johnson, 2012; Nichols, 2012; Baxter et al., 2005).

Writing requires students to reflect on their ideas (Burns, 2004). When teachers incorporate writing into the curriculum, it opens up a new way for students to demonstrate

what they know. Typically in the math classroom, students show their work using a step-by-step process. Introducing writing in the form of blog posts and/or online discussions can provide students with a 21st century style of learning in the math classroom.

Effects of Using Blogging and Online Discussion

Blogging. In answering the first research question, “What are the effects of using online discussion and blogging to incorporate writing in the math classroom?” the research evidence shows that the using blogs can provide students with many opportunities to extend the mathematic learning beyond (McGrail & McGrail, 2014; Graham & Hodgson, 2008; Roth McDuffie & Slavit, 2002). The studies explain how using blogs in the math classroom benefited students by reflecting on what they have learned (McGrail & McGrail, 2014; Graham & Hodgson, 2008; Roth McDuffie & Slavit, 2002), and share that with each other to gain a deeper understanding of the mathematical concepts (McGrail & McGrail, 2014; Graham & Hodgson, 2008; Roth McDuffie & Slavit, 2002).

The use of blogs not only provides the teacher and students with a collaboration tool, but also allows teachers to promote digital literacy (Nichols, 2012). Teaching students 21st century skills is imperative in the classroom. Students need to learn ways in which technology can be used to benefit them in the future, instead of solely used for their pleasure. This tool can also effectively engage students and assist in their learning at the same time.

Online discussion. Online discussions can help students reflect on what they have learned and/or read about a certain concept. Student-to-student online discussions help them learn from each other, whether it be during class or outside of class. At times, there are students in the classroom who have ideas, but do not always want to share their opinions. By

using online discussions, every student has a voice. They can each share their ideas and opinions with each other and learn through that process. As mentioned earlier, Graham and Hodgson said, “Electronic discussion boards facilitate rich discussions about course content and broad participation by our increasingly diverse learners” (2008, p.27). Not only do the students learn mathematical concepts from each other using this tool, but they also create a sense of community in their classroom. This tool, much like blogging, can effectively engage students and assist in their learning at the same time.

Student Reflection and Problem Solving

In answering the second question, “How does integration of reflection through writing in the math classroom effect problem solving abilities and application of content among students?” it is found that student reflection through writing helps students connect the material they are learning to other content and to their daily lives (Flores & Brittain, 2003; Olson & Johnson, 2012; Nichols, 2012; Baxter et al., 2005). The reflection allows them to learn the mathematical processes easily and allows them to truly understand the mathematical reasoning behind the process (Flores & Brittain, 2003; Olson & Johnson, 2012; Nichols, 2012; Baxter et al., 2005). When students connect what they are learning to something previously learned or to a real world situation, their conceptual understanding is improved (Flores & Brittain, 2003; Olson & Johnson, 2012; Nichols, 2012; Baxter et al., 2005; Beavers et al., 2015; Santana & Semana, 2015).

As stated in the introduction, the National Council of Teachers of Mathematics (2000) stated that written communication should be encouraged in the classroom, “because it leads to reflection, clarification of ideas, and a greater depth of understanding into the many

processes involved in mathematics” (p.80). Each of the studies described above supported this statement. The studies provided evidence that found the use of writing in the mathematics classroom offered reflection for students to create connections throughout content and application (Flores & Brittain, 2003; Olson & Johnson, 2012; Baxter et al., 2005; Nichols, 2012; Beavers et al., 2015; Santos & Semana, 2015).

Haidet (2010) and Mathews (2009) each stated, however, that their students did not have as much success as others. Haidet’s students did not raise test scores after implementing writing in the classroom, and Mathews’ students did not have the sense of community as other researchers had found. Even though this was the case, each of these researchers stated that their students still did have a better understanding of the concepts learned. This shows that writing in the math classroom does benefit students in the sense that they understand the mathematical concepts; what it means, why it applies, and how it applies. However, integrating writing into the classroom will not solve all of the problems. There will still be issues the teacher must resolve in order to manage the classroom and ensure all students demonstrate mastery of the essential concepts of the course.

Challenges That Affect Teacher Use

As stated above, there are many aspects a teacher must be aware of when incorporating writing into the math classroom. The third question, “What challenges affect teacher use of integrating technology that incorporates writing in a math classroom?” provides evidence that each of the characteristics mentioned are integral pieces for a classroom to run smoothly and effectively. The teacher must be organized, give students a sense of ownership in their learning, and have balance in the classroom, meaning the teacher

must have a balance of learning and assessment (Beavers et al., 2015; Groth, 2008; Spector, 2005). In order for a teacher to implement anything new into their classroom, he/she has to know the ramifications of doing so.

With integrating writing in the math classroom, the biggest change for the teacher will be the amount of time needed. This will take more time on the teacher's part to create the discussions, come up with questions to present to students, explain/demonstrate the process, allow for student interaction and reflection, and then read through each of them and provide feedback to make the reflection meaningful. The studies mentioned found that this challenge is worth the reward (Spector, 2005; Smith & Ferguson, 2005; Baxter et al., 2005; Seto & Meel, 2006).

As stated in the introduction, many secondary schools are implementing 1:1 initiatives, giving students technology at their fingertips at all times. Teachers must be aware of the engaging aspect of technology, but also teach students to utilize the technology for information, reflection, and communication. Seto and Meel's (2006) study explained how the use of various types of writing in the classroom gave the teacher information about the students, their understanding, and reflection, but it also provided students with ways to communicate with the teacher and peers, and find information about the concept they were learning about. These experiences for students not only help them with their mathematical understanding, but benefit them as 21st century learners as well (Smith & Ferguson, 2005; McGrail & McGrail, 2014; Spector, 2005).

Recommendations

There are three types of recommendations: research, practice, and policy making. Each

will be addressed in the following paragraphs.

In terms of research, this review has uncovered a need for more research in the area of integrating writing into the high school math classroom. There are studies that have been done at the elementary level, as well as the collegiate level, however few have been done at the high school level. There are many courses at the high school level where students question the use of the mathematics, especially with today's youth where they can typically find an answer to anything in seconds. These are the students who want to know why they are learning what they are learning. Math is not always applicable to a teenager and through the use of writing; students may be able to develop that deep understanding, instead of just thinking it is a process they have to memorize until the test is over.

Throughout the research process, it was found difficult to find research on more online tools that may be used in the math classroom to integrate writing. There are many other ways for students to reflect or share their understanding with each other; however blogging and online discussions were the only two found where someone had conducted a research study. Therefore, research needs to be conducted on additional writing tools and/or strategies to integrate in the math classroom.

In terms of recommendations for practice, it is beneficial for teachers to incorporate some type of writing into their classrooms to engage the new 21st century learner, and also to assist the students in gaining a deeper understanding of a concept. Teachers can provide prompts for the students to respond to, which can assist students with gaining an understanding of the mathematical concepts they are learning. Students can then read each other's posts and respond as well, giving each other an insight into their learning. Through

the writing prompts, teachers can also assist students in connecting mathematical concepts to other concepts, or to an application. The ability to make connections will benefit student understanding and retention of the mathematical concept as well.

Creating a sense of community in the classroom is extremely important for this to happen. Students need to feel comfortable in order to share their ideas and to learn from each other. The studies found in this review show that integrating writing in the math classroom can do these things. The writing will provide students with a supportive community in the classroom, with a voice in which they use to share their learning with others, and with an engaging opportunity to learn mathematics can change the math classroom in the 21st century. These benefits alone are enough reason for more math teachers to integrate writing in their classrooms.

Recommendations for policy makers begin with getting the technology into the students' hands. Implementing a 1:1 initiative in the school will benefit students and teachers in the 21st century. The struggle to implement technology is frustrating for teachers when technology availability is limited. The students will be able to collaborate more, cross-curricular opportunities are available for teachers, and the use for research and reflection is endless.

Another recommendation for policy makers is to create a school wide initiative of incorporating reflective writing in the classroom. Many classrooms already use this, however, not all do. Many researchers have found that reflective writing benefits student understanding of learning concepts and incorporating that throughout the building can only benefit them even more. Whether it is implemented through discussions, blogs, or some

other form of collaborative writing, students can learn from one another as well as from the teacher.

Final Conclusion Remarks

Throughout the research and writing of this literature review, I have learned how beneficial incorporating writing in the math classroom is for my students. The opportunity to communicate with peers, collaborate about a mathematical concept or application, reflect on what they have learned, and connect the concepts are all favorable. The 21st century learner has all of the information of the entire world at their fingertips and it is our job to get them to learn how to use it, learn what it means, and learn how it relates to their lives. The use of writing through blogs and/or online discussions is a step in the right direction towards achieving this goal.

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