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Using Quantum Teaching to Improve Mathematics Learning Outcomes in Junior High School: A Classroom Action Research Approach

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ABSTRACT

Background: At SMP Negeri 1 Kotagajah, student performance in mathematics was found to be below the required Kriteria Ketuntasan Minimal (KKM). This study explores how the Quantum Teaching model can be implemented to improve students' learning outcomes, particularly in exponentiation.

Aims: This research aims to assess the impact of the Quantum Teaching model on enhancing the mathematics achievement of eighth-grade students at SMP Negeri 1 Kotagajah for the 2023/2024 academic year.

Methods: A Classroom Action Research (CAR) methodology was used in this study, conducted in two cycles. Each cycle consisted of planning, implementation, observation, and reflection. Data was gathered through tests, interviews, observations, and documentation, with a focus on students' mathematics performance, especially in the topic of exponentiation.

Results: The study found notable improvements in student achievement. In the first cycle, 66% of students met the learning objectives, while in the second cycle, this increased to 97%. The application of the Quantum Teaching model led to higher levels of student participation and a deeper understanding of the material.

Conclusion: The study indicates that the Quantum Teaching model is an effective strategy for improving mathematics learning outcomes. It fosters a more engaging and interactive classroom environment, enhancing student performance in mathematics at the junior high school level.

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INTRODUCTION

Education plays a vital role in shaping the future of individuals and determining the progress of a nation. It is widely recognized that a strong educational system contributes significantly to national development and human resource quality. The Indonesian government emphasizes education to develop citizens who are intellectually competent, morally grounded, and socially responsible. Among the various components of education, the learning process is considered central in achieving educational objectives. A good learning process must not only deliver knowledge but also cultivate critical thinking, creativity, and positive character traits (Álvarez-Huerta et al., 2022; Thornhill-Miller et al., 2023). However, in practice, many learning environments in Indonesia still struggle to meet these goals. One major issue is the low academic performance of students in several key subjects (Nabil et al., 2021). Mathematics, in particular, continues to be a challenging area for both students and teachers (Ní Fhloinn & Fitzmaurice, 2021).

Mathematics is a fundamental subject that is included in the national curriculum at every level of education—from primary school to university. It provides the basic skills needed to understand other disciplines such as science, engineering, and economics (Pan & Froese, 2023). Despite its importance, many students perceive mathematics as difficult, abstract, and irrelevant to their daily lives (Di Martino et al., 2023). This perception often leads to low motivation, anxiety, and poor academic performance in mathematics (Rodríguez et al., 2021). Factors contributing to this situation include the use of conventional teaching methods, lack of engaging learning activities, and minimal student participation. In many classrooms, the learning process is still dominated by teacher-centered approaches that do not adequately involve students. These traditional methods often fail to stimulate curiosity, creativity, or a deep understanding of mathematical concepts. As a result, improving mathematics education remains a critical issue in the Indonesian school system.

Data collected from SMP Negeri 1 Kota Gajah in Central Lampung indicate that students' performance in mathematics is below the national standards. The average mastery level for the topic of exponents was recorded at only 67.1%, which is significantly lower than the school's Minimum Mastery Criteria (KKM). This statistic reflects a broader problem in the effectiveness of teaching and learning processes at school. Students tend to be passive during lessons and lack enthusiasm for mathematical problem-solving. They often rely on memorization rather than understanding, and struggle to connect mathematical concepts with real-world applications. These challenges hinder students from developing higher-order thinking skills such as analysis, synthesis, and evaluation. Moreover, such low achievement negatively affects students' confidence and attitudes toward mathematics (Wen & Dubé, 2022). Therefore, there is a strong need for an alternative instructional approach that can address these issues (Moorhouse & Wong, 2022)

One promising approach to improve mathematics learning outcomes is the Quantum Teaching model (Khozaei et al., 2022). This model was developed to create a more dynamic, interactive, and student-centered classroom environment (Bhardwaj et al., 2025). It integrates multiple teaching strategies that appeal to different learning styles—visual, auditory, and kinesthetic (Fallace, 2023). Quantum Teaching also emphasizes emotional engagement and positive reinforcement, making the learning process more meaningful and enjoyable. It is structured around the TANDUR framework: Tumbuhkan (Engage), Alami (Experience), Namai (Label), Demonstrasikan (Demonstrate), Ulangi (Review), and Rayakan (Celebrate). Each stage in this framework is designed to activate students' cognitive, emotional, and social dimensions of learning. By incorporating these stages, teachers can help students internalize mathematical concepts through meaningful experiences. Thus, Quantum Teaching holds great potential for improving students' understanding and performance in mathematics.

In addition to promoting academic achievement, Quantum Teaching encourages students to develop confidence and active participation in the classroom. The model provides students with opportunities to explore, express, and evaluate their learning in ways that are both structured and flexible (Valtonen et al., 2021). It also encourages collaborative learning, where students engage in group activities that foster communication and teamwork (Zitha et al., 2023). The emotional aspect of learning is addressed by recognizing and celebrating student progress, which helps build motivation and a sense of accomplishment (Petrasek et al., 2022). Unlike traditional methods, Quantum Teaching shifts the focus from rote learning to meaningful engagement and real-life relevance. This approach aligns well with the goals of 21st-century education, which emphasize critical thinking, creativity, and character development. As such, its implementation can contribute to more inclusive and equitable learning environments. The model is also adaptable to various school contexts, including those with limited resources.

Despite its potential, Quantum Teaching has not yet been widely adopted in many public junior high schools in Indonesia, particularly those in rural areas.Many teachers are unfamiliar with the model or lack the training necessary to implement it effectively. Furthermore, existing school systems often do not provide the time, support, or flexibility required for innovative instructional models (Niemi, 2021). In schools like SMP Negeri 1 Kotagajah, efforts to improve learning are often constrained by limited facilities and teaching materials. However, the strength of Quantum Teaching lies in its emphasis on teaching creativity rather than technological dependence (Almusaed et al., 2023; Bojic, 2022). This means the model can be implemented using simple resources, if the teacher is committed and well-prepared. Therefore, professional development for teachers is essential to support the successful application of this model. Without adequate support and training, even promising methods may fail to produce meaningful improvements in learning outcomes. This study seeks to evaluate the effectiveness of Quantum Teaching in improving mathematics learning outcomes among eighth-grade students. By implementing this model in a real classroom setting, the research will provide practical insights into how the approach influences student engagement and academic performance. The study also aims to identify challenges and best practices related to the application of the TANDUR framework. Through classroom action research, teachers can reflect on and refine their instructional methods to better meet students' needs. The cyclical process of planning, acting, observing, and reflecting allows for continuous improvement of teaching practices. Results from this study are expected to inform future instructional planning and policy decisions at the school level. They may also serve as a reference for other educators seeking to adopt innovative teaching models. Ultimately, this research contributes to ongoing efforts to enhance the quality of education in Indonesian schools

Improving mathematics learning outcomes has become a central theme in educational research, with scholars exploring various strategies across different learning contexts. Jakubowski et al. (2025) investigated the global effects of school closures on student learning using PISA data, emphasizing the urgent need for effective instructional models in mathematics. Soe et al. (2025) highlighted that autonomy-supportive environments significantly enhance student achievement, aligning with the student-centered philosophy of Quantum Teaching. Similarly, Ortiz-Rojas et al. (2025) found that gamification in STEM education improved student engagement and understanding, while Asp et al. (2025)demonstrated how teaching quality affects both confidence and achievement in mathematics. Behnamnia et al. (2025) explored how creative thinking in digital STEM environments supports learning outcomes, which resonates with the creativity-emphasizing TANDUR approach in Quantum Teaching. Michaelidou (2025) examined teacher strategies during play, reinforcing the role of enjoyment and interaction in cognitive development. Jamil et al. (2025) provided a bibliometric review of algebra education, illustrating trends and gaps that support ongoing innovation in pedagogy. Hannan & Eynon (2025)discussed how intelligent tutoring systems mediate the digital divide in mathematics achievement, a reminder of the value of adaptable models like Quantum Teaching in low-tech settings. In line with personalized learning, Oppmann et al. (2025) showed that adaptive features in digital learning environments enhance understanding of mathematical concepts. Hibi (2025) focused on using smart applications for students with arithmetic difficulties, while Chatmaneerungcharoen (2025) emphasized collaborative professional development in designing tech-integrated lesson plans. Hidayat & Saad (2025) found peer tutoring effective in STEM subjects, underscoring the importance of social learning, also embedded in the Quantum Teaching model. Joshi et al. (2025) analyzed digital resource utilization and its effect on learning outcomes across socio-economic contexts, reinforcing the importance of accessible and flexible pedagogical methods. Lin & Riccomini (2025) explored inclusive education using technology to support students with disabilities in mathematics, offering further parallels to the inclusive spirit of Quantum Teaching. Additional works such as the constructivist approach to STEM in preschool (2025) and individually appropriate early childhood STEM. Kadio (2025) support the broader framework of personalized, student-centered instruction. Deswita et al. (2025)evaluated a mobile learning application to improve mathematical understanding, while Perez et al. (2025) developed a STEAM teaching packet, indicating interdisciplinary innovations in instructional design. investigated education quality in West and Central Africa, connecting family and school factors to student outcomes. Finally, Jin et al. (2025) introduced a VR-based learning environment for programming, highlighting the rapid expansion of immersive tools for conceptual learning. Collectively, these studies confirm the global relevance of effective, student-focused learning strategies and underscore the need for further classroom-based research on the implementation of Quantum Teaching to enhance mathematics achievement in junior high schools.

Numerous studies have been conducted to enhance mathematics learning outcomes through various instructional innovations, particularly those that leverage technology such as mobile applications, gamified platforms, and intelligent tutoring systems. While these approaches have shown promise, their effectiveness often depends on technological infrastructure and digital literacy, which may not be consistently available in public junior high schools, especially in rural or resource-constrained environments. In addition, a significant portion of current research is concentrated in early childhood education or higher education contexts, leaving middle-level education (particularly junior high school) relatively underexplored. Although models promoting student autonomy, active engagement, and inclusive practices are gaining traction, few empirical studies have assessed comprehensive pedagogical frameworks like Quantum Teaching in the context of secondary mathematics education. Moreover, the TANDUR approach, central to Quantum Teaching, is frequently mentioned in teacher training literature, but its classroom application and measurable effects on student outcomes remain insufficiently documented. Most existing literature does not employ action-oriented methodologies such as classroom action research, which allows real-time reflection and iterative improvement in teaching. As a result, there is a limited understanding of how Quantum Teaching performs in real teaching scenarios, particularly within the Indonesian education system. This study seeks to fill that gap by offering practical, data-driven insights into the implementation of Quantum Teaching for improving mathematics achievement at the junior high school level.

The main objective of this study is to explore the impact of the Quantum Teaching model on students' mathematics learning outcomes in a junior high school classroom. It aims to evaluate how the application of the TANDUR framework affects student engagement, comprehension, and academic performance. By utilizing a classroom action research design, this study also intends to observe the implementation process over multiple learning cycles, allowing for continuous improvement based on feedback and reflection. The findings are expected to provide practical guidance for teachers and schools in adopting more student-centered and holistic teaching models. Additionally, the study aims to contribute to the growing body of educational literature by offering empirical data on Quantum Teaching in secondary school settings, particularly in non-digital, real-classroom environments. Research Hypotheses: H_0 (Null Hypothesis): Applying the Quantum Teaching model does not result in significant improvement in students' mathematics learning outcomes. H_1 (Alternative Hypothesis): Applying the Quantum Teaching model leads to a significant improvement in students' mathematics learning outcomes.

METHOD

Research Design

This research employs a Classroom Action Research (CAR) design, which is a practical approach aimed at improving teaching strategies within a real classroom context. The cyclical nature of CAR (consisting of planning, implementation, observation, and reflection) enables the researcher to refine the teaching methods after each cycle, ensuring continuous improvement in the learning process. The study is carried out in two distinct cycles, each focusing on applying the Quantum Teaching model to enhance students' learning outcomes in mathematics. This design is particularly suited to studies that seek to implement and assess new teaching strategies in actual educational settings.

Participants

The participants for this study are 30 eighth-grade students from SMP Negeri 1 Kotagajah. This group was selected because their mathematics scores were consistently below the Kriteria Ketuntasan Minimal (KKM), indicating a need for intervention. The students participated in both cycles of the study, allowing for continuous assessment and monitoring of their progress throughout the research period.

Instrument

The primary tools for data collection in this study are mathematics achievement tests, which were administered before and after each cycle to assess changes in student performance. The tests focused on key mathematical concepts, particularly exponentiation (Pitta-Pantazi et al., 2007). Additionally, observation forms and structured interview guides were used to gather qualitative data regarding student participation, engagement, and motivation during lessons. To further understand students' perceptions of the learning experience, questionnaires were distributed to collect feedback on their experiences with the Quantum Teaching approach.

Data Analysis

This study utilizes both qualitative and quantitative data analysis techniques. The quantitative data, derived from the pre- and post-test scores, were analyzed using descriptive statistics to track improvements in students' mathematics performance. The percentage of students meeting the Kriteria Ketuntasan Minimal (KKM) before and after each cycle was calculated to evaluate the impact of Quantum Teaching. For qualitative analysis, thematic coding was used to examine the observation notes, interview responses, and student feedback. This approach identified recurring patterns related to student engagement, motivation, and their overall learning experience with the Quantum Teaching model. By combining both qualitative and quantitative methods, this study provides a comprehensive understanding of how Quantum Teaching influences mathematics learning outcomes and classroom dynamics. To clarify the flow of the research method, here is a visualization of the process in the form of a flowchart:

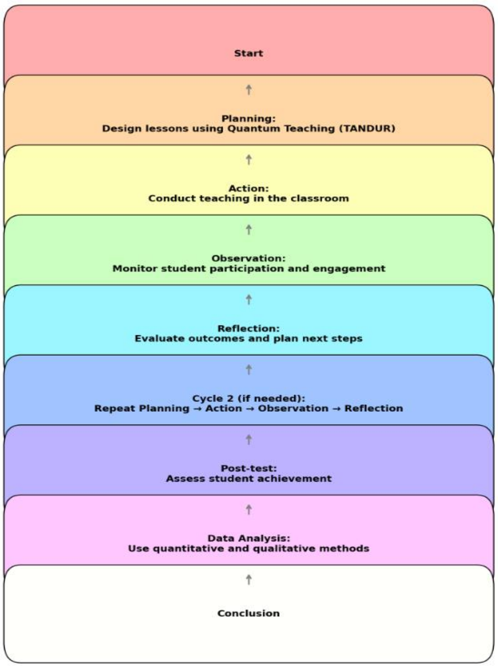

Figure 1. Classrom Action Research Method

RESULTS AND DISCUSSION

Results

The findings from the study indicated substantial improvements in the students' performance in mathematics after implementing the Quantum Teaching model. In the first cycle, only 66% of students were able to meet the required Kriteria Ketuntasan Minimal (KKM), revealing significant room for improvement. However, by the second cycle, this percentage increased dramatically to 97%, highlighting a marked improvement in their overall academic performance. Furthermore, when comparing the pre-test and post-test scores, a significant positive change was observed, particularly in their understanding of mathematical topics like exponentiation.

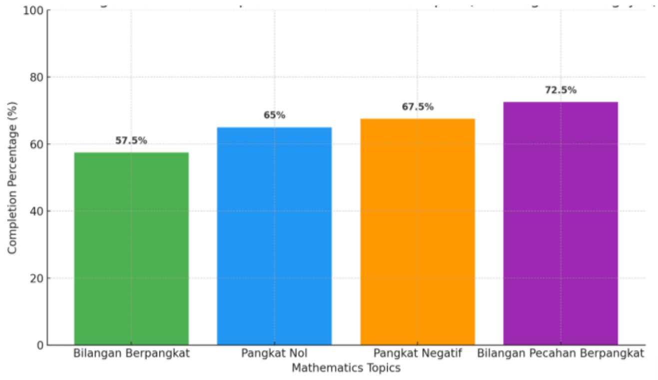

Figure 2. Percentage of Student Completion on Mathematics Topics (SMP Negeri 1 Kotagajah)

As shown, Bilangan Berpangkat had the lowest completion rate at 57.5%, while Bilangan Pecahan Berpangkat had the highest at 72.5%. These findings reflect the areas in which students faced the most difficulty and where the Quantum Teaching model was most successful in enhancing their understanding.

Discussion

The application of Quantum Teaching in this study led to substantial improvements in students' mathematics learning outcomes. Learners demonstrated increased enthusiasm and were more actively involved in classroom activities. This reflects how structured, student-centered pedagogies can significantly influence learning engagement and outcomes (Soe et al., 2025). The TANDUR stages enabled students to connect mathematical content with real-life applications, which helped demystify abstract concepts. Especially in the "Demonstrate" and "Review" phases, students engaged in active processing that supported retention. As a result, students showed better conceptual understanding in exponentiation. The flexible yet organized format of Quantum Teaching allowed differentiation based on students' learning styles. These findings support the idea that integrating cognitive and emotional elements enhances both learning quality and student confidence (Behnamnia et al., 2025).

The learning atmosphere in the classroom also became more interactive and cooperative compared to before the intervention. In the initial stages, students were passive and hesitant to participate in mathematics discussions. However, the new approach encouraged dialogue, teamwork, and mutual support among students, especially during collaborative tasks. This transition to a socially active learning model aligns with evidence that interactive strategies such as gamification and group work boost participation in STEM learning (Ortiz-Rojas et al., 2025). The "Celebrate" stage helped students feel appreciated and less anxious about failure, improving their attitude toward mathematics. Through such emotional reinforcement, students began to view learning as something enjoyable rather than stressful. This positive shift in perception also translated into better persistence when facing academic challenges. Clearly, student motivation benefits when emotional recognition is embedded in instructional design.

The comparison between pre-test and post-test results showed notable gains in student performance, particularly in their understanding of exponentiation. Many students experienced score improvements, which were also reflected in moderate to high normalized gain values. This pattern reinforces the importance of iterative instruction and regular feedback in mastering complex topics (Oppmann et al., 2025). Students were given repeated opportunities to apply and revisit concepts, which deepened their understanding. The use of varied learning tools—such as worksheets and contextual exercises—also supported multi-modal learning. Moreover, peer interaction played a critical role as students explained concepts to one another. Group-based learning strategies have been recognized as effective in enhancing mathematics outcomes (Hidayat & Saad, 2025). These outcomes illustrate the benefit of combining repetition, collaboration, and contextual practice in instructional planning.

Observations throughout the learning cycles indicated a growing sense of independence and confidence among students. Initially, quiet learners began to participate in group activities and class discussions more actively. Over time, student contributions became more thoughtful and self-initiated, especially during problem-solving sessions. This aligns with evidence that structured classroom interaction enhances student agency and classroom inclusivity (Michaelidou, 2025). The "Experience" and "Demonstrate" stages allowed students to explore ideas and test their reasoning in a supportive environment. The teacher's role also shifted—from lecturer to learning facilitator—providing space for students to lead discussions. This evolution of roles is crucial in building autonomy and intrinsic motivation. Inclusive and responsive teaching practices like these are known to improve student engagement in mathematics (Lin & Riccomini, 2025).

Reflections gathered from students reinforced the improvements observed during the study. Many learners reported that they felt more confident and relaxed when learning mathematics using this model. They described lessons as more interesting, practical, and easier to relate to in their daily lives. These student responses illustrate the importance of emotional connection and recognition in learning, especially for difficult subjects (Joshi et al., 2025). By engaging in students' feelings and values, the learning experience became more meaningful. Furthermore, students reported better understanding not just of how to solve problems, but also of why certain methods worked. This shift from procedural to conceptual understanding is vital for long-term retention. A classroom environment that fosters emotional safety supports deeper intellectual engagement. When enjoyment and structure are combined, students are more willing to persevere in learning (Deswita et al., 2025).

However, the implementation of Quantum Teaching was not without challenges. Preparing each lesson according to the TANDUR framework required more time and creativity from the teacher. Not all students were comfortable at first with group work and student-led activities, and some were reluctant to participate. These barriers are consistent with those found in efforts to introduce collaborative lesson planning or student-centered tools (Chatmaneerungcharoen, 2025). Overcoming these challenges requires constant monitoring, reflection, and strategy adjustment. Action research as a method provided the flexibility needed to adapt the approach based on classroom realities. Iterative refinement of instructional design, informed by student responses, improved the model's effectiveness. This shows that teacher adaptability is a crucial factor in the successful implementation of innovative pedagogy (Perez et al., 2025). Therefore, teacher preparation and institutional support are essential components of educational innovation.

Beyond instructional outcomes, this study contributes to the discourse on equitable education in resource-constrained environments. Unlike high-tech models, Quantum Teaching can be applied in schools with limited infrastructure, relying instead on creativity and interaction. This makes it a practical choice for many rural or under-resourced schools. Education researchers have noted that the digital divide continues to limit opportunities for students in remote areas (Hannan & Eynon, 2025). By focusing on human interaction and contextual learning, the model addresses this gap with minimal reliance on technology. Moreover, its adaptability to different contexts supports inclusion and differentiation. Instructional flexibility has been shown to accommodate diverse learners and improve educational outcomes (Jamil et al., 2025). Quantum Teaching demonstrates how pedagogical strategies can drive innovation and equity simultaneously.

In conclusion, this classroom action research validates the use of Quantum Teaching as a model for improving mathematics learning. The approach increased student participation, achievement, and enjoyment during instruction. These results reinforce the view that emotionally supportive, student-centered instruction leads to more effective learning outcomes (Kadio, 2025). Teachers benefited from the reflective cycles of planning and adaptation, gaining valuable insights into student behavior and needs. The structure of the TANDUR model encouraged both rigor and flexibility, making it suitable for diverse classroom conditions. Although it demands time and effort to implement, the model has demonstrated strong potential in enhancing both academic and affective domains. Future studies are recommended to explore its application in other subjects and grade levels. Expanding the model's use can contribute to the broader goal of improving the quality of education across Indonesia.

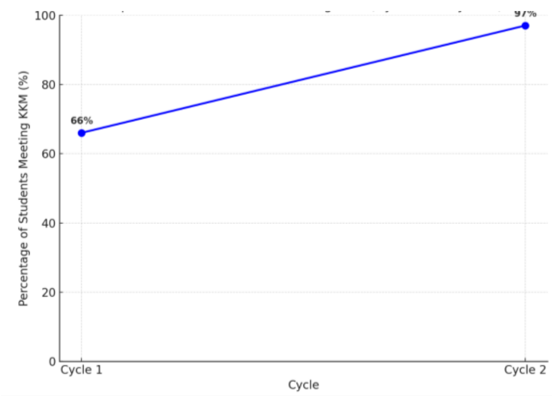

Figure 3. Improvement in Students Meeting KKM (Cycle 1 vs Cycle 2)

Implications

The study's findings provide compelling evidence for the effectiveness of the Quantum Teaching model in enhancing mathematics learning outcomes. The results suggest that implementing interactive and student-centered teaching strategies, such as those found in Quantum Teaching, can significantly improve students' motivation and performance. Educators should consider incorporating such approaches into their teaching practices, as they promote active engagement, critical thinking, and deeper understanding of mathematical concepts. Additionally, the positive impact on student motivation and engagement observed in this study highlights the need for schools to prioritize teaching methods that foster a collaborative and participatory learning environment. Teachers should be encouraged to adopt innovative teaching strategies that inspire students to take ownership of their learning and tackle mathematical challenges with confidence.

Limitations

While the results of this study are promising, there are some limitations that should be considered. The sample size was relatively small, consisting of only 30 students from a single class at SMP Negeri 1 Kotagajah, which may limit the generalizability of the findings. Moreover, the study was conducted over a relatively short period, meaning that the long-term effects of Quantum Teaching on students' mathematics learning outcomes remain unclear. Future research should include larger sample sizes and longer study durations to further validate the effectiveness of the model. Another limitation is the potential bias in the data collected from student questionnaires. While these provided useful insights into students' experiences, the responses might have been influenced by the students' positive reactions to the new teaching model, possibly skewing the results. Future studies could employ more objective measures to evaluate student engagement and motivation.

Suggestions

Given the positive results observed in this study, it is recommended that the Quantum Teaching model be implemented more widely in mathematics classrooms across various grade levels. Further research should explore its effectiveness in different mathematical topics and across diverse educational settings to evaluate its applicability and long-term impact. Additionally, efforts should be made to adapt the model to cater to the needs of diverse learners, including those with learning difficulties. Moreover, professional development programs should be designed to help teachers effectively incorporate student-centered and interactive teaching strategies into their practice. Training teachers to implement such methods is crucial for ensuring the successful adoption of Quantum Teaching and fostering better student outcomes in mathematics.

CONCLUSION

This research investigates the relevance of Ibn Taimiyah's political and legal philosophy, particularly his theory of siyāsah shar'iyyah (Islamic governance), to the reform of marriage law in Indonesia. The study finds that Ibn Taimiyah's concepts provide a strong foundation for aligning marriage law with Islamic teachings while addressing contemporary societal demands. His emphasis on the state's responsibility in enforcing Shari'ah law to ensure public welfare and justice is particularly applicable to Indonesia's legal system. While there is broad support for reforming marriage law to reflect Islamic values, challenges remain in areas like the regulation of Misyar marriage, highlighting the tension between tradition and modernity. The findings suggest that ongoing dialogue between legal scholars, policymakers, and religious authorities is essential to balance religious principles with modern human rights standards. Ibn Taimiyah's ideas offer valuable guidance for reforming marriage laws that promote both justice and public welfare, ensuring that the law is both rooted in Islamic values and relevant to current social realities. This study contributes to the broader field of Islamic legal reform and suggests pathways for applying Ibn Taimiyah's thought to other areas of family law in Indonesia, paving the way for a more inclusive and effective legal framework.

AUTHOR CONTRIBUTIONS STATEMENT

Rini Fitriyana: Conceptualized the research, designed the study, collected data, performed data analysis, and wrote the manuscript.
Astri Setyawati: Supervised the research process, provided feedback on the study design, and contributed to the analysis and revision of the manuscript.
Siti Lestari and Djatmiko: assisted in the study design, guided data collection and analysis, and contributed to manuscript editing.

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