Prospective Elementary Mathematics Teachers' Views on the Use of Islamic Geometric Patterns in Mathematics Lessons

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Abstract

This study aims to examine the views of prospective elementary mathematics teachers regarding the use of Islamic Geometric Patterns (IGPs) in mathematics lessons. Conducted within a qualitative research design, the study collected data from seven teacher candidates—third-year students who had taken an elective course on IGPs—through a semi-structured interview form. The data were analyzed using content analysis, and a descriptive approach was adopted to interpret the findings based on themes, categories, and codes. The analysis revealed that the experiences and opinions of the teacher candidates about the use of IGPs were grouped under seven main themes: "Interest and Attitude Towards Mathematics," "Establishing Interdisciplinary Context," "Creativity and Instructional Design Skills," "Visualization and the Concretization of Geometric Concepts," "Integrating Historical and Cultural Context into Teaching," "Limitations and Challenges," and "Suggestions for Effective Utilization." The findings indicate that IGPs can contribute to developing positive attitudes toward mathematics, fostering interdisciplinary integration, supporting creativity and instructional design skills, facilitating the understanding of geometric concepts, and providing a cultural-historical perspective. However, issues such as time management, topic alignment, and material shortages may prevent smooth implementation in every context. The study highlights that IGPs can serve as a potential tool for enriching mathematics teaching, enhancing students' motivation and comprehension levels, and encourages the development of guiding resources, technological support, collaborative activities, and practical applications to realize this potential.

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Introduction

One of the main objectives of mathematics education is to enable students to make sense of abstract concepts, develop geometric thinking skills, and cultivate a positive attitude toward mathematics (Ward, 2003; Rumanová & Smiešková, 2015). In this regard, instead of merely transmitting theoretical information, a learning-teaching process enriched with cultural, artistic, and historical elements can provide students with a meaningful mathematical experience (Verner, Massarwe & Bshouty, 2013; Zuliana, Dwiningrum, Wijaya & Purnomo, 2023). Particularly in the field of geometry, the importance of aesthetic and cultural motifs for creating real-life connections, establishing interdisciplinary contexts, and strengthening visual-spatial thinking skills is becoming increasingly evident (Chang, 2018; Hemmerling, 2019; Karadağ & Akar, 2020).

Ornamentation refers to covering surfaces or structures with one or more geometric shapes, without gaps or overlaps (Aktaş, Ercan & Bulut, 2024; Britton & Seymor, 1989, as cited in Aktaş et al., 2015). Throughout history, ornamentation has found correspondences in various fields such as architecture (Takva & Takva, 2023; Takva, Takva & Takva, 2023), engineering (Kizilörenli & Maden, 2021), art (Webb, 2019), ethnomathematics (Verner et al., 2019; Zuliana et al., 2023), education (Aydin-Güç & Hacisalihoglu-Karadeniz, 2020; Ovadiya, 2019), technology (Laksmiwati et al., 2023), and handicrafts (Karadağ & Akar, 2020; İpek & Özmüş, 2014). In Islamic architecture, Islamic Geometric Patterns (IGPs)—which appear on pulpits (minbar), prayer niches (mihrab), columns, and wall coverings with regular or semi-regular patterns—stand out for their use of polygons such as squares, hexagons, and octagons, formed through various applications of transformational geometry (reflection, translation, rotation) (Aktaş et al., 2015; Eryılmaz & Selimgil, 2021).

These Patterns in Islamic architecture are essentially concrete manifestations of mathematical principles in space (Takva & Takva, 2023; Bush, 2021; Eryılmaz & Selimgil, 2021). In examples such as Beyşehir Eşrefoğlu Mosque, Sivrihisar Ulu Mosque, and Konya Alâeddin Mosque in Turkey, the patterns on pulpits and mihrabs demonstrate the effectiveness of geometry in architectural production and reveal how mathematical relations intertwine with cultural-historical contexts (Takva & Takva, 2023). Similarly, patterns produced using various materials, such as stone, wood, and tiles in places like Iran, Morocco, India, Spain, Egypt, and Uzbekistan, reflect the mathematical heritage of Islamic culture (Eryılmaz & Selimgil, 2021; Kılıçoğlu & Pilehvarian, 2017).

In educational contexts, such Patterns offer opportunities for students to recognize polygons, discover types of symmetry, and make sense of the concepts of transformation geometry (reflection, rotation, translation) (Ward, 2003; Callingham, 2004). Through this process, students associate abstract concepts with cultural heritage and aesthetic elements, thus experiencing a more meaningful learning environment (Rumanová & Smiešková, 2015; Verner et al., 2013; Webb, 2019). The literature shows that this approach increases student motivation (Laksmiwati et al., 2023), supports creative problem-solving skills (Ilucová, 2004; Ovadiya, 2019), encourages the meaningful use of technology (Ward, 2003; Laksmiwati et al., 2023), and offers an ethnomathematical perspective (Zuliana et al., 2023; Verner et al., 2019).

For prospective teachers, this approach has the potential to enhance professional competencies, innovative material development skills, and cultural sensitivity (Capone et al., 2024; Hemmerling, 2019). In line with the ethnomathematical approach, prospective teachers can bring activities into the classroom that make mathematics meaningful by considering students' cultural experiences (Verner et al., 2013; Verner et al., 2019). Thus, mathematics education provides a richer learning experience at the intersection of cultural heritage, art, architecture, and technology (Karadağ & Akar, 2020; İpek & Özmüş, 2014).

Ornament-based activities not only enable students to understand concepts such as transformation geometry, symmetry, proportion, and pattern but also create opportunities to develop manual skills, use technological tools, foster collaborative learning, and build cultural awareness (Chang, 2018; Aktaş, Ercan & Bulut, 2024; Yamamoto, Nakazato & Mitani, 2022). Examples such as Anatolian ornamentations and

Islamic geometric designs help students relate mathematical content to cultural elements they might encounter in daily life (İpek & Özmüş, 2014; Eryılmaz & Selimgil, 2021; Bush, 2021).

At this point, although studies on using ornamentation in education are increasing in the literature (Tekin, 2024), there is a need for systematic research examining the views of prospective teachers specifically in the context of Islamic Geometric Patterns. Further research is required on how IGPs can be used in elementary mathematics lessons, and their effects on students' attitudes, conceptual understanding levels, and cultural awareness (Karadağ & Akar, 2020; Verner et al., 2019; Zuliana et al., 2023).

This study aims to fill this gap in mathematics education literature by determining prospective teachers' experiences, attitudes, and perceptions regarding the use of IGPs in mathematics lessons. The findings may guide teacher training programs, material development processes, curriculum design, the effective use of technology, and the adaptation of ethnomathematics-based activities to the classroom context. Thus, it is expected to contribute to adopting a holistic teaching approach that highlights the cultural, aesthetic, and interdisciplinary dimensions of mathematics education.

The main purpose of this research is to reveal the experiences, attitudes, and perceptions of prospective teachers regarding the use of IGPs in elementary mathematics teaching. In this way, the potential contributions of ornament-based activities to student motivation, conceptual understanding, relating cultural heritage, creative thinking, and developing interdisciplinary contexts will be evaluated. The results are expected to emphasize the importance of teaching approaches that consider the cultural, aesthetic, and creative dimensions of mathematics education and enrich the literature.

Method

This study is a basic qualitative inquiry conducted within a qualitative research framework (Creswell, 2013; Merriam & Tisdell, 2015). The data were thematically structured through content analysis, enabling an in-depth examination of participants' subjective perceptions, experiences, and thoughts (Braun & Clarke, 2006; Miles, Huberman & Saldaña, 2014).

Participants

The participants of the study consist of seven prospective teachers in their third year of a university's elementary mathematics teacher education program who voluntarily chose an elective course on IGPs. These participants, who formed the primary data source of the research, reflected on their experiences gained during the IGO course.

Data Collection Tool and Procedure

Data were collected through a semi-structured interview form. This form contained open-ended questions focused on the integration of IGPs into mathematics lessons, their possible contributions to mathematical thinking skills, teaching materials, the establishment of interdisciplinary contexts, lesson planning experiences, and suggestions for practice. Participants provided written responses, allowing them to express their experiences in detail. Anonymity and confidentiality were carefully observed.

Data Analysis

The collected data were analyzed through content analysis. First, the data were read holistically, and then meaningful expressions were coded. Similar codes were merged to form sub-categories, categories, and themes (Braun & Clarke, 2006). Multiple researchers independently coded the data to ensure reliability, and discrepancies were discussed until a consensus was reached. The themes allowed a comprehensive and systematic presentation of the findings.

Findings

As a result of the content analysis, the views of prospective teachers on the use of Islamic Geometric Patterns (IGPs) in mathematics lessons were gathered under seven main themes. These themes are the product of a holistic understanding of the data and reflect participants' perceptions and experiences across a broad spectrum, from attitudes toward the lesson to interdisciplinary connections, from creativity and instructional design skills to the concretization of geometric concepts,

historical-cultural dimensions, challenges encountered in practice, and suggestions for more effective use. Below, we first present the related categories and codes under each theme, followed by a detailed discussion of how these themes materialized through participant statements, thereby providing the reader with a detailed, systematic, and comprehensive account of the findings.

Theme 1: Interest and Attitude Towards Mathematics

Two key categories stand out in this theme: (1) Making Mathematics Enjoyable and (2) Increased Motivation. These categories are substantiated by codes such as "developing a positive attitude," "increased interest in the lesson," "arousing curiosity," and "fun learning environment."

Participants' statements indicate that IGPs can make abstract mathematical concepts more appealing, leading students to adopt a more positive attitude toward the lesson. For instance, one participant stated, "...this can prevent students' negative attitudes toward mathematics" (P1), emphasizing that IGO-based activities could break preconceptions. Another participant mentioned, "Islamic geometric Patterns made the topic more interesting" (P4), pointing out that IGPs transform mathematics lessons into environments that grab and pique students' curiosity. Similarly, "Experiencing mathematics in a concrete context can strengthen positive attitudes" (P2) underscores that presenting mathematics—often filled with abstract concepts—in concrete examples can bolster students' motivation. Another participant added, "It becomes easier to capture the attention of that age group, and it can be shown that math is not a subject to be feared" (P7), highlighting how IGPs can foster positive emotions toward mathematics.

Theme 2: Establishing Interdisciplinary Context

Two categories emerged here: (1) Integration with Other Courses and (2) Multi-Dimensional Learning Experience. Under these categories, codes such as "connecting with religious education and ethics," "integration with social studies," "integration with visual arts," and "relating to real life" show that mathematics can merge with various disciplines, creating meaningful learning opportunities.

One participant said, "A learning experience that blends religious culture and ethics, social studies, and visual arts can be offered" (P1), noting that IGPs provide a means to move mathematics beyond just numbers and operations, allowing for a broader contextual examination. Another participant remarked, "Teaching the history of a mosque in social studies and its ornamentation in mathematics makes a lot of sense" (P5), emphasizing that mathematics offers an analytic framework for students to interpret culturally and historically shaped spaces. Other comments included, "This demonstrates that mathematics is not just about numbers but is connected to all subjects" (P7) and "Establishing interdisciplinary connections also contributes to students' multi-faceted thinking" (P3). These views indicate how IGPs help students discover different modes of thought and regard mathematics as a discipline situated in everyday life, art, history, and culture.

Theme 3: Creativity and Instructional Design Skills

In this theme, categories such as Activity Development and Material Design and Creativity and Patience Development stand out, with relevant codes including "lesson plan preparation," "variety of activities," "manual skills," and "a process requiring patience." The statements of teacher candidates suggest that IGPs enrich instructional design processes and encourage creativity.

For example, one participant noted, "I realized I had to pay attention to every detail when preparing the lesson plan" (P1), implying that IGPs require a more meticulous approach to lesson design. "I think I can develop various activities" (P2) indicates that IGPs inspire prospective teachers to create innovative learning experiences. Moreover, "Drawing and coloring enhanced my creativity" (P4) points out how activities requiring aesthetic and manual skills can also stimulate creativity alongside professional skills. Another participant added, "It was a course that required patience and should be voluntary" (P7), emphasizing that this process further cultivated the patience and dedication of teacher

candidates. Thus, IGPs serve as a laboratory that strengthens prospective teachers' pedagogical and artistic abilities.

Theme 4: Visualization and the Concretization of Geometric Concepts

Two categories emerge here: Recognition and Classification of Geometric Shapes and Patterns and Symmetry. Codes such as "polygons," "classification by the number of edges," "repetitive patterns," and "translation and reflection" highlight how IGPs reinforce geometry topics with concrete examples.

Participants stated, "It can be used in teaching polygons; they can be classified by the number of sides" (P3), emphasizing how IGPs make abstract geometric concepts more tangible. Another participant mentioned, "In discussing patterns, one can question at what intervals certain shapes repeat" (P4), drawing attention to the mathematical structure of designs. "Teaching symmetry through designs could make it easier for students to understand" (P6) argues that visual arrangements leave more lasting impressions on students' minds. Additionally, "Presenting abstract mathematical concepts in a visual and concrete manner strengthens problem-solving skills" (P2) and "Classifying geometric shapes based on coloring or drawing provides more meaningful and lasting learning" (P1) illustrate how IGPs support students' problem-solving and analytical skills through visual methods.

Theme 5: Integrating Historical and Cultural Context into Teaching

Cultural Awareness and the Universal Nature of Mathematics stand out as categories under this theme. Codes such as "historical sites" and "connection with cultural heritage" suggest that mathematics is not merely an abstract discipline but one that holds a specific historical and cultural background.

Teacher candidates note, "Now I examine Patterns I see; I look at my surroundings with different eyes" (P7), indicating that IGPs allow students to read the geometric patterns they encounter in daily life through a cultural-historical lens. Another participant stated, "It showed that mathematics can be integrated into any field" (P2), pointing to the universality of mathematics. Also, "It's very logical to teach the mosque or tomb in religious education, its history in social studies, and its structure in mathematics" (P5) suggests that this historical and cultural context can transform lessons from isolated segments into an interdisciplinary and holistic learning experience.

Theme 6: Limitations and Challenges

The categories of Time Management Issues and Limited Integration Opportunities indicate that implementing IGPs is not always seamless, as reflected by codes such as "time-consuming" and "limited applicability to certain topics."

One participant admitted, "It took a lot of time and was challenging" (P7), implying that planning IGO activities demands meticulous work. "Time constraints can arise, so practice is needed" (P3) similarly stresses the need for effective time management. Some participants noted, "I think the scope of the lesson is not that broad; the mathematical theme that can be integrated is limited" (P1), suggesting that not all topics are suitable for IGPs. "I think it can be tackled for just one theme at most" (P5) also points to a narrowing scope. Additionally, "Procuring materials was initially challenging" (P4) highlights how material shortages could negatively impact the process.

Theme 7: Suggestions for Effective Utilization

This final theme focuses on Resource and Material Support and Hands-On and Collaborative Learning, presenting codes such as "creating a guidebook," "use of technology," "collaborative learning," and "real-life connections."

Participants noted, "Publishing books or magazines tailored to this area would clarify teachers' paths" (P1), emphasizing the importance of reference materials. "Students can develop their creativity by creating their own designs" (P2) points to the necessity of practical, student-centered activities, while "Making puzzle-like cutouts or increasing hands-on activities could be more fun, meaningful, and effective" (P6) highlights the potential for more engaging practices. In

addition, "Active use of technological tools and connecting lessons to real life is important" (P2) underlines how IGPs can be integrated with contemporary educational technologies and supported with examples closely related to students' lives.

Conclusion And Discussion

This study examined the views of prospective teachers on the use of IGPs in mathematics lessons, revealing that Patterns can contribute to a broad range of outcomes, from understanding mathematical concepts to developing cultural awareness. In line with the literature, the findings show that Patterns can enhance students' attitudes toward mathematics (Ward, 2003; Webb, 2019), facilitate the concretization of abstract topics like transformational geometry, symmetry, and polygon properties (Callingham, 2004; Rumanová & Smiešková, 2015), and offer opportunities for interdisciplinary learning (Verner et al., 2013; Zuliana et al., 2023; Karadağ & Akar, 2020).

Prospective teachers' emphasis on how IGPs can increase student motivation, foster aesthetic sensibility, and bolster creativity and material development skills aligns with existing findings about the educational potential of ornamentation (Hemmerling, 2019; Ovadiya, 2019). Moreover, it is understood that using technological tools in ornament-based activities can offer an exploratory learning environment (Chang, 2018; Laksmiwati et al., 2023; Yamamoto et al., 2022), integrating a cultural perspective into mathematics learning through an ethnomathematical approach (Verner et al., 2019; Zuliana et al., 2023).

However, the research findings also show that challenges such as time management, topic alignment, and material shortages can hinder the use of Patterns in practice. Similar limitations are highlighted in the literature, suggesting that prospective teachers overcome these barriers by utilizing guide materials, professional development programs, technology-supported activities, and collaborative study methods (Capone et al., 2024; Tekin, 2024).

Limitations And Recommendations

This study was conducted with a limited number of prospective teachers. Future research involving more diverse participants from different cultural and academic backgrounds could enhance the generalizability of the findings. Additionally, rather than focusing solely on prospective teachers' views, classroom observations, analyses of student work, and long-term impact assessments could be employed to gain a more comprehensive understanding of how ornament-based activities influence the teaching process.

In subsequent studies, the use of software such as GeoGebra and TbMT in ornament activities could be explored, supporting prospective teachers' technological literacy, creative material development, and student-centered approaches to discovering geometric concepts. By incorporating courses on planning and implementing ornament-based activities into teacher training programs, both the mathematical and cultural capital of prospective teachers could be enriched. Investigating ornamentations from various cultural heritages could also help students appreciate that mathematics is a universal language.

In summary, this study emphasizes the value that IGPs can add to mathematics education in terms of aesthetics, culture, and interdisciplinarity. By adopting this approach, prospective teachers can contribute to students experiencing mathematics as a more meaningful, engaging, culturally enriched, and creative field of activity. In this regard, the diversification of ornament-based activities, their integration with technology, incorporation into teacher training programs, and long-term impact assessments will provide opportunities to enrich mathematics education with an innovative and holistic perspective.

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