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Development of a rigorous mathematical thinking-based textbook in the house of worship context to enhance conceptual understanding

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Abstract

Background: This research develops a foundational mathematics textbook for PGMI students based on the Rigorous Mathematical Thinking (RMT) framework, contextualized within houses of worship to foster deeper understanding of mathematical concepts.
Aim: The study aims to design and evaluate the feasibility and effectiveness of the textbook while gauging students' responses and performance improvements.
Method: Using a research and development (R&D) model, this study validated the textbook through expert reviews and tested its practicality and effectiveness in small-scale and broader applications. Data were obtained through a combination of observations, interviews, surveys, and tests measuring students' conceptual comprehension. Statistical evaluations, including descriptive analysis and t-tests, were employed.
Results: The textbook received validation from subject matter, presentation, and language experts, who confirmed its content and structural accuracy. Trial phases categorized the textbook as highly practical, while broader field testing indicated that students using the textbook demonstrated significantly greater improvement in conceptual understanding compared to those without it.
Conclusion: The RMT-based textbook aligns with its intended objectives and provides a contextually appropriate tool for improving mathematical comprehension. These findings highlight its potential as an effective resource for mathematics learning in PGMI contexts.

INTRODUCTION

Mathematics is a basic science that plays an important role in everyday life, as well as in the development of other sciences and technologies (Aulia et al., 2024). Mathematics is also considered the parent of various sciences and their branches. The changing landscape of mathematics education requires new approaches that extend beyond conventional teaching methods (Khilmi et al., 2024; Kwadzo Sallah et al., 2023). As educators work to address the varied needs of students, there's an increasing awareness of the need to create teaching materials that not only improve math skills but also connect with students' cultural and spiritual backgrounds. Traditional methods often struggle to link math concepts to students' everyday experiences, which can lead to a lack of interest and understanding. To tackle this issue, more attention is being given to incorporating values-based education into math instruction (Hunter, 2020). This approach aims to

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foster both academic success and moral development, helping students to be better equipped for the challenges they will face in both their personal and academic lives.

In recent times, there's been a growing awareness that traditional methods of teaching mathematics might not fully support the overall development of students. While these methods can help with understanding math concepts, they often overlook the importance of connecting the subject to students' daily lives and cultural backgrounds (Outhwaite et al., 2019; Wronowski et al., 2022). This gap highlights the need for a more comprehensive approach that not only focuses on academic skills but also encourages personal growth and ethical understanding (Barroso et al., 2021; Benden & Lauermann, 2023). Educators are now exploring ways to make math lessons more relevant by incorporating cultural and spiritual values into the teaching materials (Kong et al., 2022). By doing this, they aim to create a more engaging learning experience that helps students succeed academically while also preparing them to face the moral and ethical challenges of life.

Understanding the challenge of meeting the diverse needs of students in mathematics education, it’s clear that we need teaching materials that are both relevant to students' lives and effective in teaching the subject. Traditional ways of teaching math often don't fully engage students or help them deeply understand the concepts, especially when these methods ignore students' cultural and spiritual backgrounds (Gerasimova et al., 2021; Múñez et al., 2021). Because of this, educators and researchers are looking for new ways to connect academic learning with values-based education (Anderman et al., 2024; Sejdiu Shala et al., 2024). By including religious and ethical aspects in math teaching materials, educators can help students not only improve their math skills but also grow as well-rounded individuals. This approach supports the goal of education to develop students who are prepared to face both academic and moral challenges in their lives.

The development of mathematics teaching materials has become a key focus in efforts to improve the quality of education, particularly in creating learning experiences that are relevant to students' needs. One approach that has been implemented is Rigorous Mathematical Thinking (RMT), which emphasizes developing mathematical understanding through real-life contexts (Firmasari et al., 2022; Pratiwi et al., 2022). This approach aims to make mathematics more accessible and applicable for students in their everyday situations. However, in practice, the available teaching materials often do not fully address the specific needs of students, especially when it comes to integrating religious values that are crucial for character building (Azahro & Agnafia, 2022; Pirma & Caswita, 2023). This limitation has prompted various efforts to develop teaching materials that are better suited to the local context and the values upheld by the community, particularly in faith-based educational environments. In this context, it is important to further explore how mathematics teaching materials can be developed not only to meet academic standards but also to strengthen students' moral and spiritual values.

Previous research had developed mathematics teaching materials based on Rigorous Mathematical Thinking (RMT) to address the limitations of existing

educational resources. For example, studies by teachers Meilantifa & Budiarto (2018), Noviandini (2021) and Anggraeni (2021) produced textbooks that were validated and deemed suitable for prospective mathematics teachers, while (DS & Budiarto, 2018) and (Hayati et al., 2022) focused on improving student learning outcomes through the implementation of these materials. Additionally, Resmi (2020) highlighted the importance of developing teaching materials that enhance students' critical thinking skills. However, these studies have not yet addressed the development of RMT-based mathematics teaching materials that explicitly integrate Islamic values, particularly those that focus on religious contexts in mathematics education. Therefore, there is a gap that needs to be filled by research that develops RMT-based mathematics teaching materials that are not only valid and effective but also aligned with religious values, supporting character education in madrasas or faith-based schools.

METHODS

Design

This study adopted the ADDIE development model, a structured framework widely used in educational research, which consists of five interconnected phases: Analysis, Design, Development, Implementation, and Evaluation (Cahyadi, 2019). Each phase played a critical role in ensuring that the development process was comprehensive and methodologically sound. This research is classified as development research, commonly referred to as Research and Development (R&D), which focuses on producing a specific product—in this case, a mathematics textbook—and rigorously testing its practicality and effectiveness in achieving the intended learning outcomes (Sugiyono, 2014). The design phase was particularly focused on systematically crafting, refining, and evaluating the textbook to ensure it meets high standards of feasibility, practicality, and effectiveness. Ultimately, this approach aimed to provide a validated learning resource capable of enhancing students' conceptual understanding of mathematics through innovative instructional strategies and contextual integration.

Participants

The participants involved in this study were drawn from PGMI students enrolled in the PGMI Study Program at UIN FAS Bengkulu during the even semester of the 2023/2024 academic year. Two groups were included: the experimental group, consisting of 23 students who engaged with the RMT-based textbook contextualized within places of worship, and the control group, comprising 20 students who participated in conventional learning activities without the use of the developed textbook. Furthermore, six expert validators contributed to the evaluation process of the textbook. These included two specialists in mathematics content, two media experts, and two language experts. The inclusion of these groups and experts ensured a robust and thorough assessment of the textbook’s design, language, content, and its potential effectiveness in enhancing mathematical concept comprehension among students.

Instruments

The instruments used in this study included:

Table 1. Research Instruments

No	Phase	Focus Data	Instrument
1	Analysis	Needs analysis	Questionnaire given to students and teaching lecturers; needs interview guide for lecturers; initial ability test for PGMI students.
		Material analysis	Questionnaire about basic mathematics material; observation and documentation sheet.
2	Design	Expert validation	Textbook validation sheet by a team of experts.
3	Development		
4	Implementation	Student response and effectiveness	Student response questionnaire; mathematical concept understanding ability test.
5	Evaluation	Formative and summative evaluations	Observation sheet; expert validation sheet; response questionnaire; mathematical concept understanding test.

Data Analysis

The data analysis involved descriptive and quantitative techniques, including validation, reliability, and effectiveness testing.

1. **Validation Analysis**:
   The Aiken's V index was used to measure the validity of the textbook. The formula is (Aiken, 1985):

$$v = \Sigma \frac{s}{n(c-1)}$$

Where:

V : Aiken Index
S : The scores given by the rater minus the lowest score in the category ($s = R\text{-}L_o$)
R : The score is given by the rater
L_o : The lowest score
c : The highest score
n : Number of raters (validators)

Table 2. Aiken-V criteria

Range of v	Criteria
V ≤ 0,4	Low
0,4 < V < 0,8	Medium
V ≥ 0,8	High

Source: (Nasional & Sains, 2017)

2. **Reliability Analysis:**
   Inter-rater reliability (IRR) was calculated using the Copen Kappa agreement coefficient (KKK). The reliability level criteria are presented below:

$$\text{Interrater reliability} = \frac{\text{sum of the mean scores of 2 rate}}{\text{s several statements}} \text{x100\%}$$

Table 3. Kappa Criteria

Reliability Percentage	Reliability Level
0 – 4%	None
4 – 15%	Minimal
15 – 35%	Weak
35 – 63%	Medium
64 – 81%	Strong
82 – 100%	Extremely Strong

Source: (Nurdahwati et al., 2023)

3. **Effectiveness Testing:**
   The effectiveness of the textbook was measured using the N-Gain index and a t-test. The N-Gain formula is:

$$N - Gain = \frac{skor\ posttest - skor\ pretest}{skor\ maksimal - skor\ pretest}$$

Tabel 4. Kriteria N-Gain

N-Gain	Criteria
g ≥ 0,7	High
0,7 > g > 0,3	Middle
g ≤ 0,3	Low

Source: (Hake, 1999)

   Pretest and posttest results from the experimental and control classes were compared using a t-test to determine statistical significance.

4. **Student Responses:**
   A response questionnaire with five alternative answers was used to measure student satisfaction.

Table 5. Student Response Criteria

No	Score range	Criteria
1	81% - 100%	Very Good
2	61% - 80%	Good
3	41% - 60%	Not so Good
4	21% - 40%	Not Good
5	0% - 20%	Very Not Good

By utilizing these instruments and analysis methods, the validity, reliability, and effectiveness of the developed textbook were thoroughly evaluated.

RESULTS AND DISCUSSION

Result

The validation process for the basic mathematics textbook began after development to ensure its compliance with predetermined criteria. The validation team, consisting of two material experts, two media experts, and two linguists, assessed the feasibility of the

textbook and provided constructive feedback for improvement. The results of the validation test using Aiken's V index for the initial product showed varying degrees of validity, as detailed in **Table 6**:

Table 6. Validity Test Results Using the Validity Agreement Index (Aiken)

Steps	Conten Expert	Media Expert	Linguist
Initial Product	0.44	0.38	0.48
Revision 1	0.86	0.88	0.91

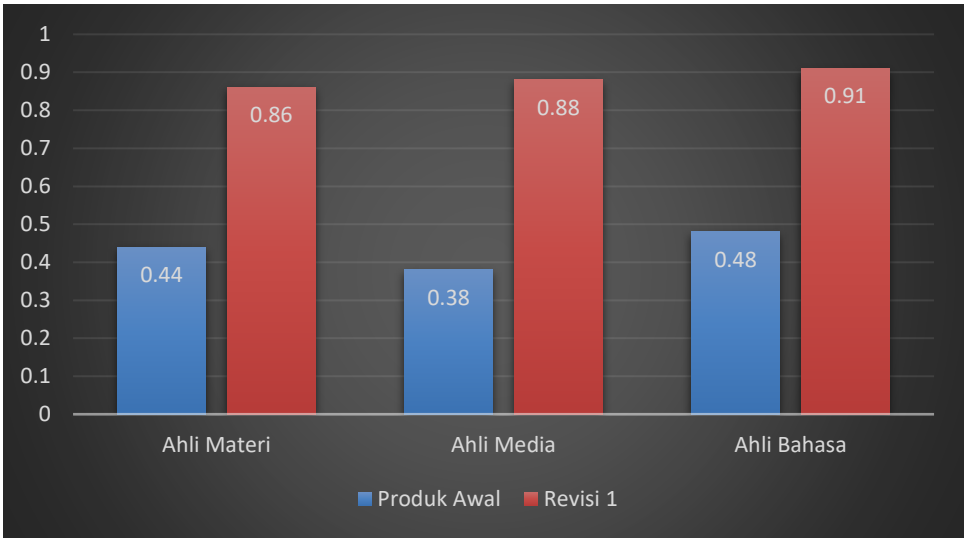


Figure 1. Validity Test Results Using the Validity Agreement Index (Aiken)

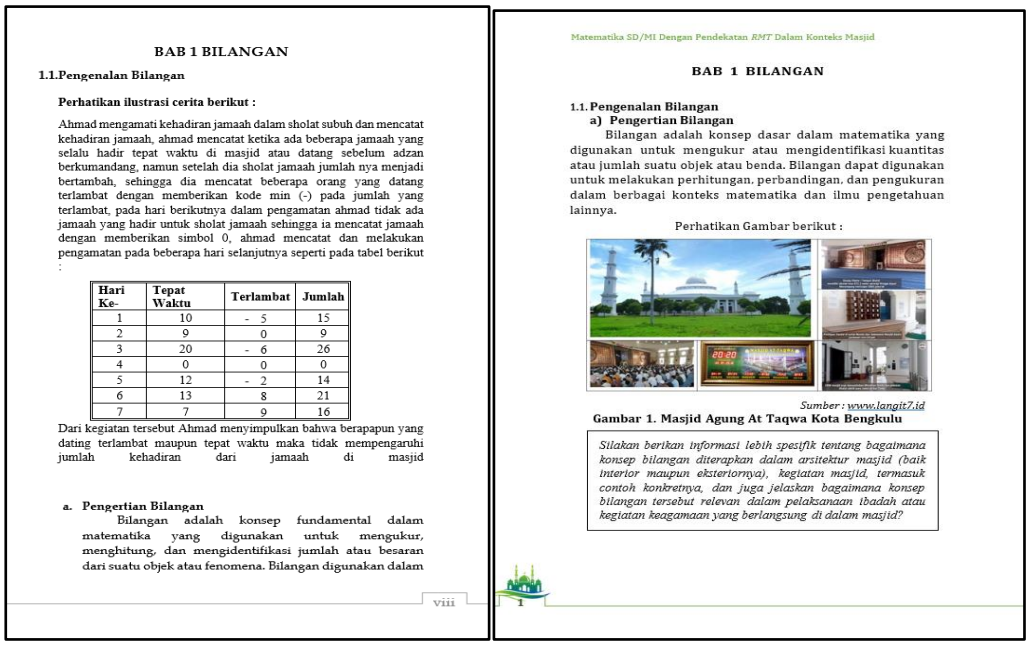
The initial product achieved moderate validity for material (0.44) and language (0.48), while media validity was lower (0.38). After revisions, all aspects achieved high validity criteria with values exceeding 0.8, as shown in Figure 1. Reliability testing using the Copen Kappa agreement coefficient is detailed in **Table 7**:

Table 7. Comparison of Reliability Test Results with Inter-Rater Reliability of the Initial Product

Aspect	Kappa Reliability	Criteria
Content Expert	0.422	Weak
Media Expert	0.507	Weak
Linguist	0.705	Medium

The reliability test for the initial product of the mathematics textbook involved evaluations by material, media, and language experts. Results revealed the need for revisions, as the initial Kappa coefficients indicated weak agreement for material (0.422) and media (0.507) aspects, while language scored moderately (0.705). Experts suggested improving consistency with learning objectives, enhancing examples and exercises, and incorporating relevant images, graphics, and animations to make the media more engaging. Revisions addressed these weaknesses, focusing on aligning content with the curriculum and improving the textbook's readability and visual appeal. These efforts aimed to ensure that the textbook met high validity and reliability standards across all aspects.

Subsequent revisions included integrating elements of houses of worship, particularly mosques, into the textbook design to align with the Rigorous Mathematical Thinking (RMT) approach. Updates included redesigning the cover with relevant cultural elements, organizing the table of contents more systematically, and adding headers and footers for better navigation. Applicative examples were incorporated to demonstrate how mathematical concepts can be applied in a religious context. These enhancements not only made the textbook more structured and professional but also provided PGMI students with a practical and engaging learning resource, bridging abstract concepts with real-life applications.



BAB 1 BILANGAN

1.1.Pengenalan Bilangan

Perhatikan ilustrasi cerita berikut :

Ahmad mengamati kehadiran jamaah dalam sholat subuh dan mencatat kehadiran jamaah, ahmad mencatat ketika ada beberapa jamaah yang selalu hadir tepat waktu di masjid atau datang sebelum adzan berkumandang, namun setelah dia sholat jamaah jumlah nya menjadi bertambah, sehingga dia mencatat beberapa orang yang datang terlambat dengan memberikan kode min (-) pada jumlah yang terlambat, pada hari berikutnya dalam pengamatan ahmad tidak ada jamaah yang hadir untuk sholat jamaah sehingga ia mencatat jamaah dengan memberikan simbol 0, ahmad mencatat dan melakukan pengamatan pada beberapa hari selanjutnya seperti pada tabel berikut :

Hari Ke-	Tepat Waktu	Terlambat	Jumlah
1	10	- 5	15
2	9	0	9
3	20	- 6	26
4	0	0	0
5	12	- 2	14
6	13	8	21
7	7	9	16

Dari kegiatan tersebut Ahmad menyimpulkan bahwa berapapun yang dating terlambat maupun tepat waktu maka tidak mempengaruhi jumlah kehadiran dari jamaah di masjid

a. Pengertian Bilangan

Bilangan adalah konsep fundamental dalam matematika yang digunakan untuk mengukur, menghitung, dan mengidentifikasi jumlah atau besaran dari suatu objek atau fenomena. Bilangan digunakan dalam

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Matematika SD/MI Dengan Pendekatan *RMT* Dalam Konteks Masjid

BAB 1 BILANGAN

1.1. **Pengenalan Bilangan**

a) Pengertian Bilangan

Bilangan adalah konsep dasar dalam matematika yang digunakan untuk mengukur atau mengidentifikasi kuantitas atau jumlah suatu objek atau benda. Bilangan dapat digunakan untuk melakukan perhitungan, perbandingan, dan pengukuran dalam berbagai konteks matematika dan ilmu pengetahuan lainnya.

Perhatikan Gambar berikut :

Sumber : www.langit7.id

Gambar 1. Masjid Agung At Taqwa Kota Bengkulu

Silakan berikan informasi lebih spesifik tentang bagaimana konsep bilangan diterapkan dalam arsitektur masjid (baik interior maupun eksteriornya), kegiatan masjid, termasuk contoh konkretnya, dan juga jelaskan bagaimana konsep bilangan tersebut relevan dalam pelaksanaan ibadah atau kegiatan keagamaan yang berlangsung di dalam masjid?

1

Figure 2. Before and After Revision

The content of the book has been revised to improve quality, as seen in Figures 2 where the material that was previously not based on houses of worship has been changed. In addition, the revision also added information about RMT that was previously absent, thus providing a clearer representation of RMT in the book. After validation, the results of feedback and suggestions from the expert team will be the basis for making further revisions if needed. This aims to ensure that the textbook not only meets academic standards but can also make a maximum contribution to improving the understanding of mathematical concepts of PGMI students through innovative and house-of-worship-based approaches. By involving a team of experts, this validation is a critical step in ensuring the quality and effectiveness of this textbook in the context of mathematics education. The details of the expert team II validation results are as follows:

Table 8. Comparison of Validity Test Results Using the Validity Agreement Index (Aiken) II

Content Expert	Media Expert	Linguist
V=0.86 with high validity criteria	V=0.88 with high validity criteria	V=0.91 with high validity criteria

However, it is necessary to conduct a small class trial field trial to improve the quality of coursebooks before they are widely used. This research is expected to produce

quality and effective textbooks in improving the understanding of mathematical concepts of PGMI students. Previously, a reliability test with inter-rater reliability will be carried out using the IRR coefficient formula using the Copen Kappa agreement coefficient (K), with the following details:

Table 9. Comparison of Reliability Test Results with Inter-Rater Reliability of the Initial Product of the Second Teaching Book

Content Expert	Media Expert	Linguist
Kappa reliability = 0.837 with strong criteria	Kappa reliability = 0.860 with strong criteria	Kappa reliability = 0.806 with strong criteria

The reliability test results for the initial coursebook showed a strong level of agreement among raters across material, media, and language aspects. The Kappa value for material (0.837) indicated high agreement, reflecting consistency in assessing the coursebook's content aligned with the Rigorous Mathematical Thinking (RMT) approach in the context of houses of worship. For media, the Kappa value (0.860) showed very high agreement, highlighting the effectiveness of visuals such as images and videos in supporting learning. The language aspect scored a Kappa value of 0.806, also reflecting high agreement, emphasizing clarity and suitability for PGMI students. These findings indicate that the coursebook has strong reliability and potential as a consistent learning resource.

Following validation, student responses were gathered using the RMT-based textbook in the experimental group. The results showed an average response score of 87.1%, categorized as very practical, demonstrating the textbook's high practicality in supporting learning. This positive feedback highlights its effectiveness in engaging students and enhancing their understanding of mathematical concepts.

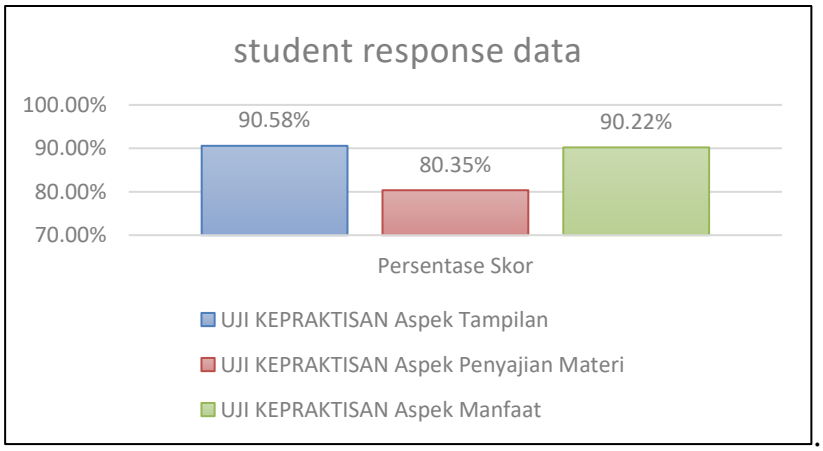

Figure 3. Graph of Student Assessment Percentage for Each Aspect from Practicality

The results of the practicality test show that this textbook with a rigorous mathematical thinking approach in the context of places of worship is very practical and useful for PGMI students. To measure the effectiveness of using basic mathematics textbooks using the RMT approach in the context of places of worship, an experiment was carried out using 2 classes, namely the experimental class and the control class using the analysis used, namely the T test. In the T test analysis, there are prerequisites that

need to be carried out, namely the normality test and the T test. homogeneity. So below are the results of analyzing the prerequisite tests in Table 10

Tabel 10. Normality Test

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pretest	Control Class	0,130	20	0,200*	0,965	20	0,648
	Experimental Class	0,104	23	0,200*	0,972	23	0,732
Postes	Control Class	0,160	20	0,190	0,935	20	0,191
	Experimental Class	0,116	23	0,200*	0,981	23	0,926
NGain	Control Class	0,150	20	0,200*	0,965	20	0,638
	Experimental Class	0,103	23	0,200*	0,982	23	0,943

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Both groups demonstrated normally distributed data, supporting the use of t-tests. Results of the N-Gain analysis and independent samples t-test are presented in Table 11 and Table 12:

Tabel 11. Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
NGain	Control Class	20	46.0331	12.53783	2.80354
	Experimental Class	23	73.7222	8.41891	1.75546

Tabel 12. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
NGain	Equal variances assumed	3,309	0,076	-8,601	41	0,000
	Equal variances not assumed			-8,371	32,504	0,000

The experimental group significantly outperformed the control group ($p<0.05p < 0.05p<0.05$) with a mean N-Gain of 73.72%, compared to 46.03% in the control group, as illustrated in Figure 3.

Discussion

The validation findings demonstrate that the developed RMT-based mathematics textbook holds significant potential as a teaching resource for PGMI students. The material experts emphasized that the textbook aligns with the curriculum and successfully incorporates mathematical concepts within the context of places of worship, making the content both rigorous and relatable. This contextual integration enhances learning by providing students with practical and meaningful examples that connect mathematical theories to real-life experiences. Media experts identified improvements in visual elements, such as diagrams and images, which contribute to better comprehension and engagement. Similarly, linguists highlighted the appropriateness of the language used, ensuring its clarity and accessibility for the intended audience. These outcomes are

consistent with previous research that underscores the benefits of contextual learning in boosting student motivation and achievement (Kahfi et al., 2022; Kirchhoff et al., 2022; Wythe, 2023).

The results from the inter-rater reliability (Table 9) indicate strong agreement among the validators after revisions, underscoring the value of a collaborative process in refining instructional materials. This iterative approach, which relied on constructive feedback from experts, helped ensure that the textbook achieved a high standard of validity and reliability across all aspects—content, media, and language. These findings affirm that the textbook is a robust and reliable tool for enhancing students' mathematical understanding (Incikabi et al., 2023; Julie & Maat, 2021).

The effectiveness of the textbook was further evidenced by the significant improvement in the experimental group's performance compared to the control group, as reflected in their N-Gain scores (Table 11). The use of places of worship as a contextual framework not only made the material more relevant but also bridged abstract mathematical concepts with familiar experiences, creating a more engaging learning environment. Such results align with prior studies showing that culturally meaningful contexts can significantly enhance student comprehension and interest in mathematics (Nasution et al., 2018; Wong & Wong, 2019).

Nevertheless, there are areas that warrant further improvement. Media components such as animations or interactive features could be developed to make the textbook even more engaging and supportive of diverse learning styles. This could particularly benefit visual learners and enhance the overall usability of the textbook. Additionally, the study could be expanded by including a larger sample size and conducting a longitudinal analysis to assess the long-term impact of the textbook on learning outcomes.

From a practical standpoint, this research offers valuable insights for mathematics educators. The textbook serves as a model for integrating cultural and religious contexts into teaching practices, which can help students better understand and apply mathematical concepts while also fostering their appreciation for the subject. Educators in the PGMI program can leverage such resources to create more engaging and culturally relevant lessons.

Implication

The results of this research carry meaningful implications for students, teachers, and the creation of learning media in educational settings. For students, the application of the Rigorous Mathematical Thinking (RMT) approach, paired with contextual examples from places of worship, aids in making abstract mathematical concepts easier to understand by connecting them to familiar, real-world situations. This approach not only deepens comprehension but also enhances motivation, as students begin to recognize the value and relevance of mathematics in their daily lives and spiritual experiences. Additionally, the RMT framework promotes critical thinking and problem-solving abilities, equipping students with essential skills needed for academic achievement and practical problem-solving.

For educators and schools, the study underscores the necessity of culturally relevant and engaging learning tools. Teachers can draw on the textbook as a blueprint for implementing contextual teaching practices that align with curriculum goals while addressing the unique needs of their students. The integration of visuals, diagrams, and culturally significant examples serves as a valuable resource for explaining challenging topics and accommodating various learning preferences. At the same time, schools can prioritize the development and integration of such materials, ensuring that they meet academic standards while enhancing the learning experience. By adopting these strategies, mathematics education can become more inclusive, engaging, and impactful for a diverse range of students.

Limitation

However, some limitations of this study should be acknowledged. The relatively small sample size and the short duration of the implementation may limit the generalizability of the findings. Future research could focus on how this approach can be adapted and scaled for different educational contexts and student demographics. Moreover, continued collaboration between teachers and curriculum developers will be essential to refine the textbook and align it with changing educational demands. In summary, the RMT-based mathematics textbook effectively combines rigorous mathematical thinking with culturally relevant contexts, offering an innovative approach to teaching mathematics. With further refinements and broader trials, this method has the potential to make mathematics education more engaging, impactful, and meaningful for students

CONCLUSIONS

This study concludes that the RMT-based mathematics textbook, contextualized within places of worship, is an effective tool for improving students' understanding of mathematical concepts. Through rigorous validation and revisions, the textbook achieved high validity and reliability, demonstrating its quality as a learning resource. Students who used the textbook showed significantly higher conceptual understanding compared to those in the control group, as indicated by their superior N-Gain scores. By integrating culturally meaningful and familiar contexts, such as places of worship, the textbook not only enhanced comprehension but also increased student engagement and motivation. These findings highlight the importance of aligning educational materials with students' cultural and real-world experiences to make learning more accessible and impactful. Further development and broader implementation of this approach could enhance the inclusivity and effectiveness of mathematics education.

AUTHOR CONTRIBUTION STATEMENTS

Fatrima Santri Syafri: Conceptualized the research framework, led the design and development of the RMT-based mathematics textbook, and conducted the data collection and analysis. She also took the lead in drafting the manuscript and addressing reviewer comments during the revision process.

Agus Susanta: Provided critical input in the validation process, focusing on the evaluation of content and media aspects of the textbook. He contributed to refining the research methodology and offered substantial feedback on the manuscript's structure and coherence.

Irwan Koto: Oversaw the statistical analysis, including the validation and reliability testing, and ensured the accuracy of the quantitative results. He also provided expertise in interpreting the findings and contributed to the discussion and conclusion sections of the manuscript.

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