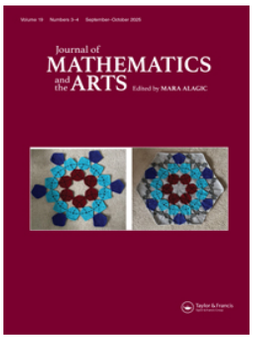

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RESEARCH ARTICLE

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Revealing and examining students' cultural mathematical knowledge and thoughts through an ethnomathematics activity

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ABSTRACT

In this study, the mathematical knowledge and thoughts of middle school 7th grade students with different cultural values were revealed through an ethnomathematics activity originally designed by the researchers and were examined together with school mathematics. In the study the ethnographic case study research design was adopted. As a result of the analysis, it was seen that there were students who used the mathematical knowledge, thoughts and skills they had due to their cultural experiences, apart from their knowledge they acquired within the scope of school mathematics. There were students who could mathematically explain the information they used as well as students who were not aware of using mathematical knowledge.

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KEYWORDS
Mathematics education; ethnomathematics; culture; mathematical thinking; problem solving

1. Introduction

With globalization, societies started to include each other's good features into their bodies by taking these features as good examples. In terms of the education system, this situation has caused societies to develop curricula that are increasingly uniform and independent of their own values (Ernest, 2008; Varghese & McCusker, 2006). Right at this point, ethnomathematics argues that mathematics education should be carried out with curricula including activities that cultures perform in their daily lives (Boaler, 1993; Pinxten, 1994; Pinxten & François, 2011). Students should be given education by giving them 'universal, multidimensional and multicultural' information, and they should be informed about and made conscious of globalization, its effects and the related requirements. In this regard, everyone, especially teachers, who are responsible for giving education and who take a role in the education system, has important duties and responsibilities (Napier, 2018).

Ethnomathematics aims to address the interaction of culture and mathematics and the use of mathematics in a cultural context, while respecting and valuing differences and diversity. Therefore, in mathematics lessons, in line with this purpose, the cultures

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of students should be taken into consideration; teachers should be made aware of this issue; and it should be ensured that their students gain this understanding (D'Ambrosio, 2001a). For a multicultural mathematics education, mathematics curriculum, course contents, teaching tools and materials, teaching methods and techniques, and measurement and evaluation should be considered and prepared appropriately (Zaslavsky, 1998).

It could be stated that ethnomathematics is used in two senses. The first is the implicit mathematics of cultures, namely the ethnomathematics of cultures, and the second is the inclusion of these implicit practices in mathematics education processes (Vithal & Skovsmose, 1997). For the second to happen, the first must be realized. Implicit mathematics is not the mathematics that is done as a goal, but the mathematics that is done in the process of a desired activity in daily life and is usually not noticed. If we think of various cultural products, we can see the unique mathematics that lies behind architectural structures, handicrafts, ornaments, carpets and rugs woven with various motifs, hand knitting and embroidery, engravings pictures drawn on sand, ropes tied in knots (Khipus), tools and equipment created for agriculture and animal husbandry, and so on, which at first glance are thought to be made for aesthetic beauty and art, but which contain information, messages and meanings to be given and conveyed. At the same time, this analysis gives us information about the sociological, anthropological structure and history of culture (Ascher, 1991; D'Ambrosio, 1985; D'Ambrosio, 2001b; Demaine et al., 2007; Gerdes, 1994; Kalinec-Craig et al., 2019).

1.1. Conceptual framework

Mathematical thinking is related to the fact that the act of thinking on any subject has a mathematical structure rather than thinking about mathematics (Burton, 1984). Mathematical thinking, which appears as different processes in different environments, should be included in mathematics education processes, and students should try to develop these skills (Stacey, 2006).

It is a well-known fact that mathematics has a cultural dimension and history and that cultures include mathematical knowledge and thoughts that they have developed and embodied. Mathematical knowledge and thoughts that exist in different cultures can be the same or specific to cultures (Bishop, 1988a; D'Ambrosio, 2001a). From an anthropological point of view, mathematical thoughts vary depending on the time and place. Therefore, it could be stated that mathematical thought is in a close relationship with the cultures in which it is formed and used (Ascher & D'Ambrosio, 1994; Sternberg, 1996).

From a cultural perspective, mathematics is a cultural product. As the formation of mathematical thoughts occurs at the end of a certain process, it is important to carry out cultural or intercultural studies in order to find the source of this formation (Bishop, 1988b). Alan J. Bishop, who investigated whether all cultures on earth have used mathematics or not, aimed to determine certain headings and examine mathematical thoughts based on these headings in order to be able to make cross-cultural analysis. In line with the results obtained by Alan J. Bishop and by other researchers in their studies regarding the relationship between mathematics and culture, Alan J. Bishop identified six fundamental activities, which were carried out in common, or universally, in all cultures. These activities were environmental activities that caused the formation of mathematical patterns within the culture. Bishop named these activities as counting, locating, measuring, designing, playing and explaining to reflect the process in the content (Bishop, 1986; Bishop, 1988b).

1.2. Purpose

The purpose of this study was to reveal and examine the mathematical thoughts of students with different cultural values through an ethnomathematics activity. Accordingly, the answers to the following two questions were sought.

In the solution processes followed by the students with different cultural values for the problem situation in the ethnomathematics activity;

- what is the culture-specific knowledge they refer to and what are the mathematical thinking processes they follow?
- what are the similarities and differences *between* the knowledge they use and the mathematical thinking processes they follow *and* the mathematical thinking processes and the knowledge acquired within the scope of school mathematics?

1.3. Importance of the study

Current undergraduate curricula were prepared by the Council of Higher Education (CoHE) in Turkey in 2018 not only because of the long time since the last update of the teacher training undergraduate programmes adopted in the education faculties of universities in Turkey but also due to the related increasing need and demand in the education system. The current curricula prepared for a total of twenty-five different teaching programmes, including the Elementary School Mathematics Teaching Program, were put into practice in the 2018–2019 academic year with the first graders who started their university education. In the current curriculum prepared for the Elementary School Mathematics Teaching Program (T.R. Council of Higher Education, 2018), a course named 'Culture and Mathematics' was included in the field education elective courses. The content of this course was stated in the curriculum as follows:

> Relationship between mathematics and culture; defining mathematical concepts in their own cultural contexts, mathematical thinking in different cultures, basic principles of research in the field of ethnomathematics, the relationship between mathematics-anthropology-linguistics; importance of including ethnomathematics in in-class practices; designing in-class math activities for different cultural contexts. (p. 23)

Although this arrangement was an important step for elementary school mathematics teacher training programmes in Turkey, it is seen that in Turkey, the number of studies on the use of cultural elements in mathematics lesson processes is quite limited. Moreover, in the literature in Turkey, there is no research on the mathematical knowledge and thoughts of different cultures. This study is important in terms of not just revealing and examining mathematical knowledge and thoughts from different cultures but using cultural elements in the mathematics lesson as well. In other words, in this study, an ethnomathematical perspective was integrated into the mathematics education process.

1.4. Limitations

This study was limited to five students from three different middle schools in Mersin and Eskişehir provinces of Turkey and to the data obtained from these students. Furthermore, the use of an ethnomathematics activity related to the Yoruk culture was the main limitation of this study.

2. Method

2.1. Research model

In this study, the ethnographic case study design, which is within the scope of the qualitative research approach, was adopted.

In the case study design, unlike other qualitative designs, the unit of analysis is the determinant, not the focus of the study. For this reason, it can be used in studies by combining a different design with a case study depending on the purpose (Merriam, 1998; Merriam & Tisdell, 2016). The ethnographic case study design is a combination of ethnographic and case study designs. This design aims to scientifically reveal and examine the lifestyles, behaviours and traditions of people in a certain cultural group or groups (Hancock & Algozzine, 2006). From this point of view, the ethnographic case study design was considered to be the most appropriate research method for this study, which aimed to examine the mathematical thoughts of students with different cultural values. The analysis unit of the study, that is, the case examined in the study, was determined as the mathematical thoughts of students with different cultural values.

2.2. Participants

The participants of this study consisted of a total of five 7th grade students selected from three different public middle schools in Mersin and Eskisehir provinces of Turkey. The purposeful sampling method was used to determine the middle schools and the students. There were two reasons why middle schools were chosen from the two cities mentioned. Firstly, the hometown of the first author was Silifke, a district of Mersin, where the Yoruk culture is dominant and thus where there is a nomadic lifestyle and middle schools with students from this culture. That is, students from the author's hometown were selected in order to find students from the Yoruk culture, of which she is a cultural expert due to her life background. The second reason was that at the time of the study, the first author was an M.A. student who continued her graduate education in Eskişehir, where there were middle schools with students from different cultures. At the same time, Eskişehir province was preferred for the diversity of data that can be obtained from a different city in Turkey on the same subject. The participants were selected on a voluntary basis among the 7th grade students determined at the end of the interviews with the mathematics teachers at the schools. While selecting the students, care was taken to ensure that each of them had a different cultural value (Table 1). The names were coded as Alper, Mehmet, Kerime, Fatma and Baran in order to evaluate the data objectively and to keep the identities of the participants confidential.

2.3. Data collection tools

The research data were collected through semi-structured interview, unstructured participant observation, audio recording, research diary and student products obtained from the participants at the end of the ethnomathematics activity. Table 2 presents the purposes of using these data collection tools in the study.

Table 1. Cultural characteristics of the participants.

Student's Name	Cultural Characteristics
Alper	He was born in Turkey and grew up in the city culture.
Mehmet	He was born in Turkey, and he grew up in a village culture. His family was Yoruk, and they moved from nomadic life to settled life.
Kerime	She was born and raised in Iraq, and she immigrated to Turkey with her family during her elementary school education.
Fatma	She was born in Turkey, and she grew up in a sea-side suburb.
Baran	He was born in Turkey, and he grew up in a sea-side suburb, and he sometimes lived with the Yoruks in his village at the time of the study.

2.4. Ethnomathematics activity: 'Let's Design a Yoruk Tent' and its application process

The ethnomathematics activity named 'Let's Design a Yoruk Tent' implemented in this study was an original activity designed by the researchers.

Within the scope of the activity, a story-based problem situation about the Yoruks was presented to the students. For the problem case, the students were expected to write down the knowledge they had about the Yoruks other than the information given in the story and to design a tent from the materials given to them (Figure 1).

After the students completed the activity process, semi-structured interviews were held with each student. During these interviews, each student was asked what they knew about the Yoruk culture before the activity, what they learned about this culture within the scope of this activity, what kind of process they followed to solve the problem situation given to them and what were the design stages of the Yoruk tent they formed at the end of the process. After detailed explanations about the questions asked by the researcher with guiding questions were given, the students were asked to explain the tents they designed mathematically. Lastly, the semi-structured interview processes were completed by taking the opinions of the students about the activity.

2.5. Data analysis

In this study, qualitative data analysis was conducted both at the stage of data collection and at the next stage after the data were collected. The data obtained were transcribed and analyzed descriptively according to the six fundamental activities determined by Bishop (1988b) in line with the purpose of the study. The findings of the study were obtained by looking at the results of the analysis, and the findings were then interpreted.

3. Findings

The findings are presented under two subheadings. The findings under both subheadings are presented after being classified according to the *planning* and *construction stages* that the students followed while forming their tent designs.

Considering the six mathematical activities identified by Bishop (1988b), the findings showed that each of the students performed five of these activities (Table 3). The activity that the students did not carry out was the *playing activity*. The reason for this was that the ethnomathematics activity was not an activity that required carrying out the *playing*

Table 2. The data collection tools used in the study and the purposes of using them.

Semi-Structured Interview	Unstructured Participant Observation	Audio Records	Research Diary	Student Products
– Collecting the data to be obtained in line with the purpose of the study by allowing the participants to express themselves verbally – Directing new questions to the participants in accordance with their responses to the interview questions in order to shed light on the research topic and to obtain appropriate research data	– Allowing the researcher to collect research data first-hand by being involved in the research process – Preventing possible data loss that will occur when the participants have not fully mentioned their experiences either verbally or in writing in the research process.	– Preventing data loss that will occur when the data obtained in the research process are forgotten, overlooked, misremembered or misremembered – Preventing the probable negative influence of the written notes taken by researchers on the participants in the research process	– Keeping the information and data obtained in the research process by taking notes or with the help of drawings as soon as possible. – Taking descriptive and detailed notes about when, where and how the research data were obtained	– Student products such as written documents, drawings and concrete designs obtained from students in the research process are important data sources for the study. – Providing the opportunity to obtain information about the steps students followed in the research process, about the methods they used and about the results they obtained.

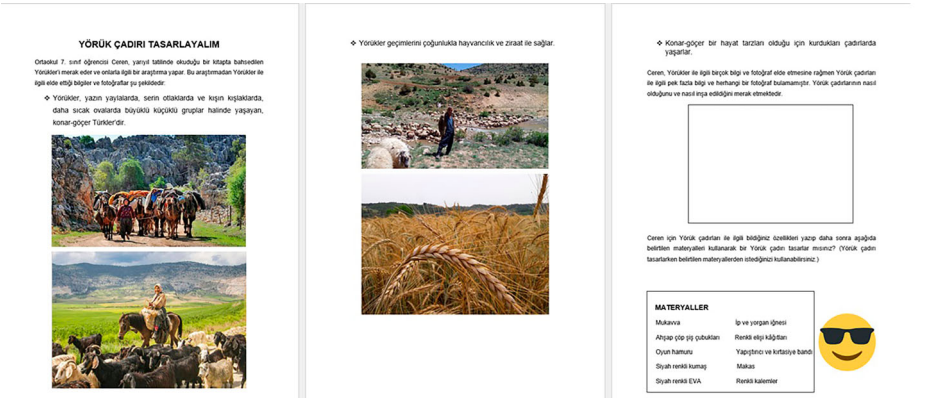

Figure 1. Activity papers of 'Let's Design a Yoruk Tent'.

Table 3. The activities carried out by the students according to Bishop's (1988b) six fundamental activities within the scope of the ethnomathematics activity.

	Counting		Locating		Measuring		Designing		Playing		Explaining	
Alper	☐	☒	☐	☒	☒	☒	☒	☒	☐	☐	☒	☒
Mehmet	☒	☒	☒	☐	☒	☒	☒	☒	☐	☐	☒	☒
Kerime	☐	☒	☒	☒	☒	☒	☒	☒	☐	☐	☒	☒
Fatma	☒	☒	☐	☒	☐	☒	☒	☒	☐	☐	☒	☒
Baran	☒	☐	☐	☒	☒	☒	☒	☒	☐	☐	☒	☒

activity. At the same time, the students did not develop any strategy to carry out this activity throughout the activity or did not make any explanation showing that they carried out this activity.

3.1. Mathematical thinking processes followed by the students and their culture-specific knowledge and mathematical thoughts used in these processes

3.1.1. The planning stage

In the semi-structured interview held at the end of the activity, the researcher directed questions to the students to learn their thoughts and comments about the Yoruk culture. **Alper**, who had limited knowledge about the Yoruk culture, answered the questions within the scope of the modern city life he was born and grew up in and still lived in and within the scope of the city culture he belonged to. The answers given by the student were not correct for the Yoruk life, or the answers were not sufficient in terms of providing detailed explanations. Despite this, the student carried out the *explaining activity* because he tried to make explanations by establishing logical relationships based on his own lifestyle. The related dialogue is given in Table 4.

It was observed that **Mehmet** had knowledge about the Yoruks and their tent-building stages and that he made valid comments about the reasons for these stages. It was understood that the student had the reasoning, estimation and inferencing skills as well as that he carried out the *explanation activity*. The related dialogue can be seen in Table 5.

Kerime reported that she did not know about the Yoruks and that tents were set up in Iraq as well. She stated that she designed a tent similar to those tents and made statements

Table 4. The dialogue between Alper and the researcher about the Yoruks' living in tents.

English Transcript	*Turkish Transcript (Original Interview)*
Researcher: *Why do you think the Yoruks live in tents and not in the concrete houses that exist around us now?* ***Alper:*** *It may be due to their lifestyle because they have nomadic life. Building a house of concrete would be much more difficult and costly. …* ***Researcher:*** *Why do you think a person lives or wants to live as a nomad?* ***Alper:*** *Maybe they want to be free, or maybe they live like that because of their job. For example, they might be doing business between one place and another; for example, between Istanbul and Ankara. For example, they are buying a product there and taking it to another place. … Hmm, shipping companies! They do the same.*	***Araştırmacı:*** *Yörükler neden çadırda yaşıyor, neden şu an etrafımızda var olan betondan yapılmış evlerde değil sence?* ***Alper:*** *Yaşam stilleri ile ilgili olabilir, göçebe yaşadıkları için. Betondan ev yapmak çok daha zor olur ve maliyetli olur. …* ***Araştırmacı:*** *Bir insan neden göçebe yaşar ya da yaşamak ister sence?* ***Alper:*** *Özgür olmak istiyordur belki veya işi gereği öyle yaşıyor olabilir. Mesela bir yerden bir yere ticaret yapıyor olabilir, mesela İstanbul-Ankara arası gibi. Oradan mesela bir mal alıyordur diğerine götürüyordur. … Hmm, kargo şirketleri! Aynısını yapıyor.*

Table 5. The Dialogue between Mehmet and the researcher about the lives of the Yoruks.

English Transcript	*Turkish Transcript (Original Interview)*
Researcher: *Why do you think the Yoruks live in tents? Why in a tent and not in a house built of concrete?* ***Mehmet:*** *Because the tent is easier to set up than (building) a house. … You put concrete under it. You build a wall. That's it, it's so hard. Poles are erected in the tent. After that, the tent is covered with something, and it goes on like that. … Maybe it's because they don't always migrate to the same place, or because they don't stay in the same place.* ***Researcher:*** *Well, what do the Yoruks eat and drink, how is their life? What do you know about that?* ***Mehmet:*** *I think they feed on natural products like the cows and goats they feed. In the evening, they provide light with candles as there is no electricity.*	***Araştırmacı:*** *Yörükler sence neden çadırda yaşıyor? Neden betondan inşa edilen bir evde değil de çadır?* ***Mehmet:*** *Çadırın kurması evden daha kolay olduğu için. … Altına beton döküyorsun. Duvar örüyorsun. Öyle yani, çok zor. Çadırda direkler dikilir. Ondan sonra çadırın etrafı bir şeyle kaplanır, öyle gidiyor. … Devamlı aynı yere göçmedikleri için olabilir belki. Aynı yerde kalmadıkları için.* ***Araştırmacı:*** *Peki, Yörükler ne yer ne içer, hayatları nasıl? Bu konuda neler biliyorsun?* ***Mehmet:*** *Doğal ürünlerden besleniyorlardır bence, besledikleri inekten, keçiden falan. Akşam olunca mumla aydınlık sağlıyorlardır, elektrik olmadığı için.*

about the Iraqi culture. From the student's statements, it was understood that the tent she mentioned was not a tent built for shelter or used as a house due to the people's lifestyles and that it was set up on certain days and for a short time. Based on the student's statements, it could be stated that she completed the *designing* and *explaining activities*. The related dialogue is given in Table 6.

It was understood that **Fatma** had knowledge about the Yoruk culture, yet it was also seen that she had no knowledge of why the Yoruks had a nomadic lifestyle. Although some of her estimations did not reflect the truth, she tried to answer the questions by making logical comments, estimations and inferences. It was seen that the student carried out the *explaining activity*. The related dialogue is given in Table 7.

Baran, who lived with his family in the city centre where the study was carried out, stated that they went to their village in this district from time to time during the school holidays. He said that Yoruks lived in their village and that he made friends with the Yoruk children when he was in the village and visited them in their tents. Although he did not use some of the knowledge he knew in relation to his own tent construction, he carried out the *explaining activity* because he explained the knowledge he got about the Yoruks by interpreting them in a logical framework.

Table 6. The Dialogue between Kerime and the researcher about the use of tents in Iraq.

English Transcript	*Turkish Transcript (Original Interview)*
Researcher: *Is this tent you designed related to the Iraqi culture?* ***Kerime:*** *Yes. … The tent, for example, when something happens, they gather in it, or they can stay there because it is big. For example, when someone dies, they set up a tent in front of the that person's house. Then, they cook something and put a chair in it. Here they put tables, sofas etc. They deliver food to other people. They read the Quran. They do it every day for three days. … Then they form a Divan and meet on certain days.* ***Researcher:*** *What's that Divan?* ***Kerime:*** *A council.* ***Researcher:*** *So what is the purpose of the Divan, what do they meet for?* ***Kerime:*** *Well, they do it to state a rule or sometimes for fun. I mean they're doing something as a family. They're doing it like an organization. They do it all together.*	***Araştırmacı:*** *Senin tasarladığın bu çadır Irak kültürü ile mi ilgili?* ***Kerime:*** *Evet. … Çadır, yani mesela bir şey olduğunda bunun içine toplanıyorlar veya bunun içinde kalabilirler, büyük olduğu için. Mesela birisi öldüğünde çadır kurarlar, ölen kişinin evinin önünde kurarlar. Sonra içinde yemek falan yapıyorlar, içine sandalye koyuyorlar. İşte masa, kanepeler falan koyuyorlar. Yemek dağıtıyorlar. Kuran okuyorlar. Üç gün boyunca yapıyorlar bunu her gün. … Sonra divan olarak belirli günlerde toplanıyorlar.* ***Araştırmacı:*** *Divan ne peki?* ***Kerime:*** *Toplanılan yer.* ***Araştırmacı:*** *Peki divanın amacı ne, ne için toplanıyorlar?* ***Kerime:*** *Yani işte bir kuralı belirtmek için veya bazen eğlenmek için yapıyorlar. Aile olarak bir şeyler yapıyorlar yani. Program gibi bir şey yapıyorlar işte. Düzenliyorlar birlikte.*

Table 7. The Dialogue between Fatma and the researcher about the lifestyle of the Yoruks.

English Transcript	*Turkish Transcript (Original Interview)*
Fatma: *Yoruks are Turks, and they are nomads. Their houses are tents because if their houses are concrete, they cannot lift or take them away. They will then have to build houses everywhere. They are engaged in animal husbandry and agriculture.* ***Researcher:*** *So, why do you think Yoruks adopt this lifestyle?* ***Fatma****: Maybe they like nature. They are against concrete houses or urbanization. Maybe they became nomads because they couldn't feed animals in the city.*	***Fatma:*** *Yörükler Türk'tür, konargöçer, göçebedirler. Evleri çadırdır çünkü beton olursa kaldıramazlar, götüremezler. Sonra her yerde ev yapmak zorunda kalırlar. Hayvancılık ve tarımla uğraşırlar.* ***Araştırmacı:*** *Peki Yörükler neden bu yaşam tarzını benimsiyorlar sence?* ***Fatma:*** *Belki doğayı seviyorlardır. Beton evlere ya da şehirleşmeye karşıdırlar. Belki de hayvanlarını şehirde besleyemeyecekleri için göçebe olmuşlardır.*

3.1.2. The construction stage

Alper designed a chimney in the Yoruk tent. This showed that he used one of the structural features of the houses, which were built in the settled life, in the Yoruk tent he designed. As a result of the *designing activity*, the student formed an unsuitable construction for the Yoruk tent. He said that he glued the tent sticks together or combined them with play dough, but in real life, the Yoruks tied the stakes together with ropes so that their tents would not fly in the wind and fixed their lower ends to the ground. He stated that the tent he designed could be suitable for the Yoruks to live in if the pieces were formed with more care. Although the student did not know the real-life Yoruk tents, it could be stated that he had an idea about the structure of the house forms necessary for people's residence. The student carried out the *designing activity* by considering the life of the Yoruks and using the materials given to him, and he carried out the *explaining activity* by mentioning the reasons for the process he followed and the materials he used.

It was seen that **Mehmet** fixed the sticks to the cardboard with play dough from the bottom of the cardboard on which he had drilled holes. He stated that by doing so he 'prevented the sticks from coming out of the cardboard'. In addition, he reported that he fixed the sticks to the cardboard with play dough, based on the method he had used before when he and his friends were building a football goal. After completing the tent design,

Figure 2. The door and tree design made by Mehmet.

Table 8. The Dialogue between Kerime and the researcher about tent decorations in Iraq.

English Transcript	*Turkish Transcript (Original Interview)*
***Kerime**: Once my father's friend passed away, and I went to the funeral with my father. I saw the inside of the tent there. It was not just black. It had squares and rectangles on it, and they were brown and red. Here the tent was black but with symbols on it.* ***Researcher**: Got it. So, do those symbols have any meaning?* ***Kerime**: No, that's how they put it. It was like an ornament.*	***Kerime:** Bir keresinde babamın arkadaşı vefat etmişti, babamla birlikte gitmiştim. Orada gördüm içini de. Sadece siyah değil. Üstünde kareler, dikdörtgenler var, o da kahverengi kırmızılı. İşte çadır siyahtı ama üstünde semboller vardı.* ***Araştırmacı:** Anladım. Peki, o sembollerin bir anlamı var mı?* ***Kerime:** Yok yani, öylesine koymuşlar. Süs gibi.*

Mehmet cut the felt of one of the side surfaces of the tent and created an opening to enter and exit the tent. Later, he designed a tree and added this tree to the side of the tent with a hole he made in the cardboard (Figure 2). From this point of view, it was possible to say that the student performed the *designing* and *explaining activities* using reasoning, association, estimation and inference skills.

Mehmet stated that he wanted to use needle and thread in the process of covering the surfaces of the tent skeleton with felt. The student formed separate pieces of felt to cover each lateral surface of the tent and stitched them together, including the sticks that made up the skeleton.

Kerime said that she was in one of the tents set up there once when he was in Iraq, and she reported that there were colourful geometric shapes on the tents. The related dialogue is given in Table 8.

The fact that Kerime told the researcher there were rectangular and square shapes on the tents and that she wanted to add these shapes to the tent she formed after the activity was an indication that Kerime knew these two geometric shapes. This was within the scope of the *designing activity*. She said these geometric shapes added to the tent surface were in different colours to prevent the light absorption of the tent made of black fabric, and it was thus understood that she carried out the *explaining activity*.

Fatma stated that she made the top of the tent as a roof so that in rain or snow, there would be a downward flow. She also stated that the Yoruks may have built their tents in the form of a square ceiling in the early days; that the tent may have collapsed on them when it rained and snowed; and that they could have found the ideal tent shape through various trials. These statements of the student were within the scope of the *designing* and *explaining activities*.

Baran said, 'so that it will not be destroyed quickly. Now, if there is rain or hail on top of this, it will stay there and its water will immediately go down (he means that rain and snow water will flow into the tent.); however, here, it flows down directly'. These statements of Baran showed that he built his tent by taking into account the adverse weather conditions. Giving reasons by establishing logical relationships about the shape of his tent was an indication that he had fulfilled the *explaining activity*. In relation to the size and width of the tent, Baran considered the living conditions of the Yoruks and the effects of the weather conditions on their lives and said 'It keeps warmer. When it is a large room, its heat does not spread everywhere; yet when it is small, its heat spreads everywhere.' This statement of Baran was within the scope of the *explaining activity,* and the design he made accordingly was within the scope of the *designing activity*.

3.2. Mathematical thinking processes followed by the students and the similarities and differences between the mathematical knowledge and thoughts used by the students and ways of mathematical thinking and the knowledge learned within the scope of school mathematics

3.2.1. The planning stage

Alper stated that the Yoruk tent he designed had a square base. Although he did not mention it himself, the researcher observed that he approximately determined the length of the stick forming one side of the square and that he cut the sticks forming the other three sides in a way to be of equal length with this stick. This base was in the form of a quadrilateral with equal side lengths. In other words, this quadrilateral could be a square or a rhombus. The student had learned both geometric shapes within the scope of school mathematics until the 7th class grade. He used the same method to form the side faces of the tent he set up in the form of a right pyramid. The fact that the student made a decision regarding which geometric object the Yoruk tent would have; that he determined a geometric shape for the tent base; and that he decided on the lengths of the tent's edges and on how to form them indicated that the student carried out the *designing activity*. In addition, his reference to the stick lengths he determined so that he could form not only the sides of the quadrilateral forming the tent base but also the lateral edges of the geometric object was an indication that he used non-standard units of measurement and therefore carried out the *measuring activity*.

Mehmet started the tent planning process by cutting one of the sticks approximately in half. He tried to form a quadrilateral by drilling holes in the cardboard he used as a floor. He created twelve holes in total (Figure 3).

Although the student stated that this shape was a square, it was seen that he created it by eye without precise measurement. After the activity, the edges of the shape were measured with a ruler by the researcher. It was seen that they were 8.2, 9.3, 7.7 and 9.2 cm in length, respectively and that the distances between the holes were not equal. It was thought that

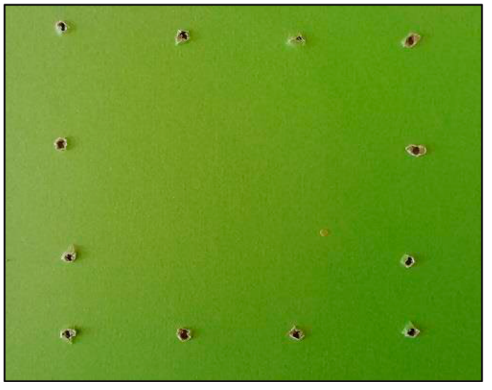

Figure 3. The tent base designed by Mehmet.

the student may have accepted it as a square because he made an equal number of holes on each side of the quadrilateral he formed. Having completed the processes of deciding on the tent base and creating the base, the student cut approximately half of a stick, accepted this stick as a unit and cut eleven more stick pieces of the same length. As a result, he formed twelve sticks for the twelve holes he made in the cardboard. **Mehmet** carried out *counting, measuring, locating, designing* and *explaining activities* in the process up to this point.

Kerime started by cutting sticks to form the skeleton of the tent. It was seen that the student brought the sticks in her hand together so that they would be parallel to each other and that she tried to cut all the sticks from the same place at the same time. As a result of the cutting process, it was seen that the sticks were cut in different lengths. In this process, although the student could not completely fulfil what she wanted to do, it could be stated that she carried out the *locating, measuring* and *designing activities*.

It was observed that **Fatma** started by determining how many sticks she would use to form the skeleton of the tent. She decided to build her tent using five sticks after several building experiments on cardboard with sticks she took in his hands. Then it was time to determine the lengths of the sticks and asked the researcher for a ruler. Thereupon, the researcher gave the student a 30 cm long ruler. Afterwards, it was seen that the student decided on the stick lengths by making measurements with a ruler. It was noted by the researcher that the student cut 4 of the sticks to be 21 cm and the other stick to be 23 cm. The fact that **Fatma** determined the number of sticks she would use in the construction of the tent as 5; that she determined the number of sticks that would be 21 cm long as 4; and that she determined the number of sticks that would be 23 cm long as 1 was an indication that she fulfilled the *counting activity* and the *designing activity*.

After deciding on the materials to use, **Baran** asked the researcher whether he could use a ruler or not. Thereupon, the researcher gave the student a ruler with a length of 30 cm. Deciding on the materials to be used and which parts of the tent will be formed and how was within the scope of the *designing activity*. The fact that the student made his measurements using a ruler was an indication that he used the ruler, one of the standard measurement tools, and the standard units of measurement that the student had learned up to the 7th grade within the scope of school mathematics. In this step, he performed the *measuring activity*.

Figure 4. Part of the tent skeleton designed by Alper.

Baran put a stick on the felt that he spread on the desk, and he drew a straight line with the help of a ruler, slightly longer than the length of the stick. He accepted this line segment as the long side of a rectangle, and after advancing the ruler a little on the felt, he drew the other long side. It was seen that he determined the length of these sides he drew as 33 cm as a result of the measurement he made with a ruler and that he noted this on the paper. Afterwards, the student, who drew the short sides with the help of a ruler, cut the felt and formed a rectangular piece. In the next step, he held 2 sticks in his hand, cut them at the same time and from the same places and obtained 4 sticks of approximately equal length. The steps he followed here were within the scope of the *counting* and *measuring activities*. In addition, it was seen that the student carried out the *explaining activity* because he explained the steps he followed by giving the reasons.

3.2.2. The construction stage

The tent designed by Alper was in the shape of a right pyramid. According to the Primary and Middle School Mathematics Curriculum prepared by the Ministry of National Education (2018), the outcomes related to the teaching of pyramid and right pyramid geometric objects are in the scope of 8^{th} grade level. In other words, it was seen that in the design of the Yoruk tent, the student used geometry-related information that he had not yet learned within the scope of school mathematics. It was observed that **Alper** formed the lateral edges of the tent to be longer than the base sides and connected one end of them at an apex (Figure 4) and that he placed each of the other ends in a corner of the quadrilateral on the base. In addition, it was observed that the felt pieces he cut to cover the surfaces of the pyramid did not completely cover the surfaces. The reason for this could be said to be the fact that the student could not think about the unfolding of the right pyramid, which he had not yet learned within the scope of school mathematics. In this process, it was seen that he performed the six fundamental activities of *counting, locating, measuring, designing* and *explaining*.

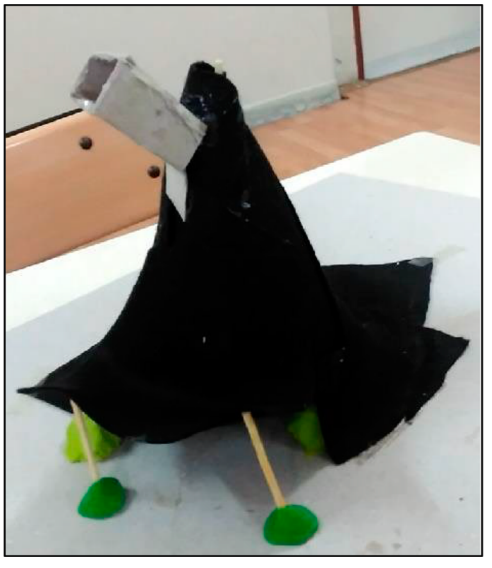

Figure 5. Alper's door and chimney design.

Later, Alper cut a part of the felt that he used to cover the surfaces, and he formed a section that could be used as a door. Finally, he designed a chimney for the tent he formed, and he placed it at the top of the pyramid at an oblique angle to the ground plane (Figure 5).

The fact that **Alper** created the door and chimney design and determined their positions on the tent was an indication that he carried out the *designing* and *locating activities*. He carried out the *explaining activity* by stating his thoughts for this stage of the tent design within the framework of logic.

Mehmet passed one end of each of the twelve stick pieces he had formed through the holes he had made on the cardboard, and he tried to connect the other ends at an apex to form a pyramid. The student, who stated that he had difficulty in connecting the sticks at the apex due to the large number of sticks, then removed the sticks from the cardboard and asked the researcher for a new cardboard. Here, he carried out the *designing* and *explaining activities*. The fact that he used four sticks in the new tent he formed and that the tent skeleton was thus more straight showed that he fulfilled the activities of *counting, designing* and *explaining*.

Mehmet stated that the tent he designed was in the shape of a triangle, and the researcher thus asked the student to think again. After thinking for a while, the student said that the tent was in the shape of a triangular prism. Knowing the geometric shapes of the rectangle and square despite being unaware of their distinctive features, using them in the tent design, and trying to explain the shape of the tent by relating it with the concepts of triangle and prism although he had formed a pyramid were all an indication that he carried out the *measuring activity* (Figure 6). The concept of pyramid is a concept taught in the 8^{th} grade according to the Ministry of National Education Primary and Middle School Mathematics Curriculum (2018). As **Mehmet** did not get this knowledge within the scope of school mathematics, he tried to made explanation with geometric shapes and objects he already

Figure 6. The tent designed by Mehmet.

Figure 7. The tent designed by Kerime in the form of a rectangular prism.

knew. In addition, as he tried to make logical explanations in the process so far, he carried out the *explaining activity*.

The tent designed by **Kerime** was in the form of a rectangular prism (Figure 7). At the end of the activity, the student wanted to decorate his tent with geometric shapes like in tents in Iraqi culture and added rectangular stripes to the surface of the tent by using brown felt.

It could be stated that she carried out the *designing* and *measuring activities* as she formed the tent in the form of a rectangular prism and decorated it by forming rectangular strips. It was seen that **Kerime** used a total of 23 sticks in the construction of the tent. Among these sticks, 22 of them were used for the skeleton of the tent in the form of a rectangular prism, and the other stick was used as a support to keep the tent in balance.

Figure 8. The curtain system designed by Kerime.

The student designed the lateral surfaces of the rectangular prism in such a way that the opposite surfaces were the same. In this process, her use of 23 sticks was in the scope of the *counting activity*, and determining how many sticks to use for which part of the tent construction and in which position to place the sticks relative to each other was within the scope of *counting, locating* and *designing activities*. As the student added a support passing through the centre of the rectangular prism to keep the tent in balance, it could be stated that she knew the concept of centre of gravity, which was not in the scope of middle school mathematics, and that she used it in daily life. Here, the student carried out *measuring* and *designing activities*. The fact that she stated the reasons for the process she followed in the tent construction was an indication that she carried out the *explaining activity*.

Kerime reported that she was trying to design a curtain system (Figure 8) for her tent although she could not form it as she had planned. In this process, she carried out the *designing activity*.

Fatma designed a Yoruk tent in the form of an isosceles triangular right prism. She did not use sticks for the edges of the surface forming the tent base (Figure 9). She started the construction by cutting sticks of 21 cm to form the isosceles of the isosceles triangles that constituted the bases of the isosceles triangular prism and by determining the other side to be 22 cm without using a stick for this side. Next, she formed the upper lateral edge of the prism with a 23 cm long stick. In this step, she carried out *counting* and *measuring activities*. The researcher said to the student, 'I see that you put a stick (the stick that formed the lateral edge of the prism) between these triangles in a way to touch their apexes' and then asked a question to her 'Why did you do this?' The student replied, 'Teacher it would not be very strong, and it would fall in and collapse. If I remove this (stick) from here, this part will be weak here. It is much stronger now.' Here, the student carried out the activity of designing by adding a stick in a way to become the lateral edge of the prism so that the tent would not collapse. Moreover, as she explained the process she followed in the tent construction with his justifications, she carried out the *explaining activity*.

Fatma's decision on how to start her design, how many sticks to use, how to determine the lengths of the sticks, which sticks to fix to the cardboard from where and how by making various experiments, where and how to combine the sticks that would make up the tent

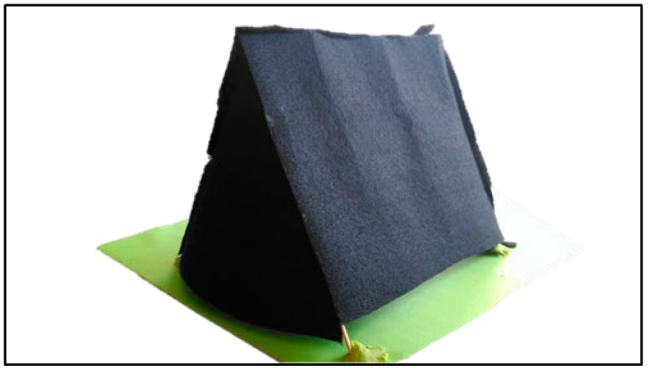

Figure 9. The Yoruk tent built by Fatma.

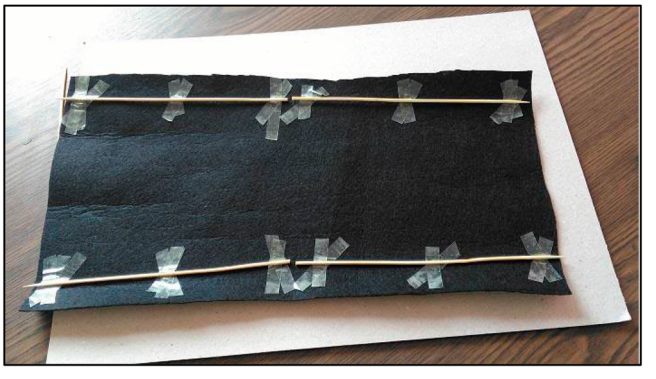

Figure 10. The tent piece formed by Baran.

skeleton, and on which surface to build the tent in the form of a prism was an indication that she carried out the *designing* and *locating activities*.

Baran started the tent design by using a piece of felt that he cut in a rectangular shape and four pieces of sticks that he cut approximately equal in length. He placed the sticks on the felt and taped them as in Figure 10. In the process up to this point, he thought about where and how he would place the stick pieces on the felt, and he put it into practice after making the related decision. In other words, he carried out the *designing* and *locating activities*. Furthermore, the fact that the student taped each stick twice from three different places was an indication that he did this consciously and that he carried out the *measuring activity*.

He dipped the pointed ends of the sticks into the cardboard and placed the tent piece he had prepared so that a triangular prism was formed on the cardboard. Then, he fixed the pointed ends of the sticks to the cardboard with the help of play dough (Figure 11). While fixing these sticks to the cardboard, the student decided approximately on the distance to be found between them, namely the angle between the sticks. At this stage, he thought about how to create the tent form with the piece of felt he had prepared, and as he put his thought into practice, he carried out the designing activity. The fact that the student approximately determined the angle between the sticks fixed on the cardboard and therefore determined

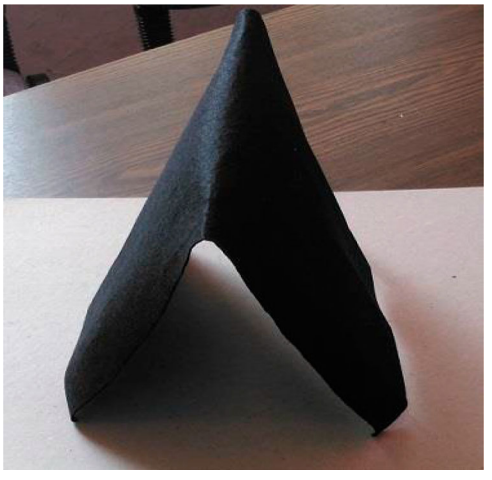

Figure 11. The step where Baran fixed the pointed ends of the sticks on the cardboard.

Figure 12. Baran's door design phase.

the width of the floor area of the tent and that he placed it on the cardboard accordingly showed that he carried out the *designing, measuring* and *locating activities* all together.

Baran finalized his tent design by designing a door. For the door design, he removed one of the triangles from where it was taped, which formed the bases of the triangular prism, and he drew a rectangle with a felt-tip pen approximately in the middle of the side of the triangle touching the base. Then he cut a triangle-shaped piece from this rectangle (Figure 12). In this step, the fact that the student drew a rectangle and cut a hypotenuse length close to the diagonal, not from the diagonal of this rectangle, showed that he had this mathematical knowledge and carried out the activity of designing. In the interview with the researcher, the student carried out the explaining activity as he, mentioning the

reasons, explained the positive and negative situations he encountered during the door design process.

4. Conclusion and discussion

During the ethnomathematics activity, all of the students carried out the *counting, locating, measuring, designing* and *explaining activities* put forward by Bishop (1988b). Similar results were obtained in the study conducted by Kørhsen and Misfeldt (2015). Therefore, these results support the conceptual framework developed by Bishop (1988b).

As the students who had the Yoruk culture had knowledge and experience about the construction stages of the Yoruk tent, they could easily design their tents with their advanced hand skills, without thinking much about it. It could be stated that these students had more advanced psychomotor skills than the others. The students, who were not Yoruks but were in interaction with them, made tent designs by using their knowledge and observations regarding this culture as well as by using their interpretation, estimation and inference skills. It was seen that the students who had not met the Yoruk culture before made tent designs by considering the tent designs existing in their own culture and by taking into account the knowledge they got about the Yoruks within the scope of the activity. While doing this, the students used estimation, reasoning and association skills. Moreover, there were some students who stated that they created the tent design based on the tent structures in the books they read or the TV series and movies they watched. It was concluded that these students used their association and reasoning skills. The students who did not know which steps to follow in the tent design process and what actions to take in these steps or those who failed to make a decision on this reached the appropriate result by using the trial-and-error method.

The cultural life and experiences of the students were effective in choosing the materials to be used in tent construction. By taking into account the climatic characteristics of the region, the students who used tents in their culture determined not only the shapes of the tents they formed but also the materials they used to cover the tent skeleton; on the other hand, the students who did not have the tent culture determined the tent shape and preferred materials for the visuality of the tent rather than its functionality.

Considering the tent designs of the students living in rural areas who had or were familiar with the Yoruk culture and the students living in urban areas, it was concluded that the students living in rural areas created more robust tent constructions. From this point of view, it could be stated that these students' mathematical thinking skills were better than other students. This result supports the study conducted by Shuaibu (2014), who found that students living in rural areas had more advanced mathematical thinking skills than those living in urban areas.

Among the students, there were those who designed structures that should not be directly present in the structure of a Yoruk tent as well as those who acted logically on a subject they did not know, taking into account environmental factors (wind direction, weather events, etc.) and using architectural and engineering knowledge. Based on this, it was concluded that these students carried out an interdisciplinary study.

While the students who created the tent design as they planned stated that the activity was fun, the students who could not create it reported that the activity was challenging and

difficult and that they were sad because they could not do the design. This shows that the students' psychomotor skills were effective on their affective behaviour.

The majority of the students said that the tent they designed was in the form of a geometric shape. This showed that the students did not know the differences between the concepts of geometric shapes and geometric objects and that they had difficulties in transition from two-dimensional thinking to three-dimensional thinking. Moreover, the fact that one of the students said several times that every three-dimensional object was a prism was an indication that s/he had misconception on this subject. It could be stated that the student made an over-generalization on this subject as the students learned prisms among geometric objects until the 7th grade within the scope of middle school mathematics curriculum.

There were some students who did not know the basic properties of square and rectangle and their differences from each other, and there were those who knew about these properties yet made decisions based on the appearance of the shapes without considering these properties.

It was seen that among the students who created the same geometric shape during the tent design process, there were those who built this shape by following different steps. The reason for this was that the students accepted different definitions for a geometric figure.

There are mathematical concepts that students do not learn within the scope of school mathematics but use in tent design, and while some of the students could explain these concepts with the help of their daily learning, some could not make any explanations. It was observed that some students were not aware of their mathematics and geometry knowledge they used in their tent design and that they even said what they did had nothing to do with mathematics. Yusuf et al. (2010), who conducted research on this subject, obtained a similar result. This shows that there are individual differences among students. These differences are related to students' ability to associate mathematics with daily life. This result is also parallel to the result obtained by Zhang and Zhang (2010), who reported that daily mathematics and school mathematics were not exactly the same.

All of the students used non-standard units of length measurement in the tent design process. Although there were some students who asked the researcher for a ruler to measure the stick lengths, the students performed this process after determining the stick lengths through approximation. In ethnomathematics practices in the literature, such as Lipka and Andrew-Irhke (2009) and Septianawati et al. (2017), it was seen that people from traditional societies made measurements with non-standard units of measurement and then converted these measurements into standard measurements. The results obtained in relation to the Yoruk tent design processes were in line with the results of this study.

The students from different cultures, living in a society that adopted the same culture, abstained during the research process and said that they were embarrassed and excited when asked questions about the activity and that they therefore failed to participate actively in the process. After the researcher showed interest in these students and stated that she valued and was curious about their culture, the students began to talk and explain eagerly and to give detailed information about their own culture. This result confirms the result obtained by Nasir (2016), who stated that race and culture should be considered in the education process and supports the views of Mukhopadhyay and Greer (2012) and Rosa and Orey (2011) that another curriculum to be prepared with a cultural point of view should be integrated into mathematics curricula.

5. Suggestions

There are mathematical knowledge and thoughts specific to people's own cultures that they use in their daily lives. In relation to this, several studies could be examined, which were for example carried out by Prahmana et al. (2021) for culture-specific birth, death, and harvest time calculations, by Powell and Temple (2001) and Yusuf et al. (2010) for games that require thinking skills and strategy development, by Pinxten and François (2011) for ways of determining directions. Undoubtedly, it is possible to multiply these examples because there are many different studies and many ethnomathematical activities waiting to be revealed. Mathematics teachers, who have students from different cultures in their classrooms, should include the mathematical knowledge and thoughts in their students' cultures within the scope of the mathematics course in order to ensure that all their students benefit equally from the education process. In addition, whether or not they have students from different cultures in their classrooms, they should include culture-specific mathematical knowledge and thoughts in their classes so that they can associate mathematics with daily life, see that there are different solution methods for problems and offer rich mathematics lessons to students.

People who are seriously interested in mathematics see the aesthetics that exist beyond numbers and symbols and experience the pleasure of dealing with mathematics. Mathematics carries aesthetic concerns not only in doing mathematics, but also in every field of its application, and reflects this in every field of its application. For this reason, there are strong links between art and ethnomathematics. The relationship between ethnomathematics and art is an area that needs to be emphasized in this sense. By showing the beauty of mathematics, learners' negative thoughts about mathematics can be made more moderate or completely transformed into positive ones. At the same time, students from different cultures can learn each other's cultural values and respect each other. In addition, better learning outcomes can be achieved in mathematics education by enriching the course content with mathematics and art activities. Providing students with an understanding of art from different cultural contexts will contribute to their aesthetic thinking skills and strengthen their connection with mathematics.

Ethnomathematics applications to be used in mathematics lessons could act as a tool to improve students' mathematical thinking and problem-solving skills, to make mathematical modelling and to develop their competencies in mathematical modelling.

In order to ensure an atmosphere of tolerance in schools where students from different cultures are educated together, all school staff, especially school administrators and other teachers, and students' parents should act in coordination. All teachers with students from different cultures in their classrooms should develop classroom environments where students respect each other, participate in lesson-related processes and classroom activities, and express themselves comfortably. The families of the students should also be informed about this issue, and their awareness should be raised. The studies conducted by Prieto et al. (2015) can be examined on this subject.

Interested researchers should do more studies in the field of ethnomathematics, which is waiting to be explored and expanded in depth. These researchers should try to introduce this subject to researchers interested in mathematics who are unaware of ethnomathematics and especially to mathematics teachers working in schools. Ethnomathematics is

thought to open the horizons of not only scientists, teachers and students who are interested in mathematics, but of all people as well. However, based on the conclusion that interdisciplinary information is used in cultural activities, it is suggested that both mathematicians and researchers from different sciences should conduct cultural studies in their own fields.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Supplementary information

This study was produced from the first author's master's thesis titled 'Investigation of the Mathematical Thoughts of Middle School 7th Grade Students with Different Cultural Values: An Ethnomathematics Practice', which was conducted under the thesis supervision of the second author. In addition, this thesis was presented as an academic paper at the 7th International Eurasian Educational Research Congress (Güreş & Ada, 2020).

Availability of data and materials

The data that support the findings of this study are not openly available as the identity of the participants must be kept confidential and are available from the corresponding author upon reasonable request.

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