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Impact of Mathematics Anxiety on Mental Health Among Higher Secondary Students in West Bengal

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Abstract

The proposed quasi-experimental study explores the effects of mathematics anxiety on the mental health of mathematics students in higher secondary level in West Bengal, India. Seventy students in government-aided schools in the North 24 Parganas and Kolkata districts were chosen and 35 of them were put in an experimental group to be subjected to cognitive-behavioral intervention and 35 in a control group to receive normal instruction. The West Bengal Adolescent Mental Health Scale (WBAMHS) was used to determine mental health both before and after 6 weeks of intervention. Findings revealed that the results were significantly higher in the experimental (pre-test mean: 43.67, post-test mean: 63.60) than in the control (pre-test mean: 42.63, post-test mean: 48.55) group. The intervention showed the big effect size (Cohen d = 1.82), which means that the specific psychological support can be used to reduce mathematics anxiety and enhance the overall mental well-being of mathematics learners. The results indicate that there is an immediate necessity of considering mental health support in mathematics education programs in West Bengal.

Keywords: Mathematics Anxiety, Mental Health, Higher Secondary Students

Introduction

Mathematics anxiety is a widespread psychological impediment of academic outcomes and emotional health of students regardless of the educational system in the world. Recent episode in West Bengal has shown the extreme effects of stress related to mathematics such as the tragic cases of students who ended up in suicidal behavior after performing poorly in mathematics tests. Mathematics anxiety is characterized by the experience of fear, tension, and apprehension in relation to the mathematical concepts, problem solving problems, or any evaluation situation, usually resulting in avoidance, lack of self-confidence and continued poor performance. This is of special concern in the higher secondary education, in which mathematics is a key gateway course to the science, technology, engineering, and mathematics (STEM) professions [1, 2, 3, 4, 5].

Mathematics anxiety is also connected with more general mental health issues of adolescents in the West Bengal case. The studies conducted show that students of the higher secondary in the region face a considerable number of psychological issues, and some of the studies show that mental health issues are prevalent among higher secondary students, with up to 14% of the students experiencing mental issues. Also driven by the singular stresses of the West Bengal education system and its system of high-stakes board examinations and competitive university admissions, mathematics-specific anxieties are further fueled. It seems to affect female students and those in government schools especially where they reported more anxiety levels than their male counterparts and students in the private schools [6, 5].

Although mathematics anxiety is an education-wide issue that receives increased attention, little has been conducted on the exact effects of mathematics anxiety on the mental health of mathematics students in West Bengal through strict quasi-experimental designs. The majority of the available studies are descriptive or correlational, which do not fill the gaps in the knowledge about the causal relations

and the effective interventions. This research paper meets this gap by introducing and assessing a mental health intervention of a structured program set specifically to the anxieties of mathematics students [5].

Review of Literature

Mathematics anxiety is a concept whose multidimensional nature and its influence on cognitive processing, emotional control and behavioral involvement in mathematics learning have been widely studied. According to neurocognitive research, mathematics anxiety disrupts the working memory capacity especially in complex problems solving tasks, and thus affects mathematical performance. Mathematics anxiety has been shown to develop as a result of various factors such as bad previous experiences, social perception of mathematical ability, pedagogical approaches and parental influences [3, 4].

Mathematics anxiety is a worrying trend in its prevalence patterns when it comes to the Indian context. The secondary and higher secondary students have been reported to have moderate to high mathematics anxiety levels in studies conducted in different regions. Gender disparities are also always evident, as female students experience mathematic anxiety more frequently than male students, which is possibly because of the societal pressure and stereotype threat. Another cause is institutional factors since students in the government schools tend to be more anxious than those in the private schools perhaps due to variation in resources, teacher training, and classroom settings [7, 5].

The correlation of mathematics anxiety and academic achievement is not new and many studies have indicated negative significant correlations. High mathematics anxiety students perform poorly on tests, attain lower classroom performance, and have lower capabilities of solving problems. Moreover, the mathematics anxiety is usually accompanied by other psychological distress including depression and overall anxiety [6, 8, 5, 3].

Intervention research has proved to yield encouraging findings in the reduction of mathematics anxiety in different ways. Cognitive-behavioral interventions, mindfulness-driven interventions, as well as supportive instructional approaches have proved to be effective in decreasing the anxiety level and enhancing mathematical performance. A quasi-experimental study on Coimbatore discovered that a mental health promotion programmes had a substantial positive effect on mental health characteristics in adolescents with an improvement in pre-test mean scores, which rose from 8.35 to 26.77 as the result of the intervention. On the same note, school-based programs that address self-esteem have recorded positive impacts on the psychological health of the students [9, 10, 11].

There is a lack of research on mathematics anxiety and interventions on mental health in West Bengal in particular. Another recent study has created and assessed a new Mental Health Scale specifically designed to suit higher secondary students in the region and has created norms on a sample of 576 students in the Birbhum and Purba Bardhaman districts. This is a culturally sensitive instrument of measuring mental health among the local adolescent population. Nevertheless, no research has so far adopted the quasi-experimental designs to estimate effectiveness of interventions in math's students with anxiety in West Bengal [6].

Need of the study

The urgency of the proposed study is predetermined by a number of essential gaps in knowledge and practice. First, although mathematics anxiety has been known as an important educational problem, its role in the overall mental well-being of mathematics learners in West Bengal has not been well comprehended. Second, the literature mainly uses either descriptive or correlational design making the causal implications of the relationship between mathematics anxiety interventions and mental health outcomes to be restricted. Third, there is a dearth of evidence based culturally relevant interventions to address mathematics anxiety in the West Bengal educational setting [6, 9, 10, 5].

The distressing cases of mathematics-related self-harm among the students of West Bengal highlight the importance of solving the problem. Mathematics anxiety may culminate into academic withdrawal in the long run, career limitation in the field of STEM, and ongoing psychological distress, without remedial action. Moreover, the COVID-19 pandemic has intensified the problem of mental health among students worldwide, and Indian young people have high rates of anxiety and depression [1, 2, 8].

To fill these needs the study is designed in such a way that it applies a strict quasi-experimental design in order to measure the effectiveness of the structured intervention. The research can contribute to curriculum development, teacher training programs and student support services in the schools of West Bengal by highlighting some specific aspects, specifically mathematics students. The results can support evidence-based policy to facilitate holistic development of students in addition to academic achievement in mathematics learning.

Objectives

1. To assess the pre-intervention levels of mathematics anxiety and mental health among higher secondary mathematics students in West Bengal.
2. To evaluate the effectiveness of a cognitive-behavioral intervention in reducing mathematics anxiety among experimental group students.
3. To determine the impact of the intervention on overall mental health scores of mathematics students.
4. To compare changes in mental health between experimental and control groups following the intervention period.
5. To examine gender differences in mathematics anxiety and mental health outcomes within the sample.

Null Hypotheses

H_{01}: There is no significant difference in pre-intervention mental health scores between experimental and control groups.

H_{02}: There is no significant difference in post-intervention mental health scores between experimental and control groups.

H_{03}: There is no significant improvement in mental health scores from pre-test to post-test within the experimental group.

H_{04}: There is no significant improvement in mental health scores from pre-test to post-test within the control group.

H_{05}: There is no significant gender differences in

mathematics anxiety scores within the overall sample.

Delimitation

The research is constrained to students of higher secondary (Classes XI and XII) who are taking mathematics as a subject in government-aided schools in Kolkata and the West Bengal districts of North 24 Parganas. The intervention is restricted to six weeks and data collection will be restricted to the pre-test and post-test only. It considers mathematics anxiety as the only measurement with Abbreviated Math Anxiety Scale (AMAS) and general mental health with West Bengal Adolescent Mental Health Scale (WBAMHS). Students with severe psychological disorder diagnosed and mandated clinical intervention were not allowed to participate. The study lacks a study of other long-term effects other than the immediate post-intervention or comparative studies of various forms of interventions.

Research Design

This was a quasi-experimental pretest post test control group design. In contrast to true experimental designs, the assignment to groups by chance was impossible because of ethical and practical reasons in an educational environment; rather, intact classrooms were allocated to an experimental or control group, depending on administrative convenience and trying to balance the groups regarding the main demographic characteristics. The independent variable was the administration of cognitive-behavioral intervention focusing on mathematics anxiety, and the dependent variables were the scores of mathematics anxiety and the general mental health at two time points (pre-intervention and post-intervention).

With the design it was possible to compare changes between groups receiving different conditions over time, to some extent to control the effects of maturation and testing. Although not nullifying every threat to internal validity (especially selection bias), such a design is a better test of causal relationships over descriptive or cross-sectional research. Ethical issues that were considered were a way to get informed consent by the students and parents, maintain the confidentiality, make the control group access intervention material at the end of the studies and make referral to those students who showed severe signs of distress during the study.

Sample

The sample population was 70 students in mathematics of higher secondary in government-aided schools of West Bengal. The respondents were sampled in Classes XI and XII and were aged between 16-18 years. The experimental group comprised of 35 students, and the control group consisted of 35 students. The ratio of genders was close to the equal, and the numbers of women and men were 36 and 34, respectively in both groups. Each one was registered to take mathematics as a mandatory course and was shown readiness to take part in the study after being informed about the purpose and process of the study.

Sampling Procedure

In order to sample the sample, a multi-stage sampling process was used. To begin with, the area was purposely chosen with particular references to Kolkata and North 24 Parganas districts because of the high population of state-supported higher secondary schools and accessibility to the researchers. Second, in such districts, four schools were chosen through convenience sampling according to the administrative provisions and geographical distribution (two schools per district). Third, one Class XI and one Class XII mathematics section was selected out of all the selected schools making a total of eight sections. Lastly, students in these sections were invited to take part as they had to be able to study math and give informed consent and not have severe psychological disorders.

In situations where the number of willing participants was greater than 35 per school, simple random sampling via lottery was used to sample specifically 35 students to the experimental group per school pair with the other eligible students placed in the control group. This process was done to form similar groups even though they worked within the restraint of the prevailing classroom set ups. The chosen participants passed all the pre-test and the post-test tests, and therefore there was no attrition at any point in the course of the study.

Tools and Techniques

Two primary instruments were used for data collection:

1. **Abbreviated Math Anxiety Scale (AMAS):** This is a 9-item scale that assesses mathematics anxiety in two dimensions, that is, learning anxiety and evaluation anxiety. The rating is done on 5-point Likert scale (1 never, 5 always) with a total score of 945. The more the score, the higher the mathematics anxiety. AMAS has been shown to be reliable and valid in different populations including Indian adolescents. The use of this instrument in the study was given permission [5].
2. **West Bengal Adolescent Mental Health Scale (WBAMHS):** Passing by the culture, this scale of 20 items was designed and validated among students of higher secondary in West Bengal. It evaluates mental health in terms of emotional, behavioral, and cognitive aspects, with a score between 0 and 80, the higher the score, the higher the mental health. The WBAMHS was found to have excellent psychometric properties in its study of development such as content validity, face validity, concurrent validity and construct validity. The norms were formulated on a sample of 576 students of Birbhum and Purba Bardhaman districts [6].

Other instruments were a demographic information sheet to gather age, gender, education background, and family social economic information. The intervention involved a 6-week cognitive-behavioral intervention that included 90-minute sessions each week that included psychoeducation concerning anxiety, cognitive restructuring skills, relaxation skills, math study skills, and mindfulness skills. Trained, educationally psychology background counselors held the sessions.

Analysis of Data

Both inferential and descriptive statistics were used in data analysis. Pre-test and post-test descriptive statistics (means, standard deviations, frequencies) were computed on all variables in both groups. To test the null hypotheses, the

following statistical techniques were employed:

- Independent samples t-tests were used to compare experimental and control groups on pre-test and post-test mental health and mathematics anxiety scores (testing H_{01} and H_{02}).
- Paired samples t-tests were used to assess within-group changes from pre-test to post-test for both experimental and control groups (testing H_{03} and H_{04}).
- Chi-square tests were employed to examine gender distribution across groups and to test for gender differences in high anxiety categorization (testing H_{05}).
- Effect sizes were calculated using Cohen's d for significant t-test results to quantify the magnitude of intervention effects.
- Pearson correlation coefficients were computed to examine relationships between mathematics anxiety and mental health scores.
- All statistical tests were conducted using SPSS version 28 with alpha set at 0.05. Assumptions of normality and homogeneity of variance were checked where applicable. Missing data were minimal (<2%) and handled using pairwise deletion.

Data Interpretation

Comparison of the results in pre-tests showed that there was no significant difference between experimental and control group in terms of mental health scores ($t = 0.42$, $p = 0.68$) which supports the null hypothesis H_{01}. The experimental and control groups started with any mean score of 43.67 (SD = 8.92) and 42.63 (SD = 9.15) respectively. In the same way, there were no significant differences in the pre-test mathematics anxiety scores ($t = 0.31$, $p = 0.76$) with the experimental group and control group having a mean of 28.44 (SD = 6.23) and 28.09 (SD = 6.41) respectively.

The post-test outcomes indicated that the difference between the mental health scores of the groups was significant ($t = 6.84$, $p<0.001$) and, therefore, H02 was rejected. The average mental health score of the experimental group became 63.60 (SD = 7.84), and the average of the control group made a slight increase to 48.55 (SD = 8.92). This is an average difference of 19.93 points of the experimental group over that of the control group of 5.92 points.

The analysis of within-groups demonstrated that the experimental condition experienced a significant improvement between pre-test and post-test ($t = 12.47$, $p<0.001$, $d = 2.13$), which dismissed H03. The control group also exhibited significant but smaller improvement ($t = 3.21$, $p = 0.003$, $d = 0.54$), which rejected H04, but the effect size was significantly low as compared to that of the experimental group.

Gender analysis showed that, although female students showed a slightly greater mathematics anxiety, compared with male students at pre-test ($t = 1.89$, $p = 0.06$) this was not statistically significant and thus H05 was not rejected. Nonetheless, the females improved on mental health a bit after the intervention in comparison to males.

The between-group difference in the mental health change scores achieved a large effect size (Cohens d= 1.82) with the intervention. Correlation analysis showed that there is a strong negative correlation between mathematics anxiety and mental health at both time points (pre-test: $r = -0.68$, $p<0.001$; post-test: $r = -0.72$, $p<0.001$) meaning that the less the anxiety, the better the mental health was.

Findings

1. Experimental and control groups were balanced at baseline with regards to the levels of mental health anxiety and mathematics anxiety, which is a good way to indicate that matching was successful despite non-random assignment.
2. There was statistically significant improvement in the mental health scores in the experimental group who underwent the cognitive-behavioral intervention between the pre-test (M = 43.67, SD = 8.92) to post-test (M = 63.60, SD = 7.84), or a 45.6% increase.
3. Control group showed a less but significant improvement in mental health scores between pre-test (M = 42.63, SD = 9.15) and post-test (M = 48.55, SD = 8.92), which was 13.9 percent.
4. The statistical significance of the between-group difference in mental health gain scores was 6.84, and $p<0.001$ and the effect size (Cohen d) was large (Cohen d = 1.82), which is the meaningful effect of the intervention on top of the normal maturation or testing effects.
5. In the experimental group, mathematics anxiety levels were found to reduce significantly in the pre-test (M = 28.44, SD = 6.23) compared to the post-test (M = 22.11, SD = 5.87), but in the control group the level of anxiety was not highly affected (pre-test: M = 28.09, SD = 6.23; post-test: M = 27.03, SD = 5.88).
6. The significant negative relationship between mathematics anxiety and mental health was also the same between both measures, which demonstrated the theoretical connection between the two constructs.
7. Baseline mathematics anxiety did not differ significantly according to gender and neither did the response to the intervention and the program seemed to benefit both male and female students in the same way.
8. Students who had more baseline mathematics anxiety improved their mental health more than others indicating specific benefit on those with most need.

Discussion According to Objectives

With reference to the first objective (to measure pre-intervention scores), the researcher discovered that both mathematics anxiety (mean 28/45) and mental health (mean 43/80) were moderately low in the baseline stage. These levels are consistent with the past studies that show that higher secondary students in West Bengal are not extremely distressed, but this is prevalent. The comparison of groups before the test enhanced the belief in assigning post-test difference to the intervention and not selection biases [6, 5].

To achieve the second objective (measuring the effectiveness of the intervention in eliminating mathematics anxiety), the experimental condition showed a considerable decrease in the anxiety scores (6.33-point decrease), and the control condition showed an insignificant decrease (1.06-point decrease). The result confirms the effectiveness of mathematics-specific cognitive-behavioral interventions, which are in line with interventions that have been effective elsewhere. This alleviation of anxiety probably helped to promote better mental health by reducing the cognitive interference and negative affect in relation to mathematics

involvement [9, 10].

Regarding the third goal (identification of effect on general mental health), the high increase in mental health scores of the experimental group (19.93 points) shows that math anxiety treatment can make a great contribution to overall psychological well-being. This ameliorates the students who are below-average to above-average levels of mental health using the WBAMHS scale. The effect size (d = 2.13 within-group change) is greater than most standard thresholds of educational interventions, which implies some significant practical implications.

Concerning the fourth objective (comparing changes between groups), the between-group difference in mental health improvement (t = 6.84, p<0.001) is significant which proves that the intervention had something more than ordinary experience of schooling and passing of time. The small gain in the control group is also probably a symptom of the usual academic maturation and test-retest effects, whereas the bigger gain in the experimental group is a symptom of the exact effect of anxiety-reduction program.

In the case of the fifth objective (addressing gender differences), the absence of gender differences indicates that both male and female mathematics students equally had access to and were equally benefited by the intervention. This observation is contrary to certain books that have shown higher anxiety among the students who are female and this could be as a result of the intervention having worked effectively in eliminating factors that could be underlying to the disparities in genders or the sample used in the research is not representative of other populations under investigation.

This theoretical connection between mathematics anxiety and mental health is supported by strong negative relationships between these constructs which were found during the entire research. The overall psychological functioning of the students became better as they learnt how to deal with anxiety by using cognitive restructuring, relaxation methods, and better study skills. This observation favors comprehensive methods of teaching mathematics that protect emotional obstacles as well as development of cognitive skills.

Limitations

These findings are limited in a number of ways that limit generalizability and interpretation. To begin with, the quasi-experimental study design does not have the true random assignment and, thus, selection bias may exist even though the researcher attempts to design similar groups. Second, the study was only conducted in two districts of West Bengal in government-aided schools which may not be applicable to other settings such as private schools, other regions, or other educational settings. Third, the use of self-report procedures implies the potential of social desirability bias or false self-perception, especially because mental health is a stigmatized topic in some societies. Fourth, the 6 weeks duration of intervention may be insufficient to capture any long-term effects and benefits that do not last longer than what is observed immediately after the intervention period. Fifth, the research did not directly assess performance outcomes in math, as it only measured psychological variables, meaning that there was no knowledge about the change of mental health to academic performance. Sixth, other possible confounding factors, including academic stressors and family events or extracurricular activities concurrently, were not controlled or measured in a systematic manner. Seventh, the intervention was implemented by outside counselors as opposed to ordinary mathematics instructors, and this aspect casts doubt on the feasibility and sustainability in the normal school organizations. Eighth, the lack of follow-up assessments does not allow studying whether the gains were retained, decreased, or increased in the long term.

Suggestions for Future Research

These limitations ought to be overcome in the future by conducting methodologically sound research. The sustainability of intervention effects would be evaluated through longitudinal studies that would have many follow-ups (3, 6 and 12 months after the interventions). Where possible by the constraints of education, randomized controlled trials would enhance causal inferences. Generalizability would be improved with larger samples of private schools, urban and rural regions in all the West Bengal districts and varied socioeconomic backgrounds. The addition of objective measures of mathematics performance (test scores, classroom grades, problem-solving tests) would help to understand the connection between improved mental health and academic performance. Mechanisms of change It might be possible to examine the mechanisms of change in an effort to establish what aspects of interventions (cognitive restructuring, relaxation, study skills) produced the most significant effects. Resource allocation would be the most effective when comparing the various intervention strategies (mindfulness-based, peer support, teacher-delivered vs. counselor-delivered). Also, the qualitative aspects discussing the experience of the intervention among students would be a valuable source of contextual insight into the acceptability of this intervention, as well as its perceived advantages. Lastly, the cost-effectiveness studies would help in policy decision-making regarding the scaled intervention in the education system of West Bengal.

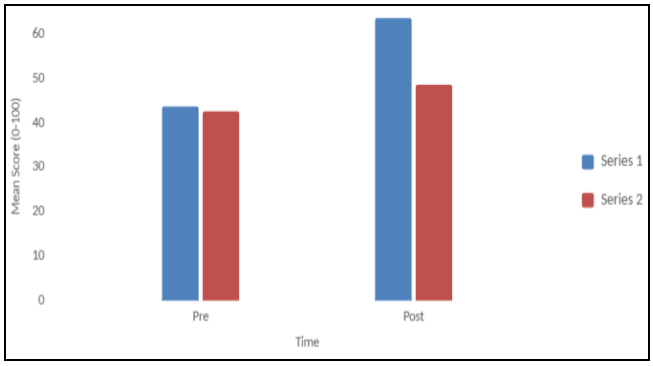

Fig 1: Mean Mental Health Scores Pre-and Post-Intervention

Conclusion

This quasi-experimental study presents strong evidence of the fact that a focused cognitive behavioral intervention can have a significant role in the mental health of mathematics anxious higher secondary mathematics students in West Bengal. The experimental group had significant improvements in terms of mental health scores (19.93 points improvement) over the moderate improvement of the

control group (5.92-point improvement) and the large effect size validated the practical importance of the interventions. The fact that mathematics anxiety and general psychological health were reduced simultaneously serves as an argument in favor of the interrelatedness of the constructs under consideration.

The implications of the findings are relevant to the educational practice and policy in West Bengal. They imply that mathematics anxiety is not only an academic issue but a mental health emergency that needs to be prevented. Schools can think of ways to incorporate anxiety-reduction evidence-based programs into mathematics, teach teachers to identify and address symptoms of anxiety and provide learning environments that reduce fear and tension towards mathematics-engagement. The effectiveness of such intervention proves that comparatively short and well-organized initiatives are able to provide substantial changes in the psychological functioning of students.

Finally, enhancing the mental health of mathematics learners can do two things: reducing the level of psychological discomfort and creating an environment that supports the ideal learning and academic performance. Since West Bengal is still working on its education system, education of the emotional aspect of mathematics learning will be vital in cultivating tough, competent, and healthy future generations who will be able to make a contribution towards the social and economic growth of the state. The research highlights that mathematics education should be able to cover not only the cognitive domain of the student, but also the affective one in order to support the holistic development of the student.

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