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STUDENT APPROACHES RESULTIMG FROM INTEGRATION OF CULTURAL CONTEXT INTO TRANSFORMATION GEOMETRY ACTIVITIES

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Abstract: The purpose of this study is to investigate how students' in senior grade of the high school participate in and interpret the transformational geometry activities integrated with cultural context. 5 students in senior grade participated in this study, all of whom live in Aydın district of Turkey. The main design of the study is qualitative. Participant students of the study involved in 9 different rotational geometry and culture integrated activities, 7 of which were performed as student activity sheets, 2 of which were performed as cultural games. 2 of the activities were constructed as a result of pilot study applied to 28 senior students by their math teacher. To collect data about how students participated in and made interpretations about the activities; various data collection tools such as observation, field notes, interview, audio recording and student activity sheets were used. The collected data were analyzed by qualitative descriptive analysis techniques. The results were presented as tables, figures constructed by students and direct quotations. Lastly, at the end of this study students were said to recognize the hidden mathematics in the objects from daily life, games with cultural background and history, and both in Turkish culture and other cultures.

Keywords: ethnomathematics, math in cultural objects, math in cultural games, transformational geometry

1. Introduction

In math education, it is important to develop and prepare the context of the lesson appropriate to the objectives and expected outcomes. Educators should take the connection between real life and math context into consideration. While making this connection, the subject of culture can be included in real life context.

The subject of culture, prevalent in daily life, has different definitions. Matsumoto (2012) defines culture as common shared attitude, behavior, value and belief of groups of people which is transmitted through generations, but it doesn't have to be accepted by all individuals of the stated groups. As another description, Güvenç (1994, as cited in Yazıcı, 2014) says culture can be identified as four different elements: civilization, educational product, fine arts, producing and nurturing. As it is seen the issue of culture has different definitions. However, all these meanings contain the topics of communication, geographic area and people's life style (Ercan, 1991/2005).

1.1. Theoretical Framework

Math, in general, is perceived as a discipline about numeric calculation that is far away from culture. However, such perception implies ignoring the fact that math is a human product. If cultural context and teaching doesn't take place in classrooms together, as an outcome, students and teachers cannot see the link between math and culture (D'Ambrosio, 2001; Bishop, 2002). In the late 1960s, Ubiratan D'Ambrosio used the term "theorem of ethnomathematics" which is the main theorem of this cultural context included mathematical study. Teaching intensified with ethnomathematical methods broadens students' mathematical perspectives, perceptions and ways of applying it through cultural context (Bishop, 2002). Mathematical thinking is affected by cultural variables around people. Through history, people have developed logical processes to understand and explain socio-historical contexts

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such as measuring, modeling, comparing and contrasting. These processes led each cultural group develop their own ways and methods to explain realities through mathematics (Rosa & Orey, 2011).

The term ethnomathematics, firstly, was used to explain the link between math and culture by Ubiratan D'Ambrosio in the late 1960s. A dynamic interpretation is needed for ethnomathematics, because the notions of ethno and math are not rigid (D'Ambrosio, 1987). The term "ethno" contains all the elements that constitutes cultural identity of certain groups such as language, jargon, codes, values, food, clothes, habits and physical appearance. The term "mathematics" implies a broader perspective that contains ciphering, arithmetics, classification, ordering, making inferences and modelling (D'Ambrosio, 2001).

The supporters of ethnomathematics state that different civilizations contributed to mathematics by their own technics and methods. Barton (1996) states through his studies that there are more than 2000 counting systems in Papua New Guinea and Oceania; various technics are possible in calculating area of a rectangle; different types of games, puzzles, dances and sports have connection with math. Moreover, there can be seen different mathematical knowledge and skills based on the needs of several professions such as fishery, tailoring, and carpentry.

1.2. Literature Review

People develop their own strategies in case of any difficulty or problem. François and Van Kerkhove (2010) states sometimes apparent sometimes hidden, math is always in people's life. However, while finding solutions for daily problems, people may not recognize that they use and do mathematics during such processes. To give an example, a kite designer may not recognize that s/he uses math, while designing the best flying kite. Stathopoulou, Kotarinou, and Appelbaum (2015) conducted a research about observing craftsmen while they were on work. Through observations, it is stated that craftsmen are able to construct geometric shapes such as rectangle, rhombus and square properly and state the center of such shapes; use ruler and compass in creating patterns and in constructing symmetric shapes. Hence, the craftsmen do and use math in their professional life. However, when they were asked how they engage in such mathematical processes, craftsmen responded that they learnt it very long time ago by apprenticeship from their masters. It can be said that while working, they do not use school math based on formulas.

Using cultural figures in math education may make teaching and learning become interesting and meaningful. Such figures do not have to be a design from a quilt, a scarf or an embroidery; they can also be taken from architectural structures accepted as important in a certain culture. Especially in Islamic and Celtic designs, there are variety of historical and cultural context that can be integrated into geometry area (Bordewyk, 2016). Eglash (1999) also conducted studies about mathematics in traditional beads and basket designs; the relationship between geometry and culture using geometric ornaments. Such studies gave a way to interpret math from formal and local perspective. Moreover, teaching mathematics becomes meaningful by including familiar concepts for people (D'Entremont, 2014).

Additionally, in order to get rid of traditional teaching technics, educational math games can be integrated to teaching process. Such games not only serve as reinforcement tools, but also become a platform to reach higher level of learning. Students also feel comfortable and become enthusiastic in doing math with educational games (Cavanagh, 2008). Oldfield (1991) describes math games as the games that have difficulty levels, rules, a starting and a finishing point which have relation with certain math objectives.

When cultural games are included in math education, it becomes possible to use mathematics language through combining mathematical ideas, concepts, generalizations and thinking (Nkopodi, 2001). The area of geometry can supply rich cultural and historical context for math lessons. Hence, students can explore the relationship between math, art and how geometry takes place in people's lives (Jones, 2002).

In the research about games and cultural heritage, ta'ab (stick game), mozkat (peeble game) and seega (digging game) which are the cultural games that contain mathematical ideas were reviewed. Firstly, the rules of the games, objectives and their connection with math which can be a fruitful source for the

educators were described. The stated mathematical context in stick game is addition and subtraction; in peeble game is permutation, addition and subtraction; in digging game is locational movements (Fouze & Amit, 2017).

When it comes to review the studies in ethnomathematics field, even in Turkey or more broadly worldwide, the number of studies is in low levels. Since Turkey is a country with rich cultural heritage, it becomes a dilemma not to have many researches about exploring hidden math in cultural context (Aktuna, 2013). To give an example, triangles, quadrilaterals, parellelograms, octagons can be seen as decorations on traditional and daily carpet designs. Such motifs also have spiritual meanings like defeating the bad and evil eye (Küçük, 2013). Besides decorations, when it comes to strategic intelligence games played in Anatolia and Middle Asia, ethnomathematical elements are also seen. For example, in Middle Asia version of mangala game, the peebles symbolize seeds which give idea about people and their relationship with agriculture; in Anatolian version of this game, the peebles represent soldiers which give idea about Turkish people and their relationship with military (Küçük, 2014).

Moreover, in the subject of transformational geometry, in 8th graders' (Kişi, 2018) and 12th graders' (Kemancı, Büyükokutan, Çelik, & Kemancı, 2018; Emin, Gerboğa, Güneş, & Kayacıer, 2018) books provided by Turkish Ministry of Education, cultural motifs are examined through the lens of transformation geometry rules such as symmetry, rotation and translation.

Taking everything into consideration, students should be raised awareness in their cultural figures and hidden math in these items. Hence, it becomes possible for them to interpret math ideas formally outside of the school and to apply these ideas to different contexts in daily life. Ethnomathematics based math curriculum may also let students gain positivite attitudes towards math lesson and learn the subject better (Küçük, 2014).

1.3. Research Question and Significance of the Study

The objective of this qualitative work is how students in senior grade of the high school participate in and interpret the transformation geometry activities integrated with cultural context. The reasearch question and sub-questions are:

How students in senior grade of the high school participate in and interpret the transformation geometry activities integrated with cultural context?

• How students in senior grade of the high school participate in and interpret the transformation geometry activities integrated with cultural figures?

• How students in senior grade of the high school participate in and interpret the transformation geometry activities integrated with cultural games?

Lastly, the significance of this study is to raise mathematical awareness of students through cultural figures and games. Through the activities of this study, students can gain awareness about hidden math in real life, hence they can get rid of their negative thoughts and stereotypes towards math. Besides, students can share their experiences with others around them and those people may also gain awareness and get the chance of exploring math in daily life.

2. Method

This is a qualitative case study which investigates deeply how environment, people, processes and the cases affect and get affected by each other (Yin, 1984, as cited in Yıldırım & Şimşek, 2016). Case studies serve as sample studies to interpret the similar cases.

2.1. Participants of the Study

In this study, one of the qualitative sampling methods, convenience sampling was used. In order to have deep data set, the participants who were easily accessible and convenient for the researcher were selected for the study (Patton, 2005, as cited in Yıldırım & Şimşek, 2016).

As participants, 5 senior grade high school students (4 female and 1 male) from Esra Karakaya Anatolian High School in Didim, Aydın district of Turkey joined the study voluntarily. The permissions from themselves and their parents were taken. Ethical considerations which can be counted as informed consent, anonymity, confidentiality, no risk of harm, respect of privacy were reminded to them before the study (Christians, 2005, as cited in Yıldırım & Şimşek, 2016). The number of female participants are remarkably high, since the researcher thought that these students could supply deep data set for the research.

2.2. Instruments and Procedure

Triangulation technique was applied in order to evaluate the data from different point of views, eliminate wrong interpretations and make the data much meaningful, verify the validity and reliability. (Yıldırım & Şimşek, 2016). Thus, the instruments used to collect data can be said as pilot work, observation and field notes, interviews, student activity sheets and cultural games.

To start with pilot work which allowed researcher to construct first and second activity, the activities were applied to 28 senior grade high school students as classroom activity by their math teacher in a high school, in Aydın province of Turkey. Later, the researcher took the views of 2 math teachers to analyze the pilot work data.

Moreover, in this study the researcher worked with students individually and went their homes to apply student activities, make observations and have interviews. Before collecting data, the researcher arranged a timetable with each student to have a structured schedule. In the process of data collection, 7 student activity sheets were distributed them individually. The researcher acted as a guide for them and made observations at the same time. Field notes were also taken during this process. After completing activity sheets, students played educational cultural games and researcher continued to make observations. Lastly, researcher had unstructured interviews with students individually and did audio recording during interview process.

2.2.1. Context of the Activities. As seen in the name of the activities in Table 1, participant students were familiar with motifs in carpets and designs on Turkish coffee cups. Moreover, apart from their culture, students were wanted to raise awareness about use of transformation geometry in other culture's items with the activities 3, 6, 7 and cultural games.

Table 1. *The Activities*

Activity number	Name of the activity
1	Learning Transformations: Examining Motifs in Turkish Carpets
2	Examining Designs in Turkish Coffee Cups
3	Describing Motifs in Carpets of Different Cultures
4	Rotating and Reflecting Strip Patterns
5	Transformations in Designs
6	Transformations in Tribal Tattoos
7	Transformations and Talavera Tiles
Cultural Game 1	Alquerque
Cultural Game 2	Billard

2.2.2. Process of Formation of Activities. First and second activities were formed with pilot work. Third one was inspired from the activity called "Identifying Geometric Motifs in Bedouin Carpet" (Katsap & Silverman, 2008). Moreover, the book called "Ethnomathematics of Negev Bedouins' Existence in Forms, Symbols and Geometric Patterns" gave idea to prepare the fourth activity (Katsap & Silverman, 2016). To form the fifth and sixth activities, "Rotational and reflective strip patterns", "Tribal tattoo transformations" activities were used, taken from University of Hawaii Ethnomathematics and Stem Institute's website. Additionally, the article called "Geometric Transformations and Talavera Tiles" gave idea to prepare the seventh activity (Kalinec, Prasad, & Luna, 2018). For the cultural games, it is stated in the work of Erdoğan, Atasay, and Çevirgen (2017), Alquerque is a cultural game which consists the ideas of transformation geometry. Hence,

"Alquerque" was included as one of the activities for this study. Lastly, the concept of "Angles" on Educational Cognitive Network (EBA, 2019), supported by Turkish Ministry of Education, gave idea to include Billard as other cultural game.

2.3. Data Collection

In this study, since the researcher collected data from participants individually, an appropriate timetable with each student was prepared at first. The activities were divided into three groups and each group of activities were applied to each student in consecutive three days. The reason of having such division in the activities is to eliminate student distraction and to create a positive dialogue between the researcher and the participants. To illustrate, first three activities were applied on the first day, the rest of the activities were applied on the second day, and students played cultural games on the third day. The researcher made observations and had fieldnotes on each day. The unstructured interview was held on the third day, while students were engaging in cultural games. During the process of data collection, students completed the activities without any need of break time.

3. Data Analysis

Descriptive analysis approach was applied for this qualitative research. Firstly, the main themes have been identified which belong to certain conceptual frame in order to make connections between each other and have meaningful data analysis (Yıldırım & Şimşek, 2016). These themes were selected as basic values explained in the curriculum of "folk culture" subject supported by Turkish Ministry of Education (2018). These values can be said as "justice, friendship, honesty, self control, patience, responsibility, loving and caring, being helpful and partriotism". In addition to basic values, other values such as "giving importance to family bonds, humility, being hardworking, solidarity, sensitivity/sensitivity to cultural heritage, trustworthiness, aesthetic, mercy, hospitality, sharing and fidelity which should also be gained by students were included, too. Hence, students' answers to personal questions were evaluated, united and related based on all these values.

The basic reason to select themes as values supported in curriculum of folk culture subject comes from one of the main goals of ethnomathematics theorem. It is about making students gain consciousness of partriotism, conveying them folk values and raising their awareness about one's rights and responsibilities in the society. The founder of the ethnomathematics, Ubiratan D'Ambrosio (2007) also supports conveying values through studies based on this theorem. In the research (Katsap & Silverman, 2008), it is stated that educators should broaden their views about teaching mathematics along with understanding socio-cultural values.

Besides relating to values, student answers about transformational geometry were evaluated based on transformations which were stated as reflection, translation, rotation and symmetry. Moreover, students' direct quotations were also used to strengthen the data set. Comparisons and contrasts in students' answers were also analyzed and interpreted.

Qualitative data analysis process can be challenging and time taking for researchers. Unlike quantitative data, qualitative data cannot be conveyed with numbers. There are various softwares to analyze qualitative data set (Weittzman & Miles, 1995). However, in analysis process no software was used in this research.

3.1. Reliability and Validity

Since no exact statistical tests exist for qualitative studies (Sutton & Austin, 2015), in order to control validity and reliability of the study, no statistical measuments were used. To control validity which stems as trustworthiness issue in qualitative studies, the researcher used data triangulation and continued to have interactions with participants in data analysis process in order to be sure about correct data interpretation.

In qualitative studies, the observed cases occur depending on the environment and the time which means it is not possible to have the same results with repeated applications. Hence, in order to meet with the requirements of validity which refers to consistency in qualitative studies, the researchers

should collect data with the same manners and processes (Erlandson, Harris, Skipper, & Allen 1993). In this study, to control validity, the researcher gave the same activity sheets to students, tried to act in similar manners as a guide and asked similar questions during interviews. Additionally, the researcher went to students' own houses to make them feel comfortable and have the similar experiences in the presence of their families.

3.2. Restrictions of the Study

The researcher conducted this qualitative study with five participants which means the collected data cannot be generalized to a larger population. It can only serve as sample study to interpret the similar cases (Erlandson et al, 1993).

4. Findings

Student approaches resulting from integration of cultural context into transformation geometry were studied in this research. The findings were divided into 2 groups.

4.1. Findings in terms of Values

In the first and third activities which are similar in context, students experienced the values of aesthetic and being hardworking. In the second activity, they experienced the values of loving and caring, hospitality and sensitivity to cultural heritage. In the activities 4, 5 and 7 students weren't asked personal questions, however with these activities they were wanted to experience aesthetic value by strip patterns, designs and Talavera tiles. In the activity 6, students experienced the values of giving importance to family bonds and patriotism.

4.2. Findings in terms of Transformation Geometry

First of all, students sometimes gave similar answers about the transformation in a motif, when they sometimes gave completely different answers for the transformations in another motif. This can be said as the result of the complexity level in the motif. When the motifs get more complex, students focused on different parts and gave various answers. However, for the simple motifs they gave consistent answers about existing transformations.

Figure 1. *Image of the material for students to analyze in activity 1*

All students answered that there are horizontal symmetry lines, vertical symmetry lines and reflection in the motif seen in Figure 1 above. Moreover, all students responded that there seemed rotation on the leafs of the flower on Turkish coffee cup motif seen in Figure 2.

Figure 2. *Image of the material for students to analyze in activity 2*

However, students were asked about the angle of the rotation in the motif seen in Figure 3. One student focused on only one rhombus shaped motif and divided it into 4, claiming that the angle of the rotation is 90^0, because 360:4=90. On the other hand, one student focused on 4 united rhombus shaped motifs and divided into 8, claiming that the angle of the rotation is 45^0, because 360:8=45. It can also be said that all students know one clockwise and counter clockwise tour with reference to center is equal to 360^0.

Figure 3. *Image of the material for students to analyze in activity 5*

In the activity 4, students constructed their own shapes on coordinate plane and applied reflection, translation and rotation transformations appropriately. Since all students knew the formula for the transformation, they didn't have trouble in answering questions. Furthermore, all students were able to construct their shapes and related images under certain transformation on coordinate plane, as seen in the sample taken from a student answer in Figure 4 below. However, without formula it was stated that students weren't capable of showing the transformations on coordinate plane.

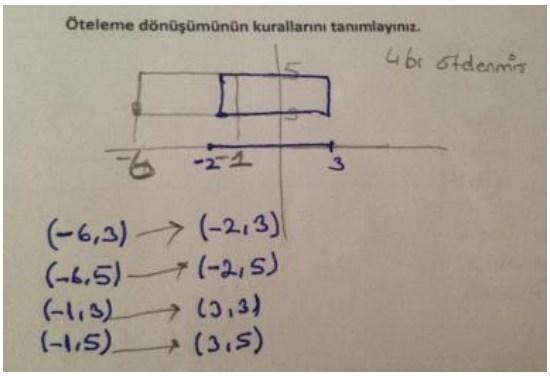

Figure 4. *A student answer about translation taken from activity 4*

Besides that, one student couldn't show the image of the shape under rotation, even though she knew the rule for the transformation (see Figure 5). This means, sometimes recognizing the rule cannot be enough to show the image of the shape under transformation. This situation happened only in applying rotation from all the transformations.

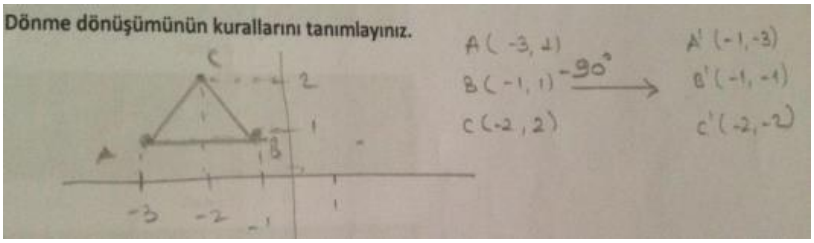

Figure 5. *A student answer about rotation taken from activity 4*

In addition to these, based on answers given in the process of applying activity 7, students can be said to know how to denote ordered pairs (x, y) on coordinate plane and show the image of a shape in the mirror. For the question about how to arrange the images in Figure 6 as each others' reflection in mirror, students gave various answers. To illustrate, one student drew a vertical line on the right side of the upper image and moved the other image on the bottom near vertical line assuming the line as a mirror standing between both images. One student also applied the similar reflection by drawing a vertical line on the left side of the upper image and moving the image on the bottom near it assuming the line as mirror, too. Another student drew a horizontal line between the images and rotated the image on the bottom 180^0 on clockwise. In addition to these, all students stated that rotation on counterclockwise 90^0 is the same as rotation on clockwise 270^0 with reference to center and vice versa on the coordinate plane.

Figure 6. *Image of the material for students to analyze in activity 7*

When it comes to cultural games, students discovered rotational geometry in Alquerque and Billard. One participant student claimed that he knew the game Alquerque since he was a student in middle school, but he had no idea about the presence of transformation geometry in the game. The other students said that it was their first time they played. When it comes to how to play, Alquerque is a game that requires two players. In collecting data, player 1 was arranged as automatic player from reseracher's personal tablet and students played against arranged player individually. The game board consists 5x5 cells which are connected each other with diagonal, vertical and horizontal lines. Players have 12 pieces stand across each other in different colours as seen in Figure 7 below. A piece can move to empty adjacent side, it can jump over the other player's piece along with consistent lines. Moreover, a piece can jump multiple times if there are available space and pieces of opponent.

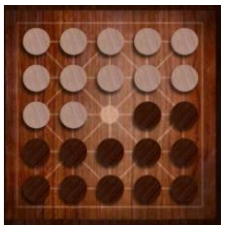

Figure 7. *Image of alquerque board*

All students claimed that they saw reflection and translation in Alquerque, while only 2 students also added rotation in their answers. All of them stated that translation occured when a piece was removed to the empty adjacent place. For the reflection, 3 students claimed, when a piece jumped over oppenent's piece reflection occurred, because that staying piece served as a mirror. 1 student said reflection could be seen on game board, because 12 pieces of both players lay on two sides of the board. When their colours were neglected, it was claimed the distribution of the pieces created reflection. When it comes to rotation, 1 student claimed the triangles on the game board rotated by 45^0. Other student claimed when a piece had double jump, one to the down and to the left, it became like the letter "L" which could be called as rotation with the angle of 180^0 with the reference to center.

Lastly, in Billard game students were supposed to discover reflection and reflection angle when the ball hit the any side of the billard table as seen in Figure 8. However, all students claimed rotation and translation could be seen in the game. They all claimed rotation and translation occured at time same time, while the balls were rolling. Because while rolling, they change place which implies translation and rotation. They didn't state any idea about reflection. All in all, students raised awareness about cultural games and their relation with transformation geometry.

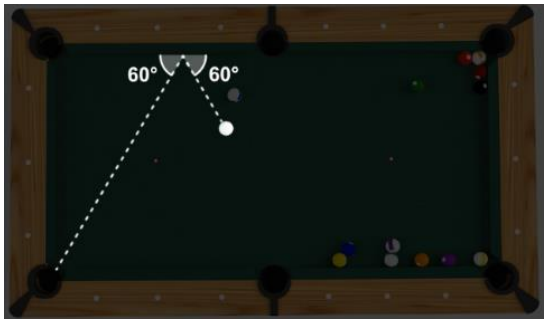

Figure 8. *Illustration for the aim of the Billard activity*

5. Discussion and Conclusion

This study provides a different perspective about combining math and culture from traditional figures and games. It can also be a sample to explore various math applications and technics about ethnomathematics. The activities were created by traditional figures and cultural games which gave a way to explore hidden math in them. Participant students gained experience about how math and culture can get combined and the hidden math in the environment enclosure them (D'Ambrosio, 1995). Additionally, they raised awareness about the idea of "math is a human product like music, art, literature and other sciences" (İzmirli, 2011).

Besides cultural figures spread in Anatolia, different cultural items were also used in the activities. Students got the chances of combining math and culture, comparing their own culture to other cultures, explore the math in real life. The idea of hybrid (third) area relates ethnomathematical ideas with math outside of the school and extend the boundries of the school math. This idea also supports developing talent by supplying a roaming area through different cultural items mixed with school math (Moje, Ciechanowski, Kramer, Ellis, Carillo, & Collazo, 2004) which can be seen in the context of this research.

Student responses to open questions in the activities were interpretated by cultural values. The ideas such as integrating cultural values into scientific thinking, raising awareness about other cultural mathematical practices, connecting school math and student experiences should be included in the studies in math area. These issues are also basic purposes of ethnomathematics based math curriculum (Orey, 2008).

In this study, students participated in activities in which the main theme was cultural items, values, games and transformational geometry. They got chances to explore hidden math in real life. Lev Vygotsky's constructivist theorem also supports the importance of culture and interaction with cultural values (Kapanadze, 2019). According to his constructivist approach, students firstly learn cultural and

mathematical concepts from their environmental settings, later develop their informal learnings with formal learnings at school (Fouze & Amit, 2017).

Lastly, D'Ambrosio (2002) supports integrating real life and traditional values into math education and learning process. An educational setting in which etnomathematical ideas and real life are combined, students become active participants (D'Ambrosio, 1987).

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