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Ethnomathematics Study at Pura Kerta Bhuwana Giri Wilis Nganjuk as a Context in Mathematics Learning Module

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Abstract:
Ethnomathematics is the study of mathematics from various cultural forms, allowing communities to discover and explore mathematical concepts within their culture. Cultural values of mathematics can be utilized in mathematics education. This research aims to identify the mathematical concepts found in *Pura Kerta Bhuwana Giri Wilis Nganjuk* and use them as components in preparing mathematics modules for seventh-grade junior high school students. *Pura Kerta Bhuwana Giri Wilis* is in the Loceret District of Nganjuk Regency. This temple has a strong traditional Javanese architectural style, featuring tiered roofs, relief decorations, and ornaments that symbolize Hindu beliefs. This research uses qualitative research with an ethnographic approach. Data collection through interviews was conducted to understand the history, philosophy, and components of *Pura Kerta Bhuwana Giri Wilis Nganjuk*. Observation and documentation were carried out to analyze the mathematical elements in the parts of the *Pura*. The research results show that *Pura Kerta Bhuwana Giri Wilis* contains mathematical concepts such as flat shapes (squares, rectangles, triangles, trapezoids, rhombuses), three-dimensional shapes (rectangular pyramids, rectangular prisms, cylinders), and geometric transformations (reflection and rotation). Using the Self-Directing Learning model, the mathematical concepts are then implemented into the Lesson Plan (RPP). The *Self-Directing Learning* model consists of three steps: *Planning, Monitoring*, and *Evaluating.* Ethnomathematics from Pura Kerta Bhuwana Giri Wilis are expected to enhance students' understanding of mathematics and develop learning media based on local culture.

Keywords: *Ethnomathematics, Pura Kerta Bhuwana Giri Wilis, Mathematical Learning Device*

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Introduction

Mathematics is a unique subject, and until now, there is still no certainty about the definition of mathematics from mathematicians (Santoso & Pamungkas, 2021). According to Muzaini et al (2021) Mathematics is one of the sciences that is very much needed in human life because, through mathematics, students are trained to think systematically, logically, and critically and to solve problems they face in real life.

However, in reality, some students consider mathematics to be quite difficult. Jalal has proved this (2022), who showed that 50% of subjects perceive mathematics as a fairly difficult subject, 75% consider mathematics important, and 50% of subjects have had the experience of receiving low grades in mathematics. Research on this matter is also related to the 2018 PISA (*Program for International Student Assessment) survey,* which stated that students in Indonesia have relatively low mathematical abilities and are ranked 75th out of 81 countries. Indonesia scored 379, with an average score of 374 for boys and 383 for girls (OECD, 2019). In this case, it can be concluded that students perceive mathematics as a difficult subject; however, mathematics is also a very important subject in daily life that can be encountered directly or indirectly around us, reflecting their mathematical competence.

Mathematics around us has quite a long history. Many mathematical concepts are contributed by culture in human life. Culture is a form or way of life related to creation, feeling, and will that grows and develops within a society, is owned by a group of people, and is continuously passed down from generation to generation (Nurhikmah et.al., 2019). Therefore, culture can be used as an alternative to learning mathematics. It can be concluded that mathematics is a cultural product that integrates into human life, which in this case can be referred to as ethnomathematics (Muhtadi et.al., 2019).

Ethnomathematics was first proposed by D'Ambrosio (1985), a Brazilian mystic. D'Ambrosio stated that ethnomathematics complements the efforts of teachers and students in the formal school mathematics learning process by providing relevant contextual meaning. The utilization of culture in mathematics education is very important because it can enhance students' knowledge or understanding of the culture to be studied (Pratami et.al., 2018). Ethnomathematics is mathematics education that conceptually raises local cultural themes, including the habits practised by students or the community around them (Yudianto et.al., 2021). In addition to using ethnomathematics to facilitate mathematics learning for students, this approach can also preserve the culture itself to anticipate the influx of foreign cultures.

According to Selo Soemardjan and Soeleman Soemardi, culture is the result of the work, feelings, and creations of society. The work of society produces technology and material culture or physical culture that humans need to master their surroundings so that its strength and results can be preserved for the needs of society. There are several forms of culture, namely traditional houses or buildings, traditional ceremonies, dances, songs, music, traditional clothing, and traditional weapons (Syakhrani & Kamil, 2022). Based on that opinion, it can be concluded that temples are one form of culture. The form of temple buildings that can be found in various regions show various shapes such as carvings, building patterns, layouts, functions, and decorations, which are the result of human creativity known as the concepts of creation, feeling, work, and will from the cultural processes that develop within society (Murtiawan dkk., 2020). The parts of the temple have geometric shapes, and mathematical concepts can be used as objects in teaching mathematics in the geometry branch at school. This is based on research by Jayanti and Puspasari (2020), which found mathematical concepts in temples in plane geometry, solid geometry, lines, angles, and geometric transformations. Research by Murtiawan et al. (2020) found mathematical concepts such as pyramids, frustums of pyramids, frustums of prisms, and cubes in temple buildings. Mathematical concepts include symmetry, parallelism, proportion, reflection, translation, and dilation. Furthermore, the research by Farhan et al. (2021) findings namely that there are mathematical elements (ethnomathematics) in *language* building, which include the concept of flat shapes such as squares, rectangles, and triangles, the relationship of parallel and perpendicular lines, three-dimensional shapes in the form of triangular prisms, and the concept of similarity in triangles. Moreover, the mathematical concepts found in the traditional house can be linked to mathematics learning in schools. From several previous researchers, it can be said that various mathematical concepts have been discovered in ethnomathematics research, one of which is flat shapes that can be applied in learning activities.

The application of learning relevant to students' daily lives is an important aspect of the curriculum in Indonesia. One way to help students better understand mathematics is by improving the quality of the learning process at school. This is done by linking the subject matter with the students' life situations in society, motivating students to learn mathematics and improving their mathematical literacy skills. Educators can integrate students' life contexts into society during the teaching planning and implementation stages. Several studies have implemented cultural context in mathematics learning at the planning stage, such as the research by Dama et al. (2021), which designed teaching materials as teaching modules with a *problem-based learning* approach based on ethnomathematics for flat-sided space. Additionally, the research by Ayuningtyas & Setiana (2019) also developed mathematics teaching materials based on the ethnomathematics of the Yogyakarta Palace in the form of student worksheets (LKS) consisting of 2 parts: part 1 contains circle material, and part 2 contains flat-sided space material. Meanwhile, studies that attempt to implement cultural context in the learning process include research by Hardiyansyah et al. (2024), which implemented ethnomathematics learning through the Sampat game on the mathematics learning outcomes of 2nd-grade elementary school students. The study found a significant average score difference between the control and experimental classes. A final test was conducted using the N-Gain test with SPSS 25, resulting in an N-Gain score of 65.29, which falls into the quite effective category. Therefore, it can be concluded that the ethnomathematics learning of the Sampat game can effectively improve mathematics learning outcomes. Additionally, research by Naitili & Nitte (2023) in their study shows that the results of the normality and homogeneity tests indicate that all data are normally and homogeneously distributed, while the hypothesis test results show a significance value of 0.05 ($0.016 < 0.05$), which means that ethnomathematics learning using the aikidoka game has a positive and significant effect on the understanding of geometric concepts for third-grade students at SDN Unina. Thus, from several studies, the researcher explored the mathematical concepts of the Pura Kerta Bhuwana Giri Wilis Nganjuk building and implemented them into educational devices.

This study's difference from previous research lies in the observed object. The objects observed in the previous research were in the form of temple buildings and sampat games, whereas in this research, they are in the form of pura buildings. Also, in previous research, the implementation of mathematical concept findings was in the form of LKS and teaching modules based on *problem-based learning*, whereas, in this research, the findings of mathematical concepts are implemented into learning devices in the form of Lesson Plans (RPP) based on *Self-Directed Learning*. *Self-directed learning* is a learning model that studies students' readiness to learn independently, with the teacher acting only as a monitor. The *Self-Directed Learning* model has three stages: *planning,* *monitoring,* and *evaluating*. This stage begins with students planning learning activities, planning the desired learning components, and setting learning targets, followed by observing and monitoring their learning. In the *planning stage*, the teacher conditions students to engage in learning, provides motivation and explains the learning objectives. At the *monitoring stage*, students observe and monitor the learning process, with the teacher providing student worksheets. At the *evaluating stage*, the teacher provides a conclusion from the learning process (Song & Hill, 2017).

Based on this, the researcher sees the need for a study related to ethnomathematics at Pura Kerta Bhuwana Giri Wilis Nganjuk. This temple, used as a Hindu place of worship, has strong characteristics of traditional Javanese architecture, such as tiered roofs, relief decorations, and ornaments that symbolize Hindu beliefs and rituals, different from places of worship of other religions. Therefore, ethnomathematics research on this temple can provide a deeper understanding of the unique culture and traditions of the Indonesian nation. Then, ethnomathematics at Pura Kerta Bhuwana Giri Wilis can be used as a mathematics learning tool as a Lesson Plan (RPP). The presence of an ethnomathematics-based RPP can provide benefits, including serving as a fundamental basis for teachers and students in achieving basic competencies and the indicators of the material being taught. It also provides an overview of the short-term work reference. (Gustiansyah dkk., 2021). Thus, it will help teachers present mathematics material in a more engaging and relevant way for students, enrich students' learning experiences and broaden their understanding of mathematics in social and cultural contexts. In addition, it can also be developed into a learning media based on local culture.

Methods

This research uses a qualitative approach with an ethnographic research type. Ethnography is qualitative research that studies people and cultures through daily activities (Nixon & Odoyo, 2020). Ethnography is used to describe, clarify, and analyze mathematical concepts, resulting in the identification of mathematical activities at Pura Kerta Bhuwana Giri Wilis Nganjuk. This research is located in Cukrik Hamlet, Bajulan Village, Loceret District, Nganjuk Regency, East Java Province. The data collection methods used are interviews, observations, and documentation. Interviews were conducted with the temple caretakers to understand the temple's history, philosophy, and components. Observations and documentation were carried out on the components within the temple, including the temple sections known as tri mandala, which aim to analyze the mathematical elements within the temple sections. At the stage of mathematical concept analysis, the researcher uses *GeoGebra* to identify the mathematical concepts present in the temple building. In qualitative research, triangulation techniques are employed to verify the validity of the data the researcher uses, where the researcher collects different types of data to obtain data from the same source (Alfansyur, 2020). The researcher collects data using observation, interviews, and documentation as data sources, which are combined to conclude. For example, data from observations are confirmed through interviews with temple caretakers and further supported by documentation in the form of photographs. Next, in testing the validity of the research data, the researcher *used Cohen's Kappa* type *Gwen's* AC_1 Coefficient because there were three evaluators for the research results. Here is the formula for *Cohen's Kappa* type *Gwetn'* AC_1 Coefficient:

$$\widehat{K_G} = \frac{P_a - P_e}{1 - P_e}$$

The results of the expert assessment were then analyzed with the assistance of Microsoft Excel. The following is the interpretation of *Cohen's Kappa* according to (McHugh, 2012):

Tabel 1. Interpretasi Cohen's Kappa

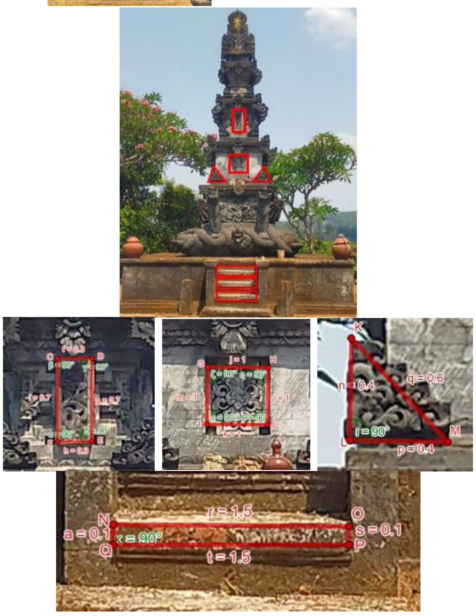
Kappa Value	Approval Rate	Percentage of reliable data
0 – 0.20	None	0 – 4%
0.21 – 0.39	Low	4 – 15%
0.40 – 0.59	Weak	15 – 35%
0.60 – 0.79	Currently	35 – 63%
0.80 – 0.90	Strong	64 – 81%
< 0.90	Almost Perfect	82 – 100%

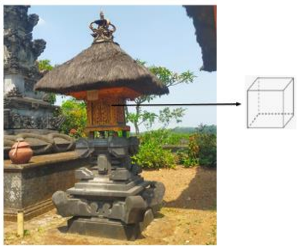
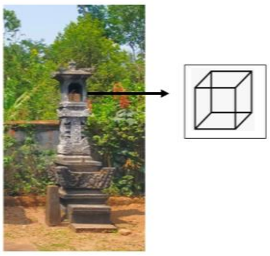
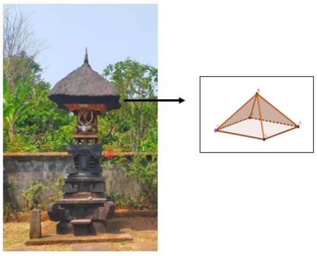
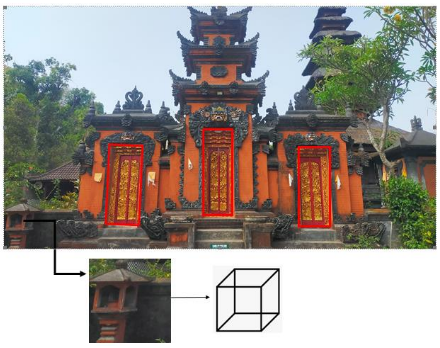
Results and Discussion

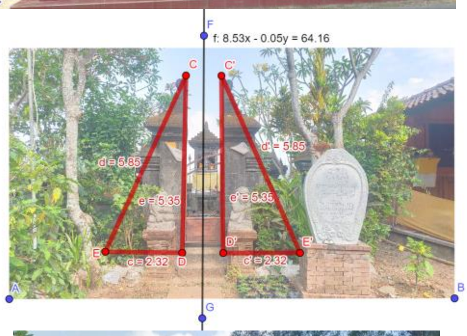
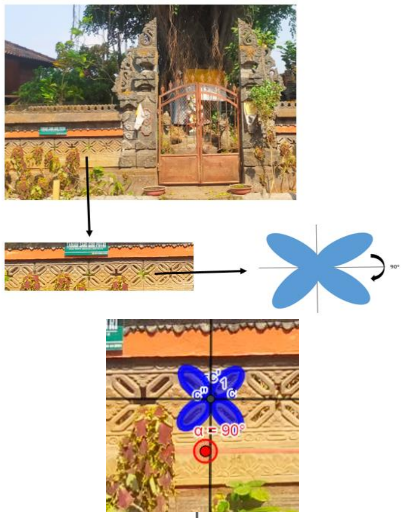
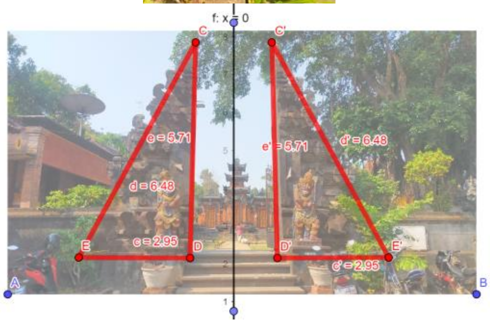
1. The Mathematical Concept at Pura Kerta Bhuwana Giri Wilis Nganjuk

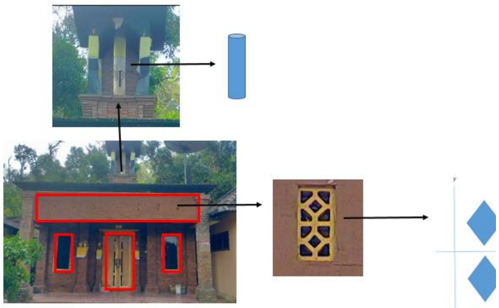
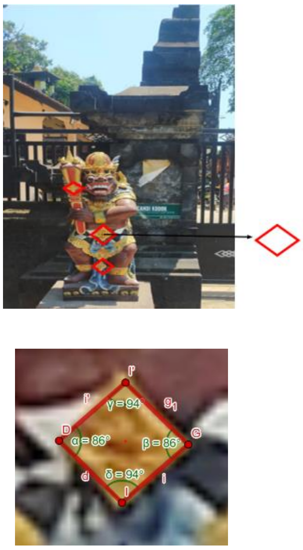
From the observations conducted at Pura Kerta Bhuwana Giri Wilis Nganjuk, it can be shown that the temple contains mathematical concepts, including the concepts of flat shapes, solid shapes, and geometric transformations. Here are the results of the ethnomathematics analysis at the Kerta Bhuwana Giri Wilis temple:

Tabel 2. Mathematical Concepts at Pura Kerta Bhuwana Giri Wilis Nganjuk

No	Object Name	Figure	Mathematical Concepts
1	Pepelik		Four-sided pyramid
2	Padamsana		Flat shapes: square, rectangle, and right triangle

3	Gedong Penyimpen		Square and rectangle
4	Pengapit		Three-dimensional shape of a rectangular prism
5	Anglurah		Three-dimensional shape of a rectangular prism
6	Manjangan Seluang		Four-sided pyramid
7	Balai Pemujaan		Flat shapes: rectangle and isosceles triangle
8	Kori Agung		Flat shape: rectangle and three-dimensional shape: rectangular prism

9	Balai Pawedan		Rectangular and trapezoidal flat shapes
10	Candi Kamulan		Geometric transformation (reflection/mirroring)
11	Balai Gong		Flat shape trapezium
12	Taman Sari		Geometric transformation (rotation)
13	Candi Bentar		Geometric transformation (reflection/mirroring)

14	Balai Kul-Kul		Flat shape rectangle, space shape cylinder, and geometric transformation (reflection/mirroring)
15	Balai Pasraman		Rectangular and trapezoidal flat shapes
16	Balai Pewaregan		Rectangular and trapezoidal flat shapes
17	Balai Manusa Yandya		Four-sided pyramid
18	Candi Kodok		Rhombus

The results of the mathematical concept analysis at Pura Kerta Bhuwana Giri Wilis Nganjuk were then tested for reliability using the inter-rater agreement test. The results of the mathematical concept analysis in this study were evaluated by 3 raters, all of whom are lecturers. Raters evaluate the analysis results based on the raters' agreement sheet, which contains 18 analyses of mathematical concepts. The assessment of rater agreement consists of 2 categories, namely "agree" or "disagree."

The data on the agreement of mathematical concepts among the three raters can be seen in the table below:

Tabel 3. Rater Agreement Results

Assesment	Rater 1	Rater 2	Rater 3
Agree	16 Mathematical Concepts	18 Mathematical Concepts	18 Mathematical Concepts
Disagree	2 Mathematical Concepts	-	-

Next, the assessment of the rater agreement results above is calculated using *Cohen's Kappa* type *Gwet's* AC_1 *Coefficient* with the help of *Microsoft Excel*. The formula for the *Cohen's Kappa* type *Gwet's* AC_1. *The coefficient* agreement coefficient is as follows:

$$\widehat{K_G} = \frac{P_a - P_e}{1 - P_e}$$

From the calculation of the rater agreement, the value was obtained from *Cohen's Kappa* type *Gwet's* AC_1 *Coefficient* as much as 0,99948. Thus, the interpretation of *Cohen's Kappa* indicates an **"Almost Perfect"** agreement with the researcher's analysis results.

2. Mathematics Learning Tools Based on Ethnomathematics at Pura Kerta Bhuwana Giri Wilis Nganjuk

After discovering the mathematical concepts in the Pura, these mathematical concepts can be developed into a mathematics learning device in the form of a Lesson Plan (RPP). The Lesson Plan (RPP) is a plan that details the steps and methods for organizing learning to achieve a predetermined basic competency. In the design of the RPP, the learning model used is the *Self-Directed Learning (SDL)* model, with the main material being flat shapes.

The Self-Directed Learning model is an educational approach that emphasizes student independence in the learning process. The *Self-Directed Learning model* can be linked to ethnomathematics because by using the *Self-Directed Learning model*, students can learn mathematics with a more relevant and engaging approach according to their cultural and life contexts. They can conduct their exploration and discovery related to mathematical concepts found in their culture. This can enhance their understanding of mathematics and increase their interest and motivation to learn mathematics. Thus, the relationship between the Self-Directed Learning model and ethnomathematics can enrich students' learning experiences and broaden their understanding of mathematics in a wider cultural context. According to (Song & Hill, 2017), there are 3 stages in the *Self-Directed Learning (SDL) model*, namely the planning, monitoring, and evaluating stages. Here are the stages of *the Self-Directed Learning (SDL) model*:

H. Langkah-langkah pembelajaran

Pertemuan Pertama:

Kegiatan	Deskripsi kegiatan	Alokasi waktu
Planning	1. Guru melakukan pembukaan dengan salam pembuka dan berdoa untuk memulai pembelajaran. 2. Guru memeriksa kehadiran siswa sebagai sikap disiplin. 3. Guru memeriksa kesiapan siswa untuk mengikuti pelajaran. 4. Guru menyampaikan tujuan pembelajaran atau kompetensi dasar yang akan dicapai. 5. Guru memberikan motivasi kepada peserta didik agar turut aktif dan sungguh-sungguh dalam proses pembelajaran.	

Figure 1. RPP Planning Stage

At the *planning stage,* the teacher conditions students to follow the learning process, provides motivation and explains the learning objectives.

Monitoring	**Mengamati** 1. Guru membagikan LKPD kepada peserta didik, kemudian peserta didik mengamati beberapa benda yang terdapat pada LKPD. Perhatikan gambar berikut:	

	2. Guru memberikan pertanyaan-pertanyaan kepada peserta didik, seperti : b. Apa saja bangun datar yang kamu ketahui setelah melihat gambar-gambar pada bangunan tersebut? c. Coba indentifikasikan sifat-sifat yang ada pada bangun datar tersebut! 3. Peserta didik menjawab pertanyaan dari guru dan kemudian menuliskannya kedalam LKPD. Sehingga peserta didik secara tidak langsung telah membuat hipotesis terkait jenis dan sifat-sifat bangun datar. **Observasi** 1. Peserta didik mengumpulkan data pada tabel guna membuktikan hipotesis. Berikut ini tabel untuk menuliskan jenis dan sifat-sifat bangun datar!	

No	Jenis Bangun Datar	Sifat Bangun Datar
1	....	....
2	....	....
3	....	....
dst	....	....

	2. Setelah mengetahui jenis dan sifat bangun datar, kemudian peserta didik menuliskan rumus keliling dan luas segitiga. 3. Peserta didik diberi kesempatan untuk mengumpulkan berbagai informasi yang relevan dan diperbolehkan untuk membaca literatur. 4. Peserta didik mengamati, memahami, dan mengidentifikasi jenis-jenis bangun datar. 5. Peserta didik mengisi tabel sesuai dengan gambar yang telah diamati. 6. Peserta didik dapat menemukan jenis dan sifat bangun datar. 7. Guru berkeliling untuk mengamati peserta didik, jikalau ada peserta didik yang merasa kesulitan dalam mengerjakan LKPD. 8. Peserta didik menyelesaikan LKPD secara rinci dan sistematis.	

Figure 2. RPP Monitoring Stage

At the *monitoring stage,* students observe by examining the objects provided by the teacher through the Student Worksheet (LKPD) and answering questions related to ethnomathematics at Pura Kerta Bhuwana Giri Wilis. Additionally, students observe the learning process, with the teacher providing the LKPD containing images related to Pura Kerta Bhuwana and several questions that students must answer. During the observation stage, students gather various relevant information or data.

Evaluating	2. Guru dan peserta didik menyimpulkan hasil dari proses pembelajaran. 3. Peserta didik diberikan kesempatan uttuk bertanya, apabila masih ada yang belum dipahami 4. Peserta didik mendengarkan arahan pendidik untuk menyampaikan materi pertemuan selanjutnya. 5. Guru menutup pelajaran dengan bacaan hamdalah bersama-sama peserta didik.	

Figure 3. RPP Evaluating Stage

At the *Evaluating stage,* the teacher and students summarize the results during the learning process, and students are allowed to ask questions about the ethnomathematics concepts found in the temple building that are still not understood.

Conclusion

Based on the results of the research conducted on ethnomathematics at Pura Kerta Bhuwana Giri Wilis Nganjuk, the following conclusions can be drawn:

1. Based on the results of the ethnomathematics analysis at Pura Kerta Bhuwana Giri Wilis Nganjuk, there are mathematical concepts, namely the concept of flat shapes, which consist of squares, rectangles, triangles, trapezoids, and rhombuses. The concept of three-dimensional shapes includes square pyramids, prisms, and cylinders. And the concept of geometric transformation in the form of reflection (mirroring and rotation).
2. The mathematical concepts acquired are then implemented into the lesson plan using the *Self-Directing Learning model*. There are three stages in the *Self-Directing Learning model*: *Planning, Monitoring*, and *Evaluating.* In the *Planning stage*, the teacher asks about the student's readiness, provides motivation, and conveys the learning objectives. In the *monitoring stage*, students observe and monitor with the teacher, who provides Student Work Sheets. In the *Evaluating stage*, the teacher gives feedback and conclusions on the learning process.

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