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Exploring Existing Knowledge using Query Type of Questions to Launch and Sequentially Conduct a Math Lesson

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ABSTRACT

The underlying logic behind most of the things is a form of mathematics. Therefore, a grasp and ownership of mathematical concepts is key to understanding how things work, particularly at tertiary level of education. Given the importance of math, from registration records, it was found that approximately 1500, i.e., 16.3% of the current student population at a private university in Bangladesh, delayed taking the foundation course on math till the final year of study. Among these are students who are retaking the subject. Among reasons found are that students do not like mathematics, or are not interested and/or have a fear of math. Based on these apprehensions in mind, the lesson delivery methodology of an existing foundation mathematics course was redesigned. The Query Based Access to Neurons (QuBAN) methodology is an interactive brain-engaging teaching methodology that first taps existing knowledge of the learners, then utilizes this to build new knowledge. This study aims to evaluate the efficacy of the QuBAN approach. Before and after the course were evaluated for measuring changes in their perceptions, interests, views, and thoughts about mathematics and the new teaching methodology through the pre and post-questionnaires respectively. Half of the students found the usefulness of the methodology is between 6.84 to 7.5 out of 10. That is, the methodology has shown its effectiveness to reduce fear of mathematics in the students.

Keywords: Mathematics Teaching; Pedagogy; Engaging students; Active learning; Query Based Access to Neurons

INTRODUCTION

Mathematical ability promotes skills such as problem-solving, critical thinking, and logical reasoning that are essential not only in most disciplines/professions but in day-to-day life. However, a prevailing attitude in educational institutes in Bangladesh has been to learn mathematics by memorizing steps together with formulae. Students often do not know why they need to learn math. As a result, students struggle to apply mathematics, particularly in engineering courses. A place to look for solutions to this problem is to place an emphasis on enhancing instruction, *i.e.,* improving the techniques teachers apply in the classroom, is likely to produce better results (Stigler & Hiebert, 2004).

To enhance the learning of mathematics or any subject, it is important first to gain students' attention. Attention-gaining can be done in a variety of ways (Gagne et al., 1992). Northern Illinois University Center for Innovative Teaching and Learning (2020) recommends that asking a question at the beginning of the lesson is an effective way to gain students' attention. A question, at the beginning of a class, is to act as a query to access the current knowledge on the subject in the brain and to allow continuing to build on the knowledge that exists in each individual student's brain. As long as the relevant knowledge site has been reached, the construction of new knowledge can continue regardless of the current perception of the student. The Greek philosopher Socrates thus explained the importance of questioning for learning. The Socratic questioning technique includes different types of questions and encourages independent thinking in students and gives them ownership of what they are learning in the classroom (*Designing Effective Projects: Questioning The Socratic Questioning Technique*, 2007). For learning mathematics, in particular, questioning is still being recommended for student success (Nahal, 2022) as has been in the past to stimulate mathematical thinking (Way, 2001), yet teaching/learning mathematics continues to pose a challenge as can be practically seen in the context of the Bangladesh education system. Undoubtedly, the asking of questions is key to learning math, however, the situation on the ground warrants a deeper look at the art of questioning.

In this research, a methodological approach to the art of questioning while delivering the teaching of mathematics is examined with a model called “Query Based Access to Neurons (QuBAN)”. In the model (Islam & Nashikh, 2023), as opposed to assessment questions, questioning is used as a cognitive learning (Main, 2023) tool to progressively arrive at mathematically based conclusions at each step of the lesson. The objective of the study is to gauge the effectiveness of the QuBAN methodology in learning mathematics and in reducing the fear of mathematics.

LITERATURE REVIEW

Mathematics is a fundamental tool for understanding and describing the working of the world. A grounding in mathematics helps develop critical thinking and problem-solving skills. Almost all technological and scientific advancements in the 19th and 20th centuries were driven by mathematics (Mangwiro & Machaba, 2022). It has a significant impact on our day-to-day social and professional activities (Maass & Schlöglmann, 2006). Despite the fact that mathematics is a crucial subject, the majority of students struggle with it (Achary, 2017). Achary (2017) also stated that it is challenging for students to study mathematics because of math anxiety, a lack of interest, and a negative attitude toward the subject. As suggested, while looking for solutions, emphasis should be placed on the teaching methodology.

As part of a solution, fewer lectures, more student-centered classes, and more discussion should be part of teaching as recommended by Lessani et al. (2017). One of the key components of a successful mathematics classroom is teacher-student interaction (Mangwiro & Machaba, 2022). Interaction is the fundamental strategy for enhancing learning and learner engagement (Pianta, 2016). The most frequent way to communicate between students and teachers is by questioning (Mangwiro & Machaba, 2022). Questioning is defined by Kebede (2015) as “a statement for which a reply is expected”. Questioning has several advantages. It encourages participation and engagement from the student, offers opportunities for peer learning, and is the best method for giving quick feedback (Henny et al., 2018; Sattes & Walsh, 2016). Furthermore, Dahal et al. (2019) defined questioning as a concept in a mathematics classroom that gets students to respond. Teachers are supposed to encourage students to "verbalize their own mathematical thoughts and queries that enable them to validate their understandings" in a productive classroom conversation (Jones, 2019) and students learn through the act of a teacher asking questions (Apriani & Marchelina, 2018). According to Setiawati (2017), who discussed the value of questioning, teachers should ask questions to incorporate students' thinking if they want to inculcate learning in their classroom activities (Mangwiro & Machaba, 2022). Cotton (1989) states that asking questions to the students is one of the most important and effective teaching strategies teachers may apply in a mathematics classroom. The results of Edwards & Bowman (1996) show that teachers' questioning is a major aspect of mathematics classroom interaction and that it appears to be essential for teachers to be able to recognize students' interests in mathematics. Additionally, according to Croom & Stair (2005), classroom exercises in mathematics are the most effective experiential teaching and learning resource for promoting student academic growth and evaluating their critical thinking. Boaler & Brodie (2004) discovered in their research that teachers' questions greatly influence the classroom environment and steer students throughout the discussions in mathematics classes. In order to encourage students to elaborate on their responses and make their reasoning clear to the teacher, peers, and themselves, teachers should employ effective questioning techniques (Mangwiro & Machaba, 2022). The National Council of Teachers of Mathematics (2014) has provided guidance on how to do this by emphasizing that teachers must be aware of the right questions to ask in order to engage students and differentiate learning for a wide range of student knowledge levels. The problem is then finding the right question, or what is the right question? Accordingly, Dahal et al. (2019) point out that good questioning requires preparation and experience, and effective questions might continue to grow students' interest in new mathematical concepts, theories, and difficulties while also promoting reflection not only about their own views, and beliefs but also related ideas. So, teachers' in-class questioning is regarded as both a valuable and crucial component of mathematics lessons. Additionally, teacher questioning is essential for eliciting prior knowledge and interest in the topic and determining acquired knowledge through feedback and reflection (Dahal et al., 2019). The Cognitivism learning theory (Mangwiro & Machaba, 2022) helps understand how mathematical problem-solving can significantly assist students in the development of a wide range of complicated mathematical structures as well as the acquisition of the ability to deal with a number of real-life issues (Tarmizi & Bayat, 2012). Islam & Nashikh (2023) develop methodological questions to delve deeper into the Theory of Cognitivism to come up with the Query Based Access to Neurons (QuBAN) model, as a classroom process, that poses query type of questions from the launching of the class topic to tap into existing knowledge and link to the next step, progressively throughout the math lesson. This research proposes to test QuBAN on a tertiary level fundamental math course.

MATERIALS AND METHODS

While research has established and confirmed the positive role of questions in learning and constructing new mathematical knowledge, the methodological questions asked by this research not only to find the right question but also at which point in the lesson should the first and subsequent questions be asked? Why? And what type of question should be asked initially? Table 1 summarizes the basic methodological questions asked to design each mathematical lesson and lesson slide as well as the reasoning assumed for the question.

Table 1. Methodological questions asked using the basic QuBAN methodology

Methodological question	Elaboration	Reasoning assumed
Why?	Why should a question be asked on a topic or subtopic?	To explore and locate in the brain what each student currently knows or perceives about the topic and subtopic. This also allows the student to retrieve current knowledge on the topic from the appropriate site in the brain and prepare the site to receive new learning at each step. To explore students' existing understanding of the topic and subtopic in the brain, facilitating the retrieval of relevant knowledge and priming the brain for new learning at each stage.
What if?	*What if students insist they know nothing?*	*The query question is designed around something that should be known by the student. Even then if students insist that they have no knowledge, they are asked to guess. The guess would then have to be retrieved from the appropriate place in the brain.*
What?	What type of question should be asked?	A non-threatening general type of question specific and related to the topic, something that the student should be able to relate to. The teacher must then have knowledge of the step-by-step learning journey of the students.
How?	How should the question be asked?	The students should be comfortable and not have a fear of being rebuked, as the student's emotion should be, "what do I happen to know about this?"
When?	When should the query question be asked?	The query should be up front, as a means to launch a discussion on the topic or sub-topic. No other distracting ice-breakers should be used.
Where?	Where should the subsequent new knowledge be stored or linked?	The newly constructed knowledge should be added at the site of existing/current knowledge be it correct or incorrect, i.e., once the student's brain is engaged.
Who?	Who should ask the question?	In the classroom, it obviously has to be the teacher or facilitator who launches the discussion on the topic. However, the teacher may also ask the students to design basic questions on the topic like the questions in the left column of the table. In the later case, students may subsequently learn how to easily reach their own relevant "construction" sites.

Assuming that the "construction" of new knowledge on a topic or subtopic should take place at a "site" in the brain at the place in which existing mathematical knowledge or perceptions are stored, should the role of the first question be to reach the site at which the current experiences/perceptions of the math topic are stored? Once the correct construction site for the topic is accessed, regular pedagogical practices, including further questioning, experiential learning, practical work, collaboration, discussion, peer work, *etc.,* can continue, helping the construction of new knowledge on the topic at the site. The topic/subtopic launching query question, as delineated in Table 1, is the basis of the proposed Query-Based Access to Neurons (QuBAN) method. The main challenge of the teacher is therefore to find/design a launching question that would allow the student to access existing knowledge on the topic/subtopic to be taught. When such a question is asked, the students' brains would internally look for existing knowledge on the topic. Once found, the student can answer from his/her existing knowledge helping the teacher and other students to see what knowledge exists in the brain. The student's brain would be engaged searching for existing knowledge/perception on the topic at every stage of the lesson. Construction and linking of new knowledge can then add on to the appropriate location. If the sum total of what is learned is stored in an organized manner, the knowledge retrieval process would be expected to be much more efficient as all aspects of a topic/subject would be available at the same site or cluster. Drawing analogies with computer memory storage and organization is not new (Zhang et al., 2020) or vice versa (Martin, 2016), however, a simple database table and access point-of-view has been adopted by this research utilizing the QuBAN model that takes into account the theory of Constructivism (*Constructivism as a Paradigm for Teaching and Learning*, n.d.; *What Is Constructivism?*, 2020) as well as the brain's active approach to questions posed (Asmus, 2017).

Research Frame

Using QuBAN a foundational mathematics course was developed lesson by lesson. The course contains 11 topics that follow the approved syllabus. Each lesson is divided into cyclic units that can be seen to implement cognitive learning (Main, 2023). As such, each cycle of teaching/learning can be called a Cognitive Learning Units (CLU) where each consists of the following steps:

1. **Engaging question**: A higher order (Working Scholars, 2003-2024) query question is asked at the beginning of each subtopic/topic to find what the student currently knows/feels about the topic.
2. **Finding existing knowledge**: Students work in pairs (or individually) to guess and write answers in their own copies or respond through an interactive web-based software in a face-to-face class. Students think about the question asked, discuss in pairs and generate the ideas that they have. They may also look for the answers individually in a remote synchronous online class.
3. **Teacher surveys answers to give feedback**: In the face-to-face physical class, teachers may randomly select two/three students to share their answers with the class. In a web-based response system, the teacher may select answers from the screen and ask the corresponding author to explain what he/she has written. Thus the students are able to expound their existing knowledge. Simply being able to answer the query question (whether right or wrong) bears witness to the fact that the student has accessed his/her existing knowledge/perceptions.
4. **Teacher discusses appropriate answers**: Teachers discuss the answers and share their own experiences and theory related to the topic. The brain, being at the correct location, is now primed to add new knowledge at this location.
5. **Teachers give conclusions to consolidate students' learning**: Teachers give their own feedback in response to the answers and help correct any misconceptions.

The lesson launching query questions designed for each of the 11 lesson topics of MAT101 (the foundational math course at a private university in Bangladesh) are listed in Table 2.

Table 2: Engaging query questions asked at the beginning of each lesson

Name of the lesson	Engaging query questions to seek existing knowledge	Building upon existing/previous knowledge
1. Mathematics in Business	As a business student would learning mathematics be important?	The idea is to access the ideas the students have regarding the subject of business and subsequently link the learning of mathematics to business concepts.
2. Variables in mathematics	How is a multiplication table created?	The students have a lot of trouble with variables. A thorough understanding of variables is essential for math and programming. The idea is to explore students' existing knowledge of multiplication tables and discover whether each line in the multiplication table can be expressed as an equation with variables. It is hoped to "construct" or link the remaining topics on this basic concept.
3. Graphs of functions	Can you work out why $y = 2n$ is called an equation?	Seeking cognition of the knowledge of equations derived from multiplication table done in lesson 2

4. Gradient	Can you comment on the quality of steepness of the road in front of the house?	Seeking cognition of the knowledge of having seen steep roads in real life and linking back to the understanding of equations and how the steepness can be represented by an equation.
5. Application of straight lines	Can we develop a general equation using variables for the steep line?	Seeking cognition of the knowledge of equations and variables done in lesson 2 and 3.
6. Quadratic Equations	How can curved steepness be described using an equation?	Seeking to build on knowledge of gradients done in lessons 3 and 4.
7. Types of numbers	How many types of numbers can you identify in the diagram?	Seeking cognition of the knowledge of types of numbers to start working with numbers.
8. Working with numbers	How are numbers used in real life?	Seeking cognition of the knowledge of how numbers are used in real life to link math.
9. Limits	How can we find the gradient at a particular point on the curve?	Seeking cognition of the knowledge of gradients done in lesson 4.
10. Differentiation	Can steepness be found by using a technique called differentiation?	Seeking cognition of the knowledge of gradients done in lesson 4 and linking with differentiation with the example of profit maximization.
11. Integration	What technique can be used to help find the volume of the cylinder?	Seeking cognition of the knowledge of area and volume to find the volume of water that a cylinder can contain linking with the word integration.

Question design: Regarding application of the Theory of Constructivism, Bächtold (2013) asked a question, *what do students 'construct' according to Constructivism in science education?* Accordingly, the launching question for each lesson was dictated by the main guiding question, *i.e.,* what are the ideas that should be accessed and linked? For the launching question for the foundation math course for business students, *as a business student would learning mathematics be important?* is designed as given in Table 2. Notice that the question is not a simple recall of facts. It is an open-ended higher-order thinking question (Working Scholars, 2003-2024) designed for critical thinking on part of the learner. Each subsequent question, while dependent upon knowledge from a prior lesson is a higher order question promoting cognitive learning (Main, 2023).

All the lessons were added to slides in a web-based software called Mentimeter (mentimeter.com - teachers' site) which is an online interactive presentation tool where students can directly interact with the teacher and give their responses using menti.com (students' site). Before embarking on the course, one adjunct faculty member from the Mathematics department was trained on this new teaching methodology and given access to the slides. In the next semester, another 12 adjunct faculty were shown the nature of each lesson and given access to the slides. The students were given a pre-questionnaire. The idea behind the pre-questionnaire was to ascertain the students' perception of mathematics as the curriculum is almost the same as that taught in classes 9 and 10 in the final two years of senior school. They were also asked questions on the teaching methodology. After completing the course, a post-questionnaire was circulated to check whether there is any change in the students' attitude and confidence towards math and asked to evaluate the teaching methodology. The teachers were also asked about their perceptions of the QuBAN methodology in the slides prepared for them.

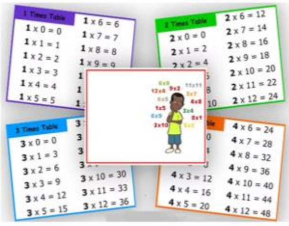
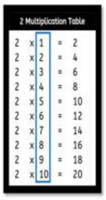
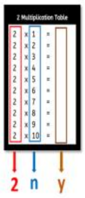
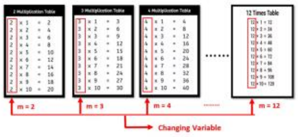
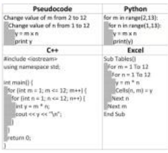
Evaluation of the Process:

Given the negative attitude/perception/mindset of students towards learning math (Achary, 2017), the main motivation behind the evaluation process was to determine whether the course delivery methodology brings about a change. Actual exam marks are not taken into account as marking criteria are not pre-published; marks are left to the discretion of the individual teacher. As multiple teachers were given to use the prepared slides, exam marks were not included in the evaluation criteria.

Individual Lesson Design:

As an example, for lesson 2, it is chosen to teach the concept of variables by using the existing concepts and perception of the multiplication times table. Variables are a fundamental concept in many areas of mathematics and also in the learning of programming. Exploration of existing knowledge of multiplication tables is used as students should have some experience from their school days. Once students reconstruct their knowledge of multiplication tables, they are invited to synthesize the need for variables through higher order questions.

Table 3: Overview of Lesson 2 questions

Lesson 2: Variables in Mathematics		
Slide 1  How is a multiplication table created?	**Slide 2** Study the table below. Notice, how the multiplier changes. As the process of multiplication is repeated, can it be summarize in one line? 	**Slide 3** For example, can we say calculate y, where y = 2 x n? After each calculation, change the value n from 1 to 10. Write all the values of y. 
Slide 4 In your opinion, why did we use y and n to calculate the values of the multiplication table? Does the formula hel to summarize the table? How?	**Slide 5** Now calculate y = 3 x n for "n" equals to 1 to 12. Alternativel carry out the instructions below (What is the difference between the two instructions): **FOR n = 1 to 12,** **calculate y = 3 x n?**	**Slide 6** Summary Method Result (Variable to show the changing result) Variable to indicate the changing multiplier **y = 3 x n** Fixed Value for 3's times table Here, y is the product of 3 an where 3 refers to multiplicand a is a variable which varies from 12. The summary method invo using variables (alphabets) indicate changing values. When use variables in this way, resulting expression is called equation- as it shows how calculate each value. For calcula the next table, when should change the value of multiplicand and then 5 and then 6, etc? How?
Slide 7 Once the 3 times table is complete, using the same summary method, can you design an equation for the other multiplication tables from 4 to 12?	**Slide 8** If we say m = 5 and are asked to calculate y = m x n then what instructions can we add to the instructions below to calculate the 5 times table? **FOR n = 1 to 12,** **calculate y = 3 x n?**	**Slide 9** Similarly, notice how the multiplicand changes from 2 to 12. Can the variable m also be used to indicate a changing multiplicand after each table? 
Slide 10 Summary method with changing multiplicand Result (Variable to show the changing result) Variable to indicate the changing multiplier **y = m x n** m indicates the changing multiplicand Now y is the product o and n, where m refers the changing multiplicand. However changes only after n h changed from 1 to 12 How can m be chang once n is complete?	**Slide 11** Using variables to indicate changing values The use of variables in this way is called algebra where y = m x n called an equation. The variables in the equation are used as symbols indicate changing numbers. These do not have any fixed values. our real-life problems, we often see certain values that keep changing. But we need to represent changing values. In algebra, the values are often represented with symbols such as x, y, z, p, q, n or and these symbols are called variables.	**Slide 12** Study the following instructions. Guess what they mean and explain how you would carry out the instructions. Why are some instructions indented? **Change value of m from 2 to 12** **Change value of n from 1 to 12** **y = m x n** **print y**
Slide 13 It is the concept of variables that has made instructing a computer possible. Identify the variables in the four unknown languages below. 	**Slide 14** Use of variables Computer programs use variables to instruct the computer how process any kind of data. Variables are also used in business describe characteristics, numbers, or quantities that can be measur or counted. A variable may also be called a data item. Age, se business income and expenses, country of birth, capital expenditu class grades, eye color and vehicle type are examples of variables. is called a variable because the value may vary between data units a population, and may change in value over time.	**Slide 15** Computer programs also use variables Similarly a computer program is made easy by using variables. Study the python program and workout how it prints the times table. 

Each slide with a higher order question is treated as a CLU. The process is repeated till the lesson is completed and the learning outcomes have been achieved for the lesson. As an overview of lesson design, the lesson on variables is demonstrated in Table 3.

Implementation of the Lesson Design:

Initially, in the Autumn 2022 semester, the newly designed course was offered as a pilot project at a reputed private university in Bangladesh for the students of two sections by the same teacher. To conduct the course, the adjunct faculty member was trained in this new methodology. This course was offered again in the Spring 2023 semester after receiving positive feedback from the students as well as from the teacher. A pre-questionnaire was provided to the students enrolled in the Spring 2023 course to understand their interests, opinions, and thoughts regarding mathematics in order to determine their attitude towards math. 557 students responded out of the total number of students (just under 600) enrolled in the open-credit course. The same students were also sent a post-questionnaire at the end of the semester to get their thoughts on the new teaching style and how they felt regarding their current situation on math where 266 students finally gave their responses. In order to gauge the success of the new approach and teaching design, a feedback form was sent to the math faculty members who taught the course and 11 faculties responded.

RESULTS AND DISCUSSION

A triangulation method was used to validate research findings. Before starting the course, a pre-questionnaire was sent to the students to understand their condition and perception about mathematics. More than 64% students had negative feelings regarding mathematics (Figure 1). That is, the students were afraid of mathematics, did not like mathematics, found it difficult, or do not consider themselves good at mathematics. However, after the course, positive perception towards math increased to almost double (69.4%). Moreover, the number of students who were afraid of math and did not like math had reduced significantly to 30.6% at the end of the course.

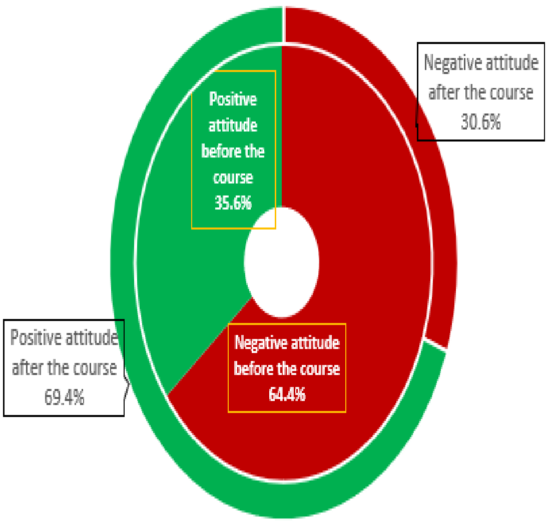


Figure 1: Students' perception before and after the course

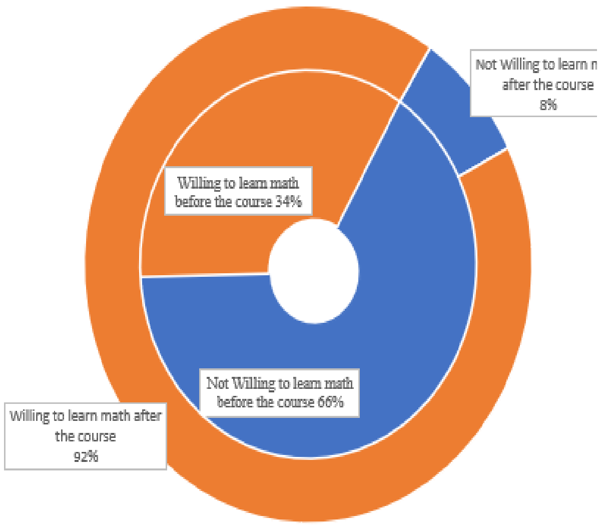


Figure 2: Willingness to learn mathematics

Figure 2 represents willingness of the students to learn mathematics before and after the completion the course. It was found that 66% of the students were unwilling to learn math before enrolled in the course. However, only a few students (8%) showed their unwillingness to learn math after completion the course.

In the post-questionnaire, students were asked to evaluate the new teaching methodology, and their responses are shown in Figure 3. After the course, 76% students felt that their mathematics basic has developed. More than 69% students become confident about mathematics and 66.3% students did better in the final exam through the course. 81.5% students mentioned that this course increased their thinking and learning ability.

Because of the teaching method, more than 82% students like to participate in the activities of every class, about 75% students become confident to solve mathematics, 67% student mentioned that the methodology reduce their fare of mathematics and about 80% students got help to learn and motivated to learning.

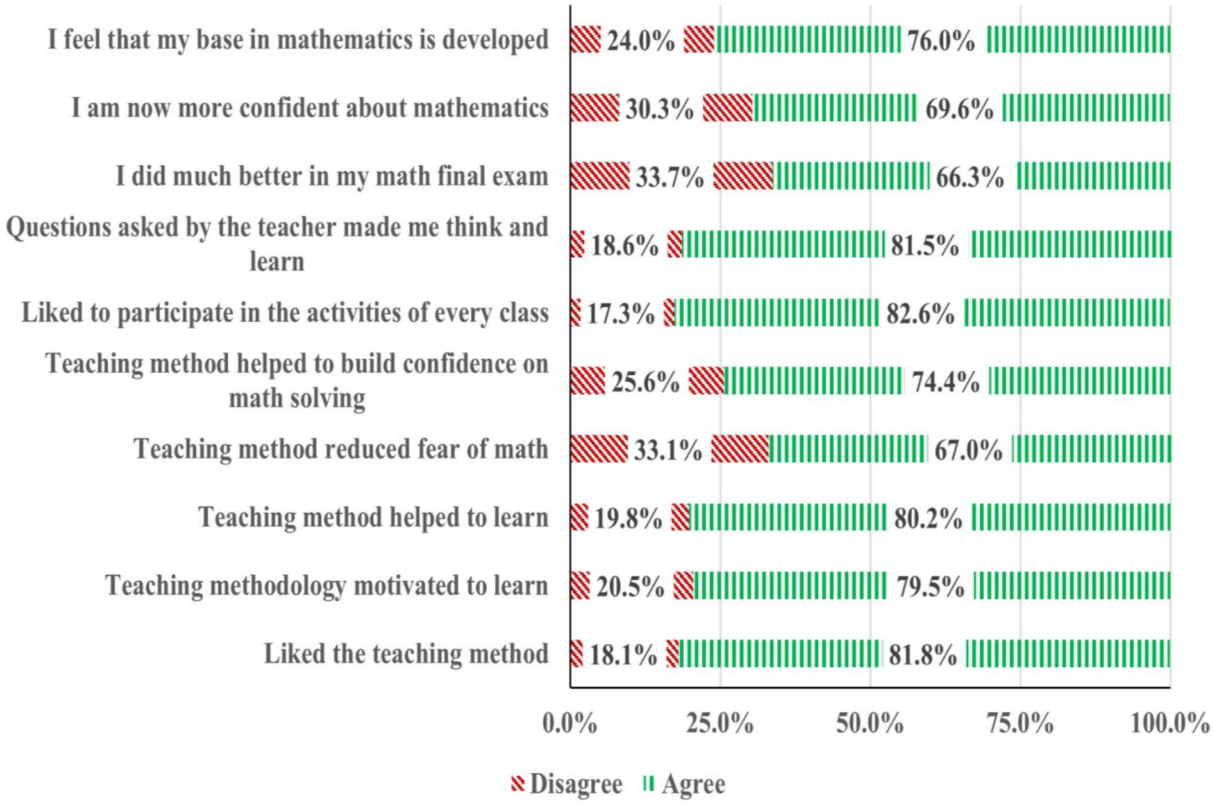


Figure 3: Students' feedback regarding the applied teaching methodology

It is found that the majority of the students have done well in their final math exam after doing this course. Figure 4 shows that 66.3% of the students did much better in their final exam.

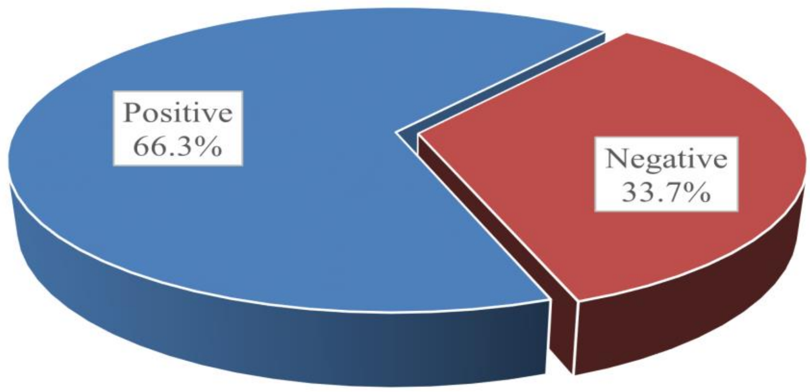


Figure 4: Feedback from students on the teaching method after their exam performance

Usefulness of the course in terms of reducing fear and making mathematics interesting was measured using the items in Table 4. Factor Analysis was applied to measure the reliability of the items to measure usefulness of the method. "building confidence" has the highest weight (0.84) to make the method effective.

Table 4. Items' loading for measuring usefulness of the course

ITEM	Loading
I liked the teaching method of MAT101	0.68
The teaching methodology motivated me to learn	0.77
The teaching method helped me to learn	0.76

The teaching method removed my fear of math	0.80
The teaching method helped build my confidence in math	0.84
I liked to participate in the activities of every class	0.71
The questions asked by the teacher made me think and learn	0.70
I did much better in my math final exam	0.62
I am now more confident about mathematics	0.77
I feel that my base in mathematics is now better developed	0.81

The range of scale of usefulness is 0 to 10. Higher scale indicates more usefulness. Based on the scale of usefulness in terms of reducing fear and making mathematics interesting, half of the students provided mark in between 6.84 to 7.5 out of 10 to the method QuBAN. 25% students evaluated the course got score in between 4.45 to 6.83 and the method scored less than 4.45 from rest 25% students (Figure 5).

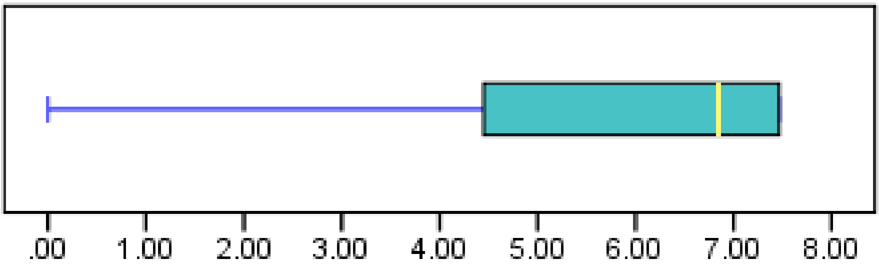


Figure 5: Usefulness of the course out of 10 scale

DISCUSSION

Questioning has its own significance. The results of Edwards & Bowman (1996) show that teachers' questioning is a major aspect of mathematics classroom interaction and that it appears to be essential for teachers to be able to recognize students' interests in mathematics. Boaler & Brodie (2004) discovered in their research that teachers' questions greatly influence the classroom environment and steer students throughout the discussions in mathematics classes. Several works show that questioning in class can help students to interact and learn effectively. However, a bigger question is ***"When should a question be asked?"*** According to the QuBAN model, a teacher should start with questions right at the beginning of the lesson and launch each sub-topic with a question. The students' attention was gained effectively by asking a query question at the beginning of the lesson as recommended as a method of gaining attention (*Gagne's Nine Events of Instruction | Center for Innovative Teaching and Learning*, 2020).

As part of the research, this newly designed interactive course was offered at a reputed private university in Bangladesh where just under 600 students from different departments across the university registered for the course and 12 faculty members conducted the course with the same interactive slides. A pre-survey was done to know students' perception of mathematics and n=557 students responded. Similarly, after finishing the course using the QuBAN methodology, a post-questionnaire was given to all the registered students and 266 students gave their feedback. Feedback was also collected from the faculty members who conducted the course using this methodology. The post-responses were thematically analyzed and compared to find the differences. To validate the research findings, the results were compared from three different angles- students' feedback on mathematics, students' and teachers' feedback on teaching methodology, and the exam performance of the student after completing the course. After analyzing the responses to each point, the methodology is found to positively affect motivation to learn math.

CONCLUSION

In the constructivist approach, students are motivated to ask questions to solve problems. The QuBAN methodology uses higher order questions to launch each cognitive learning unit (CLU) as part of a lesson. The question should not only be designed to launch discussion, but be related to the students' assumed experience of the topic. The QuBAN lesson design appears to motivate students and reduce their fear of math - a fear that is carried on from school and college days. As it was assumed, whether or not higher order questions help access the parts of the brain where previous knowledge resides was not directly tested as the questionnaire dealt with the overall effect of the methodology for the course. To confirm this, testing must be done at the individual lesson level. As the methodology was introduced and tested with adjunct faculty, this could not be done easily as all questionnaires were delivered through them. However, the results are encouraging enough for the methodology to be further tested on STEAM courses.

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