Hypothetical Learning Trajectory Design of Sinus Rules Based on PBL with Ethnomathematics of Minangkabau Culture

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Abstract

Based on the preliminary research, the tenth-grade students lacked ability in mathematical problem solving of sine rule. One of the factors that influenced this problem was the teacher's learning model, which was still mechanistic. The teacher did not relate between learning and environment or local culture. Based on this, this study aims to develop HLT on the topic of a valid ethnomathematical PBL-based sine rule. The development model used is the Plomp model and the Gravemeijer and Cobb model, which consists of the initial investigation stage, product development stage, and assessment stage. In this article, the discussion is focused on the HLT development stage. The data analysis technique used is descriptive statistics and descriptive techniques. Data collection instruments used: validation sheets, observation sheets, interview sheets, questionnaires, and field notes. This study resulted in the HLT of the sine rule based on PBL nuances of Minangkabau Culture, which met the validity criteria of 0.771 and the characteristics of validity in terms of content and constructs.

Keywords: hypothetical learning trajectory; ethnomathematics; mathematical problem-solving abilities

I. Introduction

One of the topics taught in mathematics is trigonometry. Trigonometry is a branch of mathematics used in everyday life, such as architecture, navigation, knowledge of the earth and the sun, and even penetrates the field of computers, communication satellites, and so on (Subroto & Sholihah, 2018; Daud & Kamalussafir, 2019). One of the essential competencies in trigonometry is the sine rule (change in essential competencies of Ministerial Regulation 37 of 2018 at KD KEPBALITBANGBUK No. 018/H/KR/2020). The sine rule is one of the essential competencies that must be mastered by class X SMA students

(Azizah 2021). Several studies have stated that many students have difficulty solving problems related to the sine rule (Trinanda, Syofni, & Yuanita, 2021; Nurfauzi, Kartini, & Maimunah, 2020; Ardianti, Harini, & Ayuningtyas, 2020).

The use of trigonometry in everyday life allows this material to train students' problem-solving skills. Problem-solving ability is the primary goal of learning mathematics. Problem-solving abilities need to be formed in students to help them make decisions based on existing information and symptoms (Restina, Zubainur, & Yusrizal, 2019; Armiati & La'ia, 2020; Arifin, Kartono, & Hidayah, 2019). The concept of the sine rule material can be found through problem-

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solving, which may have several alternative solutions. This will be very appropriate if, on the topic of the sine rule, an HLT is designed that can train students' abilities in solving sine rule problems.

Based on the results of research by Jaswandi and Mustamiin (2018) and Nasryah and Rahman (2020), it is known that students' mathematical problem-solving abilities can be improved by ethnomathematical-based learning. This is also in line with Law number 5 of 2017, article 7 regarding promoting Indonesian culture. Education has an essential role in growing and developing cultured human beings. Therefore we need innovative learning through a cultural approach to foster a sense of love for Indonesian culture. Tanah Datar is an area known as a cultural city that can be used as a context for ethnomathematical learning. Various artistic results can be used in understanding mathematics. It starts with the architecture of the Pagaruyung Basa Palace, traditional clothes, and on. Based on the results of researcher interviews with several mathematics teachers in Tanah Datar, information was obtained that teachers still had difficulty implementing a cultural approach in mathematics lessons. In addition, teachers cannot use a guidebook to implement culture in mathematics material.

Based on some of the problems above, an appropriate learning design is needed to improve mathematical problem-solving skills and foster a sense of love for students for Indonesian culture. One of the learning designs that can be used to overcome the problems above is a Problem Based Learning (PBL) based learning design. Several studies have stated that problem-based learning (PBL) can help students work together, learn independently, and develop good thinking skills, especially mathematical problem-solving skills (Arifin, Kartono, & Hidayah, 2019; Armiati, Anggraini, & Devi, 2018; Nalurita et al, 2019; Yerizon, Wahyuni, & Fauzan, 2021; Permatasari et al, 2019). In addition, PBL uses real contexts for students to learn active, critical thinking and intellectual skills in problem-solving abilities

(Cahyani & Setyawati, 2016). The actual context is used when introducing students to the problem. The factual context can be in the form of problems related to students' lives, such as cultural products in the area where students live.

Learning mathematics using the context of regional culture is called ethnomathematical learning. Based on the research results by Andriyani and E (2017) and Zahroh (2020), ethnomathematics can foster a sense of love for local culture in students, attract attention and increase their learning motivation. Several local cultures can be integrated into learning mathematics. For example, Minangkabau culture in the form of Rumah Gadang architecture, Rangkiang, Carano motifs and takuluak on Koto Gadang traditional clothes can be used to find the sine rule and the cosine rule. Several studies have explored and developed ethnomathematics, such as Novita et al. (2018) exploring the results of Rejang Lebong culture on the field geometry material and Padmasari et al (2021) developing ethnomathematics-based learning of wayang kulit on Limit Functions material. In addition, Minangkabau culture is also used as a context for learning mathematics, such to Rahman & Arif (2021). They use the Minangkabau typical Tanah Liek batik pattern for geometric transformation material; Rahmawati, (2020) uses Rumah Gadang architecture on the Pythagorean theorem material. However, there has been no research on the development of Minangkabau Culture ethnomathematics on the topic of the sine rule. The purpose of this study is to discuss a valid HLT design on the topic of PBL-based sinus rules with Minangkabau culture nuances by utilizing the Takuluak Koto Gadang motif and Cerano Closing Curtain.

II. Research Method

This research is design research by combining the Plomp (Plomp and Nienke Nieveen 2013), Gravemeijer, and Cobb models (Gravemeijer and Cobb 2020) to produce a valid HLT. In principle, merging these two research designs replaces the Gravemeijer development design with the Plomp development. The

activities carried out in this development procedure consist of three stages: the preliminary research/initial investigation stage, the development or prototyping stage, and the assessment stage. The researcher only focused on the HLT design at the early development stage because, at the early development stage, the validity of the HLT could be seen. To ensure a valid product, a formative evaluation is carried out, which consists of self-evaluation, expert review, and one-on-one evaluation.

Self-evaluation is performed to re-check the completeness of the components contained in the HLT, which will be developed using a checklist. The self-evaluation activity was assisted by colleagues and continued with improvements to the results of the self-evaluation analysis. The results of these improvements are then followed by an expert review, asking for expert opinion to provide an assessment and suggestions for HLT. HLT was validated by 3 experts consisting of 2 mathematics lecturers and one language lecturer. The results of validating the learning design through HLT by the validator were analyzed using Aiken's formula (Azwar 2013).

$$V_i = \frac{\sum s}{n(c-1)}$$

Description:
V_i = item validity index
$s = r - l_0$
r = scores given by the validator for each item

l_0 = Minimum score
n = number of validators

HLT is said to be valid if the analysis results of the validation sheet have an index of 0.667 and above (Azwar, 2013). A one-to-one evaluation follows the HLT that has been expertly validated and revised. The one-to-one evaluation was carried out to ask for suggestions on HLT and provide an assessment of HLT so that HLT was more valid to use. The one-to-one evaluation was conducted on three students with different abilities: high, medium, and low. Three students

of Class X IPA 1 SMAN 1 Lintau Buo became the research subjects in a one-to-one evaluation.

The data analysis technique used is descriptive statistics and descriptive techniques. Descriptive statistics were used to analyze the validity of the HLT data, and descriptive techniques were used to identify the appropriate use of HLT for students. The instruments used were validation sheets, interview guidelines, and field notes. The validation sheet observes the feasibility aspect of HLT and the language aspect.

III. Results and Discussion

At the beginning of the development stage, activities were carried out to design the HLT, consisting of three components: learning objectives, a set of activities, and hypotheses about how students learn and think. The learning objectives are conveyed at the beginning of the lesson and then followed by a series of activities, predicting student answers and triggering questions which are the teacher's anticipation of students' answers. The designed learning flow consists of two meetings. The first meeting aims to describe the ratio of the sine of the angle in a triangle to the side opposite it. There are several activities in learning, including determining the length of the side of a right triangle and determining the side of an arbitrary triangle to find the goal. The contextual problems that arise in this problem are related to the Minangkabau culture.

Figure 1. Activity 1.1

Based on the above activity, activity 1.1 uses the context of Minangkabau traditional clothing, the takuluak koto Gadang, with a suitable triangle motif. In this activity, students are asked to pay attention to the right-angled triangle motif on the takuluak. Students are asked to determine the length of the side of the triangle. With this activity, students will remember the concept of trigonometric comparisons of right triangles. The concept of trigonometric comparisons in right triangles will later be needed to lead students to describe the ratio of the sine of the angle in a triangle to the side in front, which is proportional.

Figure 2. Activity 1.2

Activity 1.2 is still related to activity 1.1, the Takuluak Koto Gadang motif. The takuluak motif used as a context is an arbitrary triangular motif using a high line. In this activity, students are asked to determine the length of the side of the triangle. Because the triangle is not a right triangle, students cannot use trigonometric comparisons in right triangles. This activity will make students use the height line on any triangle to find the length of the side of the triangle. Students are also asked to determine the circumference of the takuluak. To determine the perimeter of takuluak, students must find the lengths of the sides of the arbitrary triangle.

Through this activity, students will find that the ratio of the sine of the angle in a triangle to the opposite side is proportional.

At the second meeting, students were asked to determine the sine rule algorithm through the activity of making Carano curtains. For this purpose, students are expected to be able to determine the formula for the Sine rule. To achieve this goal, there are 2 activities, as shown in Figure 4, namely the manufacture of Carano curtains.

Figure 3. Activity 2

The Carano cover is in the shape of an inverted isosceles triangle. Students are asked to determine in advance the length of the sides to determine how many curtains are used to surround the Carano cover. Students can use the previous activity to determine the length of the side of the triangle. The process of determining the length of the side of a triangle will lead students to determine the formula for the sine rule.

After designing the HLT, validation is carried out on the product that has been designed. Several aspects used in the validation in this study include content aspek and language. Three expert mathematicians validated the HLT. Validators are given a validation sheet to determine the feasibility and input of the product that has been developed. 2 Mathematics Experts validated HLT, namely Prof. Dr. I Made Arnawa, M.Si, Dr. Dony Permana, M.Si, and one linguist, Dr. Abdurrahman, M.Pd. Validators are given a

validation sheet to determine the feasibility and input of the product that has been developed. The following is the analysis of the validation results presented in table 1. The results of the validation of each aspect have a valid category. Overall the developed HLT has a validity value of 0.771 with a valid category.

Table 1
Validation analysis

No	Aspek	Indeks validitas	Validitas
1	Content	0,778	Valid
2	language	0,776	Valid
	average	0,771	Valid

Next, the researcher met with three students individually and tested the designed HLT. The goal is to see students' responses to solving problems in HLT. When students with low abilities do the activities in the HLT, students immediately ask what they are looking for. This is because students are not used to solving the problems given. Researchers ask questions that direct students to be able to solve these problems, such as "what do you understand from the problems above?" These questions will lead students to re-read the problems given. The question "what else do you know?" is a probing question that can also be used to explore students' understanding. After the students understood the problem, the researcher continued with the question, "what strategy did you use to solve the problem? What was the solution like?" These questions will guide students with low abilities to solve the problems given.

In addition, low-ability students misunderstood the problems given in activity 1.2. Students assume that all gold ribbons are sewn to each pattern in the picture, including the circumference of the takuluak. Meanwhile, the researcher intends that the gold ribbon is only sewn on the yellow pattern, not including the circumference of the takuluak.

As in the picture on Figure 4., it can be seen that low-ability students have different intentions in solving the problems above. In contrast, students with medium and high abilities

can correct the sentence themselves to correctly determine the length of the gold ribbon needed.
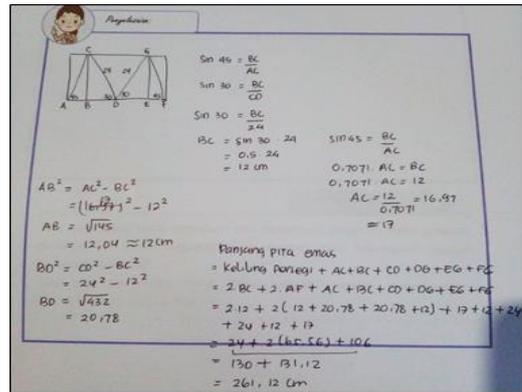
Figure 4. Answers of low-ability students

Students with moderate abilities can understand the problems but are still wrong in using the right strategy to solve these problems. This can be seen in the following student answers.
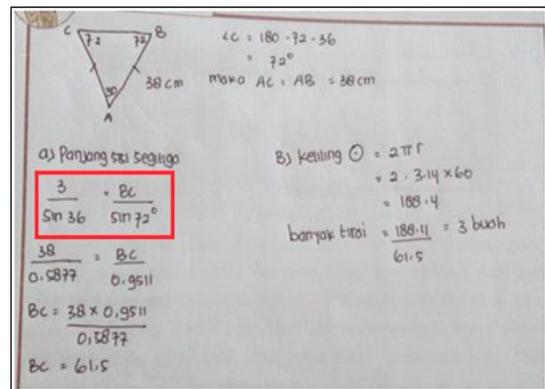
Figure 5. Answers of middle-ability students

The student's completion in the picture above shows that the solution is still wrong. To anticipate this, the researcher asked several questions, such as "Is your answer correct? Retake a look at your answer. Is the concept of the sine rule that you are using correct?" High-ability students can understand problems and use appropriate strategies to solve problems. The teacher asks the students to explain their answers and strategies. Students can explain the answers and strategies they use correctly.

In general, students with moderate and high abilities can understand the problems given in each activity and use appropriate strategies to solve problems. While students with low abilities

still need to be directed in solving the problems given. Researchers use questions that can develop mathematical problem-solving abilities. Like the question, "What do you understand from this problem? What strategy did you use to solve the problem?" After being asked some anticipatory questions, they solved the problems found in HLT.

After the one-to-one evaluation, improvements were made to activity 2 because some students were still confused about solving problems. The researcher changed the sentence "Etek Mirna will sew a gold ribbon on the tingkuluak according to the pattern as shown in the picture above" to "Etek Mirna will sew a gold ribbon and lace on the takuluak. The gold ribbon will be sewn according to the yellow pattern in the picture above, while the lace will be sewn around the takuluak." Improvements to the HLT can be seen in picture 6 below.
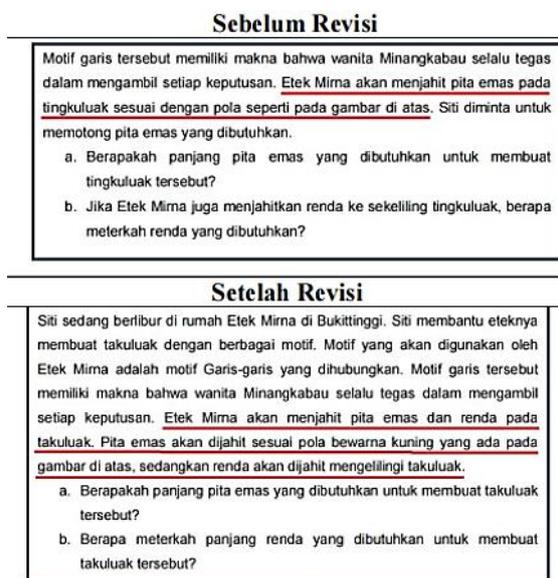
Figure 6. HLT revision

Based on the results of the one-to-one trial, high-ability students can participate in activities in the HLT well without the help of probing questions from the researcher. Students with moderate abilities can take the HLT by being given a probing question about how the strategy is used to solve the problem and what conclusions are obtained. Students with low abilities need

direction and probing questions in HLT, starting with questions to understand the problem, the strategies used, how to solve them, and what conclusions are obtained.

Based on the research results above, the problems in HLT activities can help students solve problems about the sine rule. Learners with various abilities can understand the sine rule with predictions and anticipations prepared in HLT. This follows Cahyani & Setyawati's (2016) research, which states that real context can help students learn actively and develop their thinking skills. In addition, students are very enthusiastic about solving problems related to their culture. This follows Andriyani and E (2017) and Zahroh's (2020) research, which states that ethnomathematics can attract attention and increase students' learning motivation.

IV. Conclusion

The HLT developed in this study is on the topic of the ethnomathematical PBL-based sine rule. The designed HLT contains learning objectives described in each activity and hypotheses in the form of predictions and anticipation of students' answers. In HLT, three activities contain how to teach the topic of the sine rule. The problems presented in the activities related to Minangkabau culture include the takuluak koto Gadang motif and the Carano covering cloth curtain.

After the initial HLT design is completed, the next stage is validation. Three expert experts validated HLT. Based on the analysis of the results of the HLT validation, it has an index above 0.771, so it can be said that the product is valid. Furthermore, HLT was tested on three students with high, medium, and low abilities. The HLT was tested to see the accuracy of its use by students. So it can be concluded that the HLT that has been validated and tested produces a valid PBL-based sine rule HLT with Minangkabau Culture nuances.

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