

Can inquiry math resolve math anxiety?

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Abstract

The present study investigates inquiry-based teaching as a potential solution to reducing math anxiety experienced by teachers and students. A literature review and analysis was conducted using search engines: ERIC, JSTOR, PsychInfo, ProQuest and more. It was found that both parents and teachers have the ability to pass on their math anxiety to their students, students with high levels of math anxiety are less successful in mathematics, females and other marginalized groups are at a higher risk of experiencing math anxiety and the disconnect of curriculum to students' lives contributes to poor math results and increased levels of anxiety. Inquiry Math is suggested as an effective teaching strategy that may help alleviate math anxiety experienced in both teachers and students. Future research into inquiry math as an intervention for math anxiety using a pre-post-comparison model is recommended. Implications for teachers on preparing both themselves and their students for inquiry-based learning are discussed.

Key Words: Math Anxiety, Fear of Math, Mathophobia, Teachers, Students, Attitudes, Inquiry

Introduction

As a grade six elementary school teacher, I have often noticed that many of my students do not enjoy mathematics. They avoid homework, seeking extra help and coming to class prepared. Sometimes I see myself in them. As a student, I had found mathematics boring, frustrating and I had a sense of hopelessness. I was extremely anxious every single time we had math class. I do not want to pass along my own frustrations and anxiousness about mathematics to my students. I want my students to love math and not have the same experiences that I once had. I am not sure what the solution is, but my aim is to find a teaching strategy that can help alleviate some of my students and my own fears.

The fear of math prevents many students from studying math beyond grade 11, selecting a math-intensive program at post-secondary institutions and stops individuals from selecting a career that involves mathematics in their day-to-day activities (Ashcraft, 2002). Additionally, the more severe anxiety that a student holds towards math, the less achievement and success will be experienced in math (Ashcraft & Ridley, 2005). The purpose of this study is to explore what exactly math anxiety is, who it affects and a potential solution to this serious problem which directly impacts my students, myself and many others.

Research Methodology and Methods

Information was collected through a series of Databases. Some of which include: JSTOR, Google Scholar, ProQuest, ERIC and PsychINFO. These databases were accessed through the University of Western Ontario's library website. In addition, teaching instructional books were used that have been collected throughout my years of teaching. Finally, some background information has been collected from the York Region District School Board Resources for employees. The following key words were used when searching for information: math anxiety, math AND inquiry, inquiry-based teaching AND teachers OR students, math anxiety AND teachers, mathophobia AND teachers OR students, among many other search alternatives to the above. I was mainly focused on reading literature that had been published within the last 10 years however; some research that has gone further back is still useful as a backbone for operationalizing what math anxiety is. Additionally, scholarly journals which are peer reviewed were of importance in this literature search as well as studies that mainly have taken place in North America. Results are aimed to be generalizable to the Canadian population.

I am interested in two population groups primarily: in-service teachers and elementary school students. These are two enormous groups of individuals which I feel an immediate connection to. Limiting these groups to recent studies primarily conducted in North American, helped filter out many

unrelated studies. However, some results from pre-teachers as well as secondary school students have also been found to be useful. Data has been summarized into a literature review and synthesized. Data has been analyzed based on the trustworthiness and quality of the research journal in which each article/study has been published with. Credible journals typically lend themselves to useful and meaningful results. In the sense of what a school board pushes as useful research to inform instruction, all material from a school board has gone through vigorous screening from curriculum consultants and experts in the math related field.

Literature Review

Math Anxiety: A Major Concern

For some, mathematics in elementary school was an enjoyable experience. An experience full of memorization, long division and 'BEDMAS', but for others, this subject provoked anxiety, frustration and avoidance. Many students experience math anxiety or "mathophobia" - a negative reaction towards math or a math related situation, which extends into day to day living (Reys et.al, 2009). Ashcraft & Ridley (2005), estimate that 20% of the U.S. population is highly anxious about math. Anxiety can in fact, tax working memory to such an extent that even students with high math aptitude can perform poorly (Beilock & Carr, 2005). Anxiety caused by math can range from mild apprehension or dislike towards math, to an actual phobia. In short, performance in math and related subject areas are greatly disrupted by their fear.

The single cause of math anxiety appears to be unknown. However, several contributing factors include: the passing along of a parents' and or a teachers' attitudes toward mathematics, poor self esteem, failed coping strategies, and reliance of short term memory for mathematics rather than a deep understanding (Norwood 1994). Stolpa (2004) attempted to examine the cause of math anxiety and suggests that it is the negative attitudes and anxieties in which parents and teachers hold being passed

along to children and youth. Stolpa (2004) further adds that these anxieties and poor attitudes towards math need to be reflected upon and dissected. The author believes that children are not born believing that they are incapable of being successful in math and that math anxiety is a learned phenomenon. The author further describes the very act of parents and or teachers normalizing the fear, frustration and boredom that a child faces with mathematics by saying comments such as: "Don't worry. I never got algebra either," or "Math was never my strong suit in school." Even more alarming, Hembree (1990) surveyed undergraduate students pursuing careers as elementary school teachers and found that these future teachers have the most anxiety towards math compared to students from any other discipline. So it appears according to the literature, that the major cause of math anxiety is the passing along and normalization of the fear of mathematics from parents, teacher or both, on to children and youth.

A Disconnect Between Math and Students' Real Lives

Most average students have all the cognitive equipment needed to do advanced algebra, statistics, and calculus. The problem is they don't believe they can (Tobias, 1991). It is important to know that students don't naturally hate math. Student attitudes towards math progressively get more negative with age (Lubienski, McGraw and Strutchens, 2004). Based on the findings of Stolpa (2004) and Lubienski, McGraw and Strutchens (2004), the message that it is okay to dislike math is being continuously reinforced again and again by trusted adults, as students age. It is no wonder that the older a student is; the more anxious they are about math. After all, these older students have been exposed to so many similar and unfortunately negative views of mathematics for so long.

Mathematics requires a great deal of creativity. Tom Romano (2007) says that creativity diminishes with age and that this is because there is no sense of adventure in the classroom. Steven Turner and Debby Peck (2009) found that many Canadian students are disengaged from their school work and find it irrelevant, repetitive, fragmented, presented authoritatively and remote to their own

lives. The classroom must be rethought to accommodate student needs and in response to the lack of engagement that students are expressing. Teachers need to make relevant connections between mathematics and a student's life (Coates, 2007). Additionally, Olga Jarrett (2010) says that students learn best when they are in small groups. Strategies such as small group instruction can help alleviate some of the issues being discussed.

It is clear what these authors are saying: students will not be motivated by failure, boredom or fear. Teachers and parents desperately need to: 1.) Avoid passing along their negative perceptions towards mathematics and 2.) Make math fun and relevant to their children and youths' lives.

Current Teacher Attitudes towards Math and Gender Stereotyping

Math anxiety poses the most significant attitudinal and emotional problems that an educator faces in the classroom (Baloglu, 2003; Trujillo & Hadfield, 1999). Many teachers today hold misconceptions regarding mathematics and a dangerous attitude towards this subject that they teach. For example, teachers have been found to treat girls and boys differently in the mathematical classroom. Teachers call on boys more often than girls and praise them more when they answer questions correctly. Also, teachers are less likely to prompt girls who give incorrect answers compared to male students (Ansel & Doerr, 2000). Unfortunately, teachers are not alone in this long withstanding belief. For years, math has been consistently stereotyped as a masculine subject (Ashcraft & Ridley, 2005; Jacklin & Baker, 1993; Nosek, Banaji, & Greenwald, 2002; Spencer, Steele, & Quinn, 1999). Researchers have continuously found that females have low confidence in their mathematic abilities and low expectations for their success in math (Betz & Hackett, 1983; Eccles, 1987; Lapan, Shaughnessy, & Boggs, 1996). Also, females who perform well in high school mathematics, are found to be less interested in pursuing math-related careers compared to equally successful male students (Lubinski & Benbow, 1992). Unfortunately, females are not the only group who are at a higher risk of experiencing

math anxiety. Interestingly, schools with a high concentration of ethnically marginalized students are found to often hold below average results in mathematics (Weiss and Pasley, 2004). Teachers need to be aware of the myths and misconceptions that they hold so that they can truly help encourage girls and marginalized groups of students to pursue careers in mathematics (Mewborn & Cross, 2007).

Traditional Teaching Practices in Mathematics

Traditional ways of teaching math are no longer enough to stimulate the minds of students today. Memorizing mathematics will serve no purpose in reducing math anxiety. In fact, when memory is required to complete math related activities, students who have high levels of math anxiety show a decrease in performance in reaction time and have an increase in the amount of errors made (De Stefano, 2004). Teachers need to keep in mind that math problems should not challenge so much their students' memory as it should their critical thinking (Hiebert, 2003). Thinking critically and applying prior knowledge when solving mathematical problems will increase student success. Students who have a problem-solving approach to mathematics consistently outperform students who memorize and focus on the procedures of math (Sutton & Krueger, 2002). Hamann and Ashcraft (1985) surveyed elementary math textbooks and found that simpler problems requiring less critical thinking were used more frequently than any other type of task or question. They concluded that children more easily transferred simplistic problem solving strategies into their long term memory than any other. It is clear that students on average are being less exposed to questions that trigger higher order thinking and lack meaningful connections to their current lives.

Inquiry Math as a Solution for Math Anxiety

Bush (1981) and Hembree (1990) indicated that math anxiety in a teacher can reduce the likelihood of a teacher's willingness to embrace innovation. These researchers found that teachers with high levels of math anxiety tend to use more teacher-centered approaches to math such as: lecture

based lessons and teaching from textbooks. Differentiated instruction was also found to be something these math-anxious teachers spent less time considering (Gresham, 2008). In fact, teachers who are more math anxious, spend less time teaching mathematics compared to teachers who are not anxious about math (Trice & Ogden, 1987). Before teachers consider the negative impact of math anxiety in their students, they need to address and correct their own apprehensions about math, otherwise Martinez (1987) notes that “Math-anxious teachers can result in math-anxious students.”

These math-anxious teachers with teacher-centred approaches are doing no service to their students. Teachers need to apply the same strategies they use when considering other subjects such as differentiated instruction and change the style of their teaching to suit their students’ needs. For example, lecture-based instruction often requires students to describe their thinking about math in front of an entire class. Jansen (2006) found that this can create a significant amount of stress and create unnecessary social comparisons. A better solution is small group discussions which according to Lampert, Rittenhouse, & Crumbaugh (1996) are less anxiety provoking. Another thing for educators to consider is that students in the junior years (grades four to six) are more in need of autonomy-supportive environments compared to the primary years for developing mathematical skills and capabilities (Eccles & Midgley, 1989). Researchers are advocating that teachers need to reduce the amount of control in order to increase students' mathematical thinking and encourage positive communication in the classroom (Lappan, 1993).

Asking students to sit still and listen will not turn them into lifelong lovers of learning. Wolk (2008) believes that inquiry-based teaching can promote a positive attitude towards any subject and a love of learning. If this is true, inquiry-based math might be the answer to reducing math anxiety and increasing confidence in girls, minorities and furthermore, all students. Additionally, it could be the answer in increasing their performance. Inquiry-math could also reduce the anxiety in which teachers

face as well. Wolk (2008) believes that inquiry-based teaching is the best way to learn and teach knowledge and that it makes content and skills far more purposeful and meaningful. But what is inquiry-based teaching?

Currently, inquiry-based teaching is considered an effective instructional approach by the York Region District School Board in Ontario, Canada because they believe it engages students and allows for differentiated instruction. Research supports this movement in school boards across Ontario as students are found to more likely to become engaged and autonomous in inquiry-based classrooms (Jang, Reeve & Deci, 2010). There is also a growing consensus, both provincially and internationally, that student engagement is linked to student achievement (Cummins, et al., 2005; Flessa et al., 2010; Leithwood, McAdie, Bascia, & Rodrigue, 2006; Willms, Friesen, & Milton, 2009). The aims of inquiry-based teaching go beyond encouraging the use of short term memorization by students; rather it encourages questioning, investigating and critical thinking from ones students. Inquiry-based teaching is the opposite of the traditional form of teaching which was through transmission (Wolk, 20008).

Inquiry-based teaching is a dynamic process where students can explore their questions and problems that are related to their own interests (Mathematical Literacy K-12, 2012). Students do not sit passively, instead what will be seen in the inquiry-based classroom is a community of learners who are engaged and are taking an active role in their own learning. Teaching through inquiry is promoting and facilitating the students as the driver of their own learning. They are the ones who ask the questions and express the desire to explore the answers. The teacher is now the facilitator of discussion, reflection and rethinking through the process of discovery (Wolk, 2008).

What can be observed in the inquiry-based mathematical classroom? This classroom will involve small group collaboration and effective use of technology and resources. Critical thinking will be provoked by students asking questions, discussing and debating their ideas and opinions, planning and sharing new knowledge. A teacher will be a flexible co-learner on the journey (Mathematical Literacy K-

12, 2012). However, Inquiry-based learning is more than just students problem solving a teacher's questions. In inquiry math, students will find and use many different sources to increase their understanding of their own identified questions or problems. Students are asked to do many meaningful tasks such as investigate, explore, search, research and collaborate (Kuklthau, Maniotes & Caspari, 2007).

Inquiry Based Practice

The Ministry of Ontario recently released a document in October of 2011 entitled: Capacity Building Series Getting Started with Student Inquiry (Special Edition #24). In this document, it takes the reader through the four stages of the inquiry process. It is a useful read for any educator wanting to make the shift in their own mathematical classroom. In brief, the four stages involve: Focus – this is the gathering of information and the construction of questions. An example of an inquiry-based question would involve my students in literacy asking “How much money would I need in order to furnish my dream bedroom?” The second stage is called: Share Learning- this is where students begin to share their new discoveries with one another. For example, my students determined that there are clear price differences depending on the store they shopped at and the items they wanted to buy. The third stage is called: Explore- this is where students begin to find out more by researching and discussing. My class began to read up on many places to purchase items for their dream bedroom to find the best deals. The fourth and final stage is called: Analyze- this is where information has been gathered, synthesized and conclusions have been drawn. In my classes' case many learners determined after researching prices from various stores that you can save a lot of money when you compare prices at different stores and actually get pretty close to a dream bedroom without having to spend thousands of dollars.

Both teachers and students need to be prepared to make the shift. Before students can begin to do research and inquiry on their own, they need to learn how to create good questions and learn how to find reliable resources (Tower, 2000). The York Region District School Board has compiled many

suggestions for preparing teachers for the inquiry process. Some include: In service/pre-service professional development, teachers being exposed to inquiry-based learning themselves, differentiated instructional practices, familiarizing oneself with more board initiatives such as the three part math lesson and using a big idea to inform practice.

Results/Findings

One major finding from the literature review involves that fact that math anxiety is a real and serious issue that anyone regardless of age, gender or ethnic background faces. Based on the findings of Lubienski, McGraw and Strutchens (2004), we now know that as students mature into the higher grades their anxiety increases and their attitudes are more negative towards mathematics. Based on the findings of Weiss and Pasley (2004) and Mewborn & Cross (2007) among many others, we have also noticed that girls and marginalized groups are at a higher risk of experiencing math anxiety. Causes of females experiencing math anxiety more often than males can be traced to the gender stereotypes that continue to be reinforced at home, school and in society. Teachers and parents are found to be one of the most significant causes of math anxiety in children and youth of both sexes as these adults have been found to normalize and accept negative attitudes and failure in math and pass these dangerous views onwards. Strong and prevalent links emerged from the literature: the more anxious a student feels about mathematics, the less successful they shall be in mathematics. Also, the less engaged a student is in the mathematical content, the more difficulty, reliance on short term memory and fear of mathematics will arise. Finally, inquiry math aims to restore the joy of learning mathematics in a systematic way that will allow students to make meaning of the curriculum content to their own lives.

Discussion and Recommendations

Although inquiry-based teaching and learning seems to be the answer in reducing math anxiety, there is a lack of research in the field. It is very critical not to just jump to conclusions and figure that this

is *the* solution or the *only* solution. Opinions are slow to change and there is still current resistance by both teachers and parents towards inquiry-based teaching. French (2005) argues that the actual name “inquiry-based teaching” acts as a deterrent for educators and parents to jump on board with this teaching strategy. He suggests that inquiry-based teaching should really just be called “asking good questions and finding answers”. The author suggests that rephrasing or renaming this teaching strategy may actually make inquiry-based teaching sound more appealing to many more teachers and parents. The researcher goes on to say learning by inquiry is really just doing research and teaching by inquiry is really just supporting researchers, and that’s it.

It may also be difficult to reach experienced teachers who are not receptive to. Helping teachers cope and address their own math anxiety poses as a significant challenge. Tooke & Lindstrom (1998) investigated ways of reducing math anxiety in pre-service elementary school teachers. Their study however, produced no evidence that math anxiety was significantly affected by completing a semester of mathematics for teachers, regardless of it being taught in the traditional manner or in the non-traditional manner. It would be interesting to replicate this study using inquiry-based learning as the non-traditional manner. The authors suggest that in Texas, a curriculum preparing elementary teachers, needs to include a mathematics methods course in order to reduce mathematics anxiety. Sloan (2010) decided to conduct a quantitative and qualitative study of math anxiety among pre-service teachers in the United States and found that there was a dramatic decrease in math anxiety from the onset of a mathematics methods course. With these findings in mind, it is very important that pre-service and in-service teachers receive further professional development related to math methods in order to reduce the amount of anxiety they hold. This can help reduce the likelihood that teachers will pass along their fear to their students and hopefully inspire teachers to make relevant connections between the curriculum they teach and the real world. Additionally, it is suggested that teachers should

receive professional development in the areas of math inquiry because of the positive benefits that this style of teaching creates in students.

Teachers need to bring back the meaning of what they teach to their students' lives by finding links in the curriculum to the real world, creating interesting and engaging projects and by inspiring their students to conduct research from areas that they find a personal connection to. An example of making links to the real world would be a teacher who turns their classroom into a grocery store and provides fake money to their students. This would be tapping into the strand of measurement by teaching students how to use and count money by creating a real world connection.

Based on the findings of this literature review, it is also important that teachers do not get stuck up on encouraging students to simply memorize basic mathematics skills and rather focus on teaching the deeper meaning underlying key concepts in the mathematical curriculum. An example would be making the shift from forcing students to memorize the formula for area of a triangle to understanding what the area of a triangle is and how to find the area conceptually.

Educators must ensure their classrooms are tailored to suit the needs of all learners regardless of intellectual capabilities, age, gender or ethnicity. Based on the research, it is evident who is at a higher risk of experiencing math anxiety. Ensuring that the classroom is non-judgemental, free of stereotypes, anxiousness and boredom, will promote a love of learning and increased success in the future.

Conclusions

Summary

Math anxiety is an issue that teachers, parents and students face. It affects students' ability to achieve success in mathematical courses and impacts their decisions to be associated with math-related

careers in the future. Females, older students and ethnically marginalized groups are at a greater risk of experiencing math anxiety. Teachers need to ensure that their mathematical classroom is rich with connections to the real world, free of gender or ethnic biases, differentiated and rid of undue stress on students to memorize meaningless mathematical concepts. Strategies for teachers to decrease their own math anxiety include obtaining further professional development such as a mathematics method course and implementing a teaching strategy such as inquiry-based teaching. Inquiry-based teaching appears to have many benefits for students as well as potentially having benefits for teachers in the long run as well.

Limitations

This study relied only on the results of secondary data. This means that the variability and reliability of each study included in this paper could potentially be up for question. Also, not all possible data banks were accessed, limiting the amount of literature that could have been reviewed for the purpose of this paper. This is a big idea of exploration which requires further and more extensive investigation over a longer period of time and involving primary data collection.

Suggestions for Future Research

It is highly recommended that future researchers use primary data. A population of continued interest is elementary school students and teachers. A study which is of interest is the effects of inquiry-based teaching as an intervention to three subject groups: female students of one grade who experience math anxiety, males students of the same group who experience math anxiety and a comparison group of students from the same grade who experience no math anxiety or next to none. Another group of interest is older students or teachers, and whether or not math anxiety can diminish with the intervention of math inquiry.

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