Technology and Islamic Perspective: A Study of Ethnomathematics

Muhammad Hasbi[1*], Muh Sarda[2], Baso Syafaruddin[3]

[1*,3]Universitas Islam As'adiyah Sengkang, Indonesia
[2]University of Queensland, Australia

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ABSTRACT

In the past decade, ethnomathematics-based technology has been prevalent in mathematics teaching, yet Islamic viewpoints are missing. Thus, this systematic analysis explores Islamic and digital culture-based media integration into mathematics education. PRISMA standards were used to collect research that met inclusion criteria for this systematic review. Google Scholar retrieved 2015–2025 research articles. The screening found 40 relevant articles. Thematic analysis categorized 40 papers' research trends and data. From 2020 to 2025, the number of publications increased significantly, peaking in 2024, indicating a greater focus on enhancing mathematics instruction through digital culture media and Islam. The period from 2015 to 2019 indicates a need for further research. Geometry is the main subject, with a few numbers, suggesting growth. Most participants are high school and elementary school kids, highlighting the value of digital culture and Islamic integration at both levels. Questionnaires and performance assessments revealed digital resource usability and Islamic value integration. This review suggests incorporating digital cultural elements and Islamic integration into math education. Using innovative pedagogical methods, technologies, and Islamic principles, educators can create engaging, culturally relevant learning experiences that improve students' arithmetic understanding and appreciation. Additionally, mathematics lessons can solve all problems in Islam by connecting the Quran's Words of God with mathematical concepts. The research is expected to facilitate mathematics learning and show its connection with the Quran. Mathematics lessons will be viewed within religion, not just as a regular subject.

Corresponding Author:
Muhammad Hasbi,
Faculty of Tarbiyah and Teacher Training,
Universitas Islam As'adiyah Sengkang, Indonesia,
Email: *muhammadhasbi@unisad.ac.id*

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Technology and Islamic Perspective: A Study of Ethnomathematics

1. Introduction

The development of modern technology dominates modern society. The global Muslim community grapples with ethical and philosophical dilemmas regarding the alignment of technology with Islamic principles such as tawḥīd, justice, and maslahah. Technology should be used to promote spiritual and social purposes in Muslim countries (Solahudin & Fakhruroji, 2019). Islam has a strong intellectual heritage in mathematics, science, and engineering (such as during the Islamic Golden Age), yet modern debate typically polarizes between adopting Western technology or rejecting it out of conservatism. Modern technology does not consistently integrate Islamic philosophical and mathematical roots, leading to an epistemic divide.

This study employs ethnomathematics, the study of how ethnic groups use and explain mathematics to bridge this divide. Ethnomathematics lets us investigate Islamic rites, artifacts, and mathematical practices beyond Western formalism (Baker, 2023; Frankenstein & Powell, 2023). Examples include mosque construction geometry, prayer times, Qibla direction, and inheritance distribution (farā'iḍ). These practices demonstrate logic, mathematics, and Islamic ideals. Despite its importance, most pupils' dislike arithmetic and perform poorly (Rangkuti, 2019). Math instruction without cultural context in Indonesia hurts pupils' engagement and performance (Zuliana et al., 2025). Innovation and technology were lacking in Indonesian mathematics classes, and teacher-centered and textbook-focused learning was not culturally relevant (Sunzuma & Umbara, 2025). Due to students' difficulty understanding textbook arithmetic concepts, mathematics education must be integrated into local culture.

In the fourth industrial revolution, integrating technology into math instruction can boost student performance (Ayanwale et al., 2022). Math education in the 4IR era requires inventiveness, aided by ICT. The Internet of Things, 3D printing, robotics, AI, virtual reality, and cloud computing define this era. ICT uses software and hardware to collect, process, store, present, and distribute digital information. Integration of disruptive technologies and competency-based education to address 4IR student needs are important concerns in Indonesian mathematics education (Gilbert & White, 2018). Students must learn to use technology to solve contextualized challenges in and out of class (Santos-Trigo et al., 2021).

Education, including mathematical education, influences culture, affecting society and the world (Alam & Mohanty 2023). Ethnomathematics blends math and culture, influencing teaching and learning. According to social constructivism, students learn math from their daily lives (Weinhandl et al., 2022). School mathematics is linked to cultural mathematics activities and experiences through ethnomathematics (Kabuye Batiibwe, 2024). Culturally based communities teach and learn arithmetic through ethnomathematics (Arliani & Khabibah, 2022). Researchers have deemed it appropriate to incorporate digital culture-based material and resources into mathematics teaching and learning due to learners' daily use of technology. Educational media, e-books, and e-modules combine technology, arithmetic, and culture. Comic-based ethnomathematics teaching and learning media integrates mathematics, culture, and technology (Safitri et al., 2023).

Mathematics is essential to education and all human activities. Science relies on mathematics, which improves thinking and processing (Rittle-Johnson et al., 2020). From elementary to college, maths is taught. Despite being challenging for many pupils, mathematics is crucial in everyday life and improves thinking (Jackson et al., 2017). The Qur'an is used to teach science. The Koran has a lot of life science. The Koran is the fundamental Islamic source of guidance. The Quran's sciences will show new math-Quran connections (Kefi, 2023). Mathematics is explained in the Quran. This article examines ethnomathematics. Ethnomathematics in the Quran is essential for learning. Understanding how mathematics and

the Quran relate will make math easier and more enjoyable for kids.

Ethnomathematics studies how to teach math in different cultures (Machaba & Dhlamini, 2021). Richardo (2020) studies ethnomathematics in Nusantara Islamic culture and provides examples of its use in daily life. Nusantara Islam blends culture and the Qur'an and hadith without compromising authenticity. Nusantara Islam reflects their culture. Math is used to solve life difficulties in Qur'an stories. Number theory is used to understand certain Qur'an verses, including Al-Baqarah verse 261, Al-Ankabut verse 14, Al-Kahfi verse 25, and Al-Kahfi verse 22 (Atmadi & Nuryami, 2024). The verse teaches number theory, permitting Quranic mathematics investigation. Students can learn maths, especially numbers.

Technology and culture in math education can boost students' enthusiasm, interest, learning, and thinking abilities and build a love of culture and nation (Novikasari et al., 2024). Cultural activities enhance learning and inspire students. Visual-assisted mathematics problems, culture, and technology help students understand abstract concepts (Nurdiansyah et al., 2019). We integrate mathematics and Islam by relating arithmetic to Quranic teachings and applying maths to religious activities and Islamic history. Mathematics fosters a closer relationship with God and cultivates virtue. Students should master maths as a science.

In certain studies, on AR and ethnomathematics, an Android-based AR learning medium with an ethnomathematical context helped prospective mathematics teachers understand geometry topics (Richardo et al., 2023). Researchers and educators are developing culture-focused, technology-based teaching and learning media. Media using ethnomathematics technology needs a development model. Media using ethnomathematics differ. Technology-based development models like ADDIE and Borg and Gall have been employed in mathematics teaching (Sunzuma & Umbara, 2025). Much traditional e-learning content uses the ADDIE approach.

This project intends to create a theoretical framework that links Islamic ethnomathematics to development and technology adoption. This research builds a conceptual model that educators, technology designers, and policymakers can use to combine mathematics teaching, technology development, and Islamic values to create functional, spiritual, and ethical technology. This research integrates three unexplored pillars to explore mathematical elements embedded in Islamic tradition as a cultural heritage and a conceptual foundation for understanding, designing, or criticizing modern technology. Ethnomathematics as Technology Criticism. Develop an "Ethnomathematics-Based Islamic Technology" conceptual framework. Three points suggest that your research could address the literature gap with a new and practical interdisciplinary perspective. Thus, this study is time-sensitive because it seeks to identify and analyze how a mathematical mindset rooted in Islamic epistemology can provide a theoretical and ethical foundation for the design and use of more just and dignified technology, rather than passively consuming global innovation.

This article reviews 2015–2025 journal publications on Islamic and digital culture-based media integration into mathematics instruction. The subject integrates Islamic, cultural, and technological elements with current education, particularly in the 4IR, making it relevant to mathematical education. The study examines literature to illustrate how digital culture-based media and Islam could enhance mathematics instruction in Indonesia. The systematic review synthesizes research on digital culture-based media in mathematics instruction. It highlights research gaps and offers educators and policymakers best practices for incorporating cultural and Islamic themes into digital learning environments. Indonesia's rich cultural and Islamic backgrounds can make math more exciting and accessible. The project addresses instructional design models, participants, and evaluation methodology research topics.

2. Research Method

A systematic review gathers research based on inclusion criteria to answer research issues. A systematic search was conducted using Rethlefsen et al.'s (2021) PRISMA specification for transparent and thorough systematic reviews. Indonesian peer-reviewed studies from 2015 to 2025 were searched. This systematic study included papers from 2015 to 2025 to capture technological advances, ethnomathematics progress, and Indonesian educational reforms. It's important to evaluate how digital tools have changed mathematics education's integration of technology and culture because they revolutionized instruction worldwide this decade. The selected timeframe coincides with the Fourth Industrial Revolution, a time of rapid technological advancement, making it ideal for studying their use in Indonesian education. The review includes a substantial collection of contemporary research on educational theories, practices, and outcomes that focuses on this decade.

This systematic review searched Google Scholar for journal papers (Figure 1). Google Scholar's vast search capabilities, including peer-reviewed journal papers, made systematic review possible. Researcher use of Google Scholar and its ability to locate specific scholarly publications are supported by empirical evidence (Halevi et al., 2017; Martín-Martín et al., 2018). Google Scholar's user-friendly design and broad disciplinary reach make it perfect for finding relevant literature, offering a holistic view of research, and aiding with subject synthesis.

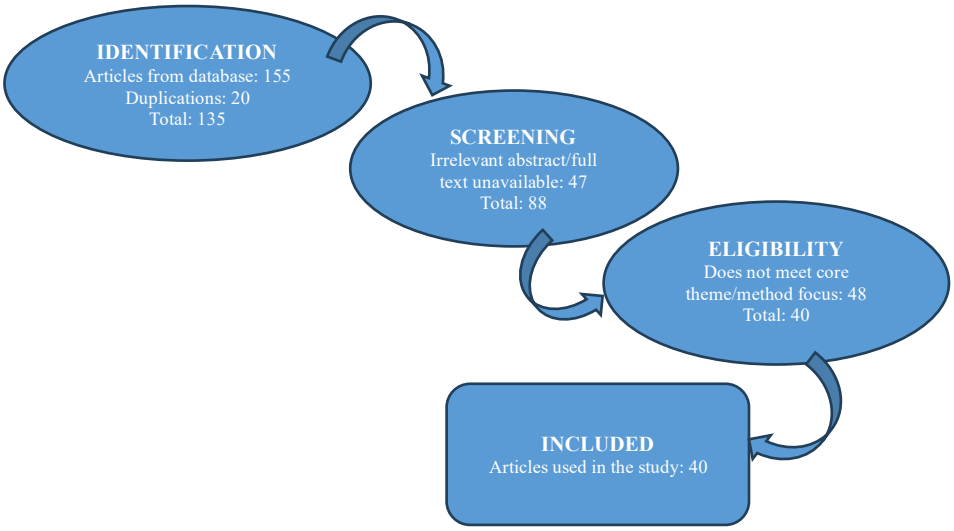

Figure 1. Flowchart PRISMA Model

Search Strategy and Data Sources

The literature search will be conducted in leading academic databases, Google Scholar and journals focusing on Islamic studies, philosophy of science, and ethnomathematics.

Table 1. Search Strategy and Data Sources

Keywords	Main Search Combination
Islamic Context	Islam, Islamic, Sharia, Syariah, Fiqh, Maslahah
Mathematics/Culture	Ethnomathematics, Etnomatematika, Islamic Geometry, Fara'id, Hisab
Technology	Technology, AI, Algorithm, Engineering, Design, FinTech
Combination 1	("Ethnomathematics" AND "Islam" AND "Technology")
Combination 2	("Islamic Geometry" AND "AI" OR

Keywords	Main Search Combination
Combination 3	"Algorithm") ("Sharia" AND "Technology" AND "Mathematical Foundation")

Inclusion and Exclusion Criteria

This review will use strict criteria to ensure the relevance and quality of the articles analyzed:

Table 2. Inclusion and Exclusion Criteria

Criteria	Inclusion
Document Type	Peer-reviewed Journal Articles, Conference Proceedings, Book Chapters
Language	English, Indonesian, Arabic
Topic Relevance	Articles that explicitly address two or three of the three main concepts (Technology, Islam, Ethnomathematics).
Year of Publication	The publication timeframe will be limited (2015–2024) to ensure relevance to modern technology.

Selection and Screening Process

The selection process will be conducted in three stages:

1. Stage 1: Identification: Conduct a search using all keyword combinations.
2. Stage 2: Screening: Remove duplicates. Researchers will review titles and abstracts to apply the initial inclusion/exclusion criteria.
3. Stage 3: Eligibility: Researchers will read the full text of articles that pass the screening stage. Articles will be evaluated based on their compliance with the Research Questions (RQs).

Data Extraction

From each selected article, the following data will be extracted using a standardized form:

1. Title, Author(s), Year, Journal.
2. Primary Research Objective.
3. Research Methods Used.
4. Identified Islamic Ethnomathematics Concepts.
5. Key Findings and Implications for Technology.

Data Analysis and Synthesis

The extracted data will be analyzed qualitatively using a thematic analysis approach.

1. Thematic Analysis: Grouping findings based on emerging themes, such as: (a) Applications of Ethnomathematics in AI, (b) Islamic Philosophical Foundations for Technology Design, and (c) Ethnomathematical Critique of Technology.
2. Narrative Synthesis: Combining and integrating findings from various studies to build a new conceptual framework. This synthesis will specifically focus on identifying the "mathematical language" shaped by Islam and how this language can guide technological innovation.
3. Conceptual Mapping: Creating a diagram that illustrates the relationship between Sharia principles, Ethnomathematics practices, and areas of technological application, which will be the main theoretical contribution of this article.

3. Results and Discussion

After careful application of the processes for selection as outlined in the methodology section, 40 articles meet the selection criteria. The findings from the articles were classified into themes as follows: trend of publications, mathematics topics, participants, instructional design models used in the studies, and evaluation instruments.

Trends of article publication

The study found a tendency in Indonesian mathematics education publications on digital culture-based media integration. Using the PRISMA methodology and following inclusion and exclusion criteria, most selected publications were published between 2015 and 2025 (see Figure 2 for number of articles and publication year). The peak in research output was in 2024, demonstrating a large increase in scholarly contributions. Biber et al. (2022) show how technology improves mathematics instruction, especially in a technologically advanced age. Technology is crucial in mathematics education and other fields in a globalized environment (Cirneanu & Moldoveanu, 2024; Sunzuma & Umbara, 2025). The rise in study implies Indonesians are realizing the need for incorporating digital culture-based media into mathematics education. It shows a shift toward innovative math pedagogy that uses technology and culture to improve learning. These articles cover ethnomathematics to the cultural use of digital tools, demonstrating the multidimensionality of this burgeoning discipline.

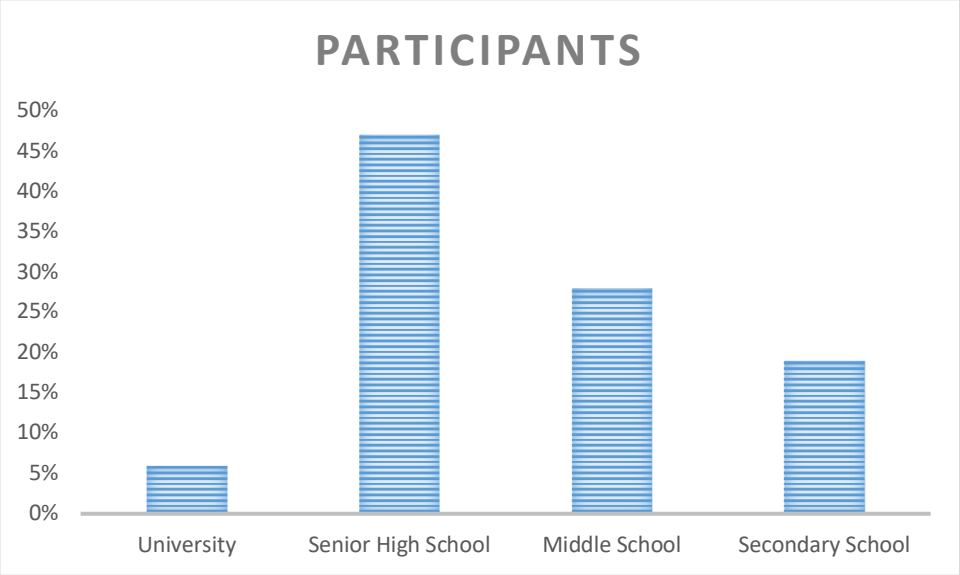

Figure 2. Trends of Publication

Scholarly contributions between 2015 and 2021 are scarce, indicating a hiatus. The study does not explain this gap; however, it may be due to changes in research priorities, financing, or other contextual factors affecting academic publishing. However, this discrepancy emphasizes the necessity to invest in research to support the field's growth. Despite this historical difference, the pattern offers a viable path for Indonesian mathematics education to include digital culture-based media. Increasing publications reflect a maturing field with growing knowledge and competence. As researchers discover new methods, technology, and theoretical frameworks, the area will advance and innovate.

Mathematics topics

Digital culture-based material can be used to teach many math topics. This study examined digital culture-based media integration across mathematical topics, revealing its distribution and prevalence. The analysis found that 37% of papers did not specify the mathematical topic. Geometry dominated the mathematical publications, accounting for 25%.

This conclusion undermines digital culture-based media's ability to improve geometric knowledge and visualization. Interactive simulations, virtual manipulatives, and cultural representations of geometric concepts can immerse pupils in spatial relationships and geometric principles.

The survey also found that area and volume, algebra, statistics, and measurement made up 5% of the mathematical concepts integrated into digital culture-based media. This range of themes demonstrates how digital culture-based media facilitates various mathematical concepts and skills. Prahmana (2022) noted that different cultures have vast collections of mathematical objects. Digital culture-based media offer creative ways to teach and learn mathematics through interactive games that reinforce algebraic principles, culturally relevant data sets for statistical analysis, and virtual tools for measuring and comparing items. Numbers were the least represented topic, with only 3% of publications.

Participants

Participation across educational levels shows the target population for digital culture-based media integration in mathematics teaching. This sample included 47% high school students (Figure 3). The importance of digital culture-based media in secondary mathematics education is shown. High school students are vital for math instruction since they are prepared for academic and occupational courses that require arithmetic. Teachers can improve high school students' math, critical thinking, and learning experiences with digital culture-based media. To help high school pupils apply abstract mathematical concepts to real-world problems, Supriyadi et al. (2024) advise adding cultural components in mathematics training.

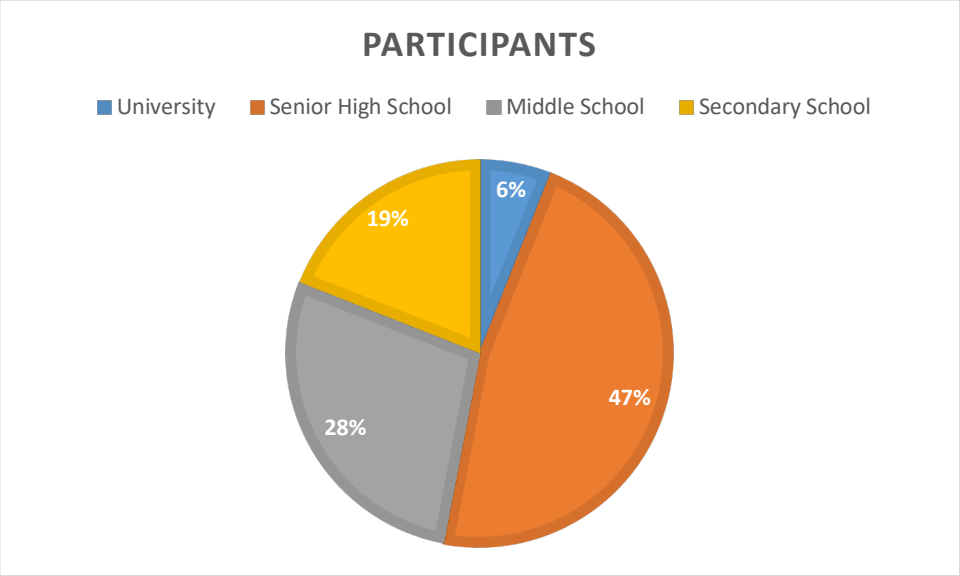

Figure 3. Participant

After high school pupils, 28% were middle school students, indicating strong elementary representation. This shows the importance of early digital culture-based media in math teaching. Early exposure to culturally relevant learning experiences may improve math attitudes and set a favorable basis for future learning (Kolovou, 2023; Beltrán-Grimm, 2024). The authors also recommended the incorporation of digital culture-based resources in middle mathematics education to foster engaging and inclusive learning environments for a diverse cohort of young learners.

However, university students made up only 6% and secondary school 19% of the overall participants, compared to middle and senior high students. This finding may be due to the study's emphasis and participant availability, but it urges future research into digital cultural-

based media integration in higher education. Digital and culturally informed mathematics education can benefit university students as they pursue academic and professional goals (Drijvers & Sinclair, 2024). The diverse distribution across educational levels underscores the necessity for age-appropriate, culturally relevant digital media in mathematics that adapts to developmental stages and academic needs. This method improves student engagement and builds a culturally and mathematically aware generation.

Participants' educational levels affect the integration and effectiveness of digital culture-based media in mathematics teaching. This distribution influences instructional instrument design, content complexity, and application tactics to satisfy each student group's developmental and learning needs. Educational tools must match target audience traits and demands. Digital culture-based media might include interactive apps and simulations that help high school pupils understand challenging mathematical concepts like calculus and statistics in culturally appropriate contexts. Digital tools can teach statistical analysis using local community data, making learning more engaging and relatable. Problem-based learning may entail students using arithmetic to estimate population growth or analyze economic patterns in their cultural contexts (Amidi et al., 2025).

In contrast, primary school pupils may need simple, engaging interfaces with vivid visuals, animations, and games to teach core concepts. Culturally relevant stories or personalities can assist in visualizing abstract arithmetic. Digital storytelling that mixes local folklore with simple arithmetic problems can help young learners understand and love math. Thus, integrating digital culture-based media at different educational levels necessitates balancing content complexity and cultural relevance to make tools accessible and useful to learners. Educational resource complexity varies greatly between levels. High school mathematics requires digital media that simplifies abstract reasoning and advanced concepts. Visualizations or interactive features can simplify complex concepts and help pupils to investigate mathematical and cultural linkages. Graphing functions that model environmental changes can help students relate math to real-world challenges in their communities.

However, elementary school educational tools must simplify and engage. The complexity of information for younger learners should match their cognitive growth, focusing on addition, subtraction, and fundamental geometry. For young learners, including local animals or foods in math problems can make these basic principles more real and easier to understand. Complexity that matches students' developmental stages enables digital culture-based media to avoid overwhelming them while boosting critical thinking and problem-solving. Participant distribution affects how digital culture-based media resources are used in education. Effective applications for high school students may involve collaborative projects using digital tools to research, analyze, and present culturally relevant mathematical applications, such as budgeting for a community project or analyzing the economic impact of local agricultural practices. This method improves numeracy, collaboration, and communication skills, preparing kids for real-world situations.

Interactive and engaging learning experiences that engage and stimulate discovery are common in primary school using digital culture-based media (Yan et al., 2025). Culturally themed educational games can drive pupils to practice math in a fun and engaging way. Children use digital tools to solve challenges in hands-on activities that promote learning at this stage. The distribution of participants across educational levels greatly affects the integration and effectiveness of digital culture-based media in mathematics teaching. By carefully considering instructional instrument design, content complexity, and application methods, educators can build more effective learning environments that fit students' developmental and cultural needs. This personalized method improves mathematical understanding and makes learning relevant, engaging, and impactful across educational environments.

Exploration of Ethnomathematics in the Qur'an

The Quran functions not just as a guide for Muslims but also as a legal source (Osman, 2019). Consequently, the author will analyze ethnomathematics inside the Quran. The subsequent poems are offered by the author:

This mathematical examination of Surah Al-Kahf investigates a verse concerning a group of young men who resided in a cave and the duration of their stay. Their responses varied; some exhibited uncertainty, while others provided their own conjectures. According to the journal, there are several discrepancies concerning the number of Ashabul Kahf, with some asserting it to be 5, 6, or 7 young men; nonetheless, the predominant view is that the number of young men in the cave is 7. The cohort of young men in the cave is delineated as follows: Collection of Ashabul Kahf youths = (youth 1, youth 2, youth 3, youth 4, youth 5, youth 6, youth 7). This group consists of young men engaged in a dispute on the duration of their stay in the cave, and they are also part of the Ashabul Kahf narrative. Mathematical exploration reveals that the two factions disputing in the cave represent a cohort of Ashabul Kahf.

The article by Hasan et al. (2022) asserts that the discovery of number theory indicates that only a select few are aware of the complete quantity of numbers. Atmadi and Nuryami (2024) contend that Surah Al-Kahf alludes to prime numbers (3, 5, and 7) and even numbers (4, 6, and 8). In verse 22 of Surah Al-Kahf, prime numbers constitute a segment as follows: Three, five, seven. The sequence is defined by the formula $Un = 2n + 1$ for $n = \{1, 2, 3\}$. The formula for the series is $Sn = n^2 + 2$. In even numbers, a pattern emerges: specifically, 4, 6, and 8. The formula for Un in the sequence is $Un = 2n + 2$ for $n = \{1, 2, 3\}$. The formula for Sn in the sequence is $Sn = n^2 + 3$.

The investigation of ethnomathematics in Al-Ankabut verse 14 reveals a subtraction operation (Hasan et al., 2022; Afifi, 2023). In his paper, he asserts that a subtraction process is present in Surah Al-Ankabut, verse 14, which recounts the narrative of the Prophet Noah. The text indicates that the Prophet Noah resided with his people for 950 years, calculated as 1,000 years minus 50 years.

Mathematical theory is present in Surah Al-Baqarah, verse 263, with Surah Al-Kahf and Surah Al-Ankabut. This verse, in relation to mathematics, imparts knowledge about multiples. According to Hasan et al. (2022), they assert the following: A solitary grain produces seven stalks, each bearing one hundred grains. Consequently, 1 grain equals 7 stalks, which is equivalent to 7 multiplied by 100 grains, resulting in 700 grains. The Quran also addresses cardinal, ordinal, and fractional numbers. Cardinal numbers denote quantity, encompassing volume, area, age, and the count of items, among others. Ordinal numbers denote sequence, exemplified by 1st, 2nd, 3rd, etc. Additionally, ordinal numbers can denote fractions, exemplified by 1/2, 1/3, and ¼, among others (Atmadi and Nuryami, 2024).

Discussion

The research constituted a systematic review about the incorporation of digital technologies and Islamic perspective-based media in mathematics teaching in Indonesia. The systematic review of 40 selected articles about the integration of the incorporation of digital technologies and Islamic perspectives in Indonesia uncovers notable trends and implications for both research and practice. The results showed that between 2015 and 2025, there was a big increase in scholarly contributions, with the highest number in 2024. This increase shows that more people are interested in using technology to improve math instruction, especially by using digital culture-based material. The findings align with Prahmana (2022), who observed an increase in ethnomathematics-related research in Indonesia.

The study delineates various mathematical topics addressed in the integration of digital technology-based and Islamic perspectives, with geometry being the most prominent. Geometry is a field of mathematics that is often researched in relation to the incorporation of ethnomathematics, as demonstrated by studies such as Verner et al. (2019) and Supriyadi et al.

(2023). The representation of numerical concepts is quite minimal. The result aligns with Hidayati and Prahmana (2022), who documented a greater emphasis on cultural activities in geometry, followed by numerical concepts. This finding may indicate the relative difficulties of incorporating cultural contexts into numerical concepts, as demonstrated by Sunzuma and Umbara (2025). It also highlights an area for potential advancement and research within the subject. Future research may focus on developing digital resources and teaching methods that effectively incorporate cultural elements into the teaching of arithmetic, numerical operations, and number sense, thus broadening the scope of cultural integration in mathematics education and Islamic perspective.

The distribution of participants across diverse educational levels illustrates the ability of digital culture-based media to influence mathematics teaching at multiple phases of students' academic trajectories. Most of the participants are high school and elementary school kids; however, there is a chance to use these resources in college to help students understand arithmetic. By focusing on different types of students and educational settings, teachers can make the most of digital culture-based media integration to improve math learning and raise cultural awareness. Future study must persist in examining the distinctive demands and obstacles linked to various educational levels to guarantee the fair integration of digital culture-based media in mathematics instruction.

4. Conclusion and Recomendation

This systematic review illuminates developments in digital technology, culture-based media, and Islamic perspective integration in mathematics instruction. Researchers and practitioners can improve mathematics teaching and learning in culturally relevant and meaningful ways by addressing gaps in scholarly contributions, exploring diverse mathematical topics, engaging students across educational levels, using systematic instructional design models, and using rigorous evaluative methods. Overall, this study concludes that a constructive ethnomathematics approach can bridge the dichotomy between modern technology and Islamic values. The reviewed literature confirms that the primary challenge is shifting from ethical criticism of existing technologies to the development of indigenous technologies—that is, technologies built from scratch using Islamic mathematics as their logical foundation.

These findings recommend the need to integrate Islamic ethnomathematics into engineering and computer science curricula so that the next generation of Muslim developers can design systems that fundamentally reflect Islamic principles of justice and spirituality. Applying this framework holds significant potential for creating innovations that are not only technically efficient but also ethically sustainable and culturally relevant for Muslim communities.

5. Conflict of Interest

This paper's publication does not constitute a conflict of interest, according to the author. Supervisors carried out their responsibilities in an impartial manner, and no personal, financial, or other relationships were a factor in the research or its findings. Honesty and openness were our top priorities while conducting and delivering the research.

6. Author Contributions

Muhammad Hasbi contributed to the formulation or evolution of overarching research goals and aims. I was involved in the preparation, creation, and presentation of the published work, which specifically included writing the initial draft and performing substantive translation. I was responsible for managing activities such as producing metadata, cleaning up

data, and maintaining research data. I am responsible for carrying out the research and investigation process, which includes conducting experiments and collecting data and evidence. Muh Sarda provided expertise in Islamic education. Muh Sarda was responsible for the development or design of the methodology, which included the creation of models. Muh Sarda was also responsible for the provision of study materials, instrumentation, and other analysis tools. Baso Syafaruddin was involved in verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results and other research outputs. The original research group members were responsible for the preparation, creation, and presentation of the published work, which included critical review, commentary, and revision, including pre- and post-publication phases. The article was conceived and designed; data was collected, analyzed, interpreted, written, and revised by all authors. All authors gave their approval to the finalized article.

7. Data Availability Statement

The authors state that the data supporting the findings of this study will be made available by the corresponding author, [muhammadhasbi@unisad.ac.id], upon reasonable request.

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Author Biography

	**Muhammad Hasbi,** is a lecturer and researcher at Faculty of Tarbiyah and Teacher Training, Universitas Islam As'adiyah Sengkang, South Sulawesi, Indonesia. His research interest is mathematics education. Email: muhammadhasbi@unisad.ac.id
	**Muh Sarda** is a graduate student, University of Queensland, Australia. His research interest is Islamic education. Email: m.sarda@students.uq.edu.au
	**Baso Syafaruddin,** is a lecturer and researcher at Faculty of Tarbiyah and Teacher Training, Universitas Islam As'adiyah Sengkang, South Sulawesi, Indonesia. His research interest is Islamic education. Email: basosyafaruddin@unisad.ac.id