Two Birds in One Shot - Bridging the Math Proficiency Gap and Addressing Math Anxiety Using Art: A Pilot Study

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Abstract

The aim of this study was to investigate whether using art in a math bridge course will reduce math anxiety among students, help students develop an interest in mathematics as a subject, and improve students' test scores in mathematics. The data presented here is based on two pilot studies conducted on students of first-year Bachelor of Commerce students. The intervention consisted of ten sessions of an hour and a half each conducted once a week for a total of 24 students. Math anxiety scores of all participants were measured using the MARS 30-item test before and after the bridge course. The difference in their math anxiety levels post and pre-intervention was found to be statistically significant for the better. The difference in their math proficiency scores post and pre-intervention was also found to be statistically significant. The subjective interviews revealed that the negative emotions attached to math anxiety saw a significant decline.The subjective interviews conducted at the end of the course revealed that the negative emotions associated with math anxiety had reduced and students were motivated and confident in their approach to mathematics.

Key words: Mathematics anxiety, Innovative pedagogy, Bridge programs, Math and art, STEAM

Introduction

Mathematics proficiency at school and college level in Maharashtra, India

According to the statistics given in the Annual Status Education Report ("ASER Centre", 2019) published by Pratham (a non-profit national level organization), in the Indian state of Maharashtra roughly 60% of all children in 8th standard struggle with division, 40% struggle with subtraction and only 33 - 49% of children in the age group of 14 -16 years could apply the math skills for calculating time, financial decision making, and calculating discount. The National Achievement Survey report of 2017 of the state of Maharashtra classifies the performance levels of students of class 8th in mathematics as 67% below basic or basic. Both these surveys imply that overall the basic math conceptual understanding as well as procedural knowledge among children is low at

the end of completion of school education. Once students complete secondary school (SSC - 10th standard), they can enter higher secondary studies by attending a junior college. In junior college (11th and 12th), students can choose one of the three streams: arts, science, or commerce. By the end of 10th standard, typically achieving secondary students have studied arithmetical concepts, number systems, algebra, geometry, trigonometry, statistics, measurement, graphs and coordinate geometry. In the Higher Secondary Certificate (HSC) Board, students can substitute math for Secretarial Practice (S.P.) during 11th and 12th standard. However, Secretarial Practice being a theoretical paper requires no mathematical skill. Lacking a strong foundation in basic math skills affects their confidence and their ability to cope, leading them to drop the subject in higher secondary. The Maharashtra State Board of Secondary and Higher Education ("STATISTICS HSC," 2019) provides the following data: Only 23% of the students opt for Mathematics at the 10+2 level in Maharashtra. In the February 2019 examination out of 180785 students, 142031 chose 'Secretarial Practice' and only 38754 students chose the 'Mathematics and Statistics' course. However, during commerce graduation, Mathematics becomes a compulsory subject for these students who drop mathematics at the 10+2 Level. Because mathematics knowledge base is hierarchical, the low levels of math proficiency amongst school students, continues to remain low at college level too. The low levels of math proficiency, having low math literacy and poor application skills increases anxiety and increases the likelihood that in higher education, they experience difficulty in grasping higher-order concepts. Causes for difficulty in mathematics could be ineffective instruction, difficulties in abstract and symbolic thinking, reading problems, poor attitudes or anxiety, mathematical disability etc (Hammill & Bartel, 1990, p. 215)

Across the globe, conventional methods for dealing with this problem have been to use bridge courses, remedial and tutorial classes and encourage and formulate peer-to-peer learning sessions (Bahr, 2008; Büchele, 2020). A bridge course is one that seeks to fill up the knowledge gaps between the students' current course and their previous course. The focus of these methods has been on bridging the gaps in the knowledge of math and using individual attention to correct the errors in knowledge and skills required for math in higher education. These include clarifying concepts and tools learned earlier like fractions, dealing with operations, solving linear and quadratic equations, understanding and interpreting word problems etc. Usually, students are given remedial education to help them develop the missing core academic skills competences. The Mathematics bridge course is an overlap between remedial coaching and a bridge program. Mathematics bridge programs are aimed at refreshing prior knowledge in Mathematics with more emphasis on conceptual learning and problem solving. And this must be true for all bridge courses in Mathematics as the mathematical knowledge base is hierarchical in form, therefore mastery of

prerequisite knowledge is crucial. Each new understanding is built upon and incorporated into the preceding knowledge gained.

As a math educator, it is not uncommon to hear statements like "I'm not good at math", 'I can't do math', 'I am afraid of numbers' etc, from students taking math courses. Over the years, we have had repeated encounters with students who express that they "went blank" during the exams. The remedial measures continue to build on processing skills but do not directly address the debilitating effects of anxiety.

Math Anxiety

Math anxiety is commonly defined as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). High levels of math anxiety can have a significant and negative impact on the math performance level (Ashcraft, 2002; Ashcraft & Krause, 2007). The stronger negative connections between math anxiety and attitudes toward math are also seen as supporting evidence for a general tendency of avoidance. The love and motivation of doing math, mathematical self-confidence, and views of mathematics as a useful subject are all adversely correlated with math anxiety. (Hembree, 1990; Mammarella et al., 2019)

A case for STEAM Education: Integrating Art in STEM

In recent years, it has been felt that Science, Engineering, Technology & Mathematics (STEM) education was missing another dimension and that of Art. The reframed STEM model now known as STEAM includes Art (A). At the cognitive level, using art for doing math reduces anxiety, increases the available working memory capacity (Ashcraft, 2002), makes the problem more concrete (Edens & Potter, 2007), and activates the right brain which allows them to better tap intuition and creativity (Edens & Potter, 2007). As a pedagogical method, using art is non-threatening to self-esteem as there are no correct/wrong answers. In the context of teaching and learning, observations in most classrooms in India focus on structured learning sequences with correct answers, that is, often "one correct answer"(Sparapani et al., 2014). Doing art allows one the capacity to dare to try different answers (Edens & Potter, 2007). Art-based interventions allow a student to reorganize and use spatial skills to represent the elements of the problem thereby reducing the impact of poor language skills (Georgette, 2008; Edens & Potter, 2007). STEAM education has benefited students in both the affective and cognitive domains by helping them converge their personal experience and knowledge in problem-solving processes to better structure concepts (cognitive) and also by internally motivating students in learning science and

math (affective). It has thus helped students improve their problem-solving and critical thinking, both desired outcomes of math education (Briggs, 2015). An intervention study was set up by Essen & Hamaker (1990) to investigate if generating drawings of arithmetic word problems will facilitate problem-solving performance for fifth graders. They found that fifth graders achieve better on a word problems test when they were instructed to make drawings of those problems. Their performance on other problems also improved and without any prompting, their action of visualizing the word problem increased post-test. A study by Edens & Potter (2007) found that the use of drawings and the level of spatial understanding were positively correlated to the problem-solving performance of the students. They commented that the art classroom could be important in developing students' spatial, proportional thinking and mathematical ability.

As previous research indicates the benefits of integrating art into the curriculum at the school level, we felt the need to integrate art into the mathematics education we provide at the graduate level also to facilitate them to become lifelong learners. The rationale of the present study is based on these findings and studies the benefits of integrating art into the bridge course for students who have dropped mathematics in the 10+2 Level.

Methodology

Objectives

A Pre-Post Exploratory design was used wherein 24 FYBCOM students who had failed their first semester math exam participated in a bridge course designed as an intervention to improve. This bridge course was designed by integrating art into the activities of the conventional math bridge course.

Their scores on math anxiety and math proficiency were assessed pre and post the bridge course. Semi-structured interviews were conducted to understand the impact of the intervention on interest in, confidence and motivation to approach the math subject related activities in future.

The broad objectives of this study were to investigate if there is a significant difference in the math anxiety levels and math proficiency levels of the participants pre and post the bridge course.

The following two hypotheses were tested:

1. There is no difference in the math anxiety levels of the participants pre and post the bridge course.
2. There is no difference in the math proficiency levels of the participants pre and post the bridge course.

Participants

The data presented here is based on two pilot studies conducted on students of first-year Bachelor of Commerce students who had failed their first-semester mathematics exam and were recommended to take the math bridge course based on art. Informed consent was taken from them. The final count of students completing the pilot studies of this intervention was 24 students (7 male participants and 17 female participants).

Measures

1. Math Anxiety: To measure students' math anxiety the Mathematics Anxiety Rating Scale (MARS) 30-brief test was used. The MARS 30-brief is a 30-item instrument developed by Suinn and Winston (2003). It measures math anxiety as defined by Richardson and Suinn (1972). The scores can range from 30 to 150, with higher scores indicative of higher levels of math anxiety. The test has a Cronbach alpha of 0.96. The MARS can be used to screen certain students in order to determine whether they should be enrolled in remedial mathematics courses and if they should be offered counselling regarding their math anxiety.
2. Math proficiency: To measure students' math proficiency, a math test was given to the students before and after each intervention session. Each test was marked out of 10. The final math proficiency score of each student was calculated as the combined marks obtained by the student sessions are (marked out of 100) These tests were based on the topics covered in the bridge course.

Procedure

Students who failed in their Semester I Mathematics Exam were invited to participate in the bridge course. Before the bridge course began, their math anxiety levels were assessed using the MARS 30-item.

The bridge course consisted of ten sessions, each session for an hour and a half, conducted once a week. Around 20 activities were conducted across these ten sessions. Before each session, a test was administered of 10 marks based on the contents that were to be covered in that session. The content of the bridge course was basic arithmetic, fractions, percentages, indices, mathematical rules involving operations, and basic algebra. Art was integrated into the activities of the bridge course. In each session, 2-3 instructors were present to guide the students. After each session, a test was administered of 10 marks based on the contents that were covered in that session.

Math anxiety scores of all participants were measured using the MARS 30-item test at the end of the bridge course.

Semi-structured interviews to understand the subjective experience of the sessions were conducted for ten participants chosen randomly at the end of the bridge course.

Art based bridge course Session Details (Integration of Fine Arts into math topics)

Activities were divided into following three categories:

- Art Activities
- Activities featuring math Manipulatives
- Presentation of math problems in the context of drawing/colouring

This categorization allows us to group the objectives in terms of the cognitive skills involved. During the ten sessions, the flow of the mathematical content was as follows: Operations, Fractions - Concept and models, Equivalent Fractions, Operations on Fractions, Order of Operations (BODMAS Rule), Recognising symbols, Linear Equations, Word problems. At the beginning of each session, the details of the activities and relevant instructions were shared with the students.

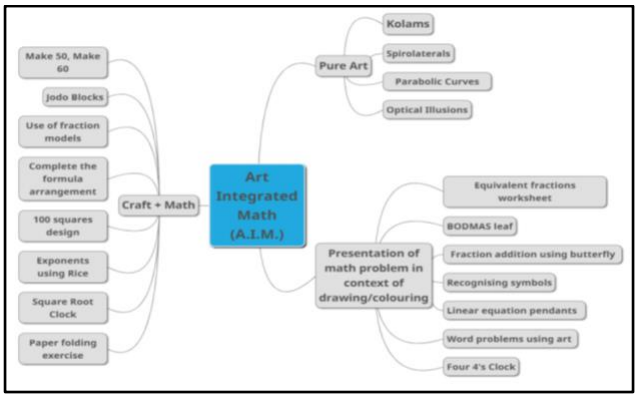

Figure 1: Mind map of the activities conducted

The activities under each of the categories along with their descriptions are mentioned below.

Art Activities

1. Making Kolams: Kolam is a form of drawing in India. Kolams are usually made in the courtyards and outside homes using rice flour etc to decorate houses during festivals. Students were provided designs of 5 kolams and asked to replicate them on a dotted sheet. A lot of confusion ensued while drawing the 20 by 20 dot kolam for almost all participants. Some changed their strategies of drawing the 20 by 20 when they made mistakes.
2. Drawing Spirolaterals: Spirolaterals are spiraled, structured designs based on a repeated series of commands using length and angle. In this session, students choose number

sequences of their choice as the length (for instance: 1,2,3,1,2,3,1...) drawn in successive 90-degree angles to create beautiful closed loops known as spirolaterals.

3. Parabolic Curves Drawing: The basic principle of Parabolic Curve line design is the creation of curved shapes from the intersection of straight lines. Students were given different templates to create and color their parabolic curves.
4. Optical Illusions: Op Art is an abstract art style that looks like an optical illusion. The students were given wooden coasters to draw on and measurements to make an optical illusion were given.
5. 100 squares design: The students were asked to divide their coaster into a hundred small squares. (10 by 10). They then created a pattern/design using different colors in the grid. Further, students calculated percentages and fractions of each color in their design. They further solved a worksheet understanding the relationship between percentages, fractions, decimals and their pictorial representation.

Cognitive skills involved: Pattern Recognition, Decision making, Cognitive flexibility, Sustained attention were some of the cognitive skills involved in these activities. Students explored mathematics concepts such as Symmetry, Measurement, Parallel lines, geometry, Algorithmic thinking, use of math in real life in the course of these activities.

Activities featuring Math Manipulatives

1. Make 50, make 60 (using triangles): Make 50 and Make 60 are addition and multiplication math games with equilateral triangles. Each side of the triangle had numbers written on them. In one set, students had to match up sides of the triangles such that the numbers on the meeting sides of two triangles add up to 50 and in another set match those whose product is 60.
2. Jodo blocks: These are snap-on cubes also known as Jodo Cubes. Concepts like addition, subtraction, multiplication, division, fractions, factors of integers, etc were taught with snap-on cubes.
3. Use of fraction models: Physical models gave a hands-on experience to students to understand parts of the whole and comparison of different fractions of a whole.
4. Complete the Formula arrangement: With the idea of developing symbol sense, a formula was cut into various parts and the students had to place together various parts to get back to the original formula.
5. Exponents using Rice: On each of the nine squares of the Tic-tac-toe board, students were asked to place rice grains in powers of 2 ranging from 21 to 29. ("Exploring exponents," 2020)

6. Square root clock: Students had to make a clock where every digit (from 1 to 12) was expressed as a square root. They had to choose from cut-outs of square roots provided to them.
7. Paper folding exercise: The students started with a square sheet of paper and made folds to construct a new shape. They were asked to construct a square and a triangle with exactly ¼ the area of the original square and construct a square with exactly ½ the area of the original square. ("Paper folding," 2020)

Cognitive skills involved: Decision-making, Visual-spatial, perceptual motor skills, and creative thinking were some of the cognitive skills involved in these activities. Students explored mathematics concepts such as operations, fractions, exponents, roots, algebra of operations, percentages, and decimals in the course of these activities.

Presentation of math problem in the context of drawing/colouring

1. Equivalent fraction worksheets: Fractions were presented in circular and rectangular shapes to aid learning of the concept of equivalent fractions. Further to consolidate their knowledge they coloured a worksheet that was color coded with respect to fraction values.
2. BODMAS Leaf: The students were taught BODMAS and given a worksheet to solve BODMAS problems. The worksheet involved painting a leaf while solving the problems. The problems were thus presented in a non-linear format thereby engaging both sides of the brain.
3. Fraction addition using the butterfly method: The students were provided a simple way to add fractions by making a butterfly. They were also taught fraction multiplication and division.
4. Recognizing symbols/formula worksheets: Three worksheets were created to improve their friendliness with symbols. These were made based on a sunflower theme to insert an element of art and playfulness into them. The first worksheet was about recognizing symbols and associating the given values with the symbols, the second was about using the symbol '$\sum$' (summation) in various contexts and the third was about recognizing and selecting the appropriate symbolic representation for a problem from a variety of choices. These three worksheets given in chronological order were aimed at first allowing them to associate with the symbols, then learn how they are used and then finally learn to differentiate between them and select the relevant ones based on the requirement.

5. Linear equation triangles/ pendants: Students were given pendants to learn how to solve linear equations.
6. Word problems using art: The students were given a worksheet to work out word problems by drawing them out. The word problems ranged from simple ones based on operations to more complicated ones that required solving simultaneous equations.
7. Four 4's Clock: The students were asked to make a clock where every digit from 1 to 12 on the clock was written using only four 4's and any operation. This was intended as a low threshold, high ceiling activity. ("four 4's," 2020)

Cognitive skills involved: One-one correspondence, Attention, visual-spatial, Memory, Language, and abstract reasoning were some of the cognitive skills involved in these activities. Students explored mathematics concepts such as BODMAS, fractions, Linear equations, Symbol sense Word problems, Pictorial representation, Estimation, Symbol sense (To extend the construct of number sense in school arithmetic to school algebra, researchers suggested the construct symbol sense (Arcavi, 2005), manipulating and interpreting symbols, number sense, operations in the course of these activities.

Data Analysis

The following analysis was conducted:

1. A descriptive analysis of MARS-30 Brief values and Math Proficiency Test values.
2. A test of normality was conducted for both pre and post test values relating to math anxiety and math proficiency.
3. The MARS Scores were found to be normally distributed, a paired t-test was conducted to test the null hypothesis relating to the math anxiety levels.
4. As the math proficiency test scores were not found to be normally distributed, a Wilcoxon Signed-Rank Test was run to determine if there was a statistically significant mean difference between the post and pre-test results of the Math Proficiency Test.
5. The semi-structured interviews were also analysed to gain insight into the impact of the bridge course.

Results and Discussion

Analysis of scores on MARS-30 Brief

No outliers were found in the MARS scores (pre and post) using the ROUT method. The average MARS-30 item scores of the participants were found to be 84 with a standard deviation of 20 before the bridge program. Post the bridge course, their average MARS-30 item scores were reduced to 70 with a standard deviation of 21. The violin plot as shown in Fig. 2 shows the median and interquartile range of the MARS Scores along with the distribution of the data. The median MARS test score reduced from 79 before the intervention to 69 after the intervention. The range of the scores before the intervention was 53-134 and post the intervention was 30-115. A higher MARS score indicates higher anxiety.

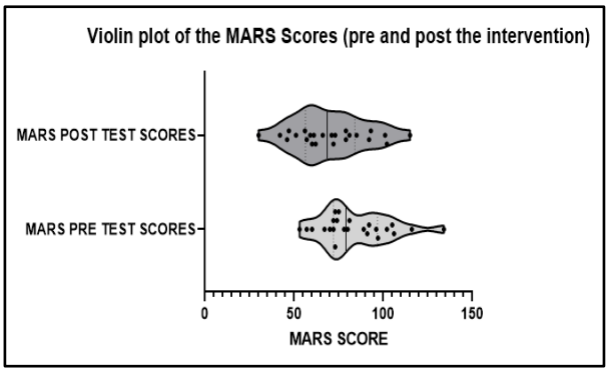

Figure 2: Mars-30 brief scores of Pre and Post Intervention

As can be seen in the area chart in Figure 3, the MARS-30 Anxiety Scores of 45% of participants were below the MARS-30 score of 65 post-intervention as compared to that of only 12.5% of participants before the intervention.

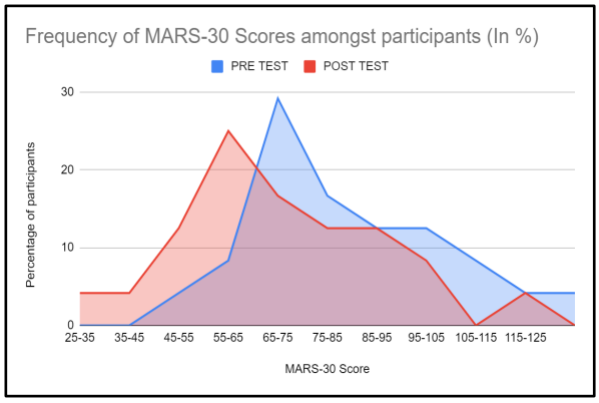

Figure 3: Frequency analysis of MARS-30 Scores amongst participants (in percentage)

Five out of the 24 participants registered an increase in their anxiety scores. Upon inquiry, they mentioned that as their final exams had drawn closer, their anxiety had increased as compared to

nine weeks earlier when the pre-test was conducted. All other students registered a decrease in their anxiety scores ranging from 2% to 69%.

Pre-test and Post-test MARS-30 Scores

Paired Difference								
Paired Difference= MARS Post-test Scores - MARS-30 Pre-test Scores	**Mean**	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval**		**t**	**df**	**Sig (1 tailed)**
				Lower	**Upper**			
	-13.88	24.26	4.952	-24.12	-3.631	-2.802	23	0.0051

Table 1: A paired t-test results of the difference in the post and pre-test MARS-30 Scores

The MARS-30 item scores (pre and post) were found to be normally distributed using the Shapiro-Wilk Test (at alpha= 0.05). A paired t-test with results as shown in Table 1 was run to determine whether there was a statistically significant mean difference between the MARS 30 item scores of the participants' pre and post-bridge course. ($t = -2.802$, $p = 0.0051$). From the above results, we can say the following:

- The difference in their anxiety levels post and pre-intervention was found to be statistically significant.
- On average, the post-intervention MARS-30 scores were 13.88 points lower than the pre-intervention anxiety scores. (95% CI [-24.12, -3.631]).

Analysis of math Competence Levels

Participants were administered mathematics tests before and after the intervention and marked out of 100. Their cumulative scores on these tests had a mean score of 51 with a standard deviation of 20 before the sessions and an average score of 74% with a standard deviation of 19 after the sessions. The adjoining violin plot shows the distribution of scores.

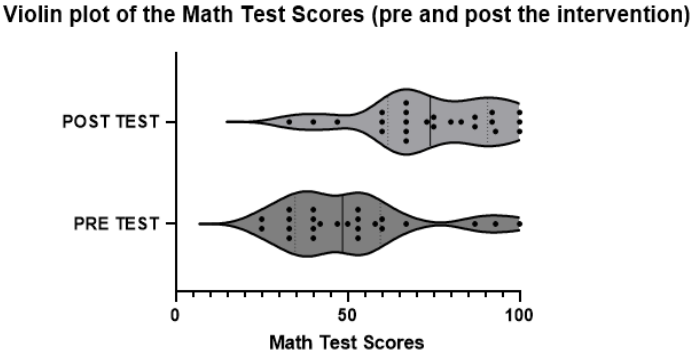

Figure 4: Math Test Score pre and post Intervention

The test scores were found to be not normally distributed by the Shapiro-Wilk Test. A Wilcoxon Signed-Rank Test was run to determine if there was a statistically significant mean difference between their post and pre-test results. It was found that 18 participants had a higher post-test Score than the pre-test score. However, 4 participants had a pre-test score higher than the post-test score and 2 participants saw no change in their score. Normal approximation was used for tie correction. The test statistic Z = -3.541323, which is not in the 95% region of acceptance: [-1.6449 : ∞] and W-=17.00, is also not in the 95% region of acceptance: [75.8700 : 253]. The result was found to be significant at $p < .05$. The observed standardized effect size, $Z/\sqrt{n}$, is large (0.76). That indicates that the magnitude of the difference between the scores from the post-test and the scores from the pre-test is large.

Results of the Interviews

Effect on motivation in solving math problems and math courses

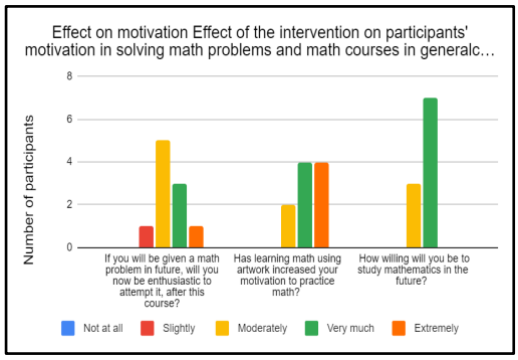

Figure 5: Effect on motivation in solving math problems and math courses

90% of the students showed moderate to extreme enthusiasm in solving a math problem. All students were moderately or extremely motivated to practice math as well as study math in the future. Avoidance is a strong negative emotion associated with math anxiety. Overall, Figure 5 suggests that after the bridge course, students felt more positive about approaching math as a subject in future.. In informal conversations, many students expressed that their outlook toward math had changed for the better. When asked why they feel like their outlook has changed, one of them said ‘ I now have doubts in math class!’ Another said she gets the right answers and understands better.

When queried about the different activities used to teach math using art, mentioned earlier, the students exhibited this new-found enthusiasm and took up the challenges head-on in the two ‘low threshold, high ceiling activities’.

The Four 4's clock activity was quite a task and students came up with multiple answers for the same number, some of them were very elegant solutions. One student didn't stop at 12 and went home and continued up to 20! The first time we did 'spirolaterals', most students couldn't complete the loop during the session and kept making mistakes. They took it up as homework and came back in the next session with completed loops. They seemed to have developed this resilience and interest in the subject. During the BODMAS session, they were asked to solve 25 problems, which in a linear format would have been extremely tedious but when presented in the form of a leaf (non-linear, artwork), not even a single one felt the monotony!

Effect on confidence in passing exams

20% of the students are moderately confident about passing their semester-end exams and 80% of them were very confident about passing. Unfortunately, due to the Covid-19 pandemic, the exams were not conducted. And hence there is no way to verify their optimism.

Effect on Approach to learning

The following ideas/responses emerged through a content analysis of their responses to how their approach to learning math had changed after the bridge course. The probes with their corresponding frequencies are highlighted in Figure 6.

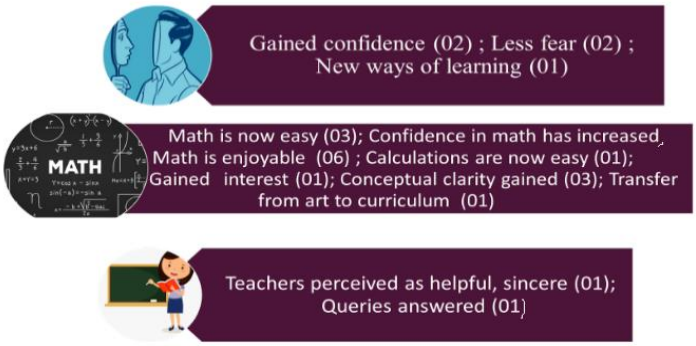

Figure 6: Shifts in the participants' approach to learning after the bridge course

Jain and Dowson (2009) described mathematics anxiety as a consequence of "an inability to handle frustration, excessive school absences, poor self-concept, internalized negative parental and teacher attitudes toward mathematics, and an emphasis on learning mathematics through drill without "real understanding". The interviews with the participants suggest that the environmental variables like teacher characteristics and the reduction in expectation to do well in the sessions, personality variables like self-concept, confidence and learning behaviour seem to have improved.

These characteristics are explained as the causal factors for math anxiety by many studies along with intellectual variables that include the child's level of more general cognitive abilities.

Effect on fear

When asked if the bridge course helped reduce their fear of mathematics, all 10 students replied in the affirmative. When probed about the reasons for the reduction in fear, the following thoughts emerged: (the numbers indicate the frequency)

1. Fear has reduced because they have a better grasp on the basics (03)
2. Fear has reduced because their confidence has increased (02)
3. Fear has reduced because the teachers have been very helpful (02)
4. Fear has reduced because their performance has improved. In their understanding improvement in performance is reflected by problem-solving becoming easier, formulae appearing easier, their understanding has improved, they have started studying from the textbooks on their own, they get the right answers. (07)
5. Fear has reduced because their self-efficacy with respect to mathematics has improved. (03)

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Effect of use of art on math learning

All 10 students resonated that learning math was easier through art-based activities. These activities helped simplify math concepts. They found them enjoyable, useful and fun. Their perception of math as a tough and less-scoring subject was changed. Math was simplified. They liked and are motivated to practice problems now. Math classes were now easier to understand. Many students specified that the BODMAS session, the session on symbols and formulas, the session on exponents, and the square root clock were especially helpful.

Growth Mindset

In our efforts to develop a growth mindset (Boaler, 2015) among the students we stressed two major points. One that "mistakes are good. Your brain fires up when you make a mistake, so please share the mistakes with others so they can learn from them too." And the other is that "math is about understanding and making sense". When asked if they feel more comfortable with making mistakes in mathematics after the bridge course, 80% of them replied in the affirmative.

The overall reception of the Bridge Course:

All students expressed that they would recommend this course to their friends

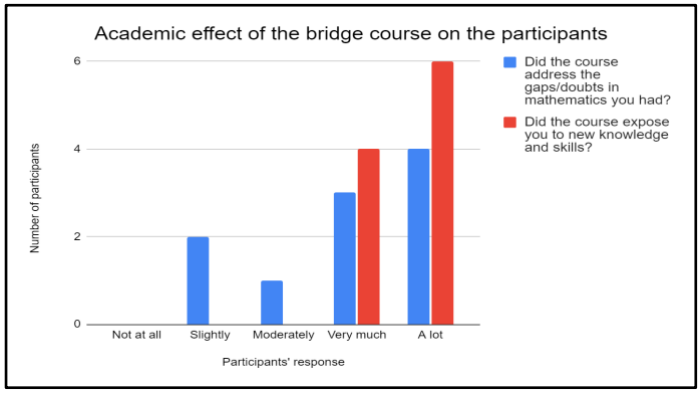

Figure 7: Academic effect of the bridge course

Figure 7 suggests that most students learned new knowledge and skills during the bridge course. The contents of the bridge course satisfied the gaps of 70% of the students but couldn't completely address those of 30%. In their answer to a separate question, all students found their current math coursework had become easier due to the bridge course. All the students said that the course would be useful and should be run in the first week of college.

Limitations of the research

Time constraint: Due to paucity of time, topics like quadratic equations and manipulations of linear equations couldn't be taught. The authors also wanted to conduct some sessions focused on building number sense and data analysis skills. These tools are important for their current curriculum and perhaps that's what some students found lacking.

2. Participation: Since the bridge course required additional time, for various personal reasons, many students dropped out of the bridge course. Also, we found that students with very high math anxiety scores didn't even enroll. As a remedy, some kind of preparatory orientation can be given before enrolment to increase sustained attendance and participation.

Conclusion

Results of the interviews indicate the impact of the Art-based Bridge program in reducing math anxiety, negative emotions such as avoidance associated with math anxiety. Art can be integrated into math classes even at the undergraduate level to address the debilitating effects of math anxiety.

In India, the Mathematics department of Azim Premji University runs a program exploring Math and Art for undergraduate students. At the University of Mumbai, however, no such integration is seen at the college level. In many schools in India today, especially at the primary/kindergarten level, such interventions are seen. There is a need for such integration at the college level since the math proficiency levels of our HSC students aren't up to the mark. Another aspect to consider is that teaching in India happens by a teacher for whom English is a second or third language and similarly, for the student, English, the usual medium of instruction in college under Mumbai University, is his/her second/third language. This makes the teaching-learning process more difficult and prone to assumptions and ambiguity. Art-based activities may reduce the need for such negotiations.(Sparapani et al., 2014)

Keeping in mind the results of this case study and the literature available, the authors plan to conduct another Art based Math bridge program and study it for a larger group of students. Worksheets created for this case study will be modified according to the feedback received during this case study and used for this larger group of students.

Acknowledgment

This research has been funded by the Minor Research Project grant 2019-20 given by the University of Mumbai, India. The authors are grateful to their Departmental colleagues, Research Circle Committee, and the College Principal with special mention to Mr. Suman Ganger for their support.

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