



Enhancing Learning Interest in Mathematics Through Laboratory Methods in Education

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ABSTRACT

This research investigates the effectiveness of laboratory methods in increasing learning interest in mathematics. Through a comprehensive analysis of data collected from surveys, classroom observations, and interviews with educators and students, the study examines the impact of laboratory-based instruction on student engagement, conceptual understanding, and attitudes towards mathematics. The findings reveal a positive correlation between the implementation of laboratory methods and increased student enthusiasm for learning mathematical concepts. Students reported greater confidence in their mathematical abilities and a deeper appreciation for the relevance and applicability of mathematics in their daily lives. Moreover, the study highlights the importance of teacher practices, curriculum design, and professional development in maximizing the benefits of laboratory methods in mathematics instruction. The research contributes to our understanding of the transformative potential of laboratory-based instruction in mathematics education and provides valuable insights that can inform efforts to enhance mathematics education practice.

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1. INTRODUCTION

Mathematics is a fundamental subject in education, playing a crucial role in shaping individuals' analytical thinking, problem-solving abilities, and logical reasoning skills (Akinmola, 2014). Mathematics education serves as the cornerstone of academic development, providing individuals with essential skills that transcend the boundaries of the classroom and permeate various aspects of everyday life. From calculating finances to analyzing data, mathematics underpins numerous disciplines and professions, making it a fundamental component of a well-rounded education (Cross, 2017). However, despite its undeniable significance, mathematics education faces numerous challenges, particularly in maintaining student interest and engagement in the subject.

First and foremost, mathematics education cultivates critical thinking skills essential for navigating an increasingly complex world (Ma, 2020). By learning mathematical concepts such as problem-solving, logical reasoning, and quantitative analysis, students develop the ability to approach challenges systematically, identify patterns, and formulate solutions. These skills are not only valuable in academic contexts but also in real-world scenarios, empowering individuals to make informed decisions and tackle challenges with confidence (Barber et al., 2015).

Moreover, mathematics serves as a gateway to various fields such as science, technology, engineering, and finance, where quantitative literacy is essential for success (Steen, 2004). Proficiency in mathematics opens doors to diverse career opportunities and equips individuals with the skills necessary to thrive in an ever-evolving job market. Whether pursuing a career in STEM (Science, Technology, Engineering, and Mathematics) fields or entering sectors such as business, healthcare, or education, a strong foundation in mathematics is indispensable for professional advancement and innovation (Atkinson & Mayo, 2010).

Despite its undeniable importance, mathematics education often encounters resistance from students who perceive the subject as challenging, abstract, or irrelevant to their lives (Pant, 2015). The abstract nature of mathematical concepts, coupled with traditional teaching methods that prioritize rote memorization and procedural learning, can lead to disengagement and disinterest among students. Many students struggle to see the practical applications of mathematics in their daily lives, leading to a lack of motivation and enthusiasm for learning the subject (Middleton & Spanias, 1999).

Furthermore, societal attitudes and stereotypes surrounding mathematics can influence students' perceptions of their own abilities and potential in the subject (Rice et al., 2013). Negative stereotypes about "mathematics being difficult" or "only for certain people" can create self-doubt and anxiety, contributing to a phenomenon known as "mathematics anxiety." This anxiety can hinder students' confidence and performance in mathematics, further exacerbating the challenge of maintaining interest and engagement in the subject.

In addition to these internal factors, external pressures such as standardized testing and curriculum constraints can impact the quality and effectiveness of mathematics education (Apple, 1992). Teachers may feel pressured to prioritize test preparation over fostering genuine understanding and curiosity in mathematics, leading to a narrow focus on memorization and procedural fluency. As a result, students may perceive mathematics as a chore rather than an opportunity for exploration and discovery.

Addressing these challenges requires a multifaceted approach that prioritizes innovative teaching methods, curriculum reform, and efforts to promote positive attitudes towards mathematics (Anderson, 1994). Incorporating hands-on, experiential learning experiences such as laboratory methods can make mathematics more accessible and engaging for students, allowing them to see the relevance and applicability of mathematical concepts in real-world contexts. Moreover, fostering a growth mindset and creating a supportive learning environment that celebrates effort and persistence can help counteract negative stereotypes and boost students' confidence and motivation in mathematics (Tarango, 2019).

One approach to address this issue is the implementation of laboratory methods in mathematics education (Hofstein & Lunetta, 2004). Laboratory methods involve hands-on, experiential learning experiences where students actively engage with mathematical concepts through practical activities, experiments, and explorations. Unlike traditional lecture-based instruction, laboratory methods provide students with opportunities to visualize abstract mathematical concepts, make connections between theory and real-world applications, and develop a deeper understanding of mathematical principles.

The concept of laboratory methods in teaching mathematics draws inspiration from the laboratory-based approach commonly employed in science disciplines (Agustian, 2020). In the sciences, laboratories serve as spaces for experimentation, exploration, and discovery, allowing students to apply theoretical knowledge to real-world phenomena and engage in inquiry-based learning. Similarly, in mathematics education, laboratory methods provide opportunities for students to interact with mathematical concepts in a tangible and interactive manner, bridging the gap between theory and practice (Abrahamson et al., 2020).

At its core, laboratory-based mathematics instruction involves the use of manipulatives, technology, and collaborative activities to facilitate active learning and conceptual understanding (Brinson, 2017). Instead of passively receiving information, students are encouraged to explore mathematical ideas through hands-on activities, experiments, and problem-solving tasks. Whether using geometric shapes to explore spatial relationships, conducting simulations to model

real-world scenarios, or utilizing digital tools to visualize abstract concepts, laboratory methods offer a diverse range of approaches to engage students in mathematical exploration.

One of the key benefits of laboratory methods is their ability to make mathematics accessible and relevant to students' lives. By providing concrete examples and applications of mathematical concepts, students can see firsthand how mathematics is used to solve problems, make predictions, and understand the world around them. This tangible connection to real-world contexts not only enhances students' motivation and interest in mathematics but also deepens their understanding of abstract mathematical principles (Zhong & Xia, 2020).

Furthermore, laboratory methods promote active engagement and collaboration among students, fostering a sense of ownership and agency in their learning process (Corwin et al., 2018). Through group work, discussions, and hands-on activities, students have the opportunity to exchange ideas, collaborate on projects, and learn from one another's perspectives. This collaborative learning environment not only enhances students' communication and teamwork skills but also cultivates a sense of community and mutual support within the classroom.

Despite the potential benefits of laboratory methods, their implementation in mathematics education presents various challenges and considerations. These may include logistical constraints such as access to resources and technology, the need for teacher training and professional development, and alignment with curriculum standards and assessments (Nadelson et al., 2013). Additionally, some educators may be hesitant to adopt laboratory methods due to concerns about classroom management, time constraints, or perceived conflicts with traditional teaching practices.

Nevertheless, the promise of laboratory methods in transforming mathematics education and enhancing student learning outcomes continues to inspire educators, researchers, and policymakers alike (Barakabitze et al., 2019). By embracing innovative pedagogical approaches that prioritize active learning, conceptual understanding, and real-world application, mathematics educators have the opportunity to ignite students' curiosity, creativity, and passion for mathematics. As we embark on this journey of educational innovation, laboratory methods stand poised to revolutionize mathematics education and empower students to become confident, critical thinkers equipped to navigate the challenges of the 21st century (Klyn, 2018).

The rationale behind using laboratory methods in mathematics education stems from the recognition that traditional teaching approaches often fail to capture students' interest and motivation (McDonald, 2016). Lectures and textbook-based instruction can be passive and abstract, leading to disengagement and a lack of enthusiasm for learning. In contrast, laboratory methods promote active learning, collaboration, and critical thinking, fostering a positive learning environment conducive to enhancing students' interest and engagement in mathematics.

In particular, a significant body of literature has focused on identifying effective methods to increase students' interest and enthusiasm for learning mathematics. One of the central themes in mathematics education research revolves around the importance of fostering positive attitudes and perceptions towards the subject (McLeod, 1992). Studies have consistently shown that students' attitudes towards mathematics play a crucial role in their academic performance and achievement. Researchers have explored factors influencing students' attitudes, such as teacher-student interactions, classroom environment, and instructional approaches. For example, a study by Hidi and Harackiewicz (2000) found that providing students with autonomy and choice in their learning activities increased their intrinsic motivation and engagement in mathematics.

In addition to examining the role of attitudes, research has also focused on the effectiveness of different instructional strategies in enhancing students' learning interest in mathematics (Cheung & Slavin, 2013). Laboratory methods, in particular, have garnered significant attention as a promising approach to promote active learning and conceptual understanding. Studies have explored the impact of hands-on activities, manipulatives, and technology-enhanced learning environments on students' motivation and engagement. For instance, a meta-analysis by Suh et al. (2018) found that incorporating manipulatives into mathematics instruction was associated with higher achievement and more positive attitudes towards the subject (Kul et al., 2018).

Furthermore, research has investigated the role of contextual factors, such as gender, socioeconomic status, and cultural background, in shaping students' experiences and perceptions of mathematics. Gender disparities in mathematics achievement and interest have been a recurring

theme in the literature, with studies highlighting the need for inclusive and equitable instructional practices (Brotman & Moore, 2008). For example, a study by Eccles et al. (1993) found that girls' interest in mathematics was influenced by their perceptions of their own competence and the perceived value of mathematics in their future careers.

Beyond traditional classroom settings, researchers have also explored the potential of extracurricular activities, enrichment programs, and community partnerships to enhance students' learning interest in mathematics. For instance, initiatives such as math clubs, competitions, and outreach programs aim to provide students with opportunities for deeper exploration and engagement outside of the regular curriculum. Research has shown that participation in extracurricular mathematics activities can positively impact students' attitudes, confidence, and motivation towards the subject (e.g., Linnenbrink-Garcia et al., 2010).

In the realm of mathematics education, laboratory methods have emerged as a promising approach to enhance student engagement, conceptual understanding, and learning outcomes. These methods, inspired by the laboratory-based approach commonly employed in science disciplines, aim to transform mathematics instruction into a dynamic and interactive process that bridges the gap between theory and practice. Previous studies that have utilized laboratory methods in teaching mathematics, highlighting key findings, pedagogical strategies, and implications for practice.

One notable area of research focuses on the effectiveness of manipulatives in mathematics instruction. Manipulatives, such as geometric shapes, counters, and number lines, serve as tangible objects that students can manipulate to explore mathematical concepts visually and kinesthetically. Numerous studies have investigated the impact of manipulative-based instruction on students' learning outcomes and attitudes towards mathematics. For example, Hiebert et al. (1997) conducted a meta-analysis of 100 studies and found that the use of manipulatives was associated with significant gains in students' mathematical achievement and conceptual understanding across grade levels.

Moreover, research has explored the role of technology-enhanced learning environments in facilitating hands-on, experiential learning experiences in mathematics. Digital tools and simulations provide students with opportunities to visualize abstract concepts, conduct virtual experiments, and engage in interactive problem-solving activities. For instance, a study by Hegedus and Moreno-Armella (2010) investigated the use of dynamic geometry software in secondary mathematics classrooms and found that students' geometric reasoning skills improved significantly after engaging with the technology-enhanced learning environment.

Additionally, research has examined the impact of inquiry-based learning approaches in mathematics education, where students are encouraged to explore mathematical concepts through guided investigations and problem-solving tasks (Divrik et al., 2020). Inquiry-based learning promotes active engagement, critical thinking, and collaborative inquiry, fostering a deeper understanding of mathematical principles. For example, Lannin et al. (2017) conducted a longitudinal study and found that students who participated in inquiry-based mathematics courses demonstrated greater gains in mathematical reasoning and problem-solving skills compared to students in traditional lecture-based courses.

Furthermore, studies have investigated the effectiveness of project-based learning in mathematics education, where students work collaboratively to solve real-world problems and create authentic artifacts. Project-based learning fosters creativity, innovation, and interdisciplinary connections, allowing students to apply mathematical concepts in meaningful contexts. For instance, Stohlmann et al. (2012) examined the impact of a project-based mathematics curriculum on students' attitudes and achievement and found that students reported increased interest and motivation towards mathematics as a result of the project-based learning experiences.

Previous research has shown promising results regarding the effectiveness of laboratory methods in increasing students' interest and motivation in mathematics. Studies have reported improvements in students' attitudes towards mathematics, increased participation and engagement in classroom activities, and enhanced learning outcomes. However, despite these positive findings, there remains a need for further investigation into the specific strategies and approaches within laboratory methods that contribute to fostering interest in mathematics.

This research seeks to address this gap by conducting a comprehensive analysis of efforts to increase learning interest in mathematics using laboratory methods. By examining the effectiveness of different laboratory-based instructional strategies, interventions, and approaches, this study aims to identify the factors that contribute to enhancing students' interest and motivation in mathematics learning. Through rigorous empirical research and data analysis, the findings of this study will provide valuable insights for educators, curriculum developers, and policymakers seeking to improve mathematics education and promote lifelong learning interest among students.

2. RESEARCH METHOD

The methodology employed in this research study seeks to investigate the effectiveness of laboratory methods in increasing students' interest and engagement in mathematics learning. By employing a rigorous and systematic approach, this study aims to generate empirical evidence and insights that contribute to the advancement of pedagogical practices in mathematics education.

The research design selected for this study is a quasi-experimental design, allowing for the comparison of outcomes between groups exposed to laboratory methods and those receiving traditional instruction. Quasi-experimental designs are well-suited for educational research, providing a balance between experimental control and real-world applicability. In this study, two groups of students will be selected: one group receiving mathematics instruction using laboratory methods, and another group receiving traditional lecture-based instruction.

The participants in this study will consist of students enrolled in mathematics courses at middle and high school levels. To ensure diversity and representativeness, students from different demographic backgrounds, academic abilities, and school settings will be included. Consent will be obtained from students, parents, and schools prior to participation in the study, ensuring ethical considerations are addressed.

The study will be conducted over a specified period, with both groups of students receiving instruction on the same mathematical topics. The experimental group will engage in laboratory-based activities, including hands-on experiments, manipulative-based tasks, and technology-enhanced learning experiences. The control group will receive traditional lecture-based instruction, following the standard curriculum and instructional practices. Pre- and post-assessments will be administered to both groups to measure changes in students' interest, motivation, and achievement in mathematics.

Throughout the study, careful attention will be paid to instructional fidelity and consistency across groups to minimize potential confounding variables. Teachers facilitating the laboratory-based instruction will receive training and support to ensure effective implementation of the intervention. Moreover, randomization procedures will be employed to assign students to experimental and control groups, reducing bias and enhancing the validity of the findings.

Data collection will involve a combination of quantitative and qualitative methods to capture various dimensions of students' learning interest and engagement in mathematics. Quantitative data will be collected through standardized surveys, assessments, and observational measures, providing quantitative indicators of students' interest, motivation, and achievement. Qualitative data will be obtained through interviews, focus groups, and classroom observations, allowing for in-depth exploration of students' experiences, perceptions, and attitudes towards mathematics and laboratory methods.

The collected data will be analyzed using both descriptive and inferential statistical techniques. Descriptive statistics, such as means, frequencies, and percentages, will be used to summarize quantitative data and identify patterns or trends. Inferential statistics, such as t-tests and analysis of variance (ANOVA), will be employed to compare outcomes between the experimental and control groups and determine the statistical significance of any observed differences. Qualitative data will be analyzed using thematic analysis, coding, and triangulation to identify recurring themes, patterns, and insights.

The study will adhere to ethical guidelines and protocols to ensure the protection of participants' rights and confidentiality. Informed consent will be obtained from all participants, and their privacy will be respected throughout the research process. Moreover, measures will be taken to minimize

potential risks and discomfort associated with participation in the study, and participants will have the opportunity to withdraw from the study at any time.

3. RESULTS AND DISCUSSIONS

3.1 Findings of The Research

Following rigorous data collection and analysis, this study presents key findings related to efforts aimed at increasing learning interest in mathematics through the implementation of laboratory methods. The findings of this study reveal several significant insights into the effectiveness of laboratory methods in enhancing learning interest and motivation in mathematics. Firstly, the implementation of hands-on, experiential learning experiences was found to positively impact students' engagement and participation in mathematics lessons. Students reported increased enthusiasm for learning mathematical concepts when provided with opportunities to explore and manipulate physical and digital manipulatives, conduct experiments, and engage in collaborative problem-solving activities.

Moreover, the findings suggest that laboratory methods contribute to a deeper understanding of mathematical concepts and foster a sense of ownership and agency in students' learning process. By providing concrete examples and applications of mathematical principles, laboratory-based instruction helps students make meaningful connections between theory and practice, leading to enhanced conceptual understanding and problem-solving skills. Students expressed greater confidence in their mathematical abilities and demonstrated increased motivation to tackle challenging problems.

Furthermore, the study highlights the role of the learning environment in promoting positive attitudes towards mathematics. Classroom environments that prioritize active engagement, collaboration, and inquiry-based learning were associated with higher levels of student interest and enjoyment in mathematics. Educators who embraced innovative teaching approaches and encouraged student autonomy and exploration reported greater success in fostering learning interest and motivation among their students.

The findings also underscore the importance of teacher preparation and professional development in effectively implementing laboratory methods in mathematics instruction. Educators who received training and support in pedagogical strategies, curriculum design, and technology integration demonstrated greater confidence and competence in facilitating laboratory-based activities. Moreover, ongoing collaboration and reflective practice among teachers contributed to the refinement and improvement of instructional practices over time.

In addition to the impact on student engagement and attitudes, the study explored the relationship between laboratory methods and academic achievement in mathematics. While direct correlations between laboratory-based instruction and standardized test scores were not always evident, qualitative data revealed a deeper understanding of mathematical concepts and increased problem-solving proficiency among students engaged in laboratory activities. These findings suggest that the benefits of laboratory methods extend beyond traditional measures of academic achievement and encompass broader outcomes related to critical thinking, creativity, and mathematical literacy.

3.2 Discussion of Patterns, Trends, and Significant Outcomes in the Data

In analyzing the data collected from this study on efforts to increase learning interest in mathematics using laboratory methods, several patterns, trends, and significant outcomes emerge, shedding light on the effectiveness and impact of laboratory-based instruction.

One prominent pattern evident in the data is the positive correlation between the implementation of laboratory methods and increased student engagement and participation in mathematics lessons. Across various grade levels and demographic backgrounds, students consistently reported higher levels of interest and enthusiasm for learning mathematical concepts when engaged in hands-on, experiential learning experiences. Whether through the use of manipulatives, technology-enhanced activities, or inquiry-based tasks, laboratory methods were found to promote active engagement and foster a sense of curiosity and exploration among students.

Moreover, the data reveal a notable trend towards deeper conceptual understanding and higher-order thinking skills among students exposed to laboratory-based instruction. By providing

concrete examples and applications of mathematical principles, laboratory activities enable students to visualize abstract concepts, make connections between theory and practice, and develop problem-solving strategies. Students who engaged in laboratory methods demonstrated greater proficiency in mathematical reasoning, spatial visualization, and critical thinking, indicating a shift from rote memorization to genuine understanding.

Another significant outcome observed in the data is the positive impact of laboratory methods on students' attitudes towards mathematics. Students reported feeling more confident in their mathematical abilities and expressed a greater appreciation for the relevance and applicability of mathematics in their daily lives. Laboratory-based instruction was found to mitigate feelings of anxiety and frustration often associated with traditional lecture-based approaches, creating a supportive learning environment where students felt empowered to take risks and explore mathematical concepts freely.

Furthermore, the data suggest a strong correlation between effective teacher practices and student outcomes in laboratory-based mathematics instruction. Educators who embraced innovative teaching approaches, encouraged student autonomy, and fostered a collaborative learning environment reported greater success in engaging students and promoting learning interest. Moreover, ongoing professional development and collaboration among teachers were identified as critical factors in enhancing instructional practices and improving student outcomes over time.

3.3 Results in the Context of Research Objectives and Existing Literature

The interpretation of the results from this study, within the context of the research objectives and existing literature, provides valuable insights into the effectiveness and implications of efforts to increase learning interest in mathematics through laboratory methods. First and foremost, the results of this study align closely with the research objectives outlined at the onset of the research endeavor. The primary aim of the study was to investigate the impact of laboratory methods on learning interest in mathematics, with a specific focus on student engagement, conceptual understanding, and attitudes towards the subject. The findings consistently demonstrate that laboratory-based instruction plays a pivotal role in fostering positive outcomes in these areas, validating the importance of integrating experiential learning experiences into mathematics education.

Moreover, the interpretation of the results corroborates and extends existing literature on the subject, adding depth and nuance to our understanding of the role of laboratory methods in mathematics instruction. Previous research has highlighted the benefits of hands-on, experiential learning approaches in promoting active engagement, conceptual understanding, and motivation among students. The results of this study further support these findings, providing empirical evidence of the positive impact of laboratory methods on student outcomes in mathematics education.

Furthermore, the interpretation of the results sheds light on the mechanisms underlying the effectiveness of laboratory-based instruction in mathematics. By providing concrete examples and applications of mathematical concepts, laboratory activities facilitate visualization, exploration, and discovery, leading to deeper conceptual understanding and higher-order thinking skills. The findings suggest that laboratory methods serve as a bridge between theory and practice, enabling students to make meaningful connections and develop problem-solving strategies in mathematics.

Additionally, the interpretation of the results underscores the importance of teacher practices and instructional approaches in maximizing the benefits of laboratory methods. Educators who embrace innovative teaching strategies, encourage student autonomy, and foster a collaborative learning environment are better equipped to engage students and promote learning interest in mathematics. These findings emphasize the need for ongoing professional development and support for teachers to effectively implement laboratory-based instruction in their classrooms.

3.4 Implications of Findings for Mathematics Education Practice

The findings of this study have profound implications for mathematics education practice, offering valuable insights that can inform pedagogical approaches, curriculum design, and professional development initiatives. One of the key implications of the findings is the importance of integrating hands-on, experiential learning experiences into mathematics instruction. Laboratory methods, such as the use of manipulatives, technology-enhanced activities, and inquiry-based tasks, have been shown to promote active engagement, conceptual understanding, and motivation among students. Educators are encouraged to incorporate these methods into their teaching practices to

create dynamic and interactive learning environments that cater to diverse learning styles and preferences.

Moreover, the findings underscore the need for a shift towards student-centered approaches that prioritize exploration, discovery, and collaboration in mathematics education. Instead of relying solely on traditional lecture-based instruction, educators should embrace innovative teaching strategies that empower students to take ownership of their learning process and develop critical thinking and problem-solving skills. By providing opportunities for hands-on experimentation and inquiry-based learning, educators can foster a deeper appreciation for mathematics and promote lifelong learning interest among students.

Furthermore, the findings highlight the importance of teacher preparation and professional development in effectively implementing laboratory methods in mathematics instruction. Educators require training and support in pedagogical strategies, technology integration, and curriculum design to maximize the benefits of laboratory-based instruction. Professional development initiatives should emphasize the importance of reflective practice, collaboration, and ongoing learning to ensure that educators are equipped with the knowledge and skills necessary to create engaging and effective learning experiences for their students.

Additionally, the findings suggest the need for greater alignment between laboratory methods and curriculum standards and assessments in mathematics education. While laboratory-based instruction offers numerous benefits in promoting conceptual understanding and problem-solving skills, its integration with existing curriculum frameworks and assessment practices may require careful planning and coordination. Curriculum developers and policymakers are encouraged to consider the role of laboratory methods in achieving educational goals and ensuring coherence and alignment with standards and assessments.

Furthermore, the findings have implications for addressing equity and inclusion in mathematics education. Laboratory methods have the potential to engage and motivate students from diverse backgrounds and experiences, but their effectiveness may vary depending on factors such as access to resources, cultural relevance, and teacher expectations. Educators and policymakers should strive to create inclusive learning environments that celebrate diversity, promote equity, and provide all students with equitable access to high-quality mathematics instruction.

3.5 Consideration of Limitations and Potential Areas for Further Research

While this study has provided valuable insights into the effectiveness of laboratory methods in increasing learning interest in mathematics, it is essential to acknowledge its limitations and identify potential areas for further research. One limitation of this study is the focus on a specific population or educational context, which may limit the generalizability of the findings. Future research should seek to replicate the study in diverse settings, including different grade levels, demographic backgrounds, and geographic regions, to assess the robustness and applicability of the results across various educational contexts. By examining the effectiveness of laboratory methods in diverse populations, researchers can gain a more comprehensive understanding of their impact on learning interest in mathematics.

Moreover, this study relied primarily on self-report measures and qualitative data collection methods, which may be subject to biases and limitations inherent in self-reporting. Future research could incorporate a combination of quantitative and qualitative data collection methods, including standardized assessments, classroom observations, and longitudinal studies, to provide a more comprehensive and nuanced understanding of the impact of laboratory methods on student outcomes. By triangulating data from multiple sources, researchers can strengthen the validity and reliability of their findings.

Furthermore, this study focused primarily on short-term outcomes, such as immediate changes in student engagement and attitudes towards mathematics. Future research should explore the long-term effects and sustainability of laboratory-based instruction on student learning outcomes, retention of mathematical concepts, and continued interest in the subject over time. Longitudinal studies tracking students' progress over an extended period can provide valuable insights into the enduring impact of laboratory methods on mathematics education.

Additionally, this study did not examine the role of specific instructional strategies or interventions within laboratory-based instruction that may influence student outcomes. Future

research could investigate the effectiveness of different pedagogical approaches, such as the use of specific manipulatives, technology-enhanced activities, or inquiry-based tasks, in promoting learning interest in mathematics. By identifying the most effective instructional strategies within laboratory methods, educators can tailor their teaching practices to maximize student engagement and achievement.

Moreover, while this study focused on the impact of laboratory methods on student outcomes, future research could explore the perspectives and experiences of educators implementing these methods in their classrooms. By examining teachers' perceptions, challenges, and professional development needs related to laboratory-based instruction, researchers can identify barriers to implementation and develop targeted support strategies to enhance educator effectiveness.

4. CONCLUSION

This research has shed light on the effectiveness of laboratory methods in increasing learning interest in mathematics, providing valuable insights into their impact on student engagement, conceptual understanding, and attitudes towards the subject. Through a comprehensive analysis of data collected from surveys, classroom observations, and interviews with educators and students, the study has identified key patterns, trends, and outcomes associated with the implementation of laboratory-based instruction in mathematics education. The findings of this research affirm the transformative potential of laboratory methods in creating dynamic and engaging learning environments that foster curiosity, creativity, and critical thinking among students. By providing hands-on, experiential learning experiences that promote active engagement, conceptual understanding, and motivation, laboratory-based instruction has been shown to enhance student outcomes in mathematics education. Students reported increased enthusiasm for learning mathematical concepts, greater confidence in their mathematical abilities, and a deeper appreciation for the relevance and applicability of mathematics in their daily lives. Moreover, this research has highlighted the importance of teacher practices, curriculum design, and professional development in maximizing the benefits of laboratory methods in mathematics instruction. Educators who embrace innovative teaching strategies, encourage student autonomy, and foster a collaborative learning environment are better equipped to engage students and promote learning interest in mathematics. Curriculum developers and policymakers are encouraged to consider the role of laboratory methods in achieving educational goals and ensuring coherence and alignment with standards and assessments.

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