EDUCATORS NAVIGATING THE INTERSECTION OF ELEMENTARY MATHEMATICS, STORYTELLING AND HISTORY: ILLUSTRATIONS FROM THE ISLAMIC CONTEXT*

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ABSTRACT

This study aimed to develop elementary curricular materials incorporating storytelling elements from the history of mathematics (HM) and investigate student and teacher perceptions of these materials. Using participatory action research methodology, we created curriculum materials featuring mathematical stories from the Islamic historical context and examined their reception among elementary students (n=90), preservice teachers (n=90), and in-service teachers (n=15). Data were collected through student interest surveys, focus groups, and teacher reflections on sample interdisciplinary units, including one featuring al-Kindī's contributions to cryptography, which we highlight in this paper. Findings reveal that elementary students expressed high interest in narrative-based mathematics instruction. Students demonstrated clear preferences for story-based learning that supported understanding and retention, while focus groups revealed gaps in their knowledge of mathematicians from their cultural backgrounds. Both preservice and in-service teachers affirmed the educational value of culturally responsive materials that use historical narratives as authentic contexts for mathematical reasoning. However, some raised concerns about balancing storytelling with mathematical rigor.

1 Introduction

Integrating the History of Mathematics (HM) into instruction can make lessons more engaging (Agterberg et al., 2022), yet teachers, especially at the elementary level, struggle to locate and apply suitable historical content (Girit-Yıldız & Ulusoy, 2024; Haydar & Durmaz, 2022; Moyon, 2022). As such, targeted professional development is needed to support classroom integration of HM (Agterberg et al., 2022). Storytelling drawn from HM can

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enhance both teacher practice and students' mathematical identities by embedding mathematics in culturally meaningful contexts. When paired with culturally relevant pedagogy, such stories can shift from being "window stories" to "mirror stories" that reflect students' lives (Sims-Bishop, 2011). Scholars further argue that HM helps convey mathematics as a dynamic field (Henningsen & Stein, 1997), reveals the human challenges behind mathematical discovery (Furinghetti, 2007), and highlights the discipline's evolution across cultures (Jankvist, 2009). Despite recognizing HM's value, teachers face a lack of curricular materials (Moyon, 2022; Tzanakis & Thomaidis, 2012). In centralized systems like Türkiye's, textbooks are often the primary resource, but their treatment of HM is limited. Studies of these materials have examined cultural diversity, representation of mathematicians, and mathematical tasks (Girit-Yıldız & Ulusoy, 2024; Moyon, 2022)**;** however, as Moyon (2022) observes, "most of these studies are descriptive... didactic devices or mathematical tasks associated with the HM in textbooks are not really developed" (pp. 1617–1618). This study aimed to develop a sample of elementary curricular materials incorporating storytelling elements with HM and investigate student and teacher perceptions of these materials.

2 Teaching with the History of Mathematics

Literature discusses various benefits of using HM in mathematics teaching. Classroom applications based on ancient Egyptian mathematics and Khwarizmi's quadratic equations can attract student interest at primary and high school levels (Barbin et al., 2018; Kafoussi & Margaritidou, 2023). Gifted students reported that HM-embedded videos expanded their knowledge of mathematicians' work, increased curiosity about mathematical concepts, enhanced motivation for invention, and developed positive attitudes toward mathematics and learning (Karataş-Aydın & Işıksal-Bostan, 2022).

Various studies examine in-service and preservice teachers' views on HM and its classroom implementation. Prospective mathematics teachers' (PMTs') evaluations of HM in textbooks served as a bridge for incorporating HM into lesson plans. When PMTs integrated HM to engage students, the integration reached higher cognitive demand levels, though they performed less well with pedagogical instructions and student thinking (Girit-Yıldız & Ulusoy, 2024; Moyon, 2022). PMTs provided mostly negative evaluations of HM quality in

textbooks, criticizing its relationship with mathematics assignments and presentation regarding content dimension (Girit-Yıldız & Ulusoy, 2024). They stated that HM content explanations were insufficient for establishing strong relationships with instructional text, lacked satisfactory explanations, and included limited information about concept origins and evolution. PMTs critiqued instances where HM was used merely as anecdotes, failed to foster mathematical thinking, or served only as motivation, since creating high cognitive-level tasks does not guarantee execution at that level (Davis et al., 2016). Efficient approaches to using HM in mathematics instruction align with the HPM perspective (Clark et al., 2016), which encourages educators to view mathematics both as a polished, logically deduced body of knowledge as well as a dynamic process of discovery shaped by historical, cultural, and interdisciplinary contexts. Teaching mathematics through this dual lens enables students to engage in authentic mathematical inquiry while recognizing its human dimensions. Integrating these perspectives can foster deeper conceptual understanding, more meaningful learning, and greater interest in mathematics, especially among students who may not identify with mathematics as it is traditionally presented. As Robertson (2022) reflects, "My interest in history came through teaching. I wanted to emphasize that mathematics was the product of people, 'like you and me.'" This perspective humanizes mathematics and helps students view it as an evolving field shaped by diverse thinkers across time and cultures. Given these documented benefits of HM alongside the identified limitations in current textbook implementations, storytelling presents a promising pedagogical approach that could address the content gaps while maintaining the engaging and motivational aspects that make HM effective in mathematics education. Based on this rationale, this study investigated how in-service and pre-service teachers can effectively use stories from HM to enhance elementary students' mathematics learning.

3 Methods

3.1 Design of the study

To answer our research questions, we adopted a participatory, proactive action research methodology. Action research provides for educators "a framework

that guides [their] energies toward a better understanding of why, when, and how students become better learners (Miller, 2007). Using participatory action research in the context of curriculum development was advocated by Plomp and Nieveen (2009) and modeled and refined by Eilks and Feierabend (2013).

3.2 Participants

Consistent with the participatory action research methodology, this study engaged multiple stakeholder groups to gather comprehensive feedback on the curriculum materials and their implementation. Three distinct participant groups were involved: elementary school students (n = 90), preservice teachers (n = 90), and in-service teachers (n = 15). The elementary school participants ranged from Grades 2 to 6, including 10 second graders, 20 third graders, 20 fourth graders, 23 fifth graders, and 17 sixth graders. The preservice teachers were undergraduate students enrolled in a mathematics education program, distributed across three academic years: 26 sophomores, 51 juniors, and 13 seniors. All had completed a History of Mathematics course in their first year, which provided relevant background knowledge for engaging with the historical content embedded in the curriculum. First-year preservice teachers were excluded from the study as they had not yet completed this prerequisite coursework. The in-service teacher group consisted of 15 practicing educators, including general classroom teachers, mathematics specialists, bilingual educators, and special education teachers working across Grades 4 through 9. To ensure confidentiality, preservice teachers were assigned pseudonyms (PT1, PT2, etc.) and in-service teachers were labeled similarly (T1, T2, etc.), with each abbreviation representing a unique participant within their respective groups.

3.3 Data sources

Multiple data sources were used to inform the design, implementation, and evaluation of the curricular materials. First, we developed a set of screening criteria grounded in historical accuracy, developmental appropriateness, and curricular alignment to guide the selection of mathematical stories. To capture student perspectives, a Student Interest Survey was administered to measure students' levels of interest in each story and to collect their rankings of the ten historical contexts. To gain deeper insight into students' experiences and

thinking, we conducted five focus groups with students from Grades 2 through 6. These focus groups explored students' general attitudes toward mathematics, included reflection questions tied to the Student Interest Instrument, and incorporated prompts aligned with the Culturally Relevant Pedagogy framework to examine issues of identity, representation, and engagement. In addition, we collected written reflections from both preservice and in-service teachers in response to the sample curricular materials. These reflections examined the use of the HM through multiple lenses, including mathematical content, curricular coherence, developmental appropriateness, interdisciplinary connections, and instructional design. Together, these varied data sources provided a robust foundation for evaluating the role of HM-based storytelling in supporting culturally responsive and developmentally appropriate mathematics instruction.

Figure 1. Cover of the Student Interest Instrument

3.4 The sample curriculum material:

In this paper, we present findings from preservice and in-service teacher reflections on a sample interdisciplinary unit: "*al-Kindî and Cryptography"*. The unit begins with Notice and Wonder routines that introduce students to the concept of code breaking, followed by an online game that engages them

in basic substitution ciphers. This leads into a historical narrative about Julius Caesar and his use of letter-shifting techniques to encode military messages, which in turn supports mini-lessons on inverse operations and functional rules that help students explore the mathematical structure of encoding and decoding. The second literacy component introduces students to the House of Wisdom and the Arab philosopher and mathematician al-Kindî. A curated reading highlights al-Kindî's early contributions to what is now known as cryptography, particularly his use of letter frequency patterns in Arabic texts, an approach foundational to modern frequency analysis. The unit concludes with social studies connections to the history of Baghdad and the scientific and mathematical advancements of the House of Wisdom. These interdisciplinary insights prepare students for a whole-class mathematical investigation in which they reconstruct al-Kindî's method for deciphering encoded messages through letter frequency patterns.

4 Findings

4.1 Elementary students' interest in the HM stories

Analysis of the Student Interest Instrument revealed that elementary students expressed a high level of interest in all ten historical mathematics (HM) story contexts drawn from the Islamic tradition. On a 5-point Likert scale (1 = Not interested at all, 5 = Very interested), mean interest ratings across grade levels were consistently above 3.0, with many ratings in the 4.0–4.7 range, indicating strong engagement with the materials. Notably, the activity involving Ibn al-Haytham's *Magic Square Puzzles* received the highest average rating among second graders (M = 4.7), while Hasib al-Tabari's *Recreational Mathematics* was particularly popular among fifth and fourth graders (M = 4.57 and 4.5, respectively). Al-Kindî's and *Cryptography* also emerged as a top-rated context across multiple grades, reflecting students' interest in puzzle-like, game-based mathematical applications.

In addition to rating each story, students were asked to rank their top three favorite activities. These rankings revealed clear developmental patterns: younger students (Grades 2–3) tended to prefer game-like and narrative-rich contexts, such as *Magic Squares* and the *Astrolabe*, while older students (Grades 5–6) favored content that aligned more directly with their

mathematical skill development, including the *Lattice Method of Multiplication* and the calculation of π (al-Kashî). It is interesting to note that these preferences were consistent with the national mathematics curriculum standards (Ministry of National Education [MoNE], 2013, 2018), reflecting grade-level expectations in areas such as multiplication fluency and number sense.

4.2 Student Focus Groups

Our analysis of the student focus group interviews is showing the following emerging themes:

Storytelling in Mathematics Instruction: Students expressed a clear preference for story-based mathematics instruction, noting that narratives supported both understanding and retention. One student reflected, *"I would have loved it if [teacher] had explained it that way, it would have been nice. The stories in the book would stay in my mind, and I would have done the math more easily."* Another described mathematics as "like a human being… like a teacher," influenced by the children's story *How Many Souls Does Mathematics Have?*, which portrayed a child interacting playfully with numbers. These accounts support how storytelling offers students both affective and cognitive entry points into mathematical thinking.

Cultural Representation in Mathematics When asked to name mathematicians from their own cultural backgrounds, younger students were unable to name any, while older students mentioned a few Islamic figures (e.g., Ibn Sina, Ali Kuşçu) alongside Western inventors such as Bell and Edison. This reflects previous findings on the limited representation of Turkish-Islamic mathematicians in the curriculum (Yıldız et al., 2016). Such gaps may hinder students' development of culturally grounded mathematical identities and growth mindsets (Kaya & Haydar, 2021). Notably, some students demonstrated a nuanced understanding of cultural affiliation in mathematics. One student remarked, *"When we use their inventions or have fun with their inventions, I feel close to them."* This response suggests that cultural affiliation alone is not sufficient; for students to feel genuinely connected, stories must also resonate with their lived experiences.

Mathematical Mindset: Stories of mathematicians served as powerful tools for cultivating a growth mindset among students. One student shared, *"They've done it, I can do it too. I give myself the determination to do better,"*

reflecting how exposure to the struggles and achievements of real mathematicians can motivate perseverance and self-belief.

4.3 Preservice teachers' views about the sample curriculum material

Our initial analysis of PST's reflections over the sample curricular materials revealed several emergent themes that both support and extend findings from the student focus groups and provide valuable insights for curriculum refinement and teacher preparation.

Cultural Representation and Interdisciplinary Connections: PSTs affirmed the curriculum's culturally responsive design, highlighting the value of including mathematicians from diverse cultures and periods. As one noted, "Including different people from different cultures would provide students with cultural richness." The use of Islamic scholars was seen as affirming students' identities, echoing Sims-Bishop's (2011) "mirror stories." PSTs also appreciated the interdisciplinary integration of mathematics with history, language, and technology, praising stories like those of Caesar and al-Kindî for fostering cross-disciplinary thinking.

Balancing Context and Content: Some PSTs raised concerns that storytelling could overshadow mathematical reasoning. One noted that the content risked drifting from core objectives, while another felt the narratives diluted mathematical rigor. These reflections echo Realistic Mathematics Education principles (Freudenthal, 1991), emphasizing the need for the story to be used as a context for rigorous mathematizing.

Bridging Past and Present: A recurring suggestion was to connect historical content with contemporary relevance. PSTs proposed including modern figures like Alan Turing and highlighting current applications such as cryptography in cybersecurity and finance. As one remarked, "Only the past is connected with the past, and the future is not connected with the future." Such feedback emphasizes the need for "window stories" that link history to students' present and future realities (Singh, 2020).

Engagement and Developmental Appropriateness: PSTs recommended strategies to enhance engagement and developmental alignment, such as gamified activities and digital tools. Suggestions included encryption games tied to story chapters and platforms like Khan Academy's Journey to Cryptography. These proposals reflect an effort to align content with students' digital learning habits and developmental needs.

4.4 Teachers' reflections on the curriculum design

In-service teachers evaluated the "*al-Kindî and Cryptography"* unit across several dimensions, including content, context, interdisciplinary integration, technological use, and historical framing. Their feedback revealed three core themes related to the use of HM:

Historical Narratives and Origins of Mathematical Ideas: Teachers valued the use of historical storytelling to introduce mathematical ideas, noting it appealed to students who are more engaged by narrative or humanities content. One teacher observed, *"Students who may be more interested in, say, humanities or history, will find this very engaging and accessible."* Historical context was praised for clarifying the real-world origins of mathematical ideas and promoting purposeful learning. Another participant noted, *"Students can understand how our everyday, common math ideas were developed out of necessity."* The narrative format was seen as a subtle yet effective way to teach concepts like inverse operations, rules, and patterns.

Interdisciplinary Strength: Teachers highlighted the seamless integration of math with history, literacy, and social studies. This approach countered the perception of mathematics as isolated, instead showing it as a discipline embedded in broader knowledge systems. One teacher remarked, *"It's great to see math concepts in other subjects and not in isolation."* The curriculum also supported co-teaching and collaborative planning across subjects. As one suggested, *"The history teacher could teach the background, the ELA teacher could support reading and writing, and the math teacher could explore decoding strategies."*

Cultural and Cross-Cultural Representation: Teachers appreciated the curriculum's emphasis on mathematical contributions from diverse traditions and times, particularly through the lens of cryptography. The juxtaposition of Caesar and al-Kindî offered students multiple cultural entry points into mathematics. One participant explained, *"We learned how Julius Caesar used coded messages... and how al-Kindî developed a system to decode them, still in use today."* This representation was seen as key to inspiring students and fostering a more inclusive understanding of mathematics. As one teacher concluded, *"It's important to have representation of cultures... to inspire them."* These observations reflect a commitment to connecting mathematics with historically diverse contributions across civilizations.

4 Conclusion

This study reveals both the promise and complexity of integrating historical mathematical narratives into elementary curricula using storytelling. While students demonstrated strong engagement with story-based mathematics instruction featuring Islamic mathematicians, their responses revealed that cultural connection extends beyond just representation; stories must resonate with lived experiences to truly function as meaningful contexts for learning. The developmental patterns we observed, with younger students preferring game-like narratives and older students gravitating toward skill-aligned content, suggest that effective HM integration requires careful attention to both mathematical objectives and age-appropriate storytelling approaches. Teacher feedback highlighted a critical tension in curriculum design. While both preservice and in-service educators valued the interdisciplinary richness and cultural responsiveness of historical narratives, they also emphasized the need to maintain mathematical rigor and avoid letting stories overshadow core learning objectives. This indicates that effectively integrating the history of mathematics requires more than featuring diverse historical figures; it involves developing meaningful narratives that both support mathematical reasoning and link historical developments to present-day applications. These findings point toward the need for teacher preparation programs that help educators navigate the complexities of using storytelling as a vehicle for meaningful mathematical learning rather than simply as motivational content.

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