Storing the information into Long Term Memory and Its impacts on Learning Mathematics

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Abstract

Memory obviously plays an important role in knowledge retention. In particular, when learning mathematics students claim that much of what is taught in classrooms is soon forgotten and learning mathematics is difficult or not interesting. Neuroscience, through its study on long term memory, has tried to identify why these phenomena occur. Then some possible solutions are suggested. Understanding the processes of memory storage including acquisition, consolidation, recoding, storing and retrieval helps teachers to efficiently plan for effective learning activities. Therefore, this paper outlines the potential implication of long term memory to mathematics learning as well as suggests some learning strategies that might solve students' and teachers' problem in learning mathematics.

Keywords: Neuroscience, Short term memory, Long term memory, Mathematics Education

Introduction

Mathematics is important for success in school, but learning mathematics can be a difficult task for students. Efforts to improve student learning of mathematics has led to reform efforts in curriculum and instruction over the past decade (Li & Li, 2003). As the improvement of mathematics learning is an extremely complex activity that requires coordinated effort from multiple resources, good research support is very important, in particular, studies based on memory should help lay a foundation for developing effective learning. It is common belief in educational contexts that the knowledge acquired during the learning process at school is rapidly lost once the class or school is over. Most students claim that they can remember only a little of the knowledge which they acquired in previous months and sometime even completely forgetting it. Consequently, scientists have become more responsive to the solutions to address the needs of educators whose memory related concerns pertain to the maintenance of knowledge (Bahrick, 2000). Some scientists claim that information in memory never disappears, but is reduced frequently and made less accessible (Baddeley, 2004). Previous research on memory has suggested that the types of learning scheduled during acquisition and the nature of acquiring knowledge are partly affected to the maintenance of knowledge existence over longer periods and the acquired knowledge can be presented schematically (Cohen & Stanhope, 1992). Another study reported that learning strategies are important to promote long-lasting retention of knowledge (Rohrer & Pashler, 2007). Therefore, the purpose of this paper is to review and analyze how long term memory works and affects a student's mathematics learning. The discussion is divided into two parts: (a) an outline of long term memory including how the information can be stored and the types of information stored that may be involved in the learning process; (b) discussion on how this potentially impacts learning mathematics. This paper finds that learning mathematics might improve by applying learning strategies such as repetition, practice or rehearsal which then can transform into a new learning knowledge for long term memory.

An outline of long term memory

Memory and learning are two parts that cannot be separated. Moreover, memory is essential in the learning process. Memory not only plays an important role in the learning process but it is also a product of learning. Saosa (2002, p. 35) points out that "learning is the process by which new knowledge and skills are acquired; memory is the process where knowledge and skills are retained for the future". In short, learning is always expected to have or remember the information in the long term. Considering this, therefore, educators want to make sure that most learning results are formed in long term memory and can be retrieved in the future.

Scientists have conducted studies on memory as a response to this solution so that can be found to address the needs of educators. The study conducted by Robert Stahl in 1985 that reported by Sausa (2000) revealed that the brain processes the information by following some procedures. The information is detected by the five senses from the environment. Then the neurons fire the specific sensory pathways when all sensory stimuli enter the brain as a stream of electrical impulses. All incoming sensory information is sent first to the thalamus then in just a millisecond, uses the individual's past experiences to determine whether the information is important. Then the sensory register allows them to drop out of the processing system. Next, the information is passed to short term memory through the immediate memory and working memory. If something else is not done with the information that is stored in the working memory, it is likely to be deleted. Due to the limitation of the working memory, the information should be moved to long term storage to be recalled or retrieved in the future (Sausa, 2000). This study has given a new insight for educational practitioners in terms of understanding how and why learning occurs. Furthermore, this finding indicates the need for another study on how to store the information in long term memory. Therefore, it is necessary for educators to know about long term memory and its processes as it is essential for learning.

Historically, the modal model of memory postulated the separation of short term memory (STM) and long term memory (LTM). Information that is processed in the STM is eventually transferred to LTM site (Freedman & Martin, 2001). It is widely accepted that learning first involves generating new memories and then consolidating them into long term memory. Thus, Bahrick (2000) argues that learning is generally viewed as a single continuous process with two sequential stages; (a) acquisition; and (b) consolidation. As Greenfield (2000, p.81) defines "long term memory is the ability to deliberately recall snippets of information or experience from the past". This means that the information that is stored in LTM should be called in the future as past knowledge. It can last for days, weeks or years. Based on the type of information stored, Gazzaniga, et al. (2000) divide long term memory into two categories: declarative (explicit) memory and non-declarative (implicit) memory. These findings are derived from the studies of brain damaged and victims suffering amnesia. The findings show that they may still be perfectly capable of doing a procedural activity such as riding a bicycle without remembering the word 'bicycle' or when they learn to ride (declarative). This indicates that declarative and non-declarative memories are stored differently (Sausa, 2000).

Gazzaniga, et al. (2000) further classify the declarative memory into 'episodic memory', which refers to the memory of events in people's life history, and 'semantic memory', the knowledge of the facts and data that may not relate to any event. Squire and Kandel (2000) argue that the ways that we encode, store, retrieve and forget information provide clues to what declarative memory is and these key features of declarative memory play an important role in storing information in long term memory. The process of these activities in the brain has enriched educators' understanding of how learning happens. For instance, Baddeley (2004) argues that the ability of retrieving information depends on the way in which new information is processed. Therefore, a teacher could use a teaching method that adopts this concept.

Non-declarative memory, on other hand, is divided into four types: procedural, perceptual representation system, classical conditioning and non-associative (habituation and sensitization) (Gazzaniga et al., 2000). These kinds of memories are acquired implicitly when people are doing an activity. Then the information from non-declarative memories is used as previous knowledge that enables people to perform a task without requiring conscious attention. For example, habituation to the environment such as reading and discriminating colors. Sausa (2000) points out that such habituation allows the brain to screen out unimportant stimuli, so the brain can focus on that particular matter. This enables people to do an activity easily.

Another study mentions that emotions are part of the non-declarative memories (Squire & Kandel; 2000, Sausa; 2000, Blakemore & Frith; 2006). Sausa (2000) argues that emotions are unconscious responses that people feel towards what they learn. A powerful emotional experience can cause a strong and long-lasting memory of an event or experience such as remembering what people were doing when the 2004 tsunami happened. Blakemore and Frith (2006) point out that emotional events are better remember than neutral events. This means that the learning process may be effective when emotions are created (Greenfield, 2000). This is because emotions actually change the structure of the neurons, so the information can last a lifetime (Squire & Kandel, 2000). Emotion can also affect the acquisition of a new learning either positively or negatively. It depends on what people feel when an event takes place. In short, Squire and Kandel (1998) state that emotion can influence what and how much the information is remembered.

The study of long term memory and its formation from short term memory has held since the 1880s. The study of Ebbinghaus's in Squire and Kandel (1998) confirms that rehearsal is a critical component in the transference of information from STM to LTM. In the learning practice, it is commonly known that repetition makes perfect. The study on LTM has found that there are two kinds of rehearsal that are essential in storing information in LTM. Schwartz and Reisberg (1991) argue that 'maintenance rehearsal' and 'elaborative rehearsal' are the activities which involve active steps that serve to establish information in LTM. Elaborative rehearsal involves thinking about what the information means and how the information is related to each other or other things in the surrounding, so that the information will be stored in LTM by doing elaborative rehearsal (Sausa, 2000). Maintenance rehearsal, in contrast, accomplishes nothing beyond what its name implies. It just repeats the information over and over, presumably with no thought about what the information means. Schwartz and Reisberg (1991) argue that maintenance rehearsal has no benefits from long term remembering. These findings have informed educators of what kind of rehearsal might be effective in helping students to store knowledge into long term storage.

In terms of understanding the brain and cognitive systems that support academic learning and mathematics learning, it is important then to look at how memory is stored in the brain and which parts of the brain are involved in memory storage. As some scientists believe that different regions are involved in storing different kinds of memory the hippocampus, thalamus, medial temporal lobe and prefrontal cortex play important roles in memory (Greenfield; 2000, Gazzanigga et al., 2000, Square & Kandel, 1998). These findings are confirmed from experiments on animals and patients with brain damage such as amnesia, epilepsy and Alzheimer. It is found that the medial temporal lobe system is essential for the long term storage of declarative memory (Squire & Kandel, 1998). However, Simon and Spear (2003) found that interaction between the pre frontal cortex and medial temporal lobe are vital for successful memory. These regions contribute in different ways to the process of the encoding storage and retrieval. During encoding, the essence of interaction between the prefrontal cortex and medial temporal lobe provide discrete and elaborated representations that are amenable to long term storage (Simon & Spear, 2003). As there are many studies on this, this paper offers only a brief review on the sections of the brain which involve memory as it is noted that these findings have shown the way people learn and store memory is the same. However, the thing that makes people different or individually different is the ability to move the information from declarative memory to non-declarative procedural learning (Gazzaniga et al., 2000). This argument is also supported by Ruchkin, et al. (2003) who reported that there are individuals with long term memory deficits but not short term memory deficits and individuals with short term memory deficits but not long term memory deficits. Therefore, it is easy to find that some students may be able to switch the information from STL to LTM more rapidly and with less effort while others may struggle to make the switch at all.

Impact on mathematic learning

As discussion in the above section suggest, some implications for learning mathematics can be drawn from the past research findings. Obviously, the information about declarative memory and its features have illuminated mathematics education practices. In learning mathematics students are mainly taught through declarative memory, especially semantic memory when students must learn fundamental concepts and procedures (OECD, 2000). These mathematical theories that a learner gets during the lesson should be saved for long term storage. It is known in mathematics education that there is connection among mathematical concepts. One concept is used to prove other concepts, so new theories can be built. This indicates that new mathematics knowledge should be remembered strongly because it will act as past knowledge, which always influences new learning in the future (Sausa, 2000). While these newly formed memories are fragile and easily disrupted, it suggests that this new mathematics knowledge is required to be used for consolidating a permanent memory trace. Therefore, mathematics teachers should use effective methods such as managing good exercise models and time, so that new mathematical knowledge can be stored for long term and can be retrieved.

It is also suggested that during mathematics lessons students are also taught non-declarative memory. Non-declarative memory is captured implicitly when students learn about semantic memory. Squire and Kandel (1998) found that declarative and non-declarative memory can be produced from the same experience. The implication that can be drawn from this is mathematics teachers could plan one mathematics lesson that includes both types of information. For example, in teaching equations, the students will learn procedural information implicitly when the teacher introduces and explains the topic. In particular, the steps in proving an equation formula that are commonly done in learning mathematics.

This means students gain two kinds of knowledge: the equation concept and the procedure in solving equation problems, at the same time which can then form robust memory. An initial consequence seems to be more effective and it is believed that the student might have a strong knowledge stored in long term retention.

As neuroscientists found that powerful emotion can cause strong and long lasting memory, the implication for mathematics education is to create a leaning activity with fun. Most students claim that they do not like mathematics. Students argue that mathematics class is boring because math educators are less creative in designing learning activities in the classroom. The National Council of Teachers of Mathematics (NCTM) reported that for more than a decade teachers have applied similar methods to teach mathematics. These boring teaching methods result in students not developing their interests in mathematics. This happens because teachers do not realize how important it is to create fun activities to affect student emotions beneficial for forming strong memory. In addition, having a strong memory does not guarantee that students will later retrieve the memory successfully. Emotions still play an important role here. Some studies found that the students tended to remember negative experiences when they are induced to a sad mood and induction to a happy mood resulted in a bias toward remembering positive experiences (Squire & Kandel, 1998). This indicates that retrieval is most successful when the classroom activities are interesting and students build positive attitudes toward mathematics. For instance, learning mathematics through games.

Apart from the importance of creating these interesting activities, the most important thing that teachers should do is to assist students in becoming emotionally competent. Blakemore and Frith (2006) argue that an optimal learning occurs when students know how to control and to inhabit their emotional reaction to the learning activities. This is especially essential for learning mathematics as students perceive mathematics as a difficult task. Without self-control of emotional reaction, this assumption can led stress among students. Therefore, understanding students' attitudes toward mathematics is firstly suggested. This will help teachers in planning an effective learning activity that sparks students' positive emotion. It is known that student can build their positive emotions toward mathematics by knowing how it is applicable in everyday life. This suggests that teacher need to find ways to show the relevance of mathematical topics to everyday application, so that students take an interest in the topic. As a result, this positive emotion can form strong memory of student mathematics knowledge.

Another possibility that may be derived from the research findings on memory studies is the importance of repetition during the learning process. This is because repetition is required to convert information from STM to LTM. As it is known that forgetting is an investable weakening of memories, learning mathematics without repetition will ensure that students have nothing after the learning process is over. Mathematics topics are delivered through a lot of formulas or theories. This makes it difficult for students to remember. The teacher should make sure that all information is repeated several times, so that retention happens; an expectation as the result of learning, can be formed. An example of repetition when learning mathematics is to reinforce the topic by summarizing at the end of a class session, asking questions or students' opinions about the topic and giving the students homework. Consequently, the student will remember that knowledge as it has been repeated frequently.

Using practice effectively is another implication which is derived from long term memory studies. Practice allows the learner to use the newly learned mathematical skill in new situations with sufficient accuracy so that it will be correctly remembered. This method is commonly applied in mathematics teaching. However, it is not used properly. The study on long term memory has exemplified how the teacher could apply it correctly. In practice, teachers should monitor their students' early practice to ensure that it is accurate. Teachers have to also provide timely feedback and correction. Saosa (2000) suggests effective practice should have the criteria such as amount of material to practice, amount of time to practice, frequency of practice and accuracy of practice. Based on these guides, this practice is applicable for all mathematical knowledge. As a result, student might have strong retention.

The information from amnesic people or other brain damaged individuals have informed educators about learning difficulty. It is found that the hippocampal region, a critical part for consolidation of information in the long term memory, does not work properly in these people's brains. Gazzaniga, et al. (2000) found that people with such damage were still able to acquire the new knowledge even though they could not remember the source of knowledge. They argue that amnesics can not form new episodic memories for newly learned material but can learn procedural information. This means that amnesic people with lost episodic learning can improve their performance by repeating the task. By understanding these finding mathematics teachers may offer special treatment for students who have that problem. As the suggestion from Gazzaniga et al., (2000) suggests, therefore, more repetitions of material will enhance mathematics learning for students with difficulties.

Conclusion

To sum up the discussion, this paper has outlined and analysed some educational implications of long term memory and its features. The study on long term memory has established a number of ideas which have indicated some directions for learning mathematics. It not only provides the information for mathematics education but also justifies what has been done in those areas. The information, such as the ways information is stored in the brain, declarative and non-declarative memory, learning difficulties and individual differences have advanced mathematics educators' understanding, which offers some helpful answers to pedagogical problems, especially in making sure that mathematical knowledge is stored for the long term. As a result, educators can improve the quality of mathematics learning and teaching. Long term memory implications for learning mathematics are significant. The findings have led to reform efforts in curriculum and instruction of mathematics education especially as a new resource for the improvement of learning mathematics. Therefore, further educational research is suggested as it is noted that there is a limitation of this paper as it discusses only some parts of the memory while successful learning is not only affected by memory but also by other aspects such as motivation, emotion and learning environment.

References

Baddeley, A. (2004). *Your Memory: A user's guide*, London: Carlton Books.

Bahrick, H. P. (2000). *Long Term Maintenance of Knowledge*, the Oxford handbook of Memory, Eds (Endel Tulving and Fergus, M, Craik), London: Oxford University Press.

Blakemore, S-J. & Frith, U. (2006) *The Learning Brain: Lessons for Education*. USA, UK, Aust: Blackwell Publishing.

Cohen, G.. & Stanhope, N. (1992) 'Very Long Term Memory for knowledge Acquired at School and University', *Applied Cognitive Psychology* 6: 476-482.

Engelbrech, J., Harding, A. & Preez, J, U. (2007) 'Long term retention of mathematical knowledge and skills with engineering student', *European Journal of Engineering Education* 32 (6): 735-744.

Freedman, M. L., & Martin, R, C. (2001) 'Dissociable components of short term memory and their relation to long term learning', *Cognitive Neuropsychology* 18 (3): 193-226.

Gazzaniga, M. S, Ivry, R, B. & Mangun, G. R. (2000). *Cognitive Neuroscience: The Biology of The mind*, New York and London: W.W Norton & Company.

Greenfield, S. (2000) *Brain Story: Unlocking our inner world of emotion, memories, ideas and desire*, London: BBC.

Li, X., & Li, Y. (2003) 'Research on Students' Misconception to Improve Teaching and Learning in School Mathematics and Science, *Research in Brief* 108 (1): 4-7.

OECD, (2002) *Understanding the Brain toward a New learning Science, Organization For Economic Co-operation and Development*, Paris.

Rohrer, D., & Pashler, D. (2007) 'Increasing retention without increasing study time', *Association for Psychology Science* 16 (4):183-186.

Ruchkin, D. S., Grafmen, J., Cameron, K., & Berndt, R, S. (2003) 'Working Memory Retention System; A state of Activated Long Term Memory', *Behavioral and Brain Sciences* 26:709-777.

Schwartz, B., and Reisberg, D. (1991). *An Alternative Approach to memory: Level of Processing*, Leaning & Memory, New York: W.W Norton and Company.

Simon, S., J. & Spiers, H. J. (2003) 'Prefrontal and Medial Temporal Lobe interaction in long term memory', *Nature Reviews: Neuroscience* 4: 637-648.

Sousa, D. A. (2000). *How the Brain Learns*, (2nd edition), Corwin Press: Thousand Oaks: California.

Squire, L. R., & Kandel, E. R. (2000). *Memory from mind to Molecules*, Scientific American Library, a division of HPHLP: New York.