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Enhancing High School Mathematics Education Through School-based Research: Development and Mechanisms

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Abstract: In the context of ongoing educational reforms aimed at fostering critical competencies among high school students, this paper explores the implementation and impact of school-based mathematics research (SBR) as a strategic innovation within the high school curriculum. Adopting mixed research methods, in the study questionnaires were distributed to all students and teachers in the early stage to collect and analyze relevant data and than the study combines quantitative analyses of student performance data with qualitative insights from teacher and student feedback to assess the effects of SBR on teaching practices and learning outcomes. This research is based on the fact that the traditional education model cannot meet the needs of cultivating students' thinking ability, and the new curriculum reform has decentralized teaching research to schools. The study is helpful to explore the effect of SBR on the cultivation of teachers' scientific research ability and the improvement of classroom quality. The results show the powerful role of SBR in promoting teaching practice and student participation. Based on school characteristics, it proposes effective teaching improvement measures to improve the quality of mathematics education.

Keywords: School-Based Research (SBR); High School Mathematics; Educational Reforms; Teaching Practices; Student Engagement.

1. Introduction

Mathematics, with its inherently abstract nature, frequently struggles to engage students and develop higher-level cognitive skills such as independent problem-solving and critical thinking. In response, the school-based teaching and research system (SBR) has emerged as a strategic innovation. By integrating research activities directly within the teaching environment, SBR facilitates immediate application and iterative adjustments to the curriculum [1]. This approach not only addresses the real-world challenges in teaching complex mathematical concepts but also adapts to the evolving educational needs and diversities of student populations [2]. Traditional educational models often prioritize theoretical knowledge over practical application, creating a disconnect that can hinder the effectiveness of teaching and learning processes [3]. This study is motivated by the urgent need to bridge this gap, driven by the recent educational reforms that emphasize the cultivation of core competencies and the reduction of academic burdens. SBR aligns with these goals by fostering a dynamic environment where theoretical research and practical teaching demands intersect, promoting a cycle of continuous improvement and innovation within schools [4]. The primary objective of this research is to systematically investigate the implementation processes and the impacts of SBR initiatives in high school mathematics [5]. The study focuses on evaluating how these initiatives can enhance the educational quality and relevance of mathematics instruction. Through a detailed analysis of both the mechanisms and outcomes of SBR, the research aims to provide insights into effective strategies for integrating research into everyday teaching practices, thereby improving student engagement, learning outcomes, and overall teaching efficacy.

2. Methods

2.1. Research Design

An action research framework was central to this study. It's chosen for its robustness in facilitating iterative assessments and refinements of educational interventions within the SBR context [6]. This approach allowed for the direct application of findings to continuously improve teaching strategies and curriculum design, mirroring the dynamic and evolving nature of educational settings [7]. The cyclical process of planning, acting, observing, and reflecting was utilized to gauge the effectiveness of various teaching methodologies adapted to local contexts.

2.2. Participants

The study's participants comprised 120 high school mathematics teachers and 2,400 students, drawn from five high schools with varied demographic and educational backgrounds. This diversity was intentional, aimed at ensuring that the findings could be generalized across different types of educational environments and student groups. Each school was selected based on distinct characteristics such as student population, geographical location, and previously implemented educational strategies, to provide a broad overview of the impact of SBR across different settings.

2.3. Data Collection

Data collection was multi-faceted to capture a comprehensive view of the impact of SBR on teaching and learning. Our surveys were administered to both teachers and students to obtain their perspectives on the changes in teaching practices and learning experiences [8]. In the early stage, this study questionnaires were distributed to all

students and teachers in to collect and analyze relevant data Then research teams conducted classroom observations, where they used standardized checklists to assess changes in instructional methods and student engagement during lessons [9]. Academic performance records provided quantitative data on student achievement before and after the implementation of SBR initiatives. Furthermore, teachers' professional development was monitored through reflective teaching journals, where teachers documented their experiences, challenges, and successes with the new approaches.

3. Experimental Procedure and Result Feedback

3.1. Experimental Process

Teachers' and students' perceptions of current teaching practices were collected through a questionnaire survey to understand their feelings and expectations of existing teaching methods. In addition, students' academic performance and other relevant data were recorded as baseline data for subsequent comparisons. As the project progressed, teachers began to implement SBR (problem-solving based teaching) activities, such as introducing more real-world problem-solving based teaching methods aimed at increasing student engagement and interest [10]. In order to track teachers' adaptation to the new approach, the research team collected teaching logs on a regular basis and communicated with teachers to obtain feedback.

In the mid-term phase, the research team conducted classroom observations to document changes in the teaching methodology, specifically observing how teachers used the SBR strategy in the classroom and how students were engaged. The impact of the SBR activities on the learning climate was assessed by collecting feedback from students and teachers, focusing on changes in student engagement and shifts in teachers' pedagogy.

At the end of the project, the research team again collected data on students‘ academic performance to assess the impact of SBR activities on students' academic performance. Teachers‘ and students' perceptions of the effects of SBR were also collected through questionnaires to understand their attitudes and opinions on the overall project.

3.2. Feedback

At the teacher level, most teachers became more confident in their teaching practice and were able to use a variety of teaching strategies flexibly. Teacher feedback showed that they felt that the SBR activities helped to increase student engagement and interest and made the classroom more lively and interesting. Reflective teaching journals showed that teachers were better able to identify and solve problems encountered by their students in the learning process, thus improving the quality of teaching and learning.

At the student level, the result was an increase in average student achievement, especially in problem-solving skills. Students' self-efficacy increased, and they were more willing to participate in classroom discussions and co-operative learning, demonstrating greater motivation to learn. The results of the student questionnaires showed a positive change in their interest and attitude towards mathematics, and a greater willingness to accept challenges and explore different solutions to mathematical problems.

In summary, the implementation of SBR activities is expected to produce positive changes at both the teacher and student levels, not only enhancing students' academic performance, but also improving teacher-student interactions and creating a more positive and supportive learning environment.

4. Results

Teachers experienced increased autonomy in the development of curricular materials, enabling them to tailor lessons to the specific needs and interests of their students. This empowerment was a direct result of the SBR approach, which encourages educators to innovate based on their professional insights and student feedback. Many educators reported that this flexibility helped in creating a more engaging learning environment, which was particularly effective in addressing the diverse educational needs across different schools.

4.1. Quantitative Outcomes

Statistical analyses of student performance data before and after the implementation of SBR initiatives showed a statistically significant improvement in mathematics scores ($p < 0.05$). Notably, there was an enhancement in students' problem-solving abilities, which was measured through specially designed assessment tools that focused on critical thinking and application of mathematical concepts in real-world scenarios. This improvement highlights the effectiveness of SBR in not just boosting academic performance but also in developing essential cognitive skills.

4.2. Qualitative Feedback

Qualitative data gathered from focus groups with students and interviews with teachers indicated a marked increase in student motivation and satisfaction with the curriculum. Students expressed a greater appreciation for mathematics lessons that were interactive and related directly to real-life applications. This feedback aligns with the teachers' observations of increased engagement and enthusiasm in the classroom. Furthermore, the qualitative insights helped identify areas for further refinement in teaching approaches, confirming the cyclical benefit of the action research framework used in SBR.

4.3. Sustainable Advancement

Reflecting on the sustainable aspects of the initiatives, both teachers and administrators noted the long-term benefits of building a collaborative and reflective teaching culture. The SBR framework promotes the improvement of teachers' self-competence and the exchange of excellent educational ideas and practices among educators, which contributed to a continuous improvement within the schools. This aspect was particularly crucial in maintaining the momentum of SBR benefits beyond the initial implementation phase.

5. Discussion

The implementation of school-based research (SBR) in high school mathematics has demonstrated significant educational benefits, including improved student outcomes and enhanced teacher autonomy. However, challenges such as variations in teachers' professional literacy and resource limitations were identified, affecting the uniformity of SBR's success across different types of schools. The study highlighted the critical role of continuous professional

development and institutional support in overcoming these barriers. This research contributes to the theoretical understanding of participative teaching by demonstrating how SBR can be effectively integrated into high school curricula. Practically, the findings advocate for a more adaptive educational system that leverages local resources and teachers' expertise to meet students' needs. The success of SBR suggests that similar approaches could be beneficial in other subjects, potentially transforming the traditional model of education by fostering a more inquiry-based and student-centered learning environment.

6. Conclusion

This study has systematically explored the implementation and impact of School-Based Research (SBR) in high school mathematics, revealing its potential to significantly improve the quality of mathematics education. By creating an environment where teachers are both researchers and curriculum developers, SBR has shown that it can not only enhance students' academic performance but also develop their critical competencies, such as the ability to solve practical problems. Future studies should assess the long-term impact of SBR on student development and explore the scalability of this model across different educational contexts and subject areas. Additionally, further research could focus on the effects of varying levels of resource availability on the effectiveness of SBR and how technology might be leveraged to address some of the challenges associated with its implementation. Such studies would provide deeper insights into improving SBR in diverse educational settings.

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