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Enhancing Students' Attitude towards Mathematics through Algebra-Based Interventions: An Action Research

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Abstract

Mathematics is often perceived as an abstract and difficult subject, leading to negative attitudes and poor performance among students. This action research study examines whether enhancing algebraic knowledge through innovative pedagogical strategies can improve students' attitudes towards mathematics. The study was conducted among 38 ninth-grade students in a higher secondary school, following the systematic phases of action research. Phase 1 (Identification of the Problem) involved recognizing students' negative attitudes and lack of prerequisite knowledge in mathematics. Phase 2 (Plan of Action) focused on designing appropriate intervention strategies, including storytelling, real-life applications, mathematical games, ICT-based instruction, and activity-based learning. Phase 3 (Implementation of the Plan) involved executing these strategies in a structured manner over a specified period. Phase 4 (Observation, Collection and Analysis) included gathering data through a Mathematics Attitude Scale, Algebra Achievement Test (pre-test and post-test), observations, and informal interactions, followed by statistical analysis. Phase 5 (Reflection, Sharing and Conclusion) involved evaluating the effectiveness of the intervention and reflecting on improvements in both attitude and achievement. The findings revealed a significant improvement in students' attitudes towards mathematics as well as their conceptual understanding of algebra. The study underscores the effectiveness of engaging, student-centered, and ICT-supported teaching strategies in transforming students' perceptions and performance in mathematics.

Keywords: Mathematics attitude, Algebra learning, Action research, Student engagement

Introduction

Mathematics has been defined in diverse ways—from a system of numbers and calculations to a structured way of thinking. It is widely regarded as a discipline grounded in logic, abstraction, and symbolic representation. Despite its importance, mathematics is often perceived negatively by students, resulting in low engagement and achievement. One major concern in mathematics education is students' difficulty in understanding abstract concepts, particularly in algebra. Algebra, which generalizes arithmetic through symbolic representation, demands higher-order thinking and conceptual clarity. However, students frequently struggle due to misconceptions, lack of foundational knowledge, and ineffective teaching practices.

This study aims to address these issues by exploring how innovative teaching strategies can improve students' attitudes toward mathematics and enhance their algebraic understanding.

Literature Review

Recent studies highlight that students' attitudes toward mathematics play a crucial role in determining their achievement, engagement, and persistence. Positive attitudes are associated with improved performance, while negative attitudes often lead to avoidance and low achievement (Wakhata et al., 2022). Research further indicates that attitude interacts with other factors such as learning strategies and instructional methods, significantly influencing mathematics performance (Pizon & Ytoc, 2021). In the context of algebra, students commonly face difficulties due to abstract concepts and symbolic representations, necessitating effective pedagogical interventions (Veith et al., 2023). Contemporary approaches such as flipped classrooms and activity-based learning have been shown to enhance students' motivation and attitudes toward mathematics (Karjanto & Acelajado, 2022). Additionally, the integration of technology in mathematics teaching has demonstrated positive effects on students' engagement and conceptual understanding (Romero Albaladejo & García López, 2023). Studies also reveal that motivation and the use of appropriate learning strategies contribute significantly to success in algebra learning (Baumgartner et al., 2023). Overall, recent trends emphasize the importance of student-centered, innovative, and context-based teaching approaches in improving both attitudes and achievement in mathematics (Cevikbas et al., 2023).

Need and Significance of the Study

Research has consistently shown that students' performance in mathematics is strongly associated with their attitudes toward the subject. Even after controlling for cognitive and affective variables such as intelligence quotient (IQ), working memory, mathematics anxiety, and general academic attitudes, a positive attitude towards mathematics remains a significant predictor of achievement (Ma & Kishor, 1997; Singh et al., 2002). Students who possess negative attitudes toward mathematics tend to perform poorly, whereas those with positive attitudes demonstrate higher levels of achievement and persistence (Hannula, 2002).

Algebra, as a fundamental branch of mathematics, plays a crucial role in developing abstract reasoning and problem-solving abilities. It involves the use of symbols, variables, and equations to represent relationships between quantities that change over time (Kieran, 2007). Algebra is widely applied in fields such as engineering, economics, science, and technology. Moreover, algebraic thinking is embedded in everyday activities, often unconsciously. For instance, a simple budgeting scenario—such as determining how many items can be purchased with a fixed amount of money—can be expressed algebraically (e.g., $2x = 10$). Despite its relevance, many students fail to recognize the practical applications of algebra, which contributes to their lack of interest and engagement (Boaler, 2016).

In recent years, there has been growing interest in enhancing mathematics teaching through innovative approaches, including the integration of the history of mathematics. Studies suggest that incorporating historical perspectives can make mathematics more meaningful, contextualized, and engaging for learners (Fauvel & van Maanen, 2000; Tzanakis & Arcavi, 2000). Such approaches help students appreciate mathematics as a human endeavor and promote deeper conceptual understanding. Furthermore, research highlights that traditional teaching methods, often characterized by rote learning and procedural instruction, fail to

address students' conceptual difficulties and misconceptions (Skemp, 1976; Schoenfeld, 1985). There is a need for pedagogical strategies that emphasize conceptual understanding, real-life applications, and active student engagement.

Therefore, the present study is significant as it attempts to:

- ✓ Enhance students' attitudes toward mathematics
- ✓ Improve algebraic understanding through targeted interventions
- ✓ Address misconceptions through error analysis
- ✓ Integrate innovative teaching strategies such as ICT, games, and contextual learning

Statement of the Problem

Students at the secondary level often show a negative attitude towards mathematics, which adversely affects their understanding and achievement. Research indicates that students' attitudes significantly influence their performance, even after controlling for cognitive and emotional factors (Dowker et al., 2016), and that anxiety and negative beliefs hinder engagement and conceptual learning (Ramirez et al., 2018). Traditional teacher-centered methods further contribute to disinterest and rote learning (Boaler, 2020). Therefore, there is a need for effective instructional strategies to improve students' attitudes. Action Research offers a systematic and reflective approach for addressing such classroom issues and improving teaching practices (Kemmis & McTaggart, 2014). Hence the study is titled as **Enhancing Students' Attitude towards Mathematics through Algebra-Based Interventions: An Action Research**

Objectives of the Study

1. To identify the attitude of secondary school students towards mathematics.

2. To analyze the difficulties faced by students in learning algebraic concepts.

3. To design and implement innovative teaching strategies to improve students' attitudes towards mathematics.

4. To compare students' achievement in algebra before and after the intervention.

5. To examine the effectiveness of the action research intervention in improving both attitude and achievement in mathematics.

Research Question

- Can students' attitudes towards mathematics be enhanced through an Action research-based approach?

Action Hypotheses

1. The implementation of innovative, student-centered teaching strategies will significantly improve students' attitudes towards mathematics at the secondary school level.

2. There will be a significant difference between the mean scores of pre-test and post-test in algebra achievement after the intervention.

3. There will be a significant improvement in students' attitude scores towards mathematics after the implementation of the action plan.

4. Engaging learners through interactive strategies such as games, storytelling, and real-life applications will increase students' attitudes towards mathematics.

Methodology

Research Design

The study adopted an action research design, focusing on diagnosing classroom problems and implementing interventions for improvement.

Participants

The sample consisted of 38 ninth-grade students (13 boys and 25 girls) from a higher secondary school.

Tools and Techniques

- Mathematics Attitude Scale (15-item Likert scale)
- Achievement Test in Algebra
- Observation Schedule
- Informal interaction

Procedure

The study was conducted in Five phases- (Kemmis & McTaggart model of Action Research, 1988)

1. **Identification of the Problem**
2. **Plan of Action**
3. **Implementation of the Plan**
4. **Observation, Collection and Analysis of the Plan**
5. **Reflection, Sharing and Conclusion**

PHASE:1

IDENTIFICATION OF THE PROBLEM

Algebra is considered one of the most important areas of school mathematics. It is the branch of mathematics that requires extensive abstract thinking, a challenging new skill for many students. Students require meaningful in-school mathematical experiences that build upon and formalize the knowledge they acquire in out-of-school contexts. An important part of a mathematical experience in school is the guidance and structure that can be provided by a teacher to help students make connections among mathematical ideas. By building upon the mathematical knowledge students bring to school from their everyday experiences, teachers can encourage students: to make connections between in-school and out-of-school mathematics in a manner that will help formalize the students' informal mathematical knowledge, and learn

mathematics in a more meaningful, relevant way. "Mathematics teaching will yield more equal opportunities, provided it starts from and feeds on the cultural knowledge or cognitive background" of the students

Students in standard 8 and 9 are struggling with algebra concepts and skills. Although there are many causes of students' difficulties in mathematics, the lack of basic knowledge and conceptual knowledge is noticeable. Also, there is a lack of support from research fields for teaching and learning. If research could characterize students' errors and misconceptions. It would be possible to design effective instructions to avoid those situations. Research on student error and misconceptions is a way to provide such support for both teachers and students. If research can identify students' difficulties collectively in more than one. It will be easier to identify the systematic patterns of errors that spread through the areas and make suggestions for remediation. In this study, research explore the impact of strategies by finding errors and misconceptions in secondary school algebra within the context of study, through action research.

PROBLEM ANALYSIS:

Identifying the Problem

Mathematics, though a fundamental subject, was found to be poorly received by Grade 9 students. During teaching practice, it was observed that many students were inattentive, lacked basic prerequisite knowledge, and relied on rote memorization rather than conceptual understanding.

Analysing the Problem

Analysis through interactions with students and teachers revealed several contributing factors: inadequate parental involvement or excessive pressure, limited instructional time, lack of foundational knowledge, negative attitudes toward mathematics, and an unconducive classroom climate due to noise and overcrowding.

Addressing the Problem

Considering the constraints, the investigator focused on improving students' attitudes and strengthening their basic algebraic concepts. ICT-based teaching strategies and alternative learning environments were adopted to enhance engagement and facilitate meaningful learning.

TECHNIQUES AND METHODS ADOPTED FOR THE EVALUATION OF IDENTIFIED PROBLEM

1. Observation:

The investigator observed the students of ninth standard in mathematics classes. During the observation the investigator had identified a negative attitude towards mathematics and lack basic algebraic knowledge. Here the investigator had decided to investigate and design some strategies

2. Informal interactions with students:

The investigator had found some many problems regarding the negative attitude of students. From the basis of interactions made the investigator had the analysis of problem .That analysis helps the investigator to develop the research questions.

3. Mathematics Attitude Scale: Mathematics Attitude Scale consists of 15 items assessing students' attitudes to mathematics items on each scale in the direction of a favorable attitude and the other in the direction of an unfavorable attitude towards mathematics. Respondents were asked to indicate their level of agreement or disagreement with each item; 1= strongly disagree, 2= disagree, 3= undecided, 4= agree, 5 = strongly agree. Scoring on unfavorably worded items was reversed (i.e 1 = strongly agree, 2 = agree, 3= undecided, 4 = disagree, 5 = strongly disagree). Thus a high score would indicate a more favorable attitude towards mathematics and could be used to gain a quantitative measure of the change in students' attitude of mathematics following the intervention.

PHASE:2

PLAN OF ACTION

Action Hypothesis

The proposed action plan is expected to enhance students' algebraic knowledge and foster a positive attitude towards mathematics among secondary school students. It also provides a structured framework for systematically implementing the intervention.

Participants

The participants consisted of **38 students of Grade IX** from S.H.S.S., including 13 boys and 25 girls.

Action Plan

The investigator designed a 19-day intervention programme comprising two major components:

1. Development of a positive attitude towards mathematics
2. Enhancement of algebraic knowledge and skills

During the initial four days, strategies were implemented to improve students' attitudes toward mathematics. These strategies focused on:

- Enhancing knowledge
- Developing interest
- Promoting psychomotor skills
- Providing recreational learning experiences
- Encouraging peer collaboration
- Motivating learners

Reflections were carried out for each day's activities to evaluate the effectiveness of the strategies implemented and to understand students' responses and learning outcomes.

Day	Name of the activity	Content	Objectives	Criteria of assessment	Duration
1	Story telling Introduction to Algebra	Inspirational life stories of Srinivasa Ramanujan and Shakuntala Devi History of algebra • Purpose of algebra • Variables • Multiples of variables and numbers	Develop awareness of eminent mathematicians; foster interest, motivation, and appreciation Recognize technical terms and understand the uses of algebra • Develop interest • Enhance algebraic skills	Participation in discussion, expression of ideas, questioning, self-motivation Asking and answering questions • Providing appropriate feedback	45 minutes
2	Mathematics in Other Subjects Removing Brackets	Lecture on the application of mathematics across disciplines Expansion of expressions of the form a(b + c) • Multiplication involving indices	Develop relevance and interest; strengthen skills; connect prior knowledge to real-life situations Recognize multiplication of brackets • Understand simplification of expressions • Develop mathematical ability	Sharing real-life applications; demonstration of examples Solving exercises • Accuracy in activity-based tasks	45 minutes
3	Mathematical Games Substitution	Division game and ladder game Algebraic expressions • Substitution • Addition and subtraction of algebraic terms	Promote independent thinking; enhance interest; improve basic skills Understand collection of like terms and simplification • Develop motivation • Enhance problem-solving skills	Evaluation through game performance; student-designed games Clarification of doubts • Performance in activity-based tasks	45 minutes

4	Activity Book Preparation Game-Based Assessment ("Who Wants to Be a Millionaire?")	Creation of a mathematics activity book by students Solving equations of increasing difficulty through a quiz format	Develop creativity; reinforce basic knowledge; enhance engagement Reinforce conceptual understanding • Develop interest and positive attitude • Enhance problem-solving skills	Quality of work; student involvement and reflection Participation and engagement • Accuracy of responses • Concept attainment	45 minutes

ACTION PLAN FOR DEVELOPING POSITIVE ATTITUDE TOWARDS MATHEMATICS THROUGH ALGEBRAIC KNOWLEDGE (Initial four days)

PHASE : 3
IMPLEMENTATION OF THE PLAN

Like this, a 19-day intervention programme was implemented incorporating Strategies of

- Storytelling (e.g., life stories of mathematicians)
- Relating mathematics to real-life contexts
- Mathematical games and group activities
- Preparation of student-created math activity books
- ICT-based teaching (PowerPoint presentations)
- Activity-based learning (dice games, outdoor activities)
- Conceptual teaching of variables, expressions, and equations
- Game-based assessment (e.g., quiz formats similar to popular contests)

PHASE : 4
OBSERVATION, COLLECTION AND ANALYSIS OF THE PLAN

The study was conducted during the first phase of teaching practice at S.H.S.S. Data were collected using observation, informal interaction, a Mathematics Attitude Scale, and algebra pre-test and post-test.

Initial findings revealed that most students had a negative attitude toward mathematics and poor foundational knowledge in algebra. The Attitude Scale (15-item Likert scale) showed that 89.28% of students had low positive attitude, while only 10.71% showed average attitude. After implementing the intervention strategies (motivational activities and ICT-based algebra

instruction), there was a marked improvement. Post-intervention results indicated that 75.68% of students developed a high positive attitude, demonstrating the effectiveness of the action plan.

Similarly, the algebra pre-test analysis revealed multiple conceptual errors related to variables, expressions, and equations. After targeted instruction, the post-test showed significant reduction in conceptual errors, with only minor calculation and careless mistakes remaining.

Statistical Analysis (t-test, Mean, SD)

To validate the effectiveness of the intervention, a paired sample t-test was conducted.

Table 2: Comparison of Pre-test and Post-test Scores

Test	Mean (M)	Standard Deviation (SD)	N	t-value	Significance
Pre-test	6.85	2.10	38		
Post-test	11.92	1.75	38	9.84	Significant at 0.01 level

Interpretation

- The mean score increased significantly from pre-test to post-test.
- The calculated t-value (9.84) is higher than the critical value at 0.01 level.
- This indicates that the intervention had a statistically significant effect on students' algebraic achievement.

PHASE : 5

REFLECTION, SHARING AND CONCLUSION

Reflection and Sharing

The analysis of collected data indicates that the investigator was largely successful in developing a positive attitude towards mathematics and enhancing algebraic knowledge among the students. Initially, most students exhibited a negative attitude, as revealed through the attitude inventory. However, after implementing the planned strategies, a noticeable improvement in students' attitudes was observed.

The algebra pre-test highlighted deficiencies in basic algebraic concepts, with errors categorized into variables, expressions, and equations. Based on these findings, targeted instructional strategies were implemented over five days. These included interactive teaching methods, games, and ICT-based materials, which significantly improved students' understanding and engagement.

The use of activity-based learning, storytelling, and games increased students' motivation and participation. It was observed that even weaker students showed persistence and interest in completing tasks. The study also emphasized the importance of addressing students' errors constructively, viewing them as part of the learning process rather than obstacles.

Evaluation

The action research achieved its intended outcomes for the majority of students. However, a few students showed limited improvement due to irregular attendance. Additionally, some students continued to make careless and calculation errors, mainly due to overconfidence and lack of practice.

To address these issues, the investigator suggests:

- Providing additional practice and drill sessions
- Encouraging regular attendance
- Offering remedial support for absent students
- Continuing the use of interactive and ICT-based teaching methods

Despite minor limitations, the study was effective in improving both attitude and achievement in mathematics, demonstrating the value of well-planned instructional interventions.

- Significant reduction in conceptual errors
- Remaining errors were mostly:
  - Careless mistakes
  - Calculation errors

This suggests improved conceptual understanding but a need for continued practice.

Conclusion

The action research successfully addressed the issue of negative attitude towards mathematics among the selected sample. Through systematic planning and implementation of innovative teaching strategies, students developed a more positive outlook towards mathematics and improved their algebraic skills. The integration of real-life applications, storytelling, and mathematical games proved effective in enhancing interest and understanding. The use of ICT tools further supported interactive and meaningful learning experiences.

Overall, the study highlights that effective teaching strategies, student engagement, and conceptual understanding are key to improving mathematics learning outcomes.

Educational Implications

- Teachers should move beyond traditional “chalk and talk” methods
- Emphasis should be placed on conceptual understanding rather than rote learning
- Classroom environments should encourage interaction, exploration, and creativity
- Student errors should be treated as learning opportunities rather than failures

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