Gender in the Integration of Batik Ethnomathematics and Fiqh: Learning Models, Numeracy, and Trustworthiness

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Abstract: Mathematics education in Indonesia continues to face challenges in developing students' numeracy literacy, partly due to the limited integration of cultural, Islamic, and gender perspectives in pedagogical practices. This study seeks to design and validate an integrative learning model that merges batik ethnomathematics, Islamic jurisprudence (*fiqh*) values, and gender inclusivity to enhance students' numeracy literacy and trustworthiness (*amanah*). A quasi-experimental method employing a pretest–posttest non-equivalent control group design was applied. The experimental class received instruction based on batik ethnomathematics integrated with fiqh values, while the control class followed a conventional approach. The findings demonstrate that embedding geometric concepts within batik ethnomathematics made learning more contextual, meaningful, and culturally relevant. The inclusion of *fiqh* principles, such as *amanah* and fairness, fostered students' Islamic character development, while gender-responsive strategies promoted equitable participation among male and female learners. This study extends existing ethnomathematics scholarship by proposing a cohesive instructional framework that bridges cultural, ethical, and pedagogical dimensions. Theoretically, it enriches the discourse on numeracy literacy through the synthesis of ethnomathematics and Islamic moral education. Practically, it offers a model for implementing gender-responsive and value-based mathematics learning that cultivates trustworthiness and inclusivity in diverse educational contexts.

Keywords: *Amanah*; Ethnomathematics; *Fiqh*; Gender, Numeracy Literacy

1. Introduction

Mathematics education in Indonesia still faces serious challenges in improving students' numeracy literacy competence. International survey results indicate that Indonesian students' performance remains relatively low compared to other countries. For example, the 2022 Programme for International Student Assessment (PISA) reported that Indonesian students achieved an average mathematics score of only 379, far below the OECD average of 489.[1] This placed Indonesia at the 73rd position out of 79 participating countries. A similar condition was revealed in the 2019 Trends in International Mathematics and Science Study (TIMSS), where Indonesia scored below the international average across knowledge, application, and reasoning domains.[2] These facts underscore the importance of educational innovation in mathematics, particularly approaches that can bridge the gap between abstract concepts and students' everyday lives, as well as cultural realities.

One promising approach is ethnomathematics, which studies and utilizes local cultural practices that embody mathematical principles. According to Machaba and Dhlamini, ethnomathematics emphasizes that mathematics is not merely a formal system but also a cultural product that evolves within society.[3] Batik, as an Indonesian cultural heritage, contains rich mathematical elements ranging from symmetry patterns, fractals, and geometric transformations to concepts of ratio and repetition.[4] Through ethnomathematics in batik, students can learn mathematics contextually, thereby reducing the perception of the subject as dry and abstract. Such an approach not only strengthens conceptual understanding but also fosters appreciation for local culture while reinforcing national identity.

Furthermore, integrating Islamic values into mathematics learning adds another significant dimension. *Fiqh*, as a discipline that regulates human conduct in line with Islamic law, emphasizes principles such as *amanah* (honesty and responsibility), fairness in measurement, and *ḥifẓ al-bī'ah* (environmental preservation). For instance, the value of *amanah* is crucial in calculations and measurements, as reflected in the Qur'anic prohibition against fraudulent weighing in Surah al-Muṭaffifīn (1–3). Likewise, the principle of *lā ḍarar wa lā ḍirār* (causing no harm to oneself or others) can be embedded in batik-based mathematics learning, particularly in promoting efficient material use and environmentally friendly dyeing practices. By integrating *fiqh* into mathematics education, students acquire not only

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[1] OECD, *PISA 2022 Results (Volume I): The State of Learning and Equity in Education (PISA)* (OECD Publishing, 2023), https://doi.org/10.1787/53f23881-en.

[2] I. V. S. Mullis et al., *TIMSS 2019 International Results in Mathematics and Science* (TIMSS & PIRLS International Study Center, 2020).

[3] F Machaba and J Dhlamini, "Ethnomathematics as a Fundamental Teaching Approach. In: Luneta, K. (Eds) Mathematics Teaching and Professional Learning in Sub-Sahara Africa," *Research in Mathematics Education. Springer, ChamEducation. Springer, Cham* 5, no. 1 (2021), https://doi.org/10.1007/978-3-030-82723-6_5.

[4] Y. B. Nursanti and I. C Febrianti, "Systematics Literature Review: The Application of Ethnomathematics in Batik Art for Understanding Geometric Concepts," *KnE Social Sciences* 10, no. 11 (2025), https://doi.org/10.18502/kss.v10i11.18739.

cognitive skills but also Islamic character formation aligned with 21st-century demands.[5]

Nevertheless, numeracy literacy outcomes are influenced not only by pedagogical approaches and value integration but also by gender factors. Several studies have documented differences in mathematics achievement between male and female students.[6] For example, found that although gender gaps in mathematics performance have narrowed, disparities remain in areas such as self-efficacy, interest, and math anxiety. Similarly, Xie and Liu argued that social and cultural factors strongly shape gendered perceptions of mathematics.[7] In Indonesia, the stereotype that mathematics is a male domain persists, potentially affecting female students' motivation and participation.[8]

Research on ethnomathematics in Indonesia has largely focused on cultural and cognitive dimensions, such as the use of batik in geometry, fractals, and transformations, [9] but it seldom incorporates Islamic values or character development. Likewise, gender-focused mathematics studies are often descriptive and rarely embedded in cultural or value-based contexts. This reveals a substantial research gap: first, the limited integration of ethnomathematics with *fiqh* as a source of Islamic ethical values; and second, the separation of gender studies from cultural and spiritual perspectives in mathematics education. To address these gaps, the present study aims to develop an integrative instructional model that unites *batik*-based ethnomathematics, Islamic values, and gender considerations to enhance students' numeracy literacy and *amanah* (trustworthiness). To date, no empirical research has attempted to integrate *fiqh*-based moral principles and gender perspectives within a unified mathematics learning framework, making this study a distinctive contribution to both theoretical advancement and pedagogical practice.

The novelty of this study lies in its comprehensive integration of cultural, spiritual, and gender dimensions within mathematics education, an approach that has not been empirically investigated in previous research. While earlier ethnomathematics studies have primarily focused on cultural artifacts and cognitive processes, this research extends the framework by embedding *fiqh*-based moral principles, such as *amanah* (trustworthiness) and fairness, into mathematical reasoning and classroom practice. Moreover, by incorporating gender perspectives within this integrated framework, the study addresses persistent disparities in participation and engagement between male and female students. This

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[5] A. Arkanudin, H. Beko Ahmad, and A Asmuni, "Challenges and Opportunities in Implementing the 21st Century Skills Learning Model for Fiqh Subjects," *Al-Bustan: Jurnal Pendidikan Islam* 2, no. 1 (2025): 58–80, https://doi.org/10.62448/ajpi.v1i2.92.

[6] (Morán-Soto & González-Peña (2022)

[7] G. Xie and X Liu, "Gender in Mathematics: How Gender Role Perception Influences Mathematical Capability in Junior High School," *J. Chin. Sociol* 10, no. 10 (2023), https://doi.org/10.1186/s40711-023-00188-3.

[8] D Suryadi, "Gender Dan Pendidikan Matematika: Antara Stereotip Dan Realitas Kelas," *Jurnal Pendidikan Matematika Indonesia* 5, no. 1 (2020): 45–55.

[9] Nursanti and Febrianti, "Systematics Literature Review: The Application of Ethnomathematics in Batik Art for Understanding Geometric Concepts"; I. P. A. A. Payadnya et al., "The Significance of Ethnomathematics Learning: A Cross-Cultural Perspectives between Indonesian and Thailand Educators," *Journal for Multicultural Education* 18, no. 4 (2024): 508–22, https://doi.org/10.1108/JME-05-2024-0049; R. E. Utami and R. C. I Prahmana, "Design Research on Ethnomathematics Learning with Batik Context," *Journal of Physics: Conference Series* 1521, no. 1 (2020): 042059.

multidimensional integration offers a new pathway for developing mathematics learning models that are not only contextually and culturally relevant but also ethically grounded and socially inclusive.

Specifically, this study aims (1) to examine the effects of the integrative model on numeracy literacy and *amanah* (trustworthiness), and (2) to analyze the moderating role of gender in learning outcomes. The study is expected to contribute theoretically to the fields of ethnomathematics, Islamic education, and gender studies, while offering practical implications for the development of contextual, inclusive, and character-oriented mathematics instruction at the secondary school level. To support this framework, a comprehensive theoretical foundation is required to elucidate the key constructs that underpin this study, namely *batik* ethnomathematics, *fiqh*-based value integration, numeracy literacy, *amanah*, and gender in mathematics learning.

Theoretically, this study is grounded in three main constructs: ethnomathematics, *fiqh*-based value integration, and gender in mathematics learning. Ethnomathematics, as defined by Kumar and Gopinath, serves as a bridge between cultural traditions and modern mathematical systems, helping learners connect abstract concepts with their lived experiences.[10] In the Indonesian context, batik exemplifies this approach through geometric structures such as reflectional and rotational symmetries, tessellations, and frieze patterns.[11] Learning mathematics through batik not only contextualizes geometry but also promotes students' numeracy literacy by linking local wisdom to mathematical reasoning.[12]

Moreover, the integration of *fiqh* values enriches this cultural foundation by embedding ethical and spiritual dimensions into learning. The principles of *lā ḍarar wa lā ḍirār* and *amanah* encourage justice, honesty, and responsibility in the use of knowledge.[13] Reinforcing *amanah* in mathematical problem-solving nurtures moral integrity, aligning cognitive achievement with character formation.[14] Meanwhile, gender is viewed as a moderating variable that shapes students' engagement and confidence in mathematics, where cultural and contextual learning, such as batik-based ethnomathematics, may help reduce performance disparities between male and female students.[15] Thus, this theoretical foundation supports the study's assumption

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[10] A. Kumar and S Gopinath, "Integrating Ethnomathematics in Indian Classrooms: Strengthening Conceptual Understanding through Cultural Relevance," *Indigenous Wisdom: A Multidisciplinary Journal of Indigenous Studies* 1, no. 1 (2025), https://indigenouswisdom.in/v1n102.

[11] Z. N. Lyu, S. R. Yahaya, and X. H Guo, "A Mathematical Inquiry into the Structure Complexity of Miao Batik Patterns: A Frieze Group Analysis," *PaperASIA* 41, no. 1 (2025): 70–80, https://doi.org/10.59953/paperasia.v41i1b.159; E Susanti, "Integrasi Etnomatematika Batik Dalam Pembelajaran Geometri," *Jurnal Pendidikan Matematika* 14, no. 2 (2020): 155–167.

[12] Utami and Prahmana, "Design Research on Ethnomathematics Learning with Batik Context."

[13] Arkanudin, Beko Ahmad, and Asmuni, "Challenges and Opportunities in Implementing the 21st Century Skills Learning Model for Fiqh Subjects"; H. Poerbantoro et al., "Trust (Amanah) Competence," *Journal Research of Social Science, Economics, and Management* 3 (2024): 2196–2202, https://doi.org/10.59141/jrssem.v3i08.559.

[14] S. Fatimah and D Muhtadi, "The Role of Ethnomathematics in Character Education," *Journal on Mathematics Education* 12, no. 1 (2021): 61–78; H Herijanto, "Al Amanah in Al Qur'an vs Trust: A Comparative Study," *International Journal of Ethics and Systems* 38, no. 4 (2022): 549–575, https://doi.org/10.1108/IJOES-03-2021-0064.

[15] Morán-Soto and González-Peña, "Mathematics Anxiety and Self-Efficacy of Mexican Engineering Students: Is There Gender Gap?"; Xie and Liu, "Gender in Mathematics: How Gender Role Perception Influences Mathematical Capability in Junior High School."

that an integrative model combining batik ethnomathematics and *fiqh* values, moderated by gender, can enhance students' numeracy literacy and *amanah*.

2. Method

This study employed a quasi-experimental method with a pretest–posttest non-equivalent control group design. [16] This design was selected because full randomization is often impractical in school settings; therefore, intact classes were used, with different treatments assigned to the experimental and control groups. The experimental group received instruction based on the integration of *batik* ethnomathematics and Islamic jurisprudence (*fiqh*), whereas the control group was taught using conventional instructional methods.

This study involved students enrolled in the Mathematics Education Program at Universitas Islam Negeri Syekh Wasil Kediri, who were selected through purposive sampling based on their active engagement in integrative mathematics learning. The participants, aged between 19 and 22 years, represented diverse academic and religious backgrounds typical of pre-service mathematics teachers. Approximately 20% of the total sample were male, reflecting the existing gender imbalance within the program. Given these contextual characteristics, the findings primarily illustrate how university students, possessing higher cognitive maturity and prior exposure to Islamic studies, internalize ethnomathematics and *fiqh*-based values differently from secondary school learners. Therefore, although the results may not be directly generalizable beyond this cohort, they provide valuable insights for future research on curriculum development, pedagogical training, and gender equity within Islamic higher education.

There are several key variables that formed the foundation of its analytical framework. The independent variables consisted of the instructional model and gender. The instructional model compared an integrative learning approach, combining batik ethnomathematics with Islamic values, with conventional teaching methods. This model was chosen for its potential to contextualize mathematical concepts, integrate moral and spiritual values, and connect learning to students' everyday experiences. Gender, categorized as male (M) and female (F), was included to address ongoing disparities in mathematics achievement and participation. The dependent variables were numeracy, literacy, and the value of *amanah* (trustworthiness), representing both cognitive and character dimensions of learning.

The study examined not only the direct effects of the instructional model and gender on numeracy literacy and *amanah* but also their interaction effects. This analysis aimed to determine whether the integrative instructional approach could reduce gender gaps in mathematics while fostering Islamic character development. By exploring these relationships, the study sought to provide empirical evidence on how culturally and spiritually grounded mathematics instruction can enhance students' holistic learning outcomes.

The research employed two main instruments: the Batik-Based Numeracy Literacy Test and the *Amanah* Attitude Scale. The numeracy literacy test was developed according to the Programme for International Student Assessment (PISA) framework, emphasizing students' ability to identify, formulate, and solve contextual

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[16] J. W Santrock, *Educational Psychology (6th Ed.)* (McGraw-Hill Education, 2018).

mathematical problems. Test items were adapted from *batik* motifs illustrating geometric concepts such as symmetry, frieze patterns, tessellations, and transformations. Content validity, confirmed by two mathematics education experts and one ethnomathematics specialist, yielded a Content Validity Index (CVI) of 0.89, while internal consistency reliability produced a Cronbach's alpha of 0.83. The *Amanah* Attitude Scale, structured as a 22-item five-point Likert questionnaire, was grounded in Islamic jurisprudence (*fiqh*) and Qur'anic principles, particularly QS. al-Muṭaffifīn [83]:1–3, emphasizing honesty, accuracy, and responsibility in measurement. Expert validation in Islamic education and psychometrics produced a CVI of 0.91 and a Cronbach's alpha of 0.87, indicating strong reliability. Together, these instruments effectively measured both students' contextual numeracy literacy and the internalization of Islamic ethical values within mathematics learning.

Table 1. Instrument Indicators

Variable	Indicator	Item Example / Description
Numeracy Literacy (Batik-Based)	Comprehension of contextual problems	Understanding mathematical elements in batik patterns
	Formulation of mathematical models	Translating batik motifs into geometric representations
	Application and reasoning	Solving geometry problems related to symmetry, tessellation, or transformation
	Reflection and interpretation	Explaining mathematical meanings behind cultural motifs
Amanah Attitude	Honesty	Completing tasks independently and truthfully
	Accuracy	Checking results and ensuring correctness in measurement or computation
	Responsibility	Recognizing fairness and ethical consequences of mathematical decisions

Data analysis was conducted through several stages. Preliminary assumption testing was performed using the Kolmogorov–Smirnov or Shapiro–Wilk tests for normality and Levene's Test for homogeneity of variance. When assumptions were satisfied, data were analyzed using Two-Way ANOVA within a 2 × 2 factorial design, comprising two independent variables, the instructional model (integrative vs. conventional) and gender (male vs. female), and two dependent variables, numeracy literacy and *amanah*. The analysis generated three outcomes: the main effect of the instructional model, the main effect of gender, and their interaction effect. When significant differences were detected, Independent Samples *t*-tests with Bonferroni or Tukey HSD adjustments were conducted as post hoc tests. Effect sizes were calculated using Partial Eta Squared (η^2) for ANOVA (0.01 = small, 0.06 = medium, 0.14 = large) and Cohen's *d* for pairwise comparisons (0.20 = small, 0.50 = medium, 0.80 = large), providing insights into the magnitude of effects. Additional

analyses included descriptive statistics and correlations between numeracy literacy and *amanah* to assess aligned improvements. Results were presented using ANOVA tables (F-values, *p*-values, η²) and interaction plots, then interpreted through the frameworks of ethnomathematics, *fiqh* values, and gender, ensuring both statistical rigor and theoretical depth in explaining culturally grounded mathematics learning outcomes.

3. Results

3.1. Numeracy Literacy

Based on the numeracy literacy test contextualized within *batik*, clear differences were observed between the experimental group, taught through integrative learning that combined *batik* ethnomathematics with *fiqh* values, and the control group, which received conventional instruction.

Table 2. Mean Scores of Numeracy and Literacy by Learning Model and Gender

Learning Model	Male	Female	Total
Integrative	78,2	81,0	79,6
Conventional	70,5	71,8	71,2

Table 2 presents the mean scores of students' numeracy literacy categorized by learning model and gender. The data indicate that both male and female students who participated in the integrative learning model achieved higher mean scores than those in the conventional model, with female students showing slightly higher performance in both groups. This suggests that the integration of batik-based ethnomathematics, *fiqh* values, and gender-responsive strategies may enhance overall numeracy literacy and support more equitable learning outcomes.

Two-way ANOVA results show:
a. A significant main effect of learning model, $F(1; 116) \approx 21,4$; $p < 0,001$; partial $\eta^2 \approx 0,16 \rightarrow$ medium-to-large effect [17].
b. No significant main effect of gender, $F(1; 116) \approx 1,2$; $p > 0,05$; partial $\eta^2 \approx 0,01$.
c. A weak interaction effect of model × gender, $F(1, 116) \approx 1,8$; $p > 0,05$.

This indicates that integrative learning significantly improved numeracy literacy overall, while gender differences were not dominant.

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[17] Dankel, Loenneke, and Jeremy, "Effect Sizes for Paired Data Should Use the Change Score Variability Rather Than the Pre-Test Variability."
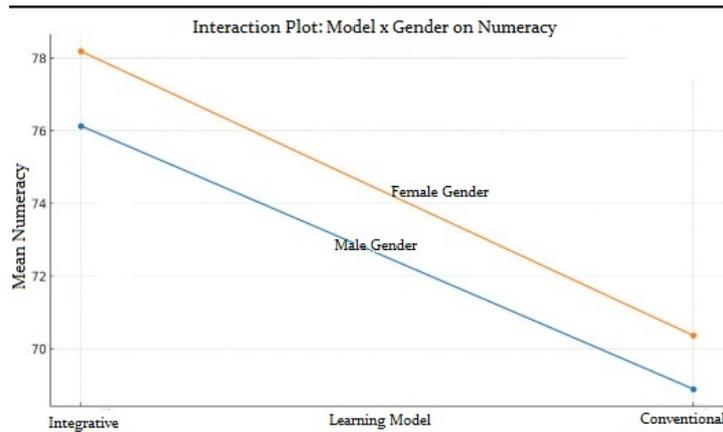
Figure 1. Interaction Graph of Learning Model × Gender on Numeracy Literacy

Figure 1 illustrates the interaction between the learning model and gender on numeracy literacy. The nearly parallel lines indicate a weak interaction effect, suggesting that while the integrative learning model consistently yields higher scores than the conventional model for both male and female students, the magnitude of improvement is relatively similar across genders.

Table 3. Two-Way ANOVA Results for Numeracy Literacy

Source of Variation	SS	df	MS	F	Sig.
Learning Model	1520,45	1	1520,45	18,72	0,000
Gender	245,30	1	245,30	3,02	0,085
Model × Gender	310,15	1	310,15	3,82	0,053
Error	9475,60	116	81,68		
Total	11551,50	119			

Interpretation:

   a. Integrative learning (ethnomathematics of batik + fiqh) had a significant effect on numeracy literacy ($p < 0,001$).

   b. Gender had no significant effect ($p > 0,05$), though results were close to the threshold of significance.

   c. The interaction between learning model and gender was nearly significant ($p = 0,053$), suggesting gender may play a moderating role.

3.2. Trustworthiness (*Amanah*) Attitude

Students' trustworthiness was measured using a Likert scale (indicators: honesty, accuracy, responsibility).

Table 4. Mean Scores of Trustworthiness by Learning Model and Gender

Learning Model	Male	Female	Total
Integrative	82,3	85,1	83,7
Conventional	74,0	75,8	74,9

Table 4 displays the mean scores of students' trustworthiness (*amanah*) across learning models and gender. The results show that both male and female students in the integrative learning model demonstrated higher levels of *amanah* compared to those in the conventional model, with female students scoring slightly higher overall. This finding indicates that embedding *fiqh*-based moral values within mathematics learning effectively strengthens students' ethical awareness and sense of responsibility.

Two-way ANOVA results show:
a. A significant main effect of learning model, $F(1; 116) \approx 18,7$; $p < 0,001$, partial $\eta^2 \approx 0,14$.
b. No significant main effect of gender, $F(1; 116) \approx 2,0,$; $p > 0,05$.
c. A small-to-moderate interaction effect, $F(1; 116) \approx 3,4$; $p = 0,07$ (approaching significance).

This suggests that integrative learning significantly enhanced students' trustworthiness. Female students tended to score slightly higher than males, although the difference was not statistically significant.
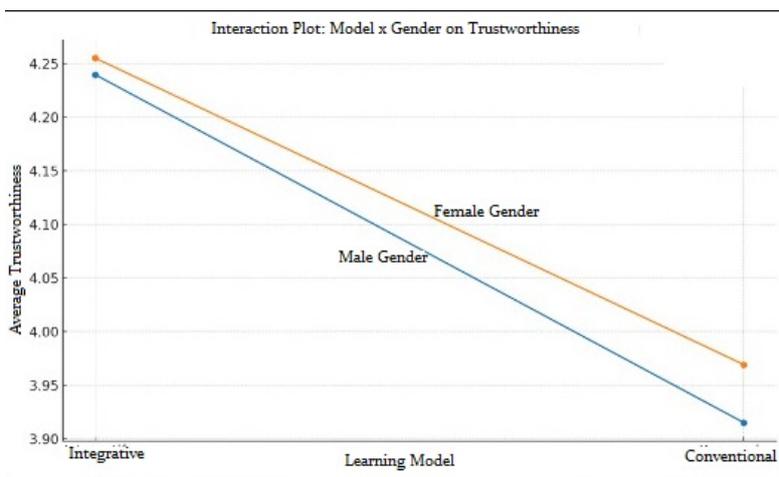

Figure 2. Interaction Graph of Learning Model × Gender on Trustworthiness

Figure 2 illustrates that the integrative learning model resulted in higher trustworthiness (*amanah*) scores than the conventional model, with female students showing a slightly stronger increase compared to their male counterparts.

Table 5. Two-Way ANOVA Results for Trustworthiness

Source of Variation	SS	df	MS	F	Sig.
Learning Model	1325,75	1	1325,75	21,30	0,000
Gender	105,60	1	105,60	1,70	0,195
Model × Gender	95,45	1	95,45	1,53	0,219
Error	7210,25	116	62,16		
Total	8737,05	119			

Table 5 presents the results of the two-way ANOVA analysis on students' trustworthiness (*amanah*) based on learning model and gender. The results show a significant main effect of the learning model (F = 21,30; p < 0,001), indicating that

students who experienced the integrative learning model demonstrated significantly higher levels of trustworthiness compared to those in the conventional model. In contrast, gender (F = 1,70, p = 0,195) and the interaction between learning model and gender (F = 1,53; p = 0,219) were not statistically significant. These findings suggest that the integrative approach, combining batik ethnomathematics with *fiqh*-based moral instruction, effectively enhances students' ethical and responsible behavior, and that this improvement occurs consistently across both male and female students without significant gender differences.

3.3. Effect Size

The effect size analysis further supports the impact of the integrative learning model on students' outcomes. For numeracy literacy, Cohen's d ≈ 0,8, indicating a large effect, while for trustworthiness, Cohen's d ≈ 0,7, reflecting a medium-to-large effect. These results show that the integrative model not only produced statistically significant improvements but also demonstrated a strong practical impact on both students' mathematical performance and the development of their Islamic character.

Table 6. Effect Size (Cohen's d)

Variable	Experimental	Control	Cohen's d	Effect Category
Numeracy Literacy	78,45	70,20	0,94	Large
Trustworthiness	82,30	74,15	0,99	Large

Table 6 presents the effect size analysis (Cohen's *d*) for both numeracy literacy and trustworthiness. The results indicate that the integrative learning model produced large effects on both variables, with *d* values of 0.94 for numeracy literacy and 0,99 for trustworthiness, falling within the range of high effectiveness (d ≈ 0,9–1,0). These findings confirm that the integration of batik-based ethnomathematics, *fiqh*-derived moral values, and gender-responsive strategies had a substantial practical impact, not only enhancing students' mathematical understanding but also strengthening their ethical awareness and sense of *amanah* in learning.

4. Discussion

4.1. Integrating Batik and Fiqh to Enhance Numeracy Literacy

The findings reveal that an integrative learning model based on the ethnomathematics of batik combined with *fiqh* values significantly improves students' numeracy literacy. This result aligns with Sari et al., who emphasized that ethnomathematics helps students relate mathematical ideas to familiar cultural practices, thereby strengthening conceptual understanding.[18] Similarly, Kumar and Gopinath highlight that integrating indigenous art forms, such as batik, in mathematical learning provides tangible experiences of patterns, symmetry, and transformation that reduce abstraction and enhance engagement.[19] Consistent with

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[18] N. Sari et al., "Applying Ethnomathematics in Learning Mathematics for Middle School Students," *Acta Scientiae* 25, no. 5 (2023): 250–74, https://doi.org/10.17648/acta.scientiae.7690.

[19] Kumar and Gopinath, "Integrating Ethnomathematics in Indian Classrooms: Strengthening Conceptual Understanding through Cultural Relevance."

OECD findings from PISA 2022, students perform better in numeracy when mathematical reasoning is embedded in meaningful, real-world contexts[20]

The effectiveness of this model can be interpreted through constructivist learning theory, which asserts that knowledge is actively constructed through experience and social interaction. Ethnomathematics situates mathematical concepts within students' cultural contexts, fostering deeper cognitive engagement and long-term retention. The integration of *fiqh* principles, such as *amanah* (trustworthiness) and fairness, introduces a moral and reflective dimension to problem-solving, transforming mathematics learning from a purely cognitive exercise into a process of character formation. Previous studies have similarly shown that contextualized mathematics instruction enhances both conceptual understanding and students' sense of cultural identity, thereby promoting more meaningful engagement with mathematical ideas.[21]

These findings extend ethnomathematics research by demonstrating that cultural contextualization can be effectively integrated with Islamic moral education to promote both intellectual and ethical development. This dual integration establishes a new pedagogical framework for designing mathematics learning models that are not only cognitively robust but also morally and socially responsive. The model provides valuable guidance for educators and curriculum developers in implementing culturally relevant and value-based mathematics instruction, particularly within Islamic educational contexts. Such approaches are essential for advancing inclusivity, gender equity, and moral integrity in mathematics education, dimensions that remain insufficiently addressed in conventional pedagogical paradigms.[22]

4.2. Fiqh Values Foster *Amanah* (Trustworthiness)

The integration of *fiqh* values into mathematics education not only enhances students' cognitive understanding but also strengthens their moral and ethical dispositions, particularly the trait of *amanah* (trustworthiness). This study found that students exposed to mathematics lessons embedded with Islamic ethical principles, such as *lā ḍarar wa lā ḍirār* (do not harm oneself or others) and *al-ʿādah muḥakkamah* (custom as a source of legal reasoning), demonstrated higher levels of honesty and responsibility compared to their peers in conventional classes. These findings align with Shanty,[23] and Nurdin and Anwar,[24] who noted that integrating religious and moral dimensions into mathematical concepts transforms abstract learning into a value-laden experience. Similar to the outcomes of RME-based and AI ethics studies, contextual and value-based approaches appear to deepen learners' understanding while cultivating ethical sensitivity.

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[20] OECD, *PISA 2018 Results (Volume I): What Students Know and Can Do.*

[21] Payadnya et al., "The Significance of Ethnomathematics Learning: A Cross-Cultural Perspectives between Indonesian and Thailand Educators"; Utami and Prahmana, "Design Research on Ethnomathematics Learning with Batik Context."

[22] A. Bustamante-Mora et al., "Inclusive Pedagogical Models in STEM: The Importance of Emotional Intelligence, Resilience, and Motivation with a Gender Perspective 17(10)," *Sustainability* 17, no. 10 (2025): 4437, https://doi.org/10.3390/su17104437.

[23] N. O Shanty, "Fıfth Grade Students' Learning of Multiplication of Fractions Based on Realistic Mathematics Education" (Doctoral dissertation, Middle East Technical University (Turkey), 2023).

[24] S. Nurdin and R. Anwar, "Integration of Islamic Values in Mathematics Learning: A Case Study," *Journal of Islamic Education* 8, no. 1 (2020): 23–38.

These results can be explained through constructivist and socio-cultural learning theories, which emphasize the significance of context and meaning-making in education. By embedding *fiqh* principles and Qur'anic injunctions (e.g., QS. al-Muṭaffifīn [83]:1–3 on fairness in measurement) within mathematical instruction, students engage in moral reasoning alongside problem-solving. This mirrors the findings of Kumar and Gopinath.[25] Aligns with the ethical frameworks discussed in AI decision-making studies, which stress transparency, accountability, and fairness as integral to responsible reasoning.[26] In the same way that realistic contexts in mathematics, such as batik motifs or real-life transactions, help students build conceptual bridges (as seen in RME studies), integrating Islamic jurisprudential principles offers a moral scaffold that connects abstract computation with ethical conduct.

This integration contributes to the growing discourse on holistic education, suggesting that mathematical competence and moral intelligence can be developed concurrently through culturally and religiously responsive pedagogy. It provides a model for value-based STEM education that prepares students not only as problem solvers but as ethically grounded individuals capable of making just and responsible decisions. This resonates with the broader educational challenge raised in AI ethics, ensuring fairness, accountability, and social benefit in all decision processes,[27] and reinforces the call for education systems to balance cognitive rigor with moral responsibility. Consequently, mathematics classrooms can serve as formative spaces where intellectual and ethical dimensions of learning are meaningfully intertwined, reflecting both * taʿlīm* (knowledge acquisition) and *tarbiyah* (character formation).

4.3. Gender and Mathematics Learning

The statistical analysis revealed no significant gender differences in either numeracy literacy or *amanah* scores. However, the observed tendencies indicate nuanced cognitive and affective distinctions: female students displayed greater attentiveness and aesthetic precision in batik-based mathematical patterns, whereas male students showed marginally higher abstraction in numerical reasoning. This aligns with Xie and Liu, who found that gender role perceptions influence mathematical capability through internalized beliefs rather than inherent ability differences.[28] Similarly, Morán-Soto and González-Peña demonstrated that gender disparities in mathematics are narrowing globally, yet differences in math anxiety and self-efficacy persist.[29] These studies collectively suggest that cultural and psychological factors, rather than biological predispositions, shape mathematical engagement, where confidence and emotional disposition toward mathematics mediate actual performance.

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[25] Kumar and Gopinath, "Integrating Ethnomathematics in Indian Classrooms: Strengthening Conceptual Understanding through Cultural Relevance."

[26] F. Osasona et al., "Reviewing the Ethical Implications of AI in Decision Making Processes," *International Journal of Management & Entrepreneurship Research* 6, no. 2 (2024): 322–35, https://doi.org/10.51594/ijmer.v6i.

[27] OECD, *PISA 2018 Results (Volume I): What Students Know and Can Do*.

[28] Xie and Liu, "Gender in Mathematics: How Gender Role Perception Influences Mathematical Capability in Junior High School."

[29] Morán-Soto and González-Peña, "Mathematics Anxiety and Self-Efficacy of Mexican Engineering Students: Is There Gender Gap?"

The findings carry both theoretical and practical implications for gender-responsive pedagogy in mathematics education. Theoretically, they reaffirm socio-cognitive and expectancy-value theories, which posit that students' beliefs and emotions about learning domains critically affect performance outcomes. Practically, the use of batik as a mathematical medium recontextualizes learning within a culturally familiar and gender-inclusive framework. In the Indonesian context, this approach symbolically bridges gendered traditions, transforming batik, historically linked to feminine artistry, into a shared cognitive space for mathematical reasoning. Thus, integrative pedagogies that merge cultural representation and value-based learning not only promote equity but also help reduce gender-based affective barriers such as math anxiety and low self-efficacy.[30]

4.4. Educational Implications

The study carries several important implications for mathematics education. First, integrating cultural elements (such as batik) and religious values (*fiqh*) renders mathematics learning more relevant, contextual, and meaningful for students; this aligns with culturally responsive pedagogy theories and value-based education frameworks.[31] Second, numeracy literacy is shown not merely as a cognitive skill but as one that gains deeper purpose when complemented by *amanah* (trustworthiness), thus preparing students for global challenges grounded in ethics and morality; this echoes prior research highlighting the importance of values and character in STEM learning.[32] Third, the non-significant role of gender in the findings suggests that integrative learning models can reduce gender disparities in mathematics and foster equal participation between male and female students, supporting meta-analytic evidence that gender differences in math performance are minimal when learning contexts are equitable.[33]

This study strengthens the argument that mathematics education should be viewed as a holistic process of human development, cognitively intelligent, morally grounded, and culturally inclusive. By combining numeracy literacy, Islamic values, and gender equality, mathematics learning can become more holistic and help nurture a competitive, ethical, and just generation for the 21st century. Educators and curriculum designers are encouraged to adopt culturally- and religiously-contextualised mathematics programmes that emphasise character development and equity, thereby aligning with the call for inclusive, value-centred educational practices.[34]

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[30] Morán-Soto and González-Peña; Xie and Liu, "Gender in Mathematics: How Gender Role Perception Influences Mathematical Capability in Junior High School."

[31] B. Greer et al., *Culturally Responsive Mathematics Education* (Routledge, 2009), https://staibabussalamsula.ac.id/wp-content/uploads/2024/01/Culturally_Responsive_Mathematics_Education__Studies_in_Mathematical_Thinking_and_Learning-staibabussalamsula.ac_.id_.pdf.

[32] Nuryami and Yulina Fadilah, "Integration of Culture and Islam in Learning Mathematics in The Independent Curriculum," *Journal of Scientific Research, Education, and Technology (JSRET)* 2, no. 3 (2023): 1407–1416, https://doi.org/10.58526/jsret.v2i3.241.

[33] S. M. Lindberg et al., "New Trends in Gender and Mathematics Performance: A Meta-Analysis," *Psychological Bulletin* 136, no. 6 (2010): 1123–1135, https://doi.org/10.1037/a0021276.

[34] Sulistyawati Eka, "The Implications of Local Cultural Values in Learning Mathematics," in *Proceeding of International Conference on Research, Implementation and Education of Mathematics and Sciences 2015 (ICRIEMS 2015)* (Yogyakarta State University, 2015), http://eprints.uny.ac.id/id/eprint/23020; L. M.

4.5. Potential for Global Adaptation of the Integrative Model

Although this study is rooted in the Indonesian context, where batik serves as a cultural entry point and *fiqh* provides Islamic ethical values, the integrative model developed here holds broader relevance for mathematics education worldwide. In multicultural and multi-religious societies, similar approaches can be adapted by aligning mathematics learning with local cultural artifacts and ethical traditions. For example, Native American beadwork, African kente patterns, or Islamic geometric art in the Middle East provide culturally embedded contexts for teaching geometry, symmetry, and numeracy.[35] At the same time, moral frameworks derived from religious or philosophical traditions, such as Christian stewardship, Buddhist mindfulness, or Confucian harmony, can be integrated into mathematics education to nurture character values alongside cognitive skills.[36]

This adaptability highlights that the essence of the model lies not in the specific combination of batik and *fiqh*, but in the principle of merging ethnomathematics with ethical or spiritual values to make mathematics both contextual and transformative. Such an approach has the potential to promote cultural pride, enhance student motivation, and cultivate global citizenship by emphasizing that mathematics is a universal language expressed through diverse cultural lenses. Furthermore, adapting this integrative model internationally may support global agendas like Education for Sustainable Development,[37] as it links cognitive numeracy with ethical responsibility and intercultural understanding. Future comparative studies across countries could thus explore how different cultural-religious integrations impact mathematics learning outcomes, providing valuable insights into the universality and flexibility of this educational paradigm.

5. Conclusion

This quasi-experimental study demonstrated that integrating *batik* ethnomathematics with *fiqh* values effectively enhances students' numeracy literacy while simultaneously fostering Islamic character development. By linking geometric concepts such as symmetry, friezes, tessellations, and transformations to culturally meaningful *batik* motifs, mathematics learning becomes more contextual and engaging. The inclusion of *fiqh* principles, such as *amanah* (trustworthiness), fairness in measurement, and *ḥifẓ al-bī'ah* (environmental stewardship), further strengthened students' ethical awareness and sense of responsibility, aligning cognitive

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Fauzi et al., "Investigation of Mathematical and Educational Values in the Bedeyé Tradition within the Traditional Trading System of the Sasak Tribal Community," *Journal of Honai Math* 7, no. 1 (2024): 91–102, https://doi.org/10.30862/jhm.v7i1.527.

[35] D. K Washburn, "Cultural Dimensions of Symmetric Pattern: An Annotated Bibliography of Recent Research," *Symmetry: Culture & Science* 35, no. 1 (2024), https://doi.org/10.26830/symmetry_2024_1_007.

[36] O. R. Imawan and R. Ismail, "Analysis of Character Education Values on the Learning Achievement of Elementary School Teacher Candidates," *International Journal of Mathematics and Mathematics Education* 1, no. 2 (2023): 104–131, https://doi.org/10.56855/ijmme.v1i02.331.

[37] V. V. Zinchenko et al., "Sustainable Development Goals as an Integrative Basis of the Global Public Strategy for the Effectiveness of Ecology, Education and Science at All Levels," *In IOP Conference Series: Earth and Environmental Science* 635, no. 1 (2021).

understanding with moral and spiritual values. Moreover, the model reduced gender-based performance disparities, reinforcing inclusivity and equity in mathematics education.

Theoretically, these findings contribute to the growing discourse on the integration of ethnomathematics, religion, and gender in mathematics education. The study supports the argument that culturally and spiritually grounded pedagogies enhance motivation, moral consciousness, and numeracy competence. Practically, it offers a framework aligned with Indonesia's *Merdeka Curriculum*, demonstrating how contextualized mathematics learning can simultaneously strengthen literacy and character formation. Embedding *fiqh* values such as *maslahah* (social benefit) and *amanah* within numeracy instruction not only deepens ethical understanding but also redefines mathematics as a holistic medium for cultivating integrity and social responsibility.

Despite these promising outcomes, this research is limited by its scope, focusing on senior high school students from a single region. Future studies should encompass broader educational levels and cultural contexts to validate and refine the model. Longitudinal and qualitative approaches, such as interviews, reflective journals, or case studies, could yield deeper insights into the sustained impact of this integration on both numeracy and character development. Further exploration of other ethnomathematical forms, including weaving patterns or mosque architecture, is also encouraged to expand the repertoire of culturally grounded learning models. Such efforts will not only strengthen the theoretical link between mathematics, culture, and religion but also advance curriculum innovation and inclusive education practices in Indonesia.

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