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BETENG CEPURI AS ETHNOMATHEMATICS FOR ELEMENTARY SCHOOL

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ABSTRACT

Ethnomathematics objects can be found in artifacts in the form of historical buildings. One of the historical buildings in Kotagede, Yogyakarta, Indoensia, is the Beteng Cepuri fortress. The purpose of this research is to conduct an exploration of any mathematical concepts contained in Beteng Cepuri that can be used as a source of learning mathematics as an effort to develop ethnomathematics for learning elementary school mathematics. The researchers invited the fifth-graders of an elementary school in Kotagede, nearby the Cepuri Beteng, to explore and learn mathematical concepts. The results show that there is a relationship between the construction of the fort building and the concept of geometry in several parts of the Cepuri Beteng. The sections are in the form of cuboids and rectangles. Taking the students to visualize the artifacts may assist them to build 3D shape recognition. It can be concluded that ethnomathematics is able to create a very good interest in learning followed by concept acquisition.

Keywords: Beteng Cepuri, building space, ethnomathematics

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INTRODUCTION

Mathematics as one of the school subjects is considered to hold an important role in improving student abilities. The abilities to think critically, systematically, logically, creatively, and to engage in an effective collaboration can be developed by learning math. According to (Zaini & Marsigit, 2014) mathematics knowledge must be acquired as early as possible by students and mathematics learning must be able to develop the competencies possessed by students, so that they are able to comprehend math appropriately.

Math and culture cannot be separated from one another in daily life. Bishop (1994) points out that math is a form of culture that has become integrated in all aspects of the community life. Yet, sometimes people view math and culture as two unrelated fields. Without realizing it, society has performed various activities using the basic concepts of mathematics, such as measuring (length, area, volume, and weight), counting, etc.

According to Stigler and Baranes (1988), mathematics does not belong in the official domain of universal knowledge, as it is a collection of cultures that build a symbolic representation and procedures that facilitate manipulation of the representation. Students develop the representation and procedures in their coginitive system, which is a process that occurs in the context of a social construction activity (Rosa & Orey, 2003). In other words, the mathematics

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abilities of school students are not logically developed based on an abstract cognitive structure, but shaped by the combination of prior knowledge and new skills and cultural input.

Hardiarti (2017) argues that mathematics is a form of culture. As a cultural form, it has in fact been integrated in all aspects of human lives. Further, Wulandari and Puspadewi (2016) suggest that mathematics does not belong in the official domain of universal knowledge, as it is a collection of cultures that build a symbolic representation and procedures that facilitate manipulation of the representation. Similarly, Dossy (1992) argues that the products of mathematics knowledge can be gained from social interactions where relevant ideas, facts, concepts, principles, and skills are a result of a cultural context. In regard to this, the development of student creativity can be done through the integration of mathematics education and culture which aims to develop student abilities as well as cultural heritage.

Astuti et al. (2019) explains that one of the branches of disciplines that can bridge culture and mathematics is ethnomathematics. In short, the notion of ethnomathematics is mathematics in culture. Ethnomathematics consists of two words, ethno (ethnic/culture) and mathematics. The term ethnomathematics was introduced by D'Ambrosio, a Brazilian mathematician in 1977. Linguistically, the prefix ethno represents a broad aspect which refers to a socio-cultural context, including language, jargon, codes of behavior, myths and symbols. The root word mathema approximately means "to explain, identify, understand, and perform activities such as coding, measuring, clarifying, concluding, an modelling." The suffix tics comes from the word techne which means "technique" (Sträßer, 1994).

Mathematics is typically considered as a difficult subject by students. One of the contributing factors to this is that teachers often deliver mathematics learning without involving the application of mathematics in relation to its use in daily life in the context of their local environment. The current mathematics learning method does not yet have an effective and efficient learning model. Therefore, innovation in learning mathematics needs to be done so that the objectives of learning mathematics can be achieved effectively. One of the innovations that can be done is to utilize cultural products in learning mathematics. Besides being able to learn mathematics well, students can also have the opportunity to get to know their culture that may be slowly beginning to be forgotten.

Teachers must have strong mathematical abilities to provide meaningful mathematics learning. Mathematics learning must be as concrete as possible for students, to make it easier to understand mathematics, namely by actualizing mathematics learning using local wisdom, referring to an approach that is also known as ethnomathematics (Astuti et al., 2019). There is great hope that the application of ethnomathematics in Indonesia can promote local culture and be used in a real learning setting at school that is interesting and fun. As stated by Supiyati et al. (2019) mathematical and cultural integration means contextual and realistic mathematics. Learning contextual and realistic mathematics is the cultural integration of mathematics. Cultural integration into mathematics by utilizing local culture will make learning more meaningful. In addition to help students learn mathematics contextually, ethnomathematics-based learning can motivate students to be active in class, understand culture and develop character values.

According to Marsigit et al. (2018), ethnomathematics serves to express the relationship between culture and mathematics. Learning by expressing the local culture will be more interesting and meaningful and is expected to motivate students to love mathematics more. As Bishop (1994) argued, ethnomathematics objects are used for mathematical activities such as counting, deter-mining locations, measuring, designing, playing, and giving explanations. The ethnomathematics objects can be in the form of traditional games, traditional crafts, artifacts, and activities (actions) in the context of culture.

Games (2009) stated that in addition to learning activities through practice, the use of culturally relevant problem solving may serve as an alternative in learning. Various alternatives can indeed be used in learning activities, but what is more important is that we must modify learning productively so that it has a beneficial impact on teaching reforms such as group work and problem-based learning (Klumb et al., 2006).

Mathematics learning will become fun and enjoyable with a field experiment. It can help eliminate the impression that math is a tedious and boring subject. Although there are a number of students that regularly win international-level mathematics olympiads, we must be aware that Indonesian students' math achievements are generally still very low in the international competitions. In general, Indonesian students still consider math as a difficult and uninteresting subject. Students view math as a subject that is distant from the real world, as it only concerns symbols and numbers. The higher the education level, math lessons become more abstract and distant from daily life. This is in line with the research finding by Rudyanto (2019) which reports that about 27.24% of 135 participants consider math as a difficult subject. Therefore, it is the task of the mathematics teachers to present mathematical concepts that exist in daily life in mathematics learning at school, one of which is by exploration to a cultural site.

One of the artifacts in the form of historical buildings that can be explored is the Beteng Cepuri fort in Kotagede Yogyakarta. Beteng Cepuri is a heritage site of the Islamic Mataram Kingdom in Kotagede. Today, the fort consists of mainly remains of the former building, which was originally aimed to protect the Kedhaton or Mataram Palace in the early days of Panembahan Senapati's reign, who is believed to be the founding royal of Yogyakarta. The construction of the fort continued until Panembahan Senapati was replaced by Panembahan Hanyakrawati to the early days of Sultan Agung's reign, before the center of government was eventually moved to Kerto (Karta).

The application of mathematical concepts in everyday life in learning mathematics at school is considered to increase student motivation. Students feel that the exploration method applied by the teacher can draw their attention and allow them to focus on the material provided by the teacher. Based on the above background, the researcher conducted an exploration using an ethnographic approach to explore and examine any mathematical concepts contained in Beteng Cepuri that can be used as a source of learning mathematics as well as efforts to develop ethnomathematics as a basis for learning mathematics.

METHOD

This study is an exploratory qualitative study aimed to explore the existence of the fort and whether the building construction of the fort has any relation with mathematics to further study the geometrical concepts in the building. The research methods involve exploration, documentation, and a literature study. Data were collected through observation, interviews, and collecting references that can contribute to the development of the research description and results.

Exploration and documentation were carried out at Beteng Cepuri fort. Beteng Cepuri is located in the district of Kotagede. Kotagede is one of the original regions in the city of Yogyakarta. The Kotagede Kemantren area was part of the former Kotagede city in addition to the surrounding area. Meanwhile, the other part of the former city of Kotagede is the Kapanewon Banguntapan area. Initially, Kotagede was the name of a city which was the capital of the Sultanate of Mataram. Subsequently, the kingdom was divided into the Surakarta Sunannate and the Yogyakarta Sultanate. Kotagede is located at coordinates 7.8188912°S 110.3979074°E with areas bordering Kapanewon Banguntapan in the north, east, and south and Kemantren Umbulharjo in the west, southwest and northwest. The exploration and documentation activity is aimed at finding geometrical figures that can be used as materials for learning mathematics. To accommodate the role of ethnomathematics in learning mathematics, the researcher invited elementary school students to explore the fort so that they were able to actively participate in learning mathematics. Researchers conducted an exploration in Beteng Cepuri with fifth-grade students of state elementary school SDN Dalem Kotagede.

RESULTS AND DISCUSSION

Based on the results of exploration, observation and documentation, Beteng Cepuri has several forms of rectangular geometrical shapes. In this discussion, we present the rectangular shapes of the Kotagede Cepuri Beteng, and the mathematical concepts that explain these shapes. Panembahan Senopati built an inner fort (known as cepuri) complete with a defensive moat around the palace, covering an area of approximately 400 x 400 meters. The ruins of the original fort can still be seen in the southwest and southeast corners. The walls are 4-feet thick made of large blocks of stone, while the rest of the defense trenches can be seen on the east, south, and west sides.

The existence of Cepuri can also be interpreted as a fortress of defense. This is evidenced by the existence of jagang (the defense trenches) on the west, south and east sides. The jagang has a depth of approximately 2 meters with a width of 25 meters and a moat length of 400 meters on each side. The fort, which is surrounded by the moat or jagang outside, functions as a means of security against outsider attacks as well as a residential area to live for relatives of the *njero beteng* (inner fort) royal palace and ordinary people or *wong njobo beteng* (outsiders of the fort) (Olthof, 2017). Based on the analysis of the jagang or trench (Figure 1), the cuboid geometrical concept is identified. The depth of the trench is conceptualized as the height of the three-dimensional figure (t), the width of the trench is conceptualized as the width of the three-dimensional figure (l) and the length of the trench is conceptualized as the length of the the three-dimensional figure (p).

The structure of the Cepuri Beteng building is made of red bricks each with a length of 30 cm, a height of 16 cm, and a width of 8 cm and made of white stones each with a length of 30 cm, a height of 16 cm, and a width of 7 cm. The ancient bricks in Cepuri Beteng can be modeled geometrically so that it can be concluded that the cuboid geometrical concept is identified in some of the ancient bricks.

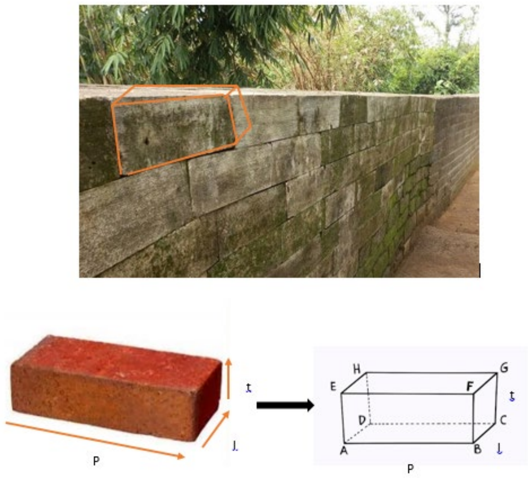

Figure 1. Geometry Modelling on an Ancient Brick

The height of the Beteng Cepuri building is about 3.5 meters, with 2-meter width, and a length of around 1.000 meters. Figure 2 below reveals the cuboid geometry concept in the Beteng Cepuri building.

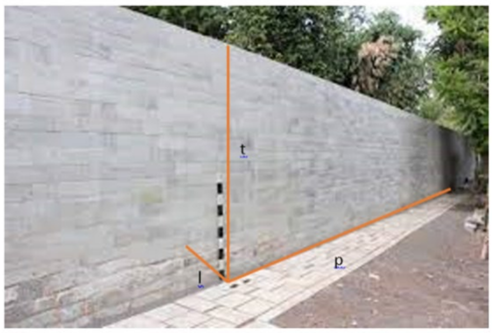

Figure 2. Geometrical Concept at the Beteng Cepuri Building

On the north side of Beteng Cepuri, there are ruins of a former fortress known as Beteng Jebolan Raden Rangga. The area within Beteng Cepuri is about 62.275 m². Other than that, there is no other heritage building left. On the west side of the fortress, there used to be ruins of part of the fortress. It has now turned into a highly populous residential complex.

Efforts made by researchers in accommodating the role of ethnomathematics in learning mathematics are by inviting elementary school students to participate in the exploration so that students can be actively involved in learning mathematics by using student worksheets. Student worksheet is a means to assist and facilitate the teaching-learning activity in order to develop an effective interaction between students and teachers as well as improve student learning achievements. The benefit of student worksheet is that it can make students more active in the learning activity as they solve the problems on their own and use their ability to think. As a result, students understand learning more as they are involved in a real practice and hands-on experiment to solve problems in the worksheet. They are also able to express their thoughts as the inquiry demands them to solve their own problems. However, the disadvantage of student worksheet is that it relies heavily on accurate instructions. If the instruction to use the worksheet is not clear, students will have a difficulty in using the worksheet. The direct proving through practice and experiment also requires adequate equipment and a long period.

Researchers conducted an exploration in Beteng Cepuri with fifth-grade students of the state elementary school SDN Dalem Kotagede. Students were divided into several groups with 5 members each. Students were then given worksheets prepared by the researchers which included the basic competencies, learning objectives, work instructions, learning steps, as well as texts and questions of the story problems about the mathematical concepts of geometry in Beteng Cepuri. Student worksheets were designed to be as attractive as possible to make students more enthusiastic in participating in the learning process. The worksheet can be seen in Figure 3.

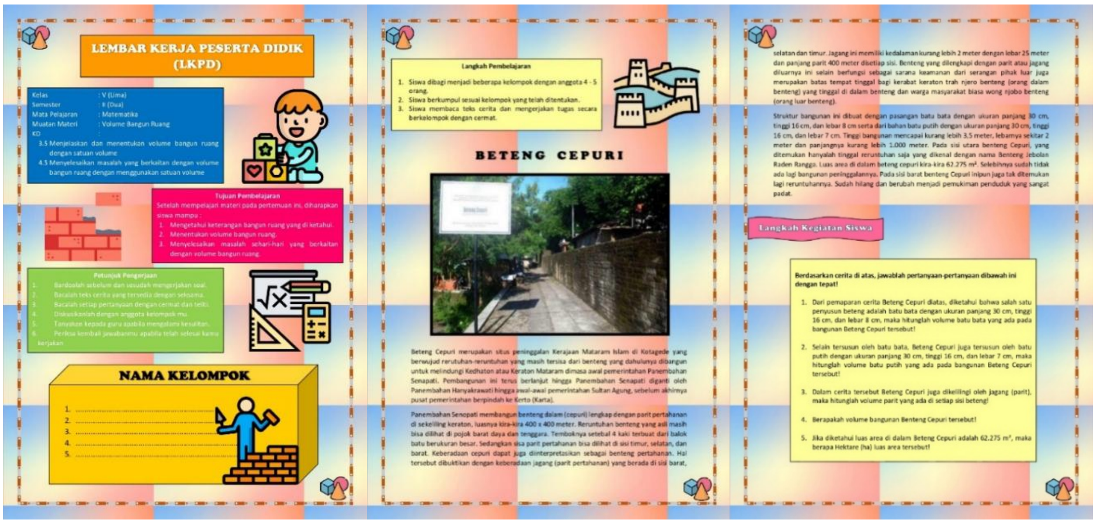

Figure 3. Student Worksheet

The researcher (teacher) explained about basic competencies, learning objectives, and a little about Beteng Cepuri after all students received the worksheet. Next, students were asked to read the story problems about Beteng Cepuri while exploring with the teacher. According to Setiana et al. (2021), in solving story problems, students are not only required to have numeracy skills, but also pay attention to the problem-solving process. It is expected that students will solve the story problems step by step so that the teacher are able to analyze the abilities that they already possess, especially their understanding on the concepts that are used to solve the problems given.

Figure 4. Exploration activity at Beteng Cepuri

During the lesson, students expressed enthusiasm and asked questions. They conducted discussions and managed to identify a number of geometrical shapes at Beteng Cepuri while solving the problems in the worksheet. They were allowed to ask the teacher if they have difficulty. Some students had yet to understand the geometry formula, so the teacher must explain the geometry concept while exploring and identifying the geometrical shapes around the fort. The documentation of the teacher and students can be seen in Figure 4.

In the mathematics learning process, the fifth-grade teacher has utilized ethnomathematics, as evident by the development of worksheet and the delivery of the lesson materials. Although it is still limited, teacher has utilized ethnomathematics in mathematics learning. The application of ethnomathematics as a means to motivate and stimulate students can overcome the tediousness and difficulty in learning mathematics. This is because ethnomathematics is part of the students' daily life, which represents the original conception that they have from the local social cultural environment. Moreover, ethnomathematics also offers a new atmosphere in mathematics learning (Firdaus et al., 2020; Wahyudi et al., 2021). The following is the result of application of worksheet among students (Table 1).

Tabel 1. Student Worksheet Answers

Group	Item Number 1	2	3	4	5
Group 1	V. bricks = 3.840 cm^3 (Correct)	V. white stone blocks = 3.360 cm^3 (Correct)	Volume of moat = 20.000 m^3 (Correct)	V. fort building = 7.000 m^3 (Correct)	62,275 m^2 = 6.227.500 ha^2 (Incorrect)
Group 2	V. bricks = 3.840 cm^3 (Correct)	V. white stone blocks = 3.360 cm^3 (Correct)	Volume of moat = 20.000 m^3 (Correct)	V. fort building = 7.000 m^3 (Correct)	62,275 m^2 = 622,75 ha^2 (Correct)
Group 3	V. bricks = 3.840 cm^3 (Correct)	V. white stone blocks = 3.360 cm^3 (Correct)	Volume of moat = 20.000 m^3 (Correct)	V. fort building = 7.000 m^3 (Correct)	62,275 m^2 = 622 ha^2 (Incorrect)
Group 4	V. bricks = 3.840 cm^3 (Correct)	V. white stone blocks = 3.360 cm^3 (Correct)	Volume of moat = 20.000 m^3 (Correct)	V. fort building = 7.000 m^3 (Correct)	62,275 m^2 = 622,75 ha^2 (Correct)
Group 5	V. bricks = 3.840 cm^3 (Correct)	V. white stone blocks = 3.360 cm^3 (Correct)	Volume of moat = 1000 m^3 (Incorrect)	V. fort building = 7.000 m^3 (Correct)	62,275 m^2 = 622,75 ha^2 (Correct)

The results obtained reveal that ethnomathematics manages to provide students with ease in mathematics learning and successfully introduce students to learn geometry lesson materials. The observation done by students at Beteng Cepuri had given them a great opportunity to learn geometry, which results in how they were able to complete the calculation well. Their ability in connecting culture with the lesson allows them to be more active in mathematics learning. The application of ethnomathematics learning also increase their learning interest, whereas the direct involvement in learning results in curious students. This result is in accordance with the research done by Sari's (2017) research entitled "The development of web-assisted learning media with ethnomathematics approach on the main topic of flat face three-dimensional figures." The population of the research was eight-grade students at state junior high school SMPN 1 Sekincau in West Lampung. The study findings show a good result in the satisfaction response of students toward the learning media based on the syllabus.

Mathematics learning should not stop at the attainment of basic competencies, and instead must be designed to achieve the high-order competencies (Rudyanto, 2019). This new perspective is a challenge that must be used as a reference in mathematics learning. Learning must be able to give as much space as possible for students to build knowledge and experience from basic to the high-order skills so that their creativity develops. This is highly relevant as real world problems are generally neither simple nor convergent, but complex and divergent, even unexpected (Irfan et al., 2019).

CONCLUSION

Based on the research findings, it can be concluded that one of the ethnomathematics objects in the form of a historical site, namely Beteng Cepuri in Kotagede has several geometrical figures. This may be used by teachers in contextual mathematics learning to motivate students to be more engaged and active in exploring resources that are relevant with the studied topics/problems. The research findings suggest that the mathematics learning is filled with enthusiasm, as well as two-way interactions between students and teacher and students with their peers. Not only they acquire mathematics knowledge, but students also are able to learn culture and study mathematics anywhere, thus creating a sense of excitement toward mathematics.

REFERENCES

Astuti, E. P., Purwoko, R. Y., & Sintiya, M. W. (2019). Bentuk etnomatematika pada batik Adipurwo dalam pembelajaran pola bilangan. *JOURNAL of MATHEMATICS SCIENCE and EDUCATION*, *1*(2), 1–16. https://doi.org/10.31540/jmse.v1i2.273

Bishop, A. J. (1994). Cultural conflicts in mathematics education: Developing a research agenda. *For the Learning of Mathematics*, *14*(2), 15–18. https://www.jstor.org/stable/40248109

Dossy, J. A. (1992). The nature of mathematics: Its role and its influence. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 39–48). National Council of Teachers of Mathematics.

Firdaus, B. A., Widodo, S. A., Taufiq, I., & Irfan, M. (2020). Studi etnomatematika: Aktivitas petani padi Dusun Panggang. *Jurnal Derivat: Jurnal Matematika Dan Pendidikan Matematika*, 7(2), 85–92. https://doi.org/10.31316/j.derivat.v7i2.983

Games, A. (2009). *The web of empire: English cosmopolitans in an Age of Expansion*. Oxford University Press.

Hardiarti, S. (2017). Etnomatematika: Aplikasi bangun datar segiempat pada Candi Muaro Jambi. *AKSIOMA: Jurnal Matematika Dan Pendidikan Matematika*, *8*(2), 99. https://doi.org/10.26877/aks.v8i2.1707

Irfan, M., Slamet Setiana, D., Fitria Ningsih, E., Kusumaningtyas, W., & Adi Widodo, S. (2019). Traditional ceremony Ki Ageng Wonolelo as mathematics learning media. *Journal of Physics: Conference Series*, *1175*, 012140. https://doi.org/10.1088/1742-6596/1175/1/012140

Klumb, P., Hoppmann, C., & Staats, M. (2006). Division of Labor in German dual-earner families: Testing equity theoretical hypotheses. *Journal of Marriage and Family*, *68*(4), 870–882. https://doi.org/10.1111/j.1741-3737.2006.00301.x

Marsigit, M., Setiana, D. S., & Hardiarti, S. (2018). Pengembangan pembelajaran matematika berbasis etnomatematika. *2018: Prosiding Seminar Nasional Pendidikan Matematika Etnomatnesia*, 20–38. https://jurnal.ustjogja.ac.id/index.php/etnomatnesia/article/view/2291

Olthof, W. L. (2017). *Babad tanah Jawi : Mulai dari Nabi Adam sampai tahun 1647* (H. R. Sumarsono (trans.)). Narasi.

Rosa, M., & Orey, D. C. (2003). Vinho e queijo: Etnomatemática e modelagem! *Bolema Em Scielo*, *16*(20), 1–16. https://www.periodicos.rc.biblioteca.unesp.br/index.php/bolema/article/view/10541

Rudyanto, H. E. (2019). Etnomatematika budaya Jawa: Inovasi pembelajaran matematika di sekolah dasar. *Jurnal Bidang Pendidikan Dasar*, *3*(2), 25–32. https://doi.org/10.21067/jbpd.v3i2.3348

Sari, A. W. (2017). *Pengembangan media pembelajaran berbantuan web dengan pendekatan etnomatematika pada pokok bahasan bangun ruang sisi datar* [UIN Raden Intan Lampung]. http://repository.radenintan.ac.id/1511/

Setiana, D. S., Ayuningtyas, A. D., Wijayanto, Z., & Kusumaningrum, B. (2021). Eksplorasi etnomatematika Museum Kereta Kraton Yogyakarta dan pengintegrasiannya ke dalam pembelajaran matematika. *Ethnomathematics Journal*, *2*(1), 1–10. https://doi.org/10.21831/ej.v2i1.36210

Stigler, J. W., & Baranes, R. (1988). Culture and mathematics learning. *Review of Research in Education*, *15*, 253. https://doi.org/10.2307/1167366

Sträßer, R. (1994). Cultural framing of teaching and learning mathematics. In *Didactics of Mathematics as a Scientific Discipline* (pp. 399–455). Kluwer Academic Publishers. https://doi.org/10.1007/0-306-47204-X_9

Supiyati, S., Hanum, F., & Jailani, J. (2019). Ethnomathematics in Sasaknese architecture. *Journal on Mathematics Education*, *10*(1), 47–58. https://doi.org/10.22342/jme.10.1.5383.47-58

Wahyudi, H., Widodo, S. A., Setiana, D. S., & Irfan, M. (2021). Etnomathematics: Batik activities in Tancep Batik. *Journal of Medives : Journal of Mathematics Education IKIP Veteran Semarang*, *5*(2), 305–315. https://doi.org/10.31331/medivesveteran.v5i2.1699

Wulandari, I. G. A. P. A., & Puspadewi, K. R. (2016). Budaya dan implikasinya terhadap pembelajaran matematika. *Jurnal Santiaji Pendidikan*, *6*(1), 31–37. http://ojs.unmas.ac.id/index.php/JSP/article/view/669

Zaini, A., & Marsigit, M. (2014). Perbandingan keefektifan pembelajaran matematika dengan pendekatan matematika realistik dan konvensional ditinjau dari kemampuan penalaran dan komunikasi matematik siswa. *Jurnal Riset Pendidikan Matematika*, *1*(2), 152–163. https://doi.org/10.21831/jrpm.v1i2.2672