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Abstract

The purpose of this paper is to discuss and analyze images, anxieties, and attitudes towards mathematics in order to foster meaningful teaching and learning of mathematics. Images of mathematics seem to be profoundly shaped by epistemological, philosophical, and pedagogical perspectives of one who views mathematics either as priori or a posteriori, absolute or relative, and concrete or nominal. These images, as perceived by an individual can play a significant role in the development of attitudes towards mathematics in the long run. Images of mathematics can have possible negative and positive impacts on teaching and learning of mathematics with the subsequent development of attitudes toward mathematics as positive or negative and also associated mathematics anxiety. A theoretical model with different combinations of images, anxieties, and attitudes toward mathematics can be a helpful tool to develop an understanding of the different relationships among them. Some pedagogical implications can be drawn from these relationships.

Key Words: Image of mathematics, Mathematics anxiety, Attitude toward mathematics, Affect in mathematics education

Introduction

How do students perceive mathematics in schools? What are different images of mathematics that students perceive? How these images impact their learning? What is math anxiety? What are the causes of math anxiety? What is the relation of image of mathematics as perceived by students with math anxiety? What are different attitudes toward mathematics? How these attitudes impact learning mathematics? How images, anxieties and attitudes are related to each other? How do they form the personality of students in terms of mathematics? There are a number of past studies on images, anxieties, and attitudes towards mathematics, but none of them clearly discuss the relationship or interaction among them. In this paper I would like to bring them together with a model and seek to understand the impact of different combinations in teaching and learning mathematics.

It seems that the number of dissertations and published articles dealing with attitude towards mathematics increased geometrically since Feierabend's (1960) report "Review of research on psychological problems in mathematics education" (Aiken, 1970). This shows a growing interest of mathematics education researchers in the area of attitudes toward mathematics. In this context, mathematics educators have considered the connection between students' attitudes toward mathematics, and their achievement in the subject as one of the major concerns (Ma & Kishor, 1997). Ma and Kishor further stated that "the research literature, however, has failed to provide consistent findings regarding the relationship between attitude toward mathematics and achievement in mathematics" (p. 27). This discrepancy of result might have stemmed from differences in research method, context, and other intervening factors. Some researchers (e.g., Deighan, 1971) demonstrated that there is a low correlation (below 0.5) between attitude toward mathematics and achievement in mathematics; however, other researchers (e.g., Kloosterman, 1991) demonstrated that the attitudinal variables are significant indicators of math achievement. This paper is an attempt to analyze the images of mathematics in relation to anxieties and attitudes toward mathematics, and their effects on teaching and learning mathematics.

From a psychological perspective, there is a general myth that mathematics is an enigmatic subject. Some people claim that they like mathematics while others claim that they dislike mathematics. Some people are even scared of simple mathematics while others enjoy challenging problem solving in mathematics. The people who

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claim that they like mathematics often choose mathematics in their college study, while those who prefer to say they dislike mathematics view mathematics as a difficult subject (Sam, 1999) and most possibly they discontinue mathematics in higher education.

According to different perspectives, mathematics can be a battle, a mountain, or a bridge, and mathematics can be viewed differently in terms of inherent characteristics as perceived by teachers and students (Sterenberg, 2008). These metaphorical images of mathematics held by students and teachers play a significant role in developing beliefs and attitudes toward mathematics in terms of having favorable or disfavorable opinions. These images reveal that relationships and meanings are produced metaphorically through a transfer between domains of mathematics and terms related to representing mathematics. Such a transfer forces us to make sense of mathematical objects (Game & Metcalfe, 1996). Many people tell stories of their childhood when they were frustrated in mathematics class and/or scared of problem solving in mathematics. The long thread of their struggle in learning mathematics in schools may create different images of mathematics; many of them, unfortunately, negative (Sterenberg, 2008).

Many past studies (e.g., Lakoff & Nunez, 2000; Ma & Kishor, 1997; McLeod, 1992; Richardson & Suinn, 1972; Sam, 1999; Wigfield & Meece, 1988; Wood, 1988) focused attention to psychological, philosophical, epistemological, and pedagogical images of mathematics. They also touched upon different attitudes toward mathematics and mathematics anxieties. Philosophical and epistemological lenses toward looking at mathematics and mathematics education in terms of realism, intuitionism, formalism, constructivism, criticalism, postmodernism, and integralism seem to have a powerful influence in shaping these images of mathematics, different attitudes toward mathematics, and different levels of positive and negative anxieties toward mathematics.

Affective States in Mathematics Learning

Historically, many researchers in mathematics education (e.g., Forgas, 2001; Goldin, 2002; McLead, 1992; Petty, DeSteno, & Rucker, 2001) discussed affect as an important aspect of teaching and learning mathematics. They clarified the psychological and cognitive meaning of affect and its implication in mathematics education. McLeod (1992) articulated affect as a major concern in teaching and learning mathematics in terms of psychological theories, cognitive approaches, and reconceptualization of the affective domain in mathematics education. He outlined some aspects of beliefs, attitudes, emotions, and confidence in learning mathematics from the contemporary literatures of research in mathematics education. He also explicated the nature of affective domains in mathematics education in terms of self-concept, mathematics anxiety, self-efficacy, effort and ability attributions, causal attributions, learned helplessness, motivation, autonomy, and aesthetics. However, these discussions did not clearly articulated how images of mathematics foster different attitudes and anxiety levels of the learners of mathematics. Also, he did not articulate the pedagogical relationship among various affective factors and how they contribute to each other. The contemporary research on affective factors in teaching and learning mathematics seemed focused heavily on measurement rather than finding the subtle reasons and implications in mathematics education. The affective states of teachers and students in terms of their experiences in mathematics, both formal and informal, may have a tremendous impact on how they think about the subject, how they interact with others mathematically, how they perceive their role, how they conceive their world, how they prepare themselves for the future, and how they make conscious efforts to overcome the sense of uncertainty. In this context, images of mathematics, mathematics anxiety, and attitude toward mathematics as a part of affective domain can be interrelated to see their implications in teaching and learning mathematics.

Images of Mathematics

When one thinks about images of mathematics, two things may come up in his or her mind: images as objects or images as abstraction. I think images as objects in relation to mathematics are related to symbols and images as abstraction is related to operations. The images as objects seem to be static view that visualizes mathematics as a subject matter. The images as an abstraction seem to be dynamic that visualizes mathematics as a process or operation.

Tall and Vinner (1981) defined a concept image as cognitive structures related to a mathematical concept, including both mental images and construction of words. A concept (e.g., the color of a leaf) must allow for variability with time and context. If we imagine an object shaped like an apple that is purple, we can still believe that it is an apple. We have the freedom to recombine familiar ideas in novel ways. Since we have never seen a purple apple, it is unlikely that we would form an image of one, when hearing the word apple (Browne, 2009).

McGinn (2004) asserts that images are part of an active nature, since they are subject to the will of the viewer. Percepts belong to the passive part of thinking and imagination. In other words, one must make an effort to form an image of something, while the same may not hold true for just looking.

In *absolutist* viewpoint, images of mathematics are viewed as an impartial, absolute, definite, and persistent body of knowledge based on deductive logic (Ernest, 1991). Ernest further claims, "among twentieth century philosophies, *logicism*, *formalism,* and, to some extent, *intuitionism* and *Platonism* may be said to be *absolutist* in this way" (Ernest, 1991, p. 2). However, Ernest (2008) claimed that absolutism is not much concerned about unfolding mathematics or mathematical knowledge in the world around us.

Rensaa (2006) asserts that in the past few decades a new tendency of epistemology, pedagogy, psychology, and philosophy of mathematics is securing a ground, and these days many mathematicians and mathematics educators propose a non-absolutist justification of mathematics. Kitcher and Aspray (1988) described this as "the 'maverick' tradition that emphasizes the practice of, and human side of mathematics, and characterizes mathematical knowledge as historical, changing, and corrigible" (Ernest, 1991, p. 2). The image of mathematics is generally viewed as falsifiable (can be wrong), contextual (changes with the situation), and relative (mathematical rules are not universal, but subject to verification within a context).

A widespread *public image* of mathematics in the West is that it is difficult, cold, abstract, theoretical, and ultra-rational, and, also important and largely masculine (Ernest, 2008). It also has the image of being *remote* (distant) and *inaccessible* (not possible to reach) to all, but a few extra-ordinary human beings with 'mathematical minds' (Buerk, 1982; Buxton, 1981; Ernest, 1996; Picker & Berry, 2000). For many people this *negative image* of mathematics is also associated with anxiety and failure in mathematics. When Brigid Sewell was gathering data on adult numeracy for the Cockcroft (1982) inquiry, she asked a sample of adults on the street if they would answer some questions. Half of them refused to answer further questions when they understood it was about mathematics, suggesting *negative attitudes*. Extremely *negative attitudes* such as '*mathephobia*' (Maxwell, 1989) probably only occur in a small minority in Western societies, and may not be significant at all in other countries. In fact, the world-wide consensus of mathematics educators is that school mathematics must counter that image, and offer, instead, something that is personally engaging and useful, or motivating in some other way, if it is to fulfill its social functions (Howson & Wilson, 1986; NCTM, 1989; Skovsmose, 1994).

Mathematics Anxiety

When one thinks about mathematics anxiety, two things may come to his or her mind: one is 'anxiety as progressive thinking' and the other is 'anxiety as regressive thinking'. To me all anxieties are not worthless things. Anxieties can be both good and worthless. If it promotes progressive thinking (like when one is puzzling in a mathematics problem for a few days and he or she is trying to solve it in a variety of ways without losing the passion), then certainly it is a good thing. Anxiety is mostly taken as regressive thinking in which a person having anxiety tries to go away or get rid of mathematical problem simply by avoiding it and taking it negatively.

Mathematics anxiety is an anxious state in response to mathematics-related situations that are perceived as threatening to self-esteem. Cemen (1987) proposed a model of mathematics anxiety reaction consisting of environmental antecedents (e.g., negative mathematics experiences, lack of parental encouragement), dispositional antecedents (e.g., negative attitudes, lack of confidence), and situational antecedents (e.g., classroom factors, instructional format) are seen to interact to produce an anxious reaction with its physiological manifestations (e.g., perspiring, increased heartbeat, and restlessness). Many researchers (e.g., Ma & Kishor, 1997; Richardson & Suinn, 1972; Tobias & Weissbrod, 1980) reported the consequences of being anxious toward mathematics, including the inability to do mathematics, the deterioration in mathematics achievement, the escaping of mathematics courses, the limitation of students in selecting college mathematics majors and related future careers, and the extremely deleterious feelings of guilt and humiliation. Ma and Kishor (1997) claimed that mathematics anxiety is usually associated with mathematics achievement individually. A student's level of mathematics anxiety can significantly predict his or her mathematics performance (Fennema & Sherman, 1977; Wigfield & Meece, 1988), probably both in negative and positive ways.

Miller and Bichsel (2004) claimed that math anxiety appears to primarily impact one's visual working memory that contradicts previous research findings that mathematical anxiety is primarily processed in verbal working memory and supporting the hypothesis that math anxiety does not function similarly to other types of anxiety. They identified two general types of anxiety: trait and state. They clarified that individuals experiencing trait anxiety have a characteristic tendency to feel anxious across all types of situations. In contrast, individuals possessing state anxiety tend to experience it only in specific personally stressful or fearful situations. Trait anxiety is more related to a wide range of situations to which one feels a kind of threat, unsecured, and challenge all the time. In mathematics, students under this anxiety have a fear of mathematics class, homework, exam and any situation when comes to mathematics. According to Spielberger et al. (1970), state anxiety reflects a temporary emotional state characterized by personal, deliberately perceived feelings of mental tension and uneasiness with a greater sensitiveness in the nervous system. Several past studies demonstrated that both state and trait anxiety affect task performance in mathematics (e.g., MacLeod & Donnellan, 1993; Miller & Bichsel, 2004). Concluding the findings from these researches, Miller and Bichsel stated that individuals with high trait anxiety show poorer performance on various tasks than low trait anxiety individuals. This difference tends to be exacerbated in a high state anxiety condition. With reference to research on the impact of gender on math anxiety, Hembree (1990) found math anxiety being more predictive of math performance in males than in females. However, further study is necessary to re-confirm this claim.

Attitude toward Mathematics

Images of mathematics as perceived by a person develop his or her *positive* or *negative* attitude towards mathematics. These images have a significant impact on one's choice of mathematics as major in higher education. In this context, many studies have been conducted on attitudes toward mathematics (e.g., Eleftherios & Theodosius, 2007; Hannula, 2002, 2004; Zan & Di Martino, 2007) with contradictory results. Eleftherios and Theodosius (2007) used the term 'beliefs' in the meaning of personal judgments and views, which constitute one's subjective knowledge, does not need formal justification. They investigated the students' beliefs and attitudes, which mainly concerned studying and learning mathematics. Specifically, they explored their factorial structure. Also, they investigated whether there were differences in students' beliefs and attitudes regarding their social status and gender; they examined whether these factors correlated and influenced students' performance, and their capability in dealing with mathematical proofs. They found a significant statistical difference between female and male students concerning "mathematical understanding is achieved through procedures and studying mathematics with understanding" (p. 101). Students' interest or motivation in learning mathematics was found to be correlated positively with studying of mathematics involving understanding and reflection, with high performance at school and with the ability to understand mathematical proofs. The results from this study identified the factors that lead to the development of students' positive and negative attitude towards mathematics with a significant impact on their learning of mathematics and achievement.

According to Zan and Di Martino (2007), the phenomenon of 'negative attitude towards mathematics' is related to the learning of the discipline. They further claimed that the negative attitude towards mathematics affects various aspects of the social context: the refusal of many students to enroll in scientific undergraduate courses due to the presence of exams in mathematics, a worrisome about even simple mathematical illiteracy, or an explicit and generalized refusal to apply mathematical rationality, and a tendency to uncritical acceptance of models that are only apparently rational. Their results suggested that the attitudes do not seem to have the characteristics of a theoretical instrument capable of directing their work. They found from personal essays that the two dimensions - vision of mathematics and like/dislike - are mutually independent. They further noticed that this independence was strongly expressed in characterizing mathematics as useful/useless and easy/ difficult subject.

Hannula (2002, 2004) asserted on *everyday-notion-of-attitude* referring as someone's basic liking and disliking of a familiar target. He discussed students' attitude towards mathematics separating them into four different evaluative processes: *emotions the students experience during the mathematics-related activities*, *the emotions that students automatically associate with the concept mathematics*, *evaluations of situations that students expect to follow as a consequence of doing mathematics*, and *the value of mathematics related goals in the students' global structure*. Through an action research, the researcher was successful to change attitudes, beliefs, and behaviors of a participating student. He also proposed a theoretical framework about emotions, associations, expectations, and values to study attitude towards mathematics. The most significant conclusion from this study was that the proposed framework of emotions, associations, expectations, and values was useful in describing attitudes, and their changes in detail. He further concluded that attitudes, sometimes, could change dramatically in a relatively short time and the negative attitude towards mathematics could be a successful defense strategy of a positive self-concept.

Relationship among Images, Anxieties and Attitudes

It seems that images, anxieties, and attitudes play a significant role in learning mathematics. These attributes are related to personal psychology, philosophy and epistemology. Wigfield and Meece (1998) assessed relations between math anxiety and other key mathematical attitudes, students' beliefs and values, and their mathematical performance measured in a large study as one way of assessing the distinctiveness of math anxiety. Several researchers (e.g., Fennema, 1977; Fennema & Shermon, 1977; Richardson & Suinn, 1972; Tobias & Weissbrod, 1980) reported a negative correlation between math anxiety and low performance in mathematics, and then poor images associated with negative attitude towards mathematics. Although research studies have been undertaken to examine the affective domain, it has become central to describe a person's attitude towards mathematics using precise but connected terminology, e.g. beliefs, emotions, confidence, anxiety, self-concept or image (McLeod, 1992).

There are some commonly held beliefs about mathematics which are still true today as they are associated with math anxiety (Kogelman & Warren, 1978). Sam (1999) reported that these beliefs are: (a) inherited mathematical ability that some people have a mathematical mind and some don't, (b) one must always know how he or she got the answer, (c) there is one best way to solve a mathematics problem, (d) mathematics requires a good memory, (e) men are better at mathematics than women, (f) it is always essential to get the answer exactly right, (g) mathematicians solve problems quickly in their heads, and (h) it is bad to count on your fingers. These beliefs seem to be more like misconceptions developed in societies about mathematics. These misconceptions are hindering factors for people's interest to study mathematics, use mathematics to solve problems, and think mathematically about their world.

Based upon above discussions on images, anxieties and attitudes towards mathematics, a theoretical model leading to the success or failure of mathematics teaching and learning with regard to student achievement, and motivation can be suggested. Images of mathematics as infallible or fallible, mathematics anxiety as high or low self-esteem, and attitude towards mathematics as positive or negative can be modeled into a triangular relation leading to a perception about mathematics. This theoretical model can be represented in a diagram as in figure 1. This untested model can be considered as a basis to relate images, anxieties and attitudes together with several possibilities of combinations. There are eight possible outcomes from the model representing different perceptions about mathematics including, (1) infallible, high self-esteem, positive attitude; (2) infallible, high self-esteem, negative attitude; (3) infallible, low self-esteem, positive attitude; (4) infallible, low self-esteem, negative attitude; (5) fallible, high self-esteem, positive attitude; (6) fallible, high self-esteem, negative attitude; (7) fallible, low self-esteem, positive attitude; and (8) fallible, low self-esteem, negative attitude.

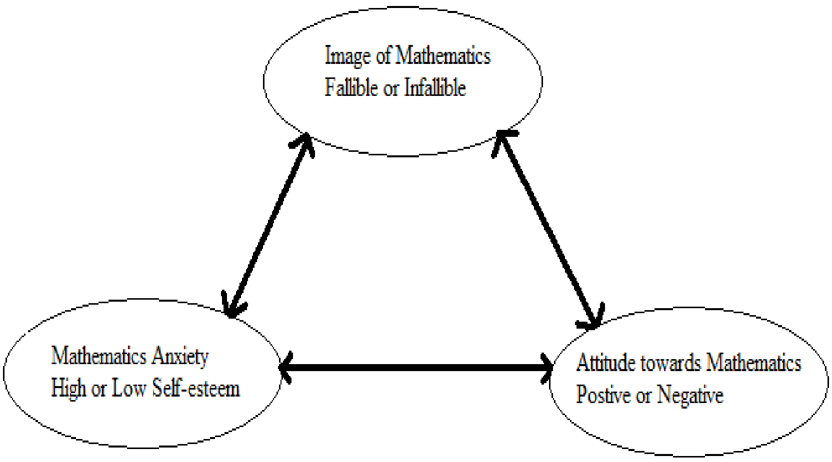

Figure 1: Model of triangular relation of images, anxieties and attitudes towards mathematics

Among these combinations, the combinations (1), (4), (5) and (8) seem practically viable psychological states in terms of the interrelation of images, anxieties, and attitudes. The rest of the combinations may be theoretically viable, but they seem to be non-practical because high self-esteem and negative attitude, and low self-esteem and positive attitude towards mathematics seem to contradict. The contradiction in high self-esteem and negative attitude, and low self-esteem and positive attitude is obvious as they represent opposite characters about one's perception towards mathematics.

Among the four possibilities, the first one is a combination of infallible (image), high self-esteem (low degree of anxiety), and a positive attitude. This combination is possible to develop a perception towards mathematics as absolute, infallible and incorrigible; however, the student has high self-esteem and positive attitude towards mathematics. The view of mathematics as absolute and infallible leads the student to develop a positivistic philosophy that can lead to the development of his or her personality as an *Absolutist*. The student with this kind of personality enjoys routine problem solving, follows a rigid procedure to solve problems, and values high scores in tests.

The fourth combination of infallible, low self-esteem and negative attitude is a problematic situation. Teacher centered teaching and learning that have fewer activities in the class for students, less emphasis to group or peer works, less questioning by the students, and authoritative instructions may result into low self-esteem and negative attitude towards mathematics. Teaching and learning mathematics guided by drill, practice, and copy from the board instead of construction of ideas by students may lead to this situation impacting severely in students' understanding of mathematics and then achievement.

The fifth combination of fallible, high self-esteem and positive attitude leads to the development a perception that mathematical objects are socially constructed, it is fallible and questionable, and the student has a high self-esteem towards mathematics leading to positive attitude. This combination develops the personality of students to question mathematical objects and processes, maintain high self-esteem about learning mathematics, and think positively about his or her ability to learn mathematics. These students value the process of learning mathematics and they try to understand the nature of mathematics from examples and practices. They enjoy non-routine type unstructured problem solving.

The eighth combination of fallible, low self-esteem and negative attitude leads to the development a perception that mathematical objects are socially constructed, fallible, and questionable; however, the student has low self-esteem due to some internal and external problems to cope with the situation in the classroom that ultimately leads to the development of negative attitude. The teacher can help such students to develop high self-esteem by changing the pace of learning and helping him or her to learn from contexts to unstructured problem solving. The triangular relation among images, anxieties, and attitudes toward mathematics has some pedagogical implications that have been discussed in the next section.

Implications in Teaching and Learning of Mathematics

Choice of instructional methods and resources and their appropriate use in classroom teaching and learning of mathematics largely depends on images of mathematics as perceived by the teacher and students. Images based on an absolutist view of mathematics as neutral and value-free regarding teaching the contents as necessitating the adoption of humanistic, connected values have raised the issue of the relationship between epistemology and philosophy of mathematics, values and teaching (Ernest, 1995). Empirical research (e.g., Cooney, 1988) confirmed the claims that teachers' personal views, opinions, perceptions, beliefs, and priorities about mathematics do influence their instructional practices (Thompson, 1984). "Thus it may be argued that any philosophy of mathematics (including personal philosophies) has many educational and pedagogical consequences when embodied in teachers' beliefs, curriculum developments, or examination systems" (Ernest, 1995, p. 457). These images of mathematics from the epistemological, psychological, and philosophical perspectives value inductive and deductive reasoning as a way to learn and teach mathematics. Those images of mathematics have possible negative and positive impacts on teaching and learning of mathematics with the subsequent development of attitudes toward mathematics as positive or negative (e.g., Ma & Kishor, 1997; Lakoff & Nunez, 2000).

Based upon the above discussion, we can say that effective teaching depends on one's image of mathematics based on personal epistemology and philosophy. It is up to a teacher to select a method of instruction in the classroom to engage students in learning mathematics. If the teacher views that school mathematics is merely a collection of formulas, rules, and procedures that must be memorized and mastered, then he may apply traditional teaching techniques like drilling in the class, working with individual worksheet practices, and using flashcards. If the teacher believes that mathematics is an integrated whole, a study of structures and the relationships among different things, and study methods and one's understanding the world, then the goal of teaching mathematics may change. Now the teacher helps students develop the skills they can use to solve mathematical, non-mathematical, and non-routine problems. This also may include the students' ability to reason mathematically or quantitatively, to clarify and justify mathematical ideas, to use mathematical and other resources, to work collaboratively with other people, and to be able to generalize situations, as well as the their ability to carry out mathematical computations and procedures (Zemelman, Daniels, & Hyde, 1998).

In summary, different studies (as discussed above) indicated a positive relationship among images, anxieties and attitudes towards mathematics, and these emotional factors had a negative relationship with student's achievement. However, there is a lack of research that examines the teachers' pedagogy and students' achievement in relation to different combinations of images, anxieties, and attitudes toward mathematics. The theoretical model presented in this paper with varying combinations of fallible or infallible images, high or low self-esteem and positive or negative attitudes can have significant pedagogical implications. A teacher's awareness to these combinations can help him or her to maintain a balance among different approaches of teaching and learning mathematics as per the needs and contexts in the classroom. Such a balance of teaching and learning approaches, followed by a constructivist approach in conjunction with instructionist approach, can be helpful to teach mathematics lessons in a meaningful way through which students gain high quality learning experiences.

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