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Prospective mathematics teachers' thoughts about the process of the preparing ethnomathematics-based materials

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Abstract

An environment shaped by students' cultural and everyday experiences contributes to meaningful learning. In this way, the knowledge learned is internalized by students as it bears traces of culture. In this context, it is thought that including cultural differences in the materials developed in the education and training process will increase the awareness of prospective mathematics teachers about the relationship between mathematics and culture. In this study, it was aimed to reveal the thoughts of prospective mathematics teachers about the process of preparing ethnomathematics-based materials and their possible effects on students. The sample of the study consisted of 25 prospective mathematics teachers enrolled in the Department of Mathematics Education at a state university in the Central Anatolia region who had taken and successfully completed the 'Material Design in Mathematics Teaching' course. The research is a qualitative study using case study design. A semi-structured interview form consisting of 7 questions was applied to the prospective teachers in order to determine their thoughts about the process of preparing ethnomathematics-based materials and their possible effects on students. The answers given by the prospective mathematics teachers to the open-ended questions were analyzed using content analysis, one of the qualitative analysis methods. As a result of the research, it was seen that prospective mathematics teachers mostly used architectural structures such as mosques, tombs, water wells and cultural elements such as carpets-rugs, tile patterns and marbling art while preparing ethnomathematics-based materials. It was determined that prospective teachers had difficulties in preparing ethnomathematics-based materials at points such as technical works and combining the subject and culture. In addition, prospective teachers stated that ethnomathematics-based materials would provide possible contributions such as making students aware of the relationship between mathematics and culture and the importance of culture.

Keywords: Ethnomathematics-based material, Prospective teacher, Material development, Ethnomathematics

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INTRODUCTION

Educational environments have become not only spaces where academic knowledge is transmitted, but also environments where students' cultural identities are shaped. Therefore, in educational environments, students are involved not only with their knowledge but also with their cultural identities. It is clear that mathematics teaching needs to be restructured in a cultural context, especially when it is considered that a field such as mathematics, which is universal, abstract, and generally presented as culture-independent, takes place in different cultures in different ways (D'Ambrosio, 2018). Because mathematics is not only a set of numbers and symbols, but also a reflection of the relationship that individuals establish with life and their efforts to produce solutions. Mathematics is part of the daily lives of individuals of all levels, ages and cultures and aims to provide them with problem-solving skills to meet their daily needs. The combination of mathematics and culture increases awareness of daily life examples (Esen & Saralar-Aras, 2022). Zaslavsky (2002) also emphasizes the use of cultural curricula in mathematics teaching to integrate mathematics with daily life. In this context, incorporating students' cultural experiences into mathematics teaching may help bridge the gap between formal mathematical knowledge and the mathematical practices embedded in their everyday lives. This situation highlights the importance of considering culture as a meaningful context in mathematics education. At this point, ethnomathematics stands out as a concept that draws attention to the cultural foundations of mathematics. The concept of ethnomathematics introduced by D'Ambrosio (1985) refers to the mathematical processes of individuals from different cultures. Ethnomathematics, which examines the interaction between mathematics and culture, is seen as a rapidly developing discipline (Çenberci & Horzum, 2023).

D'Ambrosio (2018) states that ethnomathematics refers to ways, styles, arts and techniques (tics); doing and knowing, learning and explaining, dealing with situations and solving problems (mathema); different specific natural and socio-cultural environments (ethno). The concept of ethnomathematics helps individuals to see that culture is not disconnected from mathematics and to gain cultural awareness (Ergene, Çaylan-Ergene & Yazıcı, 2020). Each civilization has mathematical ideas that they have created within the scope of their own culture (Aktekin, 2017). Individuals first see mathematics in their own culture and then their mathematical thinking develops with the education they receive. If individuals learn in relation to the culture in which they live, they will both feel more belonging to the society and those learnings will be more meaningful and permanent. In this context, ethnomathematics enables individuals to understand the structure and nature of mathematics on the one hand, and individuals to understand each other and their lives on the other (Gün-Şahin, 2023). Ethnomathematics can facilitate students to preserve their cultural identity and citizenship and achieve their learning goals academically (Latif & Talib, 2021). This will contribute to their better understanding of mathematics by protecting their self-identity. However, through ethnomathematics, it will be possible to see how mathematics shapes their own cultures in multicultural societies (Rosa & Orey, 2020). This allows individuals to be aware of practices in their own culture. As a matter of fact, during the learning of mathematics, which is expressed as an acculturation process, individuals become a part of the mathematical culture in society. (Bishop, 1988; Bishop, 2002). As part of society, students bring the characteristics of the society they live in to the learning environment (Rosa & Orey, 2011). Therefore, at this point, the importance of taking cultural differences into account in the learning environment emerges as a remarkable element. Many scholars argue that the concept of ethnomathematics should be included and used in mathematics curricula (Furuto, 2014; Fouze & Amit, 2018; Hartinah et al., 2019). By emphasizing the socio-cultural environment of individuals, the production, transfer and dissemination of knowledge can be a source of motivation for them. Arı, Demir and Ar (2019) emphasize that culture-based mathematics education increases students' interest and motivation. In the study conducted by Magallanes (2003), it was determined that mathematics courses taught with the ethnomathematics approach provided more success than the courses taught with traditional methods. However, using ethnomathematics in classroom settings enables the integration of culture and mathematics and encourages all students to make personal connections and acquire useful intercultural skills. In culturally inclusive learning environments, students gain social awareness. Students are therefore motivated to work harder and produce better results (Unodiaku, 2013). In Güreş's (2019) study, it is emphasized that cultural values, cultural knowledge and cultural

thinking processes and mathematical knowledge and thinking processes learned in school mathematics complement each other.

When the literature is examined, it is seen that there are studies that examine the place of ethnomathematics in real life and focus on mathematical concepts in crafts or fashion (Maryati & Prahmana, 2019; Rubio, 2016). There are also studies that mention ethnomathematical games (Yow, Morton & Cook, 2013), emphasize the role of ethnomathematics in mathematics learning (Iluno & Taylor, 2013) and integrate ethnomathematics into mathematics curricula (Zhang & Zhang, 2010). However, studies measuring teachers' use and knowledge of ethnomathematics attract attention (Mania & Alam, 2021; Orim & Uzoma, 2019; Aikpitanyi & Eraikhuemen, 2017). It is seen that one of the ways used to integrate ethnomathematics into the learning environment is ethnomathematical activities and there are studies in the literature on this subject (Aktuna, 2013; Kara, 2009). As a result of the study conducted by Aktuna (2013), it was seen that a teaching enriched with ethnomathematics contributed to an increase in students' motivation, interest and self-confidence. Similarly, in Kara's (2009) study, the positive effect of a teaching integrated with ethnomathematics activities on seventh grade students' attitudes towards mathematics was observed. Therefore, it is important for teachers to teach mathematics by taking into account the culture in which students live. Of course, in this process, expressing these ideas and thoughts verbally is not enough for students to realize the relationship between mathematics and culture. These need to be concretized with applications and integrated into the learning environment in a natural way. In Kang's (1992) study, the necessity of embedding ethnomathematics in mathematics curricula is emphasized. In this context, it is possible to state that another way of embedding ethnomathematics in learning environments is ethnomathematics-based materials. Practices based on using cultural elements in education are generally used for visual, aesthetic or motivational purposes. The ethnomathematics approach does not only use cultural elements for these purposes, but also aims to improve students' mathematical thinking and cultural awareness levels by analyzing the mathematical structures of these elements (D'Ambrosio, 1985; Rosa & Orey, 2016). For example, in an educational approach that uses general cultural elements, situations such as carpets, rugs, and architectural structures are only shown or used for decoration during the course. In the ethnomathematics approach, mathematical structures, concepts or models in these situations are revealed and a relationship is established between cultural elements and mathematical outcomes. In this context, it is clear that ethnomathematics-based materials will help to use culture as a learning tool different from general cultural practices. The use of these materials in learning environments will provide meaningful learning as well as cultural sensitivity. D'Ambrosio (1985) and Gerdes (2001) point to the need to articulate mathematical concepts in cultural practices and to examine the mathematical ideas, materials and activities embedded in the cultural contexts of societies.

When the literature was examined, it was observed that students' mathematical understanding was high in an application based on realistic mathematics education supported by ethnomathematics-based materials (Widada, Herewaty & Lubis, 2018). In this context, teaching materials will allow students to see the mathematics in their lives in a more concrete way and to integrate ethnomathematics into the learning environment in an embedded way. In addition, it is possible to state that ethnomathematics-based materials have an important role in helping prospective teachers establish the relationship between mathematics and culture, integrate cultural elements into mathematics courses in a concrete way, and attract students' interest. As a matter of fact, these tendencies have become more evident in the structuring of curricula in recent years. The Türkiye Century Education Model (2024) emphasizes culture and value-based education and expects students to construct their own identities through experiences.

In teaching an abstract subject such as mathematics, teachers are the key people in integrating and using the culture-mathematics relationship in learning environments. Its effective preparation and implementation is only possible if teachers and prospective teachers have sufficient equipment and competence in this regard. Ari et al. (2019) point out that the relationship between culture and mathematics is ignored in today's classrooms. This is an indication that teachers who will present this approach in learning environments do not have sufficient knowledge of ethnomathematics due to lack

of experience, materials and pedagogy. Even if teachers and prospective teachers are willing to use cultural elements in mathematics courses, they do not know how to do it. Mathematics teachers have been found to be deficient in reflecting the relationship between mathematics and culture in the classroom environment (Lewis, 2016). These deficiencies cause students to have difficulty in making in-depth sense of the mathematics they learn. For this reason, it is important to include ethnomathematics practices that can reveal the relationship between culture and mathematics in mathematics courses and increase students' awareness, and to train teachers and prospective teachers to have competence at this point. In other words, in order for students to understand the relationship between culture and mathematics, prospective mathematics teachers need to be trained in this area. In the study conducted by Çenberci and Horzum (2023), it was determined that prospective mathematics teachers did not have sufficient awareness about the use of culture in mathematics teaching. This situation negatively affects students' mathematics achievement and causes them to think that there is no interaction between their own culture and mathematics (d'Entremont, 2015; Krummel, 2013). In our country, it is seen that the Ministry of National Education (MoNE) and the Council of Higher Education (CoHE) emphasized culture in mathematics teaching with the curriculum programs renewed in 2018. CoHE (2018) contributes to this awareness with the elective 'Culture and Mathematics' course added to the undergraduate program. In the context of the Turkish Qualifications Framework of the Ministry of National Education (MoNE, 2018), one of the competencies that students are expected to have is "cultural awareness and expression", which further reveals the importance of using ethnomathematics in the learning environment. The emphasis of MoNE and CoHE is an important step in promoting cultural awareness. Therefore, cultural integration into teacher education programs becomes even more important. Considering all these, the inclusion of culture in mathematics in the learning environment will not only attract students' attention to the course, but will also contribute to raising awareness about ethnomathematics in students. This study is expected to contribute both to the prospective teachers' awareness of ethnomathematics and to their students' understanding of the relationship between mathematics and culture. In addition, prospective mathematics teachers will have the opportunity to see the ethnomathematics-based materials prepared by their friends and will have the opportunity to develop a perspective on what can be done differently on this subject. Quan, Tseng and Guan (2023) emphasize that prospective teachers' experiences and thoughts in cultural environments will affect their professional lives. Based on all these, this study aimed to examine the views of prospective teachers on the process of preparing ethnomathematics-based materials and the possible effects of these materials on students. In this context, the research problem was determined as "How are the thoughts of prospective teachers about the process of preparing ethnomathematics-based materials and the possible effects of the materials on students?". Answers were sought to the following sub-problems:

1. How are the thoughts of prospective teachers about the preparation of ethnomathematics-based materials?
 - a) How are the cultural elements (situations) that prospective teachers use while preparing ethnomathematics-based materials?
 - b) How are the learning domains preferred by prospective teachers when preparing ethnomathematics-based materials?
 - c) How are prospective teachers' thoughts on at which stage of mathematics courses ethnomathematics-based materials can be used?
 - d) How are the difficulties experienced by prospective teachers while preparing their ethnomathematics-based materials?
2. How are prospective teachers' thoughts about the possible effects of ethnomathematics-based materials on students?
 - a) How are prospective teachers' thoughts about the possible effects of ethnomathematics-based materials on students' ideas about culture?
 - b) How do prospective teachers thoughts about the possible effects of ethnomathematics-

based materials on students' learning?

METHOD

Research Design

In this study, it was aimed to determine the thoughts of prospective teachers on the process of preparing ethnomathematics-based materials and the possible effects of the materials on students in case of implementation. A case study was used in the research in which qualitative method was adopted. Qualitative research is a research method in which qualitative data collection tools such as observation, interview and document analysis are used to reveal the events observed within their own limits (Yıldırım & Şimşek, 2011). Qualitative researchers are interested in the concepts that people put forward and the meanings of these concepts (Merriam, 2013). A case study is a type of study that examines and analyzes a limited situation, environment or system in depth for the purpose of the research (Creswell, 2007). In a case study, a single situation is addressed and more situations are explained accordingly (Gerring, 2007).

Participants

The participants of this study consisted of 25 prospective teachers who were studying in the second year of the Department of Mathematics Education of a state university in the Central Anatolia Region and who had taken and successfully completed the “Material Design in Mathematics Teaching” course and participated in the study on a voluntary basis. The participants of the study included 6 male and 19 female prospective mathematics teachers. It was determined that approximately two-thirds of the prospective teachers live in the Central Anatolia Region. Participants were selected in accordance with the easily accessible case sampling method (Yıldırım & Şimşek, 2011), one of the purposive sampling methods used in qualitative research. The purposive sampling method is a sampling method that allows for detailed investigation of situations that are assumed to have deep knowledge. In the accessible sampling method, which is one of the types of purposive sampling, the researcher gains speed and practicality by choosing a situation that is close to him/her and easy to access. Accessible samples are generally less costly and more practical for researchers (Yıldırım & Şimşek, 2011). In order to keep the identities of the participants, who were determined on the basis of volunteerism, confidential, each participant was given codes as S1, S2,

Data Collection Tools and Data Collection Process

The participants of the study took the elective course “Material Design in Mathematics Teaching” for 14 weeks. The content of this course includes the design and development of materials to be used in mathematics teaching, designing three-dimensional materials, using field-specific instructional technologies, and conducting studies on classroom applications of teaching materials. In this context, prospective teachers gained knowledge about the materials and how to design materials within the scope of the course. In addition to these topics, detailed information about ethnomathematics was given, the relationship between culture and mathematics and examples were explained, students were provided to read and examine the academic studies, the importance of including ethnomathematics in classroom practices and the studies conducted in the field of ethnomathematics were emphasized. At the end of the semester, prospective teachers were asked to prepare original ethnomathematics-based materials that would combine culture and mathematics. In the next stage, prospective teachers were asked to think about the ethnomathematics-based material they wanted to prepare and to put their ideas on paper and present them to the whole class. Feedback was given to prospective teachers on their ideas for ethnomathematics-based materials. They have been supported with continuous feedback to complete the material design process efficiently and effectively. At the end of this process, the data of the study were collected online in written form with a semi-structured interview form prepared at the end of the semester. Two experienced experts in the field were consulted in the preparation of the interview form used to collect the data of the study. The research questions aim to determine the thoughts of prospective mathematics teachers regarding the process of preparing ethnomathematics-based materials and the possible effects these materials may

have on students when used. In the process of preparing these open-ended questions, qualitative studies in different fields were examined and question types that would serve the purpose in material design were utilized. The views of the prospective teachers were obtained in detail with these questions. Before the interview form questions, the informed consent form and voluntary participation consent form were presented to the prospective teachers, and then their opinions were obtained with the interview form. The thoughts of prospective mathematics teachers about the preparation process of ethnomathematics-based materials were examined within the scope of the first, second, third, fourth and seventh questions in the semi-structured interview form and the possible effects of ethnomathematics materials on students were examined within the scope of the fifth and sixth questions. The prospective mathematics teachers who participated in the study were asked to give correct and sincere answers to the open-ended questions in order to reflect their true feelings and thoughts.

Data Analysis

The answers given to the questions posed to the prospective mathematics teachers participating in the study were analyzed using content analysis, one of the qualitative analysis methods. Content analysis is the coding of the data obtained in various ways and categorizing them into themes, trying to explain and interpret them within this framework (Aydın, 2019). During the analysis of the data, coding was done separately by each researcher and then the points of difference were determined by mutual checks. For example, the open-ended questions asked within the scope of the problems of the first research were analyzed separately by the researchers and the emerging themes and ideas were determined. In this context, different views were discussed and a common decision was reached. In the analysis of the question “What are the cultural elements (situations) you used in the ethnomathematics-themed material you prepared?” there was indecision about which sub-theme to place the expression “hımış house structure”. One of the researchers wanted this statement to be handled in the context of “architectural structures” and the other one wanted it to be handled in the context of “daily life”. Later, it was decided to consider the expression in question in the context of “architectural structures”, considering it to be a more complex expression. In this way, the process was continued until full agreement was achieved in data analysis.

FINDINGS

The study sought to answer the main research question, “What are the thoughts of prospective teachers about the process of preparing ethnomathematics-based materials and the possible effects of the materials on students?” Two sub-questions were formulated within this scope. In this section, the findings obtained from the answers to the first and second sub-problems of the research are presented respectively.

Findings Regarding the Thoughts of Prospective Teachers About the Preparation Process of Ethnomathematics-Based Materials

The first sub-problem was determined as ‘How are the thoughts of prospective teachers about the preparation of ethnomathematics-based materials?’ This sub-problem was examined in four sections: the cultural elements used by prospective teachers when preparing materials, which learning domain they preferred when preparing ethnomathematics-based materials, their thoughts on which phase of the course ethnomathematics-based materials could be used, and the difficulties experienced by prospective teachers in the process of preparing ethnomathematics-based materials. Accordingly the answers given by prospective mathematics teachers about the cultural elements used in ethnomathematics-based material design are given in Table 1.

Table 1. Cultural Elements (Situations) Used in the Ethnomathematics-Based Material Prepared by Prospective Teachers

Themes	Sub-themes	Participants
Elements in the context of architectural structures	Galata Tower	S4
	Hıdırs house structure	S25
	Mosque	S1, S8, S11, S21, S13
	Tomb	S22
	Water well	S10
Elements in the context of handicrafts	Felt	S2, S20
	Carpet-rug motifs	S3, S5, S6, S14, S17, S18, S21, S24
	Tile patterns	S11, S23
	Marbling art	S19
Elements in the context of the history of mathematics	The decimal system of	S9
	Metehan	
Elements in the context of daily life	Tent	S12
	Tea picking cable car	S25
	Tile Floors	S15, S13
Elements in the context of games	Chess	S16

Table 1 shows that prospective teachers used cultural elements related to handicrafts most frequently when preparing ethnomathematics-based materials, followed by elements related to architectural structures, and then, in order, elements related to daily life, elements related to the history of mathematics, and elements related to games. Prospective teachers are seen to use elements such as mosques, tombs, Galata Tower, water wells, and hıdırs house structures in the context of architectural structures. In the context of architectural structures, it can be seen that the focus is on Islamic geometric shapes, such as the motifs found on mosque walls and the patterns on mosque domes, on the one hand, and Rumi patterns found in Mevlana, on the other. For example; S13's statement "*I used examples from Selimiye mosque and the tiles we use in our homes. I used these examples to help them make connections with polygons.*", and S4's statement "*I used historical buildings with the architecture of our culture, for example, the Galata Tower, because everyone knows this tower.*" emphasize the elements in the context of architectural structures. Prospective teachers stated that they used carpet and rug motifs, felt, marbling art, and ceramic designs as elements in the context of handicrafts. It is seen that they focus on drawing attention to the elements used in the context of handicrafts, ensuring that they are in line with the learning outcomes of mathematics courses while also raising awareness of cultural heritage.

For example, S3's '*Carpet and rug motifs. The learning outcome I wanted to give my students was "to name polygons and recognize their basic elements"*', so I chose the theme of carpets and rugs,

which contain quite a lot of polygon examples.', S13's "rug motif. Because there are frequent examples where translation is used.", S2's "It was felt. Since it was a woven product, it was brought together with a certain mathematical form.", S23's "Tile pattern. I preferred it because it is suitable for reflecting and reflecting the location." and S19's "I used marbling art. I liked it because it is a cultural heritage that I like subjectively and I thought it would appeal to the general public." These statements support the elements in the context of handicrafts. It is seen that prospective teachers also emphasize elements in the context of the history of mathematics. For example, S9's statement, 'I used the decimal system of the Hun emperor Metehan. I wanted to combine numbers such as 10, 100, 1000, and 10,000 in the decimal system with exponential expressions,' supports the use of elements in the context of the history of mathematics. In the context of daily life, prospective teachers state that they use elements such as tents, tea-picking cable cars, and tile flooring in the ethnomathematics-based materials they prepare. For example, S12's statement, 'Native American tent. My reason for choosing it is that I am curious about Native American culture and why they use this prismatic structure,' supports elements in the context of daily life. It is noteworthy that a prospective teacher chose to use chess in the ethnomathematics-based material they prepared in the context of games. The statements of S16, one of the prospective teachers, 'I preferred to use chess as an ethnomathematics-based material suitable for my learning outcome. With this material, I aimed for students to associate a mathematical situation with a cultural value based on the story of chess in my learning outcome...' emphasize the elements in the context of games.

As a second step, findings regarding which learning domain prospective teachers preferred when preparing ethnomathematics-based materials are presented in Table 2.

Table 2. Prospective Teachers' Preferred Learning Domains in Preparing Ethnomathematics-Based Materials

Themes	Sub-themes	Participants
Numbers and operations learning domain	Operations with numbers	S1, S10, S15
	Pattern	S21
	Fractions and ordering	S2, S22, S18
	Percentages	S7
	Operations on natural numbers-exponential expressions	S9, S16
Geometry and measurement learning domain	Geometry	S3, S4,
	Triangles and quadrilaterals	S5
	Geometry and measurement	S6, S13, S19, S23, S24
	Accompaniment and resemblance	S14
	Polygons	S11
	Pythagorean theorem	S25
	Area of the circle	S8

Rectangular prism	S20
Other answers	S12, S21

Table 2 shows that prospective teachers prefer to prepare ethnomathematics-based materials in the geometry and measurement learning domain, followed by numbers and operations. In this context, it is seen that they have addressed topics such as triangles and quadrilaterals, accompaniment and resemblance, polygons, the Pythagorean theorem, the area of a circle, and rectangular prisms in the geometry and measurement learning domain. In addition it is seen that they stated that they preferred the subjects they dealt with because they were the most challenging but also the subjects that could be easily prepared for material. For example, S3 states, "*Geometry, because I could adapt the culture to geometry,*" and S6 states, "*Geometry and measurement. I thought this would be the most challenging learning domain and the one that needed the most material.*" and S13's "*Geometry and measurement, I thought I could prepare more effective material in this learning domain.*" support this learning domain. In addition, when prospective teachers select topics related to numbers and operations learning domain, they tend to choose topics for which there is not much material available, thinking that this will make it easier to relate this learning domain to the history of mathematics. For example; S9's "*Operations with Natural Numbers - Exponents, I chose this subject so that I could reach the history of mathematics more easily.*", S10's "*Numbers and operations because this subject is a subject that students have difficulty with.*" and S15's "*I studied in the field of numbers and operations learning domain because it contains the basic skills in mathematics.*" emphasize the theme of numbers and operations learning domain. In addition, it was observed that some of the prospective teachers' answers to the question of the learning domain they included while preparing ethnomathematics-based materials were not related to the research problem. Therefore, these answers were included in the other category.

Table 3 shows the answers regarding the stage of the mathematics course at which prospective teachers can use the ethnomathematics-based materials they have prepared.

Table 3. Prospective Teachers' Thoughts on the Phases of Mathematics Courses in Which Ethnomathematics-Based Materials They Have Prepared Can Be Used

Themes	Sub-themes	Participants
5E Model Stages	Engage	S2, S4, S5, S6, S7, S8, S9, S12, S14, S16, S19, S23
	Explore	S3, S4, S11, S13, S14, S15, S20, S21, S22, S25
	Explain	S6, S10, S16, S17
	Elaborate	S1, S21, S25
	Evaluate	S6, S14, S16, S18, S24

Table 3 shows that prospective teachers believe that ethnomathematics-based materials can be used in mathematics courses in accordance with the stages of the 5E Learning Model. Therefore, this model was identified as the theme and each stage of the learning model was expressed as a sub-theme. In this context, it is noteworthy that prospective teachers (S2, S4, S5, S6, S7, S8, S9, S12, S14, S16, S19, S23) indicate that ethnomathematical materials can be used to attract attention and motivate students, especially at the engage stage. Prospective teachers stated that they would prefer to use ethnomathematics-based materials after the engage stage of the course, especially during the explore stage. Prospective teachers who stated that the materials could be used in the explore stage of courses (S3, S4, S11, S13, S14, S15, S20, S21, S22, S25) indicated that this choice would contribute to students' own learning and meaningful learning.

For example, S13's statement *"It would be more appropriate to use it in the explore stage. Because it will enable students to learn personally."* and S22's statements as *"In exploration because it is to guide the students with the material and enable them to understand fractions themselves."* support the use in the explore stage with their justifications. In addition, it was determined that prospective teachers emphasized the elaborate stage the least. For example, the statement in S25 that '...it can be used in the elaborate stage because they will be practicing' supports this sub-theme. In addition, it is observed that prospective teachers indicate that they intend to use the materials during the evaluate stage for the purpose of practicing and reinforcing their skills. S16's statement "...it was designed in such a way that it can be used for students to practice during the evaluate stage." emphasizes the evaluate stage..

Within the scope of the study, the data regarding the answers given by the prospective teachers about the difficulties they experienced while preparing ethnomathematics-based materials are given in Table 4.

Table 4. Difficulties Experienced by Prospective Teachers in Preparing Ethnomathematics-Based Materials

Themes	Sub-themes	Participants
Pre-construction phase	Choosing a topic	S17, S23
	Combining culture with mathematical subjects	S10, S19, S20, S21, S25
	Selecting cultural elements	S8, S14
	Adding culture to material	S3, S5, S6, S7, S9, S11, S15, S18
	Making the subject matter understandable for students	S1, S8
Construction phase	Finding and selecting materials	S6
	Manual labor-technical works	S12, S16, S17, S22, S24, S25
I had no difficulty	I had no difficulty	S2, S4, S13

Looking at Table 4, some prospective teachers stated that they had difficulty in the pre-production and production phase while preparing ethnomathematics-based materials, while others stated that they did not experience any difficulties. It is also noteworthy that prospective teachers' thoughts are concentrated on the pre-production phase. At the pre-construction phase, it is seen that prospective mathematics teachers (S3, S5, S6, S7, S9, S11, S15, S18) stated that they had more difficulty in adding culture to the material. For example, S3's statement as *"I had a lot of difficulty in adding culture to the material. I thought that if my topic was on polygons, I would design a material on carpets and rugs and I chose my last learning outcome accordingly."* emphasizes this situation. In addition, some prospective teachers (S10, S19, S20, S21, S25) stated that they had difficulty combining mathematics topics with culture. S20's statement, 'I had chosen the topic beforehand, but I found it difficult to apply ethnomathematics to rectangular prisms,' also supports this view. When looking at the situations that prospective teachers find difficult during the production phase, it can be

seen that some of them (S12, S16, S17, S22, S24, S25) refer to manual labour and technical work, while the prospective teacher with code S6 refers to the difficulty of finding and selecting materials. The statement by prospective teacher S22, “I had a lot of trouble making sure all the circle segments were equal when making the material. It was very difficult to cut with a craft knife,” is one of the statements that fits this theme. However, there are also prospective mathematics teachers (S2, S4, S13) who stated that they did not experience any difficulties.

Findings Regarding Prospective Teachers' Thoughts on the Possible Effects of Ethnomathematics-Based Materials on Students

The second sub-problem was determined as ‘What are the thoughts of prospective teachers about the possible effects of ethnomathematics-based materials on students?’ and this sub-problem was analyzed in two parts as the possible effects of the materials on students’ thoughts about culture and their thoughts about the possible effects on students’ learning. First, the findings regarding prospective teachers' thoughts on the possible impact of the materials on students' learning (Table 5) are presented, followed by the findings regarding the possible impact of the materials on students' thoughts about culture (Table 6).

Table 5. Prospective Mathematics Teachers' Thoughts on the Possible Effect of Ethnomathematics-Based Material on Student Learning

Themes	Sub-themes	Participants
Creating consciousness and awareness in learning	Gaining perspective and awareness	S1, S21, S23
	Realizing the usage areas of the subjects in daily life	S12, S17, S19, S21, S23
Providing effectiveness and efficiency in learning	More comfortable and easy comprehension-learning	S2, S7, S10, S14, S17, S18, S22
	Learning by doing and experiencing	S3, S11, S13
	Permanent and meaningful learning	S5, S8, S10, S11, S13, S15, S20, S24, S25
	Concretization	S15, S16, S19
	Providing reinforcement	S7, S24
	Preventing misconceptions	S9, S16
Making learning enjoyable and motivating	Attracting attention and interest	S4
	Making the course fun	S6

Looking at Table 5, it can be seen that prospective teachers focused on the possible effects of ethnomathematics-based materials on student learning, effectiveness and efficiency in student learning, and that they also stated that these materials would contribute to raising awareness and consciousness in student learning and making learning enjoyable and desirable. Prospective teachers seem to place the most emphasis on permanent and meaningful learning in terms of the effectiveness and efficiency of ethnomathematics-based materials on student learning. For example, S20's *"I think it will make learning more meaningful and permanent"*, S15's *"...In addition, a course content that will make a great contribution to the formation of the basic concepts of the algebra subject they will see in the 8th grade will be given and taught to the students permanently with concrete material."* and S8's *"They will discover the formula instead of memorizing it. There will be permanent learning"* are statements that support permanent and meaningful learning. Then, the emphasis on the theme of more comfortable and easy comprehension-learning draws attention. For example, S2's *"I believe that children will comprehend more easily"* and S14's *"Thanks to this material, I think it will be easier to comprehend the subject of percentages without relying on memorization."* are the statements that support this theme. Another sub-theme that supports effectiveness and efficiency in learning is concretization. S19's statement *"By making learning more concrete with the material...."* and S16's statement *"Since 6th grade students will learn exponential expressions for the first time, I think that using such a material will enable them to concretize an abstract situation more easily and minimize the possibility of misconceptions."* emphasize both concretization and prevention of misconceptions. Prospective teachers draw attention to two different situations: raising awareness and consciousness in students' learning by helping them realize how the topics are used in daily life, and gaining perspective and awareness. S12's *"To show that mathematics is used in many areas in daily life. To show that it is not only on paper."* and S17's statements such as *"When students see the rug patterns and tile patterns on the carpets in our daily life, they will see that they are also used in mathematics....."* support the awareness of the areas of use in daily life. S1's statement that *"Students' perspective and awareness will increase"* also indicates that he supports gaining perspective and awareness sub-theme. Although few prospective teachers believe that materials will make learning enjoyable and motivating for students, their awareness of this point is quite important. The statement by the prospective teacher with code S4, *'It will both attract the student's interest in learning this subject and ...'* shows the emphasis placed on attracting the interest and attention of students. With the statement, *'Although it depends on the teacher, I think students will generally have fun,'* prospective teacher S6 supports the idea that learning can be fun for students.

Prospective teachers considered the possible effects of ethnomathematics-based materials on students' cultural beliefs in four different ways: *'Recognizing the relationship between mathematics and culture in their environment,' 'Understanding the importance of cultural artefacts,' 'Recognizing the historical development of culture,'* and *'No effect.'*

Table 6. Prospective Teachers' Thoughts on the Possible Effects of Ethnomathematics-Based Materials on Students' Cultural Beliefs

Themes	Sub-themes	Participants
Recognising the relationship between mathematics and culture in their environment	Understanding the place of mathematics in	S1, S3, S7, S9, S10, S14,
	cultural values	S15, S17, S22
	Realizing that mathematics and culture are	S12
	universal	
	Versatile thinking and different perspectives	S1, S4, S13, S21, S24

Knowing the importance of cultural artifacts	Increased attention and interest in cultural artifacts	S4, S5, S8, S19
	Understanding of protecting cultural artifacts and transferring them to the future	S4, S17
	Understanding the meaning of cultural artifacts and recognizing culture	S5, S17, S20
	Opportunity to closely examine cultural artifacts	S11
Recognizing the historical development of culture	Recognizing materials used in the past	S2, S20
	Knowing how cultural elements emerge and develop	S16, S20, S23
	Understanding the historical development of mathematics	S9
No effect	No effect	S18
Other answers		S6, S25

Looking at Table 6, in the context of the theme of awareness of the relationship between mathematics and culture in their environment, prospective teachers (S1, S3, S7, S9, S10, S14, S15, S17, S22) stated that ethnomathematics-based materials would be useful in understanding the place of mathematics in cultural values. S1's statement "It will enable students to think in a multidimensional way when they come to the idea that mathematics can leave the classroom and be found in a place of worship." and S10's statement "It will enable students to see that mathematics with ethnomathematical patterns or in their culture is actually everywhere" emphasized this sub-theme. In addition, prospective teachers (S1, S4, S13, S21, S24) stated that the materials would provide students with a multifaceted and different perspective on culture. In this context, S13's statement "...I think it broadens their cultural perspectives." and S21's statement "Since you need to find examples in the material I made because you have to design it yourself, they can examine the mosques around them with a different perspective." can be shown as examples. In addition, the sub-themes of increasing attention and interest in cultural artifacts, understanding the meaning of cultural artifacts and recognizing culture, and knowing how cultural elements emerge and develop were identified. In this sense, S4's, "While showing this material, we can also increase their interest in historical artifacts...", S17's "Students will now see the motifs used in the materials on the carpets they see. Since they know what they mean, they will tell others about them..." and S16's "Students learn about how chess emerged. They learn how Turks incorporated chess into their culture..." expressions can be given as examples. In the other answers, it was stated by the prospective mathematics teachers that the materials would contribute to students in terms of the understanding of protecting cultural artifacts and transferring them to the future, recognizing the materials used in the past, realizing that mathematics and culture are universal,

the opportunity to closely examine cultural artifacts, and understanding the historical development of mathematics. For example; S4's "While showing this material, I can also increase their interest in historical artifacts and explain how important it is to protect them and pass them on to future generations.", S20's "I think they can know the use of felt in various objects such as rugs, clothes and accessories and jewellery and the history of felt and interpret it accordingly. " and S9's "I think it is important for them to know that exponential expressions were also used in the past thanks to Metehan's army system and to see the place of the history of mathematics in our lives." point to these sub-themes. There is a prospective mathematics teacher (S18) who stated that ethnomathematics-themed materials would have no effect on students' thoughts about culture.

DISCUSSION, CONCLUSION AND SUGGESTIONS

In this study, prospective teachers' thoughts on the process of preparing ethnomathematics-based materials and the possible effects of the materials on students were examined. At the same time, prospective teachers experienced the process of combining ethnomathematics with teaching materials in this process. The diversity of cultural elements used by prospective teachers in the process of preparing ethnomathematics-based materials emerges as a remarkable result. This diversity in cultural elements provides important clues on how to make cultural context functional and concrete in mathematics teaching. In Şişman's (2022) study, it is pointed out that prospective teachers use various cultural elements in ethnomathematical activities, which supports the results of the study. However, it is seen that they mostly included elements in the context of handicrafts, followed by elements in the context of architectural structures, elements in the context of daily life, elements in the context of the history of mathematics and elements in the context of games. This shows that prospective teachers are aware of mathematics in their culture as a result of the emphasis in the curriculum of the CoHE (2018). Cultural elements in the context of architectural structures, which are among the most frequently preferred areas of prospective teachers, were evaluated as an effective tool especially in the concretization of achievements in the field of geometry. The findings of Putra et al. (2025) that local architecture is effective in the difficulties experienced in geometry learning in ethnomathematics-based teaching practices support the research in this context. In addition, the cultural elements used by prospective teachers in the context of handicrafts such as carpet-rug motifs and tile patterns can contribute to prospective teachers' understanding of mathematical concepts such as pattern symmetry through these cultural elements. In particular, the geometric structures and repetitive patterns found in traditional handicrafts may provide meaningful contexts for exploring mathematical concepts such as symmetry, transformations and geometric patterns. Similarly, Kabuye Batiibwe (2024) pointed out in a systematic review that ethnomathematics practices based on handicrafts increased students' awareness and interest. Prospective teachers mostly preferred to use architectural structures such as mosques, tombs, water wells and handicrafts such as carpets-rugs, tile patterns, marbling art as ethnomathematics-based material elements. The cultural elements that prospective teachers encounter in the university where they study or in their immediate surroundings may cause this situation to arise. In Doğan and Eryılmaz's (2022) study examining the knowledge levels and awareness of prospective teachers about ethnomathematics, the mathematical information they noticed in cultural values emerged in architecture, weaving and games, which is similar to the findings of the study. Similarly, in Ergene, Çaylan-Ergene, and Yazıcı's (2020) study on the process of designing and implementing ethnomathematics activities involving prospective teachers, teachers and students, examples of mosques, cross-stitch, and motifs were seen in the activities prepared. Another result obtained is that the prospective teachers, especially when using the elements in the context of handicrafts, stated that on the one hand it is appropriate for their subjects and on the other hand it draws attention by making them aware of their cultural heritage. Arı et al. (2019) emphasized that culture-based mathematics education increases students' interest and motivation, which is in line with the results of the study.

The learning domain preferred by prospective teachers were examined and it was concluded that the answers given were limited to two learning domain. It is seen that they wanted to prepare ethnomathematics-based materials only in the learning domains of numbers and operations with geometry and measurement. Prospective teachers may have thought that they could relate mathematics and culture more easily by using the topics in these learning domains. The reason for the prospective

teachers' preference of geometry and measurement and numbers and operations learning domains may be that these domains can be directly associated with cultural elements such as traditional handicrafts, architectural structures, measurement practices and games. In fact, the fact that prospective teachers are mostly focused oriented on geometry learning may indicate that they tend to associate cultural elements with more concrete and visual qualities. This may be due to the fact that the ethnomathematics approach is a natural fit with geometry teaching. Snipes and Moses' (2001) emphasis on the fact that geometric concepts are encountered more in cultural contexts supports the results of the study. Similarly, Çenberci and Horzum (2023) concluded that the mathematical situations encountered in cultures are mostly related to the geometry and measurement learning domain. In the study by Maryati and Prahmana (2019), it was observed that geometry fields such as reflection, rotation, translation were used in bamboo handicrafts made by local people in Indonesia. It is possible to say that all these support the results of the research. In addition, it can be stated that the use of geometric shapes in most of the structures in the culture in which they live prompted prospective teachers to think in this way. In the study conducted by Ergene, Çaylan Ergene, and Yazıcı (2020) on designing and implementing ethnomathematics activities, it is seen that most of the designed activities are related to transformation geometry and geometric shapes. On the other hand, it is noteworthy that the numbers and operations learning domain is less preferred than the geometry and measurement learning domain. This situation suggests that associating number and operation-based concepts in a cultural context and creating materials are perceived as more abstract and challenging by prospective teachers. In this context, examples such as the historical development of number systems, the change of units of measurement over time, and old calculation methods can be powerful resources in raising the awareness of prospective teachers.

It was concluded that the stages preferred by prospective teachers during the use of ethnomathematics-based materials in mathematics courses were identified with the stages of the 5E Learning Model. It can be stated that this situation arises from the awareness of the prospective teachers that the 5E learning model within the constructivist approach is a model that enables students to be active and supports the learning environment in the process of preparing and using materials. It is noteworthy that the prospective teachers stated that these activities can be used mostly in the engage and explore stages of the courses within the steps of the 5E Learning Model. As a matter of fact, it is known that the engagement stage of the model is the stage where student motivation is provided, connections with daily life are established, and studies are carried out to increase interest and attention; the exploration stage is the stage where student knowledge is structured and the targeted knowledge and concept are reached as a result of the desired discoveries (Boz-Yaman, 2021). The reason why these stages were chosen may be that the prospective teachers thought that the materials could be used to attract attention in the course, to ensure active participation of the students, and to explore the knowledge or concept. They may have thought that ethnomathematics-based materials could be remarkable, especially at the engage stage, and that the materials could ensure active participation because they were close to students' lives. This result is in line with D'Ambrosio's (2001) principle of students making meaning with their own cultural background. However, the low number of prospective teachers who suggested the use of ethnomathematics-based materials at the explain, elaborate and evaluate stages may have resulted from their lack of knowledge about the use of materials at these stages. In the study conducted by Öztürk and Işık (2018), it was stated that prospective teachers prepared the activities mostly for the purpose of transition to the course such as comprehension and concretization. This supports the result of the study. However, the fact that there were prospective teachers who suggested the use of cultural elements in the explain and elaborate stages shows that these prospective teachers have more developed awareness of integrating cultural elements with mathematical concepts. In addition, the fact that prospective teachers stated that ethnomathematics-based materials can be used in the evaluate stage can shed light on alternative evaluation approaches.

When the process of prospective teachers' preparation of ethnomathematics-based materials was examined, it was emphasized that there were various difficulties not only before but also during the construction phase. However, it was concluded that prospective teachers especially focused on the difficulties experienced in the pre-construction phase. At this stage, they expressed difficulties such as

adding culture to the material, combining culture with mathematics topics, choosing a topic, making the topic understandable for students, and choosing cultural elements. It can be stated that this situation may be due to the lack of knowledge of prospective teachers on how to transfer culture and mathematics to the material, as well as their difficulty in establishing a meaningful relationship between cultural context and mathematical outcome. Therefore, prospective teachers should be supported not only in selecting cultural content but also in relating it to the learning objective. Similarly, the difficulties of associating culture and mathematics are also experienced in the preparation of mathematical activities (Ergene, Çaylan Ergene & Yazıcı, 2020). In addition, when determining ethnomathematics-based activities, instead of decorative activities in which the cultural element is used superficially, it should be in a way that the student can interact with the cultural element, discover it, encourage group work, and ensure understanding of concepts (Baştürk, 2024). Therefore, it is possible to state that prospective teachers lack knowledge and experience in this regard. Putra et al. (2025) also emphasized the need to improve prospective teachers' ability to relate mathematical content to cultural elements in a meaningful way. It is seen that prospective teachers had difficulties in finding and selecting materials and manual labor-technical works during the construction phase. The results of the study conducted by Ergene, Çaylan Ergene, and Yazıcı (2020) show similarities with this study in that the prospective teachers had difficulties in selecting activities, combining subject matter and ethnomathematics, transferring the activity to the classroom environment, and using tools and materials that require manual skills while designing activities. Similarly, according to the results of Öge Yaşar's (2017) study, it is stated that students who take the Instructional Technology and Material Design course face difficulties such as lack of materials, inability to decide on the material to be prepared, cost and lack of skills. As a result, these difficulties experienced by prospective teachers while preparing ethnomathematics-based materials vary depending on their personal experiences and manual skills related to the concept of ethnomathematics on the one hand and material preparation on the other hand.

The sub-problem in which prospective teachers' views on the possible effects of the ethnomathematics-based materials they prepared on students' thoughts and learning about culture were determined was analyzed in two stages. In the first stage of this sub-problem, prospective teachers expressed opinions on the possible effects of ethnomathematics-based materials on students' learning and focused on the theme of providing effectiveness and efficiency in learning. In the context of providing effectiveness and efficiency in learning, the emphasis on permanent and meaningful learning, more comfortable and easy learning, concretization of concepts, students' learning by doing, experiencing, experimenting and exploring draws attention. These data support Gerdes' (2010) findings that abstract mathematical concepts become more understandable for students when they are associated with cultural examples. It is also possible to state that prospective teachers are aware that the use of ethnomathematics-based materials will help students to be active in the learning process and to experience the process of discovery. In this case, it can be stated that the emphasis on effectiveness and efficiency is made in terms of ethnomathematics on the one hand and concrete materials on the other. In their study, Sharma and Orey (2017) concluded that students realized meaningful learning in geometry teaching with the method they applied by including a cultural musical instrument called "dhol". Similarly, Gravemeijer and Terwel (2000) found that prospective teachers' determination that students' combining mathematics with their own culture would contribute to meaningful learning supports the results of the study. In addition, in the study conducted by Çiftçi, Yıldız, and Bozkurt (2015), teachers stated that the use of materials in mathematics courses would contribute to concretization and increase retention. In addition, prospective teachers state that the materials will be effective in terms of comfortable and easy learning, preventing misconceptions, providing reinforcement and faster learning. These views expressed by prospective teachers clearly show that they also emphasize the constructivist approach. Some prospective teachers emphasized that the materials would make learning enjoyable and enthusiastic, that they would attract attention and interest, and that they would make the learning environment fun. This situation offers a prediction that ethnomathematics approach can contribute to students' affective skills. In particular, it is said that cultural elements such as games, art and architecture that can attract students' interest will make students more enthusiastic (Kabuye Batiibwe, 2024). Prospective teachers emphasize the importance of making the learning environment remarkable and fun, and they think that bringing mathematics in

the culture they live in to the classroom environment will provide students with a pleasant and interesting environment. In Ergene, Çaylan Ergene, and Yazıcı's (2020) study on prospective teachers' design and implementation of ethnomathematics activities, it is stated that ethnomathematics activities positively affect students' perspective on mathematics, increase students' knowledge about our culture, and increase their interest and motivation towards the course. Therefore, it is possible to say that it supports the results of this study. In the context of creating consciousness and awareness in learning, prospective teachers emphasize that the materials will raise students' awareness about the usage of mathematics subjects in daily life. According to prospective teachers, students' awareness of mathematics in carpets, rugs and mosque decorations in the materials will support them to discover mathematics in culture.

In the second stage of the research sub-problem, prospective teachers' predictions about how the ethnomathematics-based materials they prepared would affect students' thoughts about culture were analyzed. Accordingly, it was seen that three different themes emerged such as noticing the relationship between mathematics and culture in their environment, knowing the importance of cultural artefacts, and noticing the historical development of culture. This situation emphasizes that prospective teachers think that the ethnomathematics-based materials they prepared have the potential to support students' understanding of culture. It can be said that most of the prospective teachers thought that students would be able to recognize the traces of mathematics in the cultural elements around them thanks to the materials prepared. Prospective teachers emphasize that within the scope of being aware of the relationship between culture and mathematics in their environment, students will understand that mathematics is included in cultural values, that mathematics and culture are universal, and that it will enable students to develop multidimensional thinking and different perspectives. This also points to awareness of the impact of culture and mathematics on each other. However, it shows that prospective teachers are aware of the fact that mathematics education is not only limited to numbers and formulae, but also has a deep meaning in cultural contexts. In Şişman's (2022) study, prospective teachers stated that integrating culture into mathematics courses would provide students with positive attitudes, interest and participation, retention in learning, and cultural awareness. In this sense, it is possible to state that it supports this study. The prospective teachers also stated that the materials can contribute to students in terms of knowing the importance of cultural artefacts. In this context, it is stated that with the use of materials, students' attention and interest in cultural artefacts will increase, their understanding of protecting and transferring cultural artefacts to the future will develop, understanding and recognition of cultural artefacts will be ensured and the opportunity to examine them closely will be provided. In this respect, the materials prepared can provide gains not only in terms of mathematics but also in terms of cultural heritage. The views of D'Ambrosio (2001) that mathematical learning in a cultural context can contribute to the identity development of individuals are consistent with the results of the study. However, when we look at the discourses of prospective teachers in this process, it is seen that they mostly take into account the situation they and their students are in, cultural values and elements. However, it is stated that ethnomathematics can also contribute to learning and accepting different cultures, being tolerant towards differences and contributing to students' ability to look at the world from different perspectives (Spring, 2019). Therefore, it is possible to state that prospective teachers did not emphasize these points clearly and explicitly. In addition, the prospective teachers in the study emphasized that ethnomathematics-based materials can enable students to realize the historical development of culture by stating that they will learn the materials used in the past, how cultural elements emerged and developed, and the historical development of mathematics. On the other hand, some participants stated that the material would have no effect on cultural thinking. This situation shows that individual experiences of prospective teachers may affect their perceptions of cultural awareness level. In addition, some candidates could not clarify their thoughts by giving answers in the category of other answers or addressing them from different dimensions.

As a result, the fact that the prospective teachers emphasized various cultural elements while preparing ethnomathematics-based materials shows that they took into account the instructional side of this process and aimed to ensure that the elements encountered in daily life are learned effectively and meaningfully by the students through embodied materials. In addition to all these, it is possible to state

that they think that the materials will have a positive effect on both students' learning and their thoughts about culture. It can be emphasized that prospective teachers are aware of the importance of culture in mathematics education, and their knowledge and experience in this subject should be further increased. However, it is also understood that prospective teachers need more systematic support in order to develop such materials effectively.

In line with the results obtained in this study, which examined in detail the thoughts of prospective teachers about preparing ethnomathematics-based materials and the possible effects on students in case ethnomathematics-based materials are used, the following suggestions can be made:

- Games with cultural content can be used in mathematics courses.
- For prospective teachers, it may be useful to provide sample scenarios and course plans on how ethnomathematics-based materials can be used in the whole teaching phase.
- In future studies, ethnomathematics-based materials can be developed for topics in the mathematics curriculum and their impact on students' performance, achievement and attitudes can be examined.
- A research on classroom applications of ethnomathematics-based materials could be conducted on teachers or prospective teachers.

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