

## Proposed Learning Agent for Reducing Different Mathematics Anxiety Levels

Huai-Swan Khoo, Choo-Kim Tan\*, and Wooi-Ping Cheah

Faculty of Information Science and Technology, Multimedia University, 75450 Melaka, Malaysia

**Correspondence Author:** Choo-Kim Tan. Faculty of Information Science and Technology, Multimedia University, 75450 Melaka, Malaysia  
E-mail: cktan@mmu.edu.my

Received date: April 2018, Accepted date: 28 July 2018, Online date: 5 August 2018

**Copyright:** © 2018 Khoo et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### Abstract

In Science, Technology, Engineering and Mathematics (STEM), Mathematics is the fundamental core of all three subjects of Science, Technology, and Engineering in attaining precision. Hence, Mathematics is known to be the primary gateway to STEM. However, there is a phenomenon known as mathematics anxiety which has caused the drop-in performance of students in Mathematics and caused them to opt out the choices in pursuing STEM majors and careers. With the advanced development of technology, animated learning agent can be used to provide anxiety treatment messages to students when they are learning mathematics in computer-based virtual learning environment. The purpose of this study is to propose a framework of an animated learning agent which will provide anxiety treatment messages of the appropriate type and amount of anxiety treatment messages to students based on their prior mathematics anxiety levels and effectively alleviate their mathematics anxiety. This is because students with different levels of prior mathematics anxiety level will react differently to different type of messages and number of messages provided. It is hoped that this study will be significant for researchers, educators and system developers to identify the type and amount of anxiety treatment messages that should be provided on effectively alleviate students' mathematics anxiety.

**Keywords:** Learning Agent, Mathematics Anxiety.

### INTRODUCTION

In this globalization era where science and technology play an important role in our daily life and nation's economy. Science, Technology, Engineering and Mathematics (STEM) education has been an important agenda to many countries. Many efforts are in place on improving STEM education and specifically in Mathematics that is known to be the fundamental core of all three subjects of Science, Technology, and Engineering in attaining precision. Mathematics is known to be the primary gateway to STEM fields. According to international assessment TIMSS 2015 and PISA 2015, Malaysia's performance in mathematics is not satisfying and has brought about the interest among academics, politicians, and stakeholders. As shown in Table 1, in TIMSS 2015, the sixth study results showed that there is a trend of downward in performance of Malaysia since 1999 when Malaysia first participated. In 1999, Malaysia was ranked 16th had dropped to 26th in 2011. The achievement is then improved with an increase of 25 points from 2011 and made it to the rank of 18th (Mullis, I. V. et al., 2012). Table 2 showed that since Malaysia first participated in PISA in 2009, the achievement in mathematics score are increasing gradually but is still below the global average score. The efforts made are reported to be focused merely on innovating the teaching and learning of mathematics overlooking the important role of mathematics anxiety plays in mathematics success and STEM engagement. Mathematics anxiety is a psychological factor that affects mathematics achievement and eventually causes students to lose interest in pursuing STEM majors and careers (Zakaria et al., 2012). Recently, research in psychology, education, and neuroscience on mathematics anxiety found that collaboration of psychology and education with technology has unveiled effective techniques on reducing mathematics anxiety and improve mathematics performance (Beilock & Maloney, 2015).

**Table 1:** Ranking of Malaysia in TIMSS

	1999	2003	2007	2011	2015
<b>Scores</b>	519	508	474	440	465
<b>Rank in TIMSS</b>	16 <sup>th</sup>	10 <sup>th</sup>	20 <sup>th</sup>	26 <sup>th</sup>	18 <sup>th</sup>

**Table 2:** Global Average Score and Ranking of Malaysia in PISA

	2009	2012	2015
<b>Mathematics</b>	404	421	446
<b>Global Average Score</b>	496	494	490

### LITERATURE REVIEW

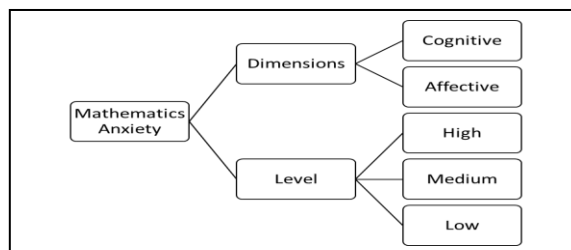
#### Mathematics Anxiety

Mathematics anxiety is first discovered in the late 1950s by Dreger and Aiken and originally named as "emotional reactions syndrome shown to mathematics and arithmetic" (Dreger, R. M., & Aiken, 1957). Since then it is studied as a new concept where researchers began to study the concept of students capable of success

in mathematics are not related intelligence but hindrance of mental. Tobias has stated that it was not the lack of ability but is the anxiety that affect an individual's mathematics performance (Tobias, 1993). The most commonly used definition of mathematics anxiety is by Richardson and Suinn. They defined mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972).

Mathematics anxiety consists of two dimensions which are the affective dimension and cognitive dimension, similar to the findings of study in the area of test anxiety. The affective dimension refers to nervousness and tension in testing situations and respective autonomic reactions, labelled as "emotionality" while cognitive dimension refers to concern about one's performance and the consequences of failure, labelled as "worry" (Liebert & Morris, 1967). Regarding to this, Im and Shen had described affective mathematics anxiety as the feelings of nervousness, tension and fear on mathematics while cognitive mathematics anxiety as the negative expectancy of doing well in mathematics (Im, 2012; Shen, 2010). Besides the dual dimension of mathematics anxiety, mathematics anxiety is also being grouped into three different levels which are low, medium, and high (Wei, 2010). Research had found that high performing students have low mathematics anxiety whereas low performing students tend to have higher level of mathematics anxiety.

Figure 1: Mathematics Anxiety's Dimension and Level



### Intervention

In recent years, with the thorough understanding of the antecedents of mathematics anxiety and how it may affect an individual daily life and on students' mathematics achievement, many interventions are being designed to help reducing mathematics anxiety in traditional classroom settings. Hadfield and McNeil had divided the causes of mathematics anxiety into three areas: environmental, intellectual and personality factors (Hadfield, Oakley D. & McNeil, 1994). These different factors had led to the mismatched teaching-learning styles that caused student to self-doubt and lost and most students tends to be reluctance to ask questions as they feel ashamed to ask in front of their classmates. Hembree had categorized the interventions into three different groups which is classroom intervention, behavioural, and cognitive. From his study, the result showed that classroom intervention does not have any effect on alleviating mathematics anxiety while cognitive restructuring has moderate effects and intervention of type behavioural had strong effects in alleviating mathematics anxiety. Over and above, Hembree also found that the combination of both treatment of type cognitive and behavioural, the effects on mathematics was increased more as compared to behavioural which has strong effect in alleviating mathematics anxiety. This showed that the mixed use of two types of interventions effectively helped to alleviate both affective and cognitive dimension of mathematics anxiety (Hembree, 1990). All the interventions proposed were to help students to generate positive feelings towards mathematics. With the advanced technology nowadays, researchers and educators had turned their attentions on using technology to help alleviating students' mathematics anxiety by providing a good learning experience in computer-based learning environment. Several studies are being conducted on simulating the proposed interventions in computer-based learning environment by using animated learning agent. Shen and Im had carried their study on alleviating different dimension of mathematics anxiety using learning agent (Im, 2012; Shen, 2010).

### Animated Learning Agent

Animated learning agent is a life-like character used as cognition tools to support student's learning by interacting with them. It provides sophisticated, real-time problem solving advice with strong visual appeal that make learning more engaging and affective (Ahmed, 2005). Animated learning agents were being built based on the research areas of knowledge-based learning environments and animated interface agents. Knowledge-based learning environments are the virtual learning environments that provide personalized learning structures based on students' preferences to adapt their needs by using artificial intelligence. While animated interface agents are the visualized animated character which interact with students in the virtual learning environment (Johnson & Lester, 2016). By integrating a life-like character in the computer-based learning environment, a social layer is added to the interaction between user and the agent (Kim & Baylor, 2007). This has social interaction between a computer and student will enhance the learning of student in mathematics according to Vygotsky theory which stated learning acquire a social context (Vygotsky, 1978). Besides, an affective learning agent who have the features of gestures, body movements, and facial expressions are conveying different modal sensorimotor information to learners. Learning agents may take the role as expert (instructor) which is knowledgeable, motivator (peer) which is supportive and mentor which is both knowledgeable and supportive (Im, 2012; Smith et al., 1999). These roles are known as each of these role carried out different function in supporting students in learning in the computer-based learning environment. The expert agent provides information; the motivator which is supportive provides encouragement and support to students, and mentor who provide both information and encouragement (Smith et al., 1999). Studies carried out by researchers also showed that mentor agent led the highest improved in information acquisition and self-efficacy than expert agent which improved only information acquisition while motivation agent improved only self-efficacy (Kim & Baylor, 2016).

### Proposed Framework

Based on the literature review on learning agent and mathematics in general, learning agents are being used on different areas of education such as medicine, programming, internet packet routing, language and plants. Most of these studies focus on the effects of using learning agent in learning based on the interaction between students with various features and characters of the learning agent. With all the research carried out, researchers had overlooked on the impact that might be brought out from the type of messages and the amount of messages that provided by learning agent to students with different preferences and different prior anxiety levels. Figure 2 illustrates the proposed framework for learning agent to be designed in this study. The system will first request students to perform the pre-test on Mathematics Anxiety Rating Scale (MARS). The results from MARS will then determine their prior mathematics anxiety levels. Prior mathematics anxiety levels in this study will be divided into three levels: high, medium, and low mathematics anxiety levels. Based on the results of the MARS, students will be assigned respectively to the system with learning agent which are specifically designed for students of different mathematics anxiety level. As proposed in Tan et al. (2015)'s study, the learning agent that is designed will provide the appropriate type and amount of messages based on students' prior mathematics anxiety levels. High mathematics anxiety level students will be assigned to the learning agent who provides high number of anxiety treatment messages. Medium mathematics anxiety level students will be assigned to the learning agent that will provide medium amount of anxiety treatment messages. Low mathematics anxiety level students will be assigned to learning agent that will provide low number of anxiety treatment messages (Tan et al., 2015). Hence, this study will be based on their proposal to design the system in such a way that each prior mathematics anxiety level of students will be assigned to specifically designed learning agent respectively.

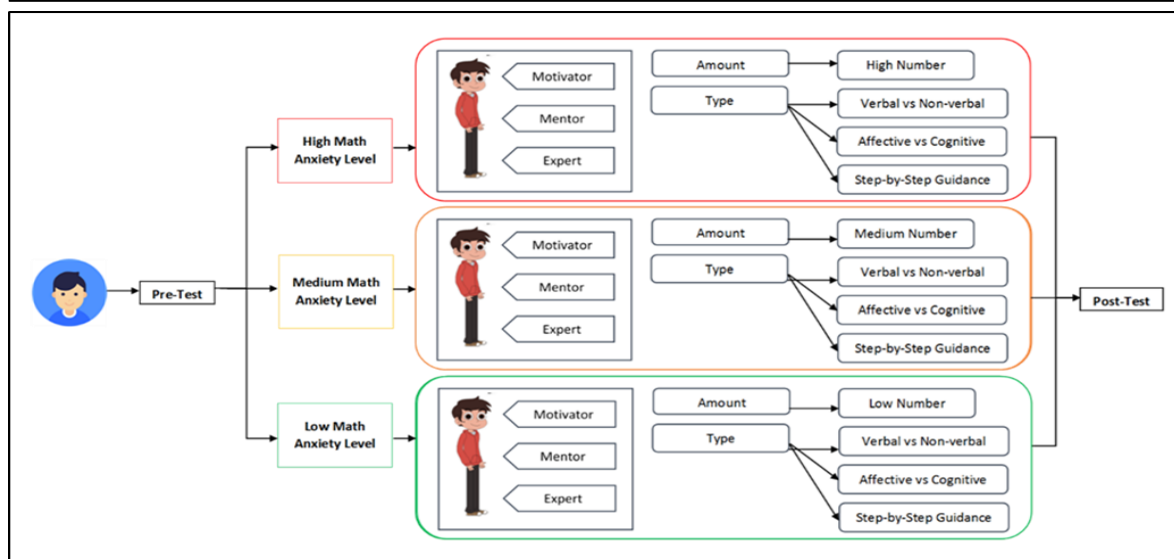


Figure 2: Proposed Framework

The interaction between learning agent and students is carried out through verbal or non-verbal messages. Verbal or non-verbal messages are to be determined based on the preferences of different level of prior mathematics anxiety level. Type of anxiety treatment messages are also being differentiate for alleviating both dimension of mathematics anxiety. The type of anxiety treatment messages which may differ among students of different level of prior mathematics anxiety are to be determined through data collection in post-experiment. They may prefer only one type of messages for different dimension of mathematics anxiety or combination of both dimensions of anxiety treatment messages provided by either verbal or non-verbal messages.

#### Learning Agent

In designing of learning agent, there are features such as the role, the voices, and the animation of agent will be taken into account. In terms of the role of agent, there will be the expert (instructor) which is knowledgeable, motivator (peer) which is supportive, and mentor which is both knowledgeable and supportive.

The voices and the animation of agent determine the type of messages to be provided by the learning agent which is the verbal (voice) and non-verbal (gestures, facial expression) messages. The voice of the agent is the key communication channels for human information transfer. As research found that voice give better result on the test of retention and transfer (Moreno et al., 2001). So the voice used must be in a more interactive human voice rather than a machine voice. As there are different learners such as learners of auditory, visual and tactile. Hence, the agent of the proposed framework will provide messages not just in text but as well in voice that speak out the messages.

The animation of a learning agent which includes gestures, facial expressions, and body movement that are to be appropriately executed as they are interacting with student will improved learning and raise motivation of students in learning.

#### Anxiety Treatment Messages

The type of messages provided can be categorised into different ways of learning agent conveying the messages to students and also being differentiate into two dimension of affective dimension and cognitive dimension of mathematics anxiety. Different type of messages will cause student of different prior mathematics anxiety level to react differently.

In this proposed framework, the anxiety treatment messages will be messages designed specifically for cognitive dimension and affective dimension of mathematics anxiety, and also the step-by-step guidance messages which guide students throughout the session in the system. The design of anxiety treatment on both affective dimension and cognitive dimension of mathematics anxiety will be adopted from Shen (2010) and Im (2012)'s study. Similar to the study of Hembree (1990), Shen (2010) and Im (2012) had proposed and focused on alleviating both dimension of mathematics anxiety by using learning agent to provide anxiety treatment messages for both dimensions namely emotional support and cognitive motivational messages.

Emotional support alleviates affective domain of mathematics anxiety which it helps to relieve the feelings of dreads and nervousness of students towards mathematics. It is designed based on COPE's model (Carver et al., 1989; Shen, 2010) Cognitive motivational messages alleviate cognitive dimension of mathematics by increasing motivation of students in studying mathematics. The cognitive motivational messages are designed based on Keller's ARCS motivational model (Shen, 2010; Visser & Keller, 1990). ARCS model proposed by Visser and Keller (1990) consists of four factors that are believed to have influence on learner motivation: Attention, Relevance, Confidence, and Satisfaction (ARCS). However, from the study of Shen, cognitive motivational messages showed no effect on alleviating math anxiety, motivation, and math learning (Shen, 2010). In the opinion of Im, this is due to the possibility of the overlapping nature of emotional support and cognitive motivational messages. To overcome this problem, Im had specifically added incremental ability belief into cognitive motivational messages to reduce student's cognitive dimension of math anxiety to resolve in Shen study (Im, 2012).

Step-by-step guidance messages will be included as study showed that student of low mathematics anxiety preferred step-by-step guidance. They found that these messages helped them a lot in understanding the mathematical concept. This can prevent students to increase their anxiety level when they faced difficulty in solving mathematics problem (Yeo, 2016).

These messages will be provided in the form of verbal and non-verbal form respectively. When students answer the exercise question correctly, the learning agent will give feedback to students with messages in verbal forms or gestures of assurance through non-verbal form such as nodding head. When the student answers the question wrongly, the learning agent will feedback with messages in verbal forms and in non-verbal forms by showing sad faces.

#### Amount of Messages

The amount of messages provided will affect the effectiveness of learning agent in helping student learning and alleviating anxiety. As student of different level of prior mathematics anxiety level reacts differently accordingly towards the type of anxiety treatment messages provided and the amount of anxiety treatment messages provided. With regards to the amount of messages provided, too little messages that are provided might not help students in alleviating students' mathematics anxiety level while too much messages that are provided might cause students' anxiety level to increase. Hence, suitable type of messages and an appropriate amount of messages that are to be provided by learning agent should be study to carry out the maximum function of the anxiety treatment messages provided by the learning agent.

Hence this study is to determine the effectiveness of learning agent in alleviating different level of students' prior mathematics anxiety by assigning students with different mathematics anxiety level to different system that is designed specifically for different level of mathematics anxiety.

Mixed-method approach will be used in the study, which involves qualitative and quantitative methods for collecting the data. Quantitative data is collected on the performance, mathematics anxiety, and the perceptions of learning agent and anxiety treatment messages. Qualitative data is to be collected through interviews and journals to provide insights on the perceptions of agent and anxiety treatment messages.

Convenient sampling is used with 100 participants of undergraduates who are taking mathematics subjects at a private university in Malaysia as the existing groups are the group assigned to the lecturer who agreed that the study is to be carried on her students. The sample will be consisted of both female and male with different ethnics of Malay, Chinese, Indian, and others.

Mathematics Anxiety Rating Scale (MARS) by Richardson and Suinn is used to measure students' mathematics anxiety level. It is the most frequent used instruments which is being used in more than 9 studies (Suinn & Winston, 2003). MARS consists of 98 items with 5-point Likert scale relating to the feeling of anxious in dealing with mathematics problem in everyday situations. Most of the other scales are also adaptation of MARS (Arslan et al., 2015). Mathematics Achievement Test for collecting students' performance is designed and validated by experienced lecturers. While the instruments to examine students' perceptions of learning agent and anxiety treatment messages will be adopted from other research and with some self-designed questions.

The study will be carried out in three stages: pre-experiment, experiment, and post-experiment on a control group and an experimental group. In pre-experiment, all participants are given the pre-test on MARS to measure their prior mathematics anxiety level before they are being assigned to the learning agent that is designed to assist students of different mathematics anxiety level in learning mathematics. Students' mathematics achievement of students will also be tested in pre-test to measure the performance of students before they learn with learning agent. In the experiment stages, the participants of experimental group will learn mathematics with learning agent being assigned and keep a journal throughout the process while control group will learn mathematics without the presence of learning agent. As in the post-experiment stage, post-test on MARS will be given to experimental group who learnt with learning agent and control group who learnt without learning agent to measure their mathematics anxiety level. Mathematics achievement of students will also be tested to determine whether there is an increase in performance after students learn mathematics with learning agent. After the three stages of experiment, the data collected will be analysed using SPSS. Students' mathematics achievement will also be tested to determine whether there is an increase in performance after students learn mathematics with learning agent. It is also being carried out for the purpose of ensuring there is no difference in the prior knowledge of selected topics among participants. After the three stages of experiment, the data collected will be analysed using SPSS.

## 5. CONCLUSION

In conclusion, this study is aimed to reduce students' mathematics anxiety in order to improve their achievement. A different approach of using learning agent is proposed to effectively alleviate students' mathematics anxiety by taking into account of students' prior mathematics anxiety level and provide the appropriate amount and type of messages. This is because from previous studies, different amount and type of anxiety treatment messages will affect students of different level of mathematics anxiety differently. It is expected that the proposed framework will bring greater impact in reducing mathematics anxiety as compared to previous study. This will help educators, researchers and system developers in enhancing the existing learning agent in helping student in their learning process.

## REFERENCES AND NOTES

- Ahmed, K., 2005. Animated pedagogical agents in web-based intelligent learning environment. Retrieved from <http://citeseerx.ist.psu.edu/> on 5th February 2016
- Arslan, C., Deringol-Karatas, Y., Yavuz, G., & Erbay, H. N., 2015. Analysis of Research on Mathematics Anxiety in Selected Journals (2000 – 2013). In *Procedia - Social and Behavioral Sciences*, 177: 118–121.
- Beilock, S. L., & Maloney, E. A., 2015. Math anxiety: a factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences*, 2(1): 4–12.
- Carver, C. S., Scheier, M. F., & Weintraub, J. K., 1989. Assessing coping strategies: A theoretically based approach. *Journal of Personality and Social Psychology*, 56(2): 267.
- Dreger, R. M., & Aiken, L. R., 1957. The identification of number anxiety in a college population. *Journal of Educational Psychology*, 48(6): 344.
- Hadfield, Oakley D. & McNeil, K., 1994. The relationship between Myers-Briggs personality type and mathematics anxiety among preservice elementary teachers. *Journal of Instructional Psychology*, 21(4): 375–384.
- Hembree, R., 1990. The Nature, Effects, and Relief of Mathematics Anxiety. *Journal for Research in Mathematics Education*, 21(1): 33–46.
- Im, T., 2012. Effects of Emotional Support and Cognitive Motivational Messages on Math Anxiety, Self-Efficacy, and Math Problem Solving, Ph.D. thesis, Florida State University, Tallahassee, Florida.
- Johnson, W. L., & Lester, J. C., 2016. Face-to-Face Interaction with Pedagogical Agents, Twenty Years Later. *International Journal of Artificial Intelligence in Education*, 26(1): 25–36.
- Kim, Y., & Baylor, A. L., 2007. Pedagogical Agents as Social Models to Influence Learner Attitudes. *Educational Technology*, 47(1): 23–28.
- Kim, Y., & Baylor, A. L., 2016. Research-Based Design of Pedagogical Agent Roles: A Review, Progress, and Recommendations. *International Journal of Artificial Intelligence in Education*, 26(1): 160–169.
- Liebert, R. M., & Morris, L. W., 1967. Cognitive and Emotional Components of Test Anxiety: A Distinction and Some Initial Data. *Psychological Reports*, 20(3): 975–978.
- Moreno, R., Mayer, R. E., Spire, H. A., & Lester, J. C., 2001. The Case for Social Agency in Computer-Based Teaching: Do Students Learn More Deeply When They Interact With Animated Pedagogical Agents? *Cognition and Instruction*, 19(2): 177–213.
- Mullis, I. V., M., M. O., Foy, P., & Arora, A., 2012. TIMSS 2011 international results in mathematics. International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam, 1017 BT, The Netherlands.
- Richardson, F. C., & Suinn, R. M., 1972. The mathematics anxiety rating scale: psychometric data. *Journal of Counseling Psychology*, 19(6): 551–554.
- Shen, E., 2010. The effects of agent emotional support and cognitive motivational messages on math anxiety, learning, and motivation, Ph.D. thesis, Florida State University, Tallahassee, Florida
- Smith, T., Affleck, G., Lees, B., & Branki, C., 1999. Implementing a generic framework for a web-based pedagogical agent. *Annual Australasian Society for Computers in Learning in Tertiary Education*, Brisbane, Queensland.
- Suinn, R. M., & Winston, E. H., 2003. The Mathematics Anxiety Rating Scale, A Brief Version: Psychometric Data. *Psychological Reports*, 92(1): 167–173.
- Tan, C., Yeo, W., & Lew, S., 2015. A Proposed Framework for Reducing Mathematics Anxiety Using Learning Agent. *Australian Journal of Sustainable Business and Society*, 1(2): 47–53.
- Tobias, S., 1993. *Overcoming Math Anxiety*.
- Visser, J., & Keller, J. M., 1990. The clinical use of motivational messages: an inquiry into the validity of the ARCS model of motivational design. *Instructional Science*, 19(6), 467–500.
- Vygotsky, L. S., 1978. *Mind in society: The development of higher psychological processes*. Mind in Society The Development of Higher Psychological Processes. Cambridge: Harvard University Press.
- Wei, Q., 2010. The effects of pedagogical agents on mathematics anxiety and mathematics learning. All Graduate Theses and Dissertations, Ph.D. thesis, Utah State University, Logan, Utah.
- Yeo, W., 2016. Reducing Anxiety Level in Mathematics Learning Using Pedagogical Agent, M.S. thesis, Multimedia University, Malaysia .
- Zakaria, E., Zain, N. M., Ahmad, N. A., & Erlina, A., 2012. Mathematics anxiety and achievement among secondary school students. *American Journal of Applied Sciences*, 9(11): 1828.