Innovative Classroom Strategy: Impact on Students' Mathematics Motivation, Anxiety and Achievement in Pre-University Studies

Farah Liyana Azizan, Nur Fazliana Rahim, Emmerline Shelda Siaw, Kartini Abd Ghani, and Saratha Sathasivam

***Abstract*—One aspect that influences mathematics achievement is students' mathematics motivation, which is closely related to their mathematics anxiety. This study aims to incorporate a classroom intervention strategy using a brain-based teaching approach (BBTA) with technological tools to improve students' mathematics performance in pre-university studies. BBTA was used in the classroom to increase students' mathematics interest and minimise their mathematics anxiety to increase mathematics performance. Two hundred and six (206) pre-university students were exposed to both BBTA and conventional instructions during their Statistic lessons. Questionnaire comprises of motivation and anxiety-related questions as well as pre and post mathematics tests were administered to these students. Based on the findings, students with low anxiety appeared to have more self-confidence when studying mathematics, which simultaneously improved their examination results. These two elements are critical in students' learning of mathematics because students who have low levels of anxiety and high levels of motivation in learning mathematics attain high achievement in mathematics.**

***Index Terms*—Brain-based teaching approach (BBTA), mathematics motivations, mathematics anxiety, mathematics performance, pre-university, technological tools.**

I. Introduction

In a classroom setting, students regard mathematics as a difficult topic, and they have difficulties in attempting to solve mathematical problems in the formative assessment or examination. When faced with issues involving counting and numbers, some students experience anxiety. Among all forms of anxiety that students have experienced, mathematics anxiety is the most common [1]. Mathematics anxiety is a state of diminished emotions, perplexity, and dissatisfaction in mathematical thought and comprehension [2]. Nervousness and discomfort caused by mathematics in high school students occur when students lack self-confidence [3]. Since anxiety in mathematics is often posed inside mathematical problems [1], it is an obstacle that students must resolve because it affects their mathematics achievement [4].

Students' mathematics anxiety is a reliable predictor of their achievement in the subject as students who are continually grappling with mathematics often experience negative impacts of this form of anxiety [5]. A number of investigations have been performed to see whether there is a connection between the learners' mathematics anxiety and their mathematics achievement. Mathematics anxiety affects daily classroom activities such as circumstances in which students must answer mathematics questions in front of the class, assessments, and multiple classrooms learning evaluations [6]. Those with high levels of mathematics anxiety performed badly in mathematics tests [7]. However, some discussions show contrasting results. Recent researchers discovered a positive correlation between mathematics anxiety and arithmetic anxiety on learners' mathematical outcomes where students with high anxiety levels were found to perform well on mathematics examinations [8], [9].

Mathematics motivation is closely linked to mathematics anxiety and plays an important role in mathematics learning. Motivation is heavily influenced by self-efficacy. Low mathematics self-efficacy for university students can lead to a lack of desire to learn mathematics, thus, leading to poor mathematics achievement [10]. Emotional factors which influence how students learn mathematics must be considered by mathematics educators in universities. It is generally believed that highly motivated university students are more prone to perform better than less motivated students. Educators can change their instructional methods with little effort, which might cause increased enthusiasm and decreased anxiety level in their students. Four sources of evidence support motivation confidence assessments: mastery of one's past achievement, momentary experiences of seeing others succeed, process and results that one retains certain capacities and physiological states. Approaches such as evaluations of others as models and emotional awareness were used in the classroom to maximise the results of such sources, resulting in students who are more confident in their academic abilities, have less anxiety and have higher motivation to learn mathematics. The efficient output of the activity builds a sense of motivation, while ineffective achievements threaten the development of self-efficacy [11].

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Performance experience is an important component of self-efficacy confidence and directly impacts students' motivation and academic success. If students have performed well in the past in a subject, they will believe that they will perform just as good or better in that subject in the future [11], [12]. Vicarious experience is the other source. Vicarious interactions play an essential part as seeing a learner excel or fail in a subject will affect other students' motivations level in that subject [11]. If students see a classmate excel at a difficult mathematics question, they tend to think that they, too, can master the challenging problem [12]. One source of self-efficacy-belief in the motivation aspect is verbal influence, which involves support from parents, educators, and friends. Other cause of motivational level includes physiological arousal, which explains mathematics anxiety, stress, exhaustion and mood. Encouragement from trusted individuals such as parents, teachers and peers will help students to gain their spirit in the pursuit of their academic abilities while also fostering healthy emotional states and decreasing negative emotional experiences.

With the progress of technology, the education industry has included technological devices such as smartphones or video and audio recording devices as an instructional tool that can be utilized both within and outside of the classroom [13]. The use of technological devices develop an interactive learning atmosphere by creating learning materials in video and multimedia forms available via mobile devices such as tablets, handheld devices and smartphones [14]. As a result, this technology has the potential to make the learning experience more student-centered, engaging and capable of encouraging students to discover their imagination while also encouraging innovation by both instructors and learners. When these aspects are combined, they can benefit the student's learning and give positive impact on the students' motivation [15]. Technology may be utilised to reorganise and remodel the classroom to foster the development of higher-order thinking capabilities, thus it can foster student motivation [16].

Current education demands more than what was previously required to adhere to a more diverse learning environment. According to the discipline of neuroscience, the Inclusive Approach is a useful teaching tool to enhance instruction and learning [17]. These advancements have been used to investigate a brain-friendly methodology aptly named as the Brain-Based Teaching Approach (BBTA). The Brain-Based Teaching Approach is a technique built on the Brain-Based Learning Principles which is developed based on brain science. The approach was designed to be more compatible and effective with the form, inclination and optimum human brain structure, resulting in a more efficient individual learning experience [18], [19]. While all teaching strategies are inherently brain-based, the BBTA is a technique created precisely to benefit the actual ability of the brain [18], [19]. Unlike conventional approaches, this system is based on the idea that each person continues to discover knowledge only if the brain is not prevented after carrying out its usual functions [18]. This method of instruction would support students of all learning styles.

A. Brain-Based Learning Principles

According to the Brain-Based Learning Principles, the following are three essential instructional techniques that can be adapted in teaching and learning [20], [21].

1) Relaxed alertness — Emotional climate

It establishes learning conditions in which students are fully engaged in an instructive practice.

- The brain learns better while it is in its optimum state.
- Emotions play an important role in the brain's patterning mechanism.
- Danger inhibits learning while difficulty enhances it.
- A positive environment stimulates brain activity.
- Brain activity is stimulated by a suitable setting, music and fragrance.

2) Orchestrated immersion — Instruction

Attempt to remove learners' anxieties by maintaining a high-demanding atmosphere.

- The brain is one-of-a-kind and works in tandem.
- The mechanism of brain patterning leads to the search for sense.
- The brain processor operates in both wholes and pieces at the same time.
- Movement-based stimuli that are complex and active promote brain growth.
- Learning activates the whole physiology of the brain.

3) Active processing — Strengthening

Allow learners to process knowledge in order to consolidate and internalise it actively.

- Conscious and unconscious processes are involved in learning.
- Learning necessitates both concentrated and peripheral vision.
- The brain can quickly understand and recall particulars and abilities inserted in its retention space. Learning often requires position in two memory methods – to remember facts, knowledge and processes; and/or to gain an understanding of one's own experiences.

The relationships among mathematics anxiety, motivation and performance have been frequently studied. Students' mathematics motivation, which is closely linked to mathematics anxiety, is one factor that affects mathematics success. Therefore, this study aims to address them by introducing a classroom intervention approach using BBTA to increase students' mathematics results. The educational approach played a role in determining the students' degree of motivation and anxiety to understand the mathematical concepts. Thus, a creative curriculum-based approach will be adopted as a classroom strategy to enhance students' mathematics engagement and reduce mathematics anxiety, which may lead to high performance in the subject. The research objectives are i) to examine the impact of classroom-based intervention strategy using BBTA on students' mathematics anxiety ii) to investigate classroom-based intervention strategy using BBTA on students' mathematics motivation and performance.

II. Methodology

A. Participant

This research was conducted on 206 pre-university students in one of the public Higher Education Institutions (HIEs) in Malaysia. The students were between 18 and 19 years old. They were divided into two groups where 111 students were in the experimental group, and the other 95 students were in the control group. The students were picked and placed at random into the two groups at the start of their studies in the pre-university institution. Students in both groups took a pre-university mathematics course and the intervention period covered the topic of Data Descriptions in Statistic. The experimental group were exposed to an innovative classroom-based technique using BBTA for two weeks (5 hours per week). To ensure fairness, students in the control group were taught using a conventional teaching strategy by the same instructor.

B. Research Instruments

The innovative classroom-based strategy using the BBTA approach was administered to the experimental group. In contrast, the control group followed the usual conventional approach in learning Data Descriptions in Statistics according to the current mathematics syllabus in pre-university studies. This research used two types of instruments to ascertain the BBTA approach's efficacy: a test and a questionnaire. The students' learning motivation, anxiety, prior knowledge and conceptual understanding of the subject were measured, particularly in the data description topic, before and after the intervention through a questionnaire and a test for both groups. The instruments included a test on the topic in Data Descriptions in Statistics and a questionnaire of Students' Motivation and Anxiety Towards Mathematics subjects to decide the effectiveness of the implemented BBTA at the end of the intervention.

The questionnaire for the student's motivation and anxiety consists of two parts. Section A includes six questions based on the student's personal background and their previous mathematics examination results. Section B consists of 29 questions on their levels of motivation and anxiety towards mathematics [10]. Students were asked to answer using the scale shown in the given column to indicate their compliance with the claims. A 5-Likert Scale questionnaire was used in this analysis, in which each student was given five options: strongly disagree, disagree, not sure, accept and strongly agree.

The test consists of nine main questions with 20 sub-questions that include questions from Data Description in Statistics. The instructor set the questions based on the syllabus for pre-university levels. It has three levels of questions which are low, medium and hard. Both pre and post-test are the same set of questions. Before delivering the topic's content, students were asked to answer the pre-test to assess the student's prior knowledge. Meanwhile, the post-test is to determine the levels of students' understanding after the intervention period ends to see the effectiveness of the teaching approach.

C. Intervention

The researchers adapted the brain-based learning principles [20], [21] incorporating technological tool to reduce students' anxiety and increase their motivation, which will impact their mathematics results. It is revolutionary because the researchers have aligned the motivation development approach and mathematics anxiety reduction strategy with their lectures and incorporated the method regularly while teaching the experimental group. There is a wealth of empirical and theoretical research demonstrating the success of this approach in affecting students' motivation, mathematics fear and academic achievement in mathematics [22]. An innovative classroom-based approach using BBTA was expected to affect the students' mathematics achievements, inspiration and anxiety.

1) The brain-based teaching approach (BBTA)

The intervention approach of this research for the experimental groups were as follows:

- Brain-based cycle

It is critical to vary educational practices and limit passive learning to no more than 15 minutes. The students were given a 5-minutes break after every 15 minutes of lecture and 10 minutes of exercise.

- Repetition

Knowledge repetition enhances brain connections, and the brain transmits memory more effectively when it is replicated in different forms. The content was explained repeatedly several times for a better understanding.

- Active learning

To elicit active participation from students by physical or mental success, students were asked to do a quick stretch during their break time to increase the blood flow circulation in their bodies, hence improving their memories, reducing their anxiety and boosting their confidence.

- Images and videos

Graphics and videos assist individuals in making sense of the material, directing attention and improving the learner's ability to recall. This means that text should be paired with pictures and videos whenever feasible. Sections of text with should be combined with illustrations, charts, images and videos wherever possible

- Use colours

People recall colours better than auditory or textual cues alone because colour links neuropathways. The contents in the slides were colourised with various colours to indicate the important key points and increase the student's interest and retain their focus.

- Automatic learning

During their discussions, music was played to create a positive environment, thus stimulating their motivations and lessening their anxiety to finish the task. During their break time, a slow version of music was played to create a calm atmosphere.

- Social brain

Practical classes can have enough social contact opportunities, allowing students to improve their understanding of new content using digital platforms. Inspire students to be interactive using the Internet, whether by a blog with feedback, a talk or a Padlet forum.

- Develop thinking skills

Incorporating problem-solving into content makes it more relevant to the real world. Effective classes also encourage students to collect knowledge, conceptualise a challenge,

produce potential outcomes and display the outcome publicly.

- Incorporating technology devices

It emphasizes the need of learners to continue their learning activities using technological devices such as tablets and smartphones in or outside the classroom.

- Autonomous learning

It emphasizes on students engaging in online or offline learning activities via digital learning. It highlights individual independent learning and requires students to take part in autonomous learning prior to learning activity.

- Emphasizing digital teaching resources

It highlights that student may discover more by extracting some of the subjects of digital instruction items. Some of the examples of digital teaching material contents are e-books and digitalised data.

III. Results and Discussion

Both the questionnaire and the test papers by both groups were analysed. Additionally, both instruments were distributed twice, before and after the intervention strategy is performed. Students were given a questionnaire and a set of pre-test questions before implementing the BBTA. The descriptive analysis of the questionnaire revealed that the overall students' motivation towards mathematics from both the control and experimental group was in the average category with a mean value of 2.23 and 2.29, respectively. On the other hand, students' anxiety level towards mathematics was in high category for both the control and experimental group with a mean of 3.46 and 3.45, respectively. The result showed that the highest score is for Item 6 for both classes. Item 6 was about their feeling before they attended mathematics class.

Item 6: "*I am worried that I will not be able to get a good grade in my Mathematics course*"

These findings suggest that students seemed to have an average level of motivations but high anxiety towards learning mathematics. The results of the pre-test questions were very low for both classes, which indicates that the students with high anxiety towards mathematics would feel down and cannot focus on the given task. However, the analysis of results of the questionnaire after implementing the BBTA on the experimental group showed that most of the students had lower anxiety towards mathematics with a mean of 2.17. On the other hand, the anxiety level of the control group remained high with a mean of 3.47. This finding the intervention strategies have successfully lower the students' anxiety in learning mathematics. The results also showed that the score for Item 6 is lower among the experimental group after the intervention.

Fig. 1 presents the students' anxiety towards mathematics before and after taking the pre and post-test. Initially, the students' anxiety towards mathematics before taking the pre-test was almost similar for both groups, with a mean value of 3.46 for the control group and 3.45 for the experimental group. The initial mean value shows that the students had a slightly high anxiety level towards mathematics. After implementing the innovative classroom-based strategy of BBTA for the experimental group, the students' anxiety towards mathematics before taking the post-test was lower compared to the control group with a mean value of 2.17. It shows that the classroom-based intervention strategy using BBTA is able to reduce students' anxiety towards mathematics to a moderate level. The students felt comfortable with the atmosphere and the class environment during the classroom-based intervention strategy, thus lowering their anxiety to a moderate level where they feel better towards learning mathematics and are confident in their assessment [23]. In short, students who have received the BBTA intervention have lower mathematics anxiety than students who did not receive the intervention.

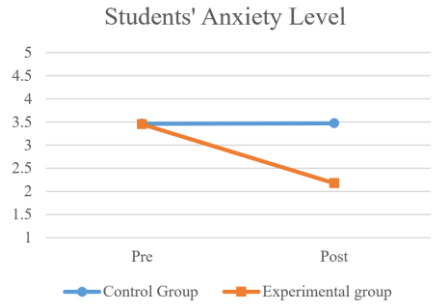

Fig. 1. Student's anxiety.

Fig. 2 shows the results of the student's motivation toward mathematics before taking the pre and post-test for both groups. Based on Fig. 2, the blue line refers to the students' motivation towards mathematics before taking the pre-test for the control group. Meanwhile, the orange line refers to the students' motivation towards mathematics before taking the pre-test for the experimental group. The result indicated that students' motivation towards mathematics before taking the pre-test was similar for both classes, with a value of a mean of 2.23 for the control group and 2.29 for the experimental group. This means that all students have average motivation towards learning mathematics. Then, after implementing BBTA for the experimental group, the students' motivation towards mathematics for the students in this class increased to a mean value of 4.44.

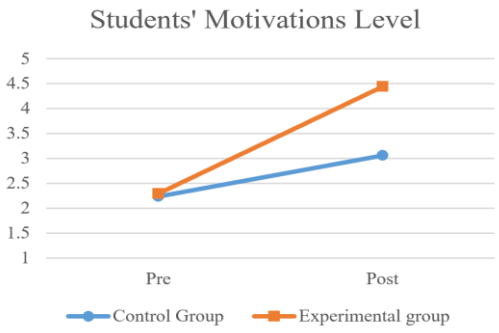

Fig. 2. Student's motivation.

The results of their motivation level indicate that the experimental group scored higher than the students from the control group with a mean value of 3.06. This shows that the classroom-based intervention strategy using BBTA can improve student's motivation towards learning mathematics.

With the implementation of BBTA by using different learning environment in the experimental group, students feel confident and motivated to ask questions or be involved with the learning process [24].

Fig. 3 shows the relationship between students' anxiety and their motivation towards mathematics. It shows that students' anxiety towards mathematic is associated to their motivation. The results for the experimental group showed that as their motivation towards mathematics increases, their mathematics anxiety decreases. The anxiety level for the control group was the same before both pre and post-test. Some students could benefit from maintaining moderate levels of mathematics anxiety. This is because a mix of moderate mathematics anxiety and high motivation can motivate students to learn harder while also enjoying the experience of learning mathematics [23].

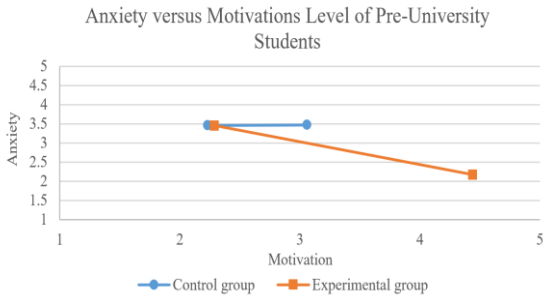

Fig. 3. Student's anxiety versus their motivation on mathematics.

Table I shows the correlation analysis between students' motivation towards mathematics and their achievement in the subject. The relationship between motivation towards mathematics and achievement was analysed using the Pearson correlation coefficient. It was found that there is a strong correlation between the students' motivation towards mathematics and their mathematics achievement ($r=0.78$, $p=0.025$). This means that students' motivation towards mathematics affect their achievement in the subject. The students who have received the treatment (classroom-based intervention strategy using BBTA) scored higher in mathematics motivation and mathematics performance than students who have not received the treatment. The analysis revealed that students with a high level of motivation towards mathematics performed better in mathematics. The implementation of BBTA as one of the creative learning strategies in order to improve student engagement and learning outcomes by optimizing brain activity could lead to good performance [25].

However, it should be noted that this research has a few limitations. The first issue was the limitation of time. The researchers did not have adequate time to conduct more face-to-face sessions since the students only have one year to complete their pre-university studies. The proposed focus group discussion and the continuation of the intervention in the classroom were both interrupted due to the Covid-19 lockdown where students were asked to stay at home and classes were done online as universities were forced to close. Secondly, the data for this study were collected using only two instruments based on a questionnaire by May (2009) on their levels of motivation and anxiety toward the topic of Data Description and a set of tests. This means that the variables can only be described by the data obtained within the limits of the measurement instruments. In future studies, it is recommended that various approaches of prospective research, such as focus group discussions, one-on-one interviews and peer review to be used.

TABLE I: CORRELATION ANALYSIS BETWEEN STUDENTS' MOTIVATION TOWARDS MATHEMATICS WITH THEIR MATHEMATICS' ACHIEVEMENT

		Mathematics Achievement
Students' Motivation	Pearson Correlation	0.78
	Sig. (2-sample)	0.025
	N	206

IV. CONCLUSION

The research objectives, which is to examine the effect of classroom-based intervention strategy using BBTA on students' mathematics anxiety and investigate the effectiveness of classroom-based intervention strategies on students' mathematics motivation and performance, are successfully achieved. Technology has the potential to turn the classroom into a more interactive educational setting and making students feels motivated to learn. Students are now expected to get more comfortable with digital tools. Technology is a component in increasing learning as it is a vital part of our daily lives. This research hypothesised that students who have received the treatment (classroom-based intervention strategy using BBTA) scored lower in mathematics anxiety than students who have not received the treatment. Furthermore, students who have received the treatment (classroom-based intervention strategy using BBTA) scored higher in mathematics motivation and their mathematics performance than students who have not received the treatment. The results of this study supported these hypotheses as there were changes to the correlation between anxiety and motivation towards mathematics after the class received the treatment. The findings also showed that a high level of motivation towards mathematics are expected to lower students' anxiety levels. This finding suggests that both anxiety and motivation are valuable and important factors to be considered in students' learning of mathematics. Students who have low anxiety tend to have more self-confidence in learning mathematics, thus improving their performance in the examination. This statement can be supported by the strong correlation between these two factors. It can be said that students who perform well in the subjects are expected to have low anxiety and high motivations towards mathematics. For future works, we would like to examine different strategies in dealing with students' mathematics anxiety. Besides that, we want to explore the effects or implications on their anxiety towards the motivations and achievement if educators take no further action.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Farah Liyana Azizan, Nur Fazliana Rahim, Emmerline Shelda Siaw and Kartini Abd Ghani conducted the research

and prepared the manuscript. Saratha Sathasivam contributed to the write-up of the manuscript. All authors edited and reviewed the manuscript. All authors have approved the final version.

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