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STUDYING MATHEMATICS AROUND KERATON YOGYAKARTA

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ABSTRACT

Studying mathematics in elementary school using cultural resources can make the learning process more meaningful. Students can explore learning resources for mathematics at the Yogyakarta Palace while getting to know the local culture. Learning resources that can be used for elementary school mathematics learning include gunungan sekaten, batik, the Bangsal Manganti hall, the stairs at the palace, etc. Based on the analysis carried out by the researcher, the identified learning resources at the Kraton can be used for Grades 1 to 6. From D'Ambrosio's theory of classification of ethnomathematics activities, there are 5 categories of learning resources in the Palace, including counting, weighing, measuring, ordering and classifying which can be used in elementary school mathematics learning.

Keywords: Ethnomathematics, learning resource, Yogyakarta Palace

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INTRODUCTION

Ethnomathematics has become an interesting topic of discussion since a few decades ago. These discussions involve various perspectives, whether in the development of mathematics at school, the challenges, the epistemology criticisms, or the advantages and disadvantages (Pais, 2011). Despite his criticism on ethnomathematics to reject dogma, Pais (2011) intended ethnomathematics to keep growing as a research field. Nevertheless, based on numerous studies, ethnomathematics have been reported to have a positive contribution to the development of mathematics education (Budiarto et al., 2019; Widada et al., 2019) especially in appreciating ethnicity (Presmeg, 1998; Rosa & Gavarrete, 2017).

In order to create a good mathematics learning, it is suggested that teachers attempt to explore students' informal knowledge to teach formal mathematics (Marsigit et al., 2014). Therefore, there needs to be concrete learning resources for creating an interesting learning experience, one of which is through the local culture. This idea is in line with the realistic spirit of mathematics, which supports the notion that learning should be closely related to the students' contextual experience (Dickinson & Hough, 2012; Prahmana et al., 2020). Realistic learning consists of the following principles: the presence of activities, reality, competency level, relation between the materials, interactive elements, and assisted by a teacher's guidance. Based on this principle, ethnomathematics that study mathematics in a certain community and culture can serve as the relevant alternative to implement mathematics learning that is innovative, student-centered, and provides real and contextual learning resources (Marsigit et al., 2018).

Mathematics learning that is connected to culture will make it more meaningful for students, especially to develop greater sense of respect for those who are different from them

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(D'Ambrosio, 2001). This is in accordance with the findings (Wahyudiati, 2020) which report that students experience improvements in their scientific attitude, cognitive achievements, and learning motivation (Purnama et al., 2019). On the other hand, teachers must also improve their skill in the management of student diversity (Haghi et al., 2013).

Exploration of the cultural heritage existence around the students' learning environment can be used to facilitate mathematics learning while simultaneously strengthening the love for culture and the use of contextual media. In the regions of Yogyakarta, there are many artifacts and cultural heritage of Javanese culture, including cultural sites, shadow puppets, temples, traditional dances, and many others that have yet to be incorporated in mathematics learning. The cultural resources in Yogyakarta Palace including traditional parties, batik, the jumenengan (coronation) anniversaries, the annual celebration of sekaten (to commemorate the birth of prophet Muhammad), as well as historical objects, etc., must be explored for the mathematics learning development.

The selection of mathematics learning resources related to culture must consider their relevance with the learning materials, the students' level of understanding, and the aimed learning objectives. Classification theory by D'Ambrosio and Rosa (2017) on ethnomathematics activities can serve as the analysis tool to classify the integration of ethnomathematics learning resources in elementary school mathematics classes. Ethnomathematics activities include comparing, ordering, counting, weighing, measuring, classifying and quantifying (D'Ambrosio & Rosa, 2017b; Katsap & Silverman, 2016; Rosa & Orey, 2016).

METHOD

This study used the qualitative approach in an analytical descriptive manner. The research participants consisted of 2 *abdi dalem* (royal servants) of the Yogyakarta Palace, and 1 mathematics lecturer for elementary education. The data collection technique included interviews, followed by observation by 5 observers in a field visitation to Yogyakarta Palace, in addition to documentation. The instruments were interview guidelines, observation sheets, and documents. Data analysis began by conducting data reduction on the results of interviews with the research participants, as well as reduction of the observation and documentation data, followed by classifying and analyzing the data. The analysis was done by applying the classification theory on ethnomathematics activities by D'Ambrosio's. Ethnomathematics activities may include counting, measuring, classifying, weighing, ordering. Based on the learning resources explored from the Yogyakarta Palace, materials were sorted and selected into the most relevant to apply according to the basic competencies of the appropriate grade. Afterwards, they were labeled by the classification according to D'Ambrosio's theory. Data were presented in tables.

RESULTS AND DISCUSSION

The selection, and evaluation of learning resources should be aimed at supporting educational and learning objectives, according to the applicable curriculum (Davies et al., 2008). Based on Regulation of Minister of National Education Number 22 of 2006 on Content Standards, the unit of mathematics subject aims to make students have the following abilities: (1) Understand mathematical concepts, explain the relationship between concepts and multiply concepts or logarithms in a flexible, accurate, efficient and precise way in problem solving; (2) Use reasoning on patterns and traits, performing mathematical manipulations in making generalizations, compiling evidence or explaining mathematical ideas and statements; (3) Solving problems which include the ability to understand and design mathematical models, complete models and interpret the solutions obtained; (4) Communicate ideas with symbols, tables, diagrams or other media to clarify the situation or problem; and (5) Have an attitude of appreciating the use of mathematics in life.

There are several rules in determining the learning resources, i.e. (1) Support local/regional curriculum; (2) Developed by teachers with adequate competence; (3) In accordance with the development of age, emotional, material, ability, learning style and condition of students; (4). Contains aesthetic values, social values, and literacy (Davies et al., 2008). The use of learning resources in Yogyakarta Palace site certainly becomes an appeal to students as one of the tourist destinations in the city. Furthermore, a theory states that learning will develop when teacher integrates learning with students' background (Díez-Palomar et al., 2006), in this case their region's cultural environment.

In relation to the mathematics learning resources, D'Ambrosio categorizes ethnomathematics based on the following activities: counting, weighing, measuring, comparing, sorting, and classifying (Gerdes, 1996). Table 1 presents the learning resources at Yogyakarta Palace with analysis based on the learning materials, basic competencies, grade relevance, and classification of ethnomathematics activities by D'Ambrosio.

Table 1. Analysis of Learning Resources at Yogyakarta Palace

Learning Resource	Learning Material	Basic Competency	Grade	D'ambrosio's Classification
Facade of the Palace Figure 1	Combination of two-dimensional shapes, combination of three-dimensional figures	3.7, 4.7	6	Measuring
Batik pattern Figure 2	Calculating the area with Batik pattern	4.4	4	Measuring
Gunungan sekaten Figure 3	Volume, area of surface	3.4, 3.5, 4.4, 4.5	5	Measuring, Weighing
Tile patterns, wall ornaments in Bangsal Manganti Figure 4	One-dimensional/two-dimensional shapes	3.8, 3.9, 4.8, 4.9	2	Classifying
Pawukon, *dina pasaran*	Numerical multiplications	3.6, 4.6	4	Counting
Calendar of Sultan Agung (*Anno Javanica*)	The concept of numerical quantity, *selapan* (35-day milestone), octennium	3.4, 4.4	4	Counting
Design of the Palace	Two-dimensional shapes	3.8, 3.9, 4.8, 4.9	2	Classifying
Bangsal Manganti Figure 5	Area, perimeter	3.10, 3.11, 3.12, 4.10, 4.11, 4.12	3	Measuring
Tessellation: Figure 6	Pattern	3.5, 3.6, 4.5, 4.6, 4.7	1	Ordering, Classifying, Measuring

Learning resources from the Yogyakarta Palace identified in this study are presented in Figure 1 to Figure 6, as follows.

Figure 1. The Facade of the Palace has a Distinct Traditional Yogyakarta Shape Serves as a Learning Resource for Combination of Two-Dimensional Shapes and Three-Dimensional Figures (Measuring)

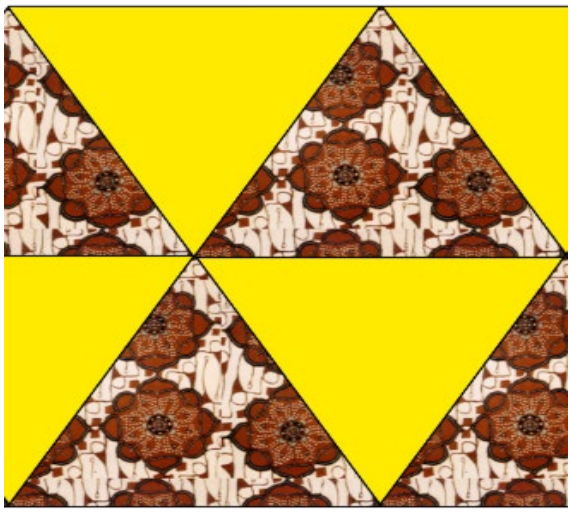

Figure 2. The Barong Purbonegoro Batik can be Used as a Mozaic in Mathematics Learning and as a Learning Resource to Calculate the Area with the Batik Motif (Measuring), as well as be used to Explore the Learning Materials of Folding Symmetry and Rotational Symmetry

Figure 3. The Sekaten Festival's Gunungan (Cone-Shaped Food Ornaments or Dishes) is Yogyakarta's Traditional Culinary Product that Resembles the Geometry Shape of a Cone in Mathematics. This Shape Serves as a Learning Resource for Learning Volumes and Area of Surface (Measuring, Weighing).

Figure 4. The Pattern and Shape of Ornaments in the Bangsal Manganti Hall Serves as a Learning Resource for Patterns and Two-dimensional Shapes (Classifying)

Figure 5. The Design of the Bangsal Manganti Hall with Traditional Javanese Architecture Serves as a Mathematics Learning Resource for Lesson of Area and Perimeter (Measuring)

Figure 6. Floor Pattern at Yogyakarta Palace in a Classical Tile Pattern Serves as a Learning Resource for Tessellation (Ordering, Classifying, and Measuring)

Based on Table 1, after an analysis is conducted with the basic competencies of the revised Curriculum 2013, it is identified that the learning resources at Yogyakarta Palace facilitate the learning resources of mathematics learning from Grade 1 to Grade 6 of elementary school. Hence, it serves as an alternative learning media with a cultural background or ethnomathematics.

Several ethnomathematics-based studies related to elementary mathematics learning have been carried out in Indonesia. These studies include the use of teaching materials for learning two-dimensional shapes based on ethnomathematics at the Komering tribe in Lampung (Nelawati et al., 2018), and the uses of ethnomathematics-based mathematics learning which offer the potential for enrichment and variation to develop mathematics learning and improve the quality of learning (Tandililing, 2013). Moreover, research by Tandililing (2013) reveals that the life practice of the Kanayat Dayak's mathematical activities can be developed into a discussion for the learning materials of number sequences, addition and subtraction, and geometry of two-dimensional shapes. Another study reports that the fourth grade two-dimensional shapes lesson can be better understood when using the thnomathematics elements of tapis fabric and the siger image of the Lampung culture (Putra & Indriani, 2017).

Ethnomathematics activities that have been implemented in elementary mathematics learning related to counting, comparing and measuring have also been carried out (Sirate, 2012). The activity of counting and measuring in the Manggarai community in ethnomathematics activities can be used in elementary mathematics learning (Tamur et al., 2017). Elementary mathematics learning can also use ethnomathematics elements at the Yogyakarta Kraton Train Museum, especially regarding the discussion of the concepts of two-dimensional shapes, volume, symmetry, and tessellation/tiling. At a higher level learning, ethnomathematics exploration for junior and senior high school levels can be applied through studying the fractal geometry of the Borobudur Temple or the modulo numbers used in the Baduy community. In addition, other learning materials for geometry can be incorporated, such as straight lines, curved lines, parallel lines, symmetry, points, angles, rectangles, triangles, and circles (Zayyadi & Subaidi, 2017).

In its practice, the development of learning tools based on ethnomathematics has been done (Marsigit et al., 2014). Inclusive learning can also be integrated with ethnomathematics (Duranczyk & Higbee, 2012) and is reported to contribute to better education, especially in

increasing motivation. Further, ethnomathematics plays a role in creating and promoting the awareness of values. Educational research in Latin America has proven that proper integration of Ethnomathematics addresses the learning objectives outlined in the OEI (Blanco-Álvarez & Oliveras, 2016). Even the use of ethnomathematics elements by teachers results in effective mathematics learning (Balamurgan, 2015). Based on these findings, it appears to be necessary to continue to strive for the development and research in using ethnomathematics in learning as an effort to expand and enrich the discourse of education in Indonesia.

CONCLUSION

Elementary school mathematics learning may use cultural objects in the Yogyakarta Palace site as learning resources, including *gunungan sekaten*, batik, the Bangsal Manganti hall, the images and shapes on the floors, walls, and stairs of the palace, etc. These learning resources can be applied to Grade 1 to Grade 6 of elementaryg school according to the relevant basic competencies. From the six categories in D'Ambrosio's mathematics activities, five are identified in the Yogyakarta Palace, namely counting (using the traditional Javanese *pasaran* days), weighing and measuring (using the cone-shaped *tumpeng* rice dish and *sekaten's gunungan*), ordering (tessellation) and classifying (two-dimensional shapes).

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