The Influence of Emotion, Confidence, Experience and Practice on the Learning Process in Mathematics

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Introduction
A few years ago while I was teaching a grade 12 mathematics class I discovered that one of the girl learners, (Shahieda1) had major difficulties in learning mathematics. While teaching the class I would do some examples of a topic on the board and then request that the learners attempt one or more similar problems on their own. While the learners were attempting the problems I would walk around in the class and invariably I found that Shahieda was struggling. I would then sit next to her and point out the mistakes in her solution and then proceed to correct her argument. Subsequently I would request the class to attempt another problem of the same kind. Shahieda would then provide the correct solution to this follow-up problem. Satisfied that she was now cognizant of the requirements of such problems I would proceed to the next topic.

To my amazement when a test was written that covered the same topic Shahieda would make exactly the same mistakes that I had pointed out to her. Her results in the two exams of that year were even worse. She scored less than 10 for both the first and second paper of both exams. This was despite my numerous attempts to get her to reason correctly. What puzzled me was that in the class she would seem to understand and even provide correct arguments, but as soon as she wrote tests or exams she would revert to her erroneous arguments. I therefore came to the conclusion that factors other than the normal reasoning problems were responsible for this behavior. This is not an isolated case since some of my colleagues have encountered similar problems with learners and I would venture to suggest that this is a widespread problem especially amongst the previously disadvantaged communities. It is therefore imperative that we investigate and find solutions for this phenomenon. The following paragraphs provide some possible reasons for the behavior of the learner and attempt to provide some solutions to this problem.

The influence of emotion
An intriguing question is how does the human brain deal with new incoming information? How the human brain deals with incoming information is explained by McGeehan (2001) as follows: “First the sensory stimuli hit the neurons in the appropriate sensory cortex2. These crude sensations are then relayed through the thalamus3 and sent to the sensory association area of the neocortex where they are put together into objects we recognize. Next (and almost simultaneously) the information is sent to the amygdala4 for emotional evaluation and to the frontal cortex for content evaluation. On the basis of its analysis of physical features of the stimuli, the brain begins to construct meaning.”

Emotions can affect learning, in both a positive and negative way. Kort et al. (2001) confirm this in the following quote: “When a learner experiences positive emotions, the learning process can be enhanced. When a learner experiences negative emotions, the learning process can be disabled.” Goleman (1995) is of similar opinion as the following quote shows: “Students who are anxious, angry, or depressed don’t learn; people who are caught in these states do not take in information efficiently or deal with it well.” The importance of the effect of emotion on the learning process is shown in the following quote from Sylwester

1 Not her real name
2 The cortex is a neuron-packed outer layer of the brain in which conscious thought takes place.
3 The thalamus is a sensory relay station located deep within the middle of the brain.
4 The amygdala is an almond–shaped structure in the middle of the brain, connected to the hippocampus, which detects the emotional content of sensory data and plays a role in the formation of emotion-laden memories.
“Emotion drives attention, which drives learning, memory and problem solving and almost everything else we do . . . by not exploring the role that emotion plays in learning and memory, our profession has fallen decades behind in devising useful instructional procedures that incorporate and enhance emotion.” Sylwester further emphasizes this as follows: “Far more neural fibers project from our brain’s emotional center into the logical/rational centers than the reverse, so emotion is often a more powerful determinant of our behavior than our brain’s logical/rational processes.”

Incoming information also needs to have personal meaning and emotional importance for students as a prerequisite to being stored in the long-term memory. In other words students tend not to remember for long those things that lack personal meaning and emotional importance for them. This is confirmed in the following quote of McGeehan (2001): “…when information lacks personal meaning and an emotional hook, the neural networks needed to create long-term memories are not formed.” It is clear therefore that emotion plays a crucial role in the learning process.

When I was at primary school some of the mathematics teachers used to call learners to the board to solve mathematics problems on the board. The teacher would stand behind the learner with a cane and as soon as the learner made a mistake the teacher would beat the learner. Another popular method was where the teacher would do mathematics revision with a cane. Any learner that could not supply an answer to a question would routinely receive a beating. I think the teacher’s motivation for using these methods was that the teacher was under the impression that the learners were lazy and that the beatings and resulting pain would inspire them to become industrious and would cause them to learn and understand. The strongest emotions that these learners therefore came to associate with mathematics is one of paralyzing fear, humiliation and also that not understanding is a bad thing. The sad part is that neuroscience has shown that memories that are strongly charged with emotion are most likely to go into the long term memory. So these learners that had a traumatic experience with mathematics will tend to remember it for a long time. The result of this is that since all the previous experiences of these learners with mathematics have been bad they expect that their next experience with the learning of mathematics would also be bad. This then becomes a self-fulfilling prophecy. In other words the learner expects a negative experience because the emotions in their long term memory prepare them for a bad experience and hence they get a bad experience. Such learners will struggle with mathematics not necessarily because they do not understand it, but because their previous experience dictates that it must be so. Hence, contrary to their aim of teaching the learners to learn and understand, these teachers instead taught them anxiety, fear, humiliation and confusion.

Even teachers who do not use intimidation as a method of teaching and who have good intentions sometimes do not take into consideration the effect of emotion on the learning process. This is starkly illustrated in the following quote from Kort et al. (2001): “When teachers present material to the class, it is usually in a polished form that omits the natural steps of making mistakes (e.g. feeling confused) recovering from them (e.g. overcoming frustration), deconstructing what went wrong (e.g. not becoming dispirited), and starting over again (with hope and enthusiasm). Those who work in science, math, engineering, and technology (SMET) as professions know that learning naturally involves failure and a host of associated affective responses.” Kort et al. therefore conclude that what we fail to teach students is that these feelings associated with various levels of failure are normal parts of learning, and that they can actually be helpful signals for how to learn better. It is evident therefore that instructors in mathematics should be cognizant of the emotional requirements of their subject and should include examples that allow students to experience a variety of emotions in the learning process so as to prepare the student for the emotional rigours involved in doing mathematics.

The influence of Confidence
It is my contention that in order to become proficient in theorem proving (or any mathematical process) students need to be confident in what they are doing. The literature is commensurate with my view of the connection between confidence and success in mathematics. Burton (2004) for example states: “This teacher is reflecting a widely held view that performance in mathematics and confidence go hand-in-hand. Success in mathematics breeds confidence. Confidence in mathematics breeds success.” Research done in
Canada by PISA\(^5\) found that a student’s self-confidence and level of anxiety about mathematics were strongly associated with their performance. They found that those with high levels of confidence in their ability to learn mathematics performed much higher than those with low levels. Conversely students with a high level of anxiety about mathematics, such as feelings of helplessness or stress when dealing with mathematics, performed much lower than students with less anxiety.

In order to inform our discussion on the relationship between confidence and success in mathematics I think it is imperative that we define what we mean when we are referring to confidence. Although there are different views as to the meaning and definition of confidence in mathematics our understanding of mathematical confidence will be informed by that of Burton (2004) which is as follows: “I saw confidence as a label for a confluence of feelings relating to beliefs about the self and about one’s efficacy to act within a social setting, in this case the mathematics classroom.” Since the two main protagonists in the mathematics classroom are the teacher and the student we therefore have to ascertain their views on confidence. The study done by Burton found that teachers regarded confidence as individual and behavioural. That is the teachers did not think that confidence in mathematics involved a social act and that confidence in the individual is exhibited by behaviour such as willingness to answer or to attempt. Conversely, the students associated confidence with feelings and how the classroom could function to make those feelings better or worse. The students were in favour of a collaborative working style and were of the opinion that getting answers correct fueled the confidence level. Furthermore, they were convinced that both knowledge and understanding contributed to confidence.

If confidence is as crucial as the literature suggests an important question then would be what do teachers have to do in order to inculcate their students with confidence in mathematics? I am of the opinion that some of the student responses of the Burton study provide an answer to this question. These include the following: “They wanted teachers to facilitate discussion, teamwork, a light-hearted approach, a relaxed classroom where you are not afraid of making errors…they did not want to be put down, persistently asked the same question, made to look a fool or feel patronized, put into a position where others laugh at you, …the students felt that teachers should explain well, should not rush the work, should know what they are talking about and should be sensitive to students who are struggling to understand.” Clute (1984) on the other hand was of the opinion that instructional strategy plays a crucial role in mathematics achievement. The study done by Clute indicates that students with low levels of anxiety and hence high confidence were better served by the discovery method of teaching\(^6\). Conversely students with a high level of mathematical anxiety and low confidence relied heavily on a well-structured, controlled plan for learning.

**The influence of Experience**

Another question that deserves our attention is, is there a relationship between confidence and experience? The answer provided by neuroscience is compelling. Findings from brain research indicates that intelligence is a function of experience. McGehee (2001) explains it as follows: “New experiences physically change the brain by causing neurons, the brain cells principally involved in cognition, to sprout new branches, or dendrites, and thus increase communication among neurons across microscopic gaps called synapses…The findings of neuroscientists affirm the importance of experience in the development of dendrites and, by extension, in the results of this development which we call learning and observe as intelligence.” Clute (1984) has the following opinion about the relationship between confidence and the learning of mathematics: “If one lacks confidence in one’s ability to perform mathematical tasks, it seems reasonable to conclude that there is a lack of respect for or trust in one’s own instincts or judgments when it comes to learning mathematics.” Therefore since confidence influences the learning of mathematics and in turn learning is influenced by experience it is clear that experience does influence confidence. I would therefore suggest that the more experienced one becomes in mathematical procedures and techniques the more your

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\(^5\) PISA (Programme for International Student Assessment) is a collaborative effort among member countries of the Organisation for Economic Co-operation and Development (OECD) – this program is designed to regularly assess the achievement of 15-year-olds in reading, mathematical and scientific literacy using a common international test.

\(^6\) The discovery method of teaching was devised by Clute for her study. In this method the focus is on the teacher interacting with students to develop subject matter concepts from which the students then “discover” the answer.
confidence will be enhanced. An important next question then, is how does one gain experience in mathematics?

**The influence of Practice**

Bransford et al. (1999) use chess to provide an answer to the above question. They argue that it is estimated that world-class chess masters require from 50,000 to 100,000 hours of practice to reach that level of expertise. Much of the practice time involves the development of pattern recognition skills that support the fluent identification of meaningful patterns of information plus knowledge of their implications for future outcomes. Bransford et al. therefore quote Singley and Anderson to make the point that in all domains of learning, the development of expertise occurs only with major investments of time, and the amount of time it takes to learn material is roughly proportional to the amount of material being learned. It is clear therefore that in order to gain experience one has to do extensive practice.

**Negotiating the learning process**

Based on the above argument the following is our view as to some of the things that contribute towards making a student successful in the study of mathematics. First the teacher has to endeavor to create an atmosphere in the classroom that students find non-threatening. This can be done by using some of the suggestions of the students in the Burton (2004) study, for example creating an atmosphere where learners are not afraid of making mistakes. In order to become confident, the student needs to practice what he/she has been taught. This has to be done by the student on his/her own. What this also requires is a commitment on the part of the student which requires the student to have a thirst for this kind of knowledge. In other words, there must be another reason besides studying for tests or exams to master the required concepts in mathematics. The student must have an emotional connection with the knowledge i.e. a hunger for knowledge for knowledge’s sake. This then becomes a cycle i.e. a student is extended beyond his/her knowledge then he/she consolidates this by practicing and hence becomes more confident as he/she masters the subject matter. This confidence therefore is fuelled by being successful in attempting the subject matter and hence building more experience.

**References**


Proof without words of area of a rhombus

Submitted by Marcus Bizony

\[ Area = \frac{1}{2} \times (\text{product of diagonals}) \]