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Trigonometric Problem Solving Learning Design for Cadets' Polytechnic of Transportation

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ABSTRACT
This study aimed to produce learning trajectory with trigonometric learning based on problem solving that can help cadets understand and solve trigonometric contextual problem. Subjects of the research were cadets of nautical technology study program of Inland Water and Ferries Transport Polytechnic of Palembang. The method used was design research with three stages, those are preparing for the experiment, the design experiments, and the retrospective analysis. Data colection conducted through video recordings and photos to see the learning process in the classroom, written tests, observation and interviews during the learning process with the students. At the informal stage, contextual problems will be used as a starting point for learning to explore students' knowledge. The results showed that the use of problem solving approach in trigonometric learning can help the cadets in understanding about how to solve trigonometric contextual problem systematically.

Keywords: *Learning Design, Trigonometry, Problem Solving.*

1. INTRODUCTION

Mathematics is one of the subjects studied at every level of education from elementary school to higher education. Applied mathematics courses are one of the subjects that must be taught by cadets of the Inland Water and Ferries Transport Polytechnic of Palembang. Based on the Regulation of the Minister of Transportation No.105 of 2018, the cadets are students registered at the *Palembang SDP Poltektrans* to develop their potential through the learning process [1].

Mathematics is a way to get students to practice solving problems faced by humans [2]. Although not all problems are mathematical problems, to solve the problems there are many that require mathematical thinking [3]. The ability to solve problems is very necessary in order to prepare students to face global competition, so that students will be better prepared to participate in the world of work [4].

The ability to solve problems is one of the abilities that students must have after learning in class, and it is explicitly stated in the curriculum [5]. This ability must also be possessed by every cadet as a student at the higher education level. This is stated in the attachment to Ministry of Research and Higher Education regulation No. 44 of 2015, regarding general attitudes and skills that each graduate must demonstrate and have various character values and be able to solve work problems with the nature and context in accordance with their field of expertise [6].

In general, mathematics problems can be divided into two types, namely routine and non-routine problems. Routine questions are ordinary practice questions that can be solved using the procedures learned in class. Meanwhile, non-routine questions are questions that require further thinking because the procedures are not as clear as those learned in class [7]&[8]. Other research results also recommend that teachers be able to provide non-routine questions to students because non-routine problems can trigger the emergence of happy characters such as honesty, hard work, creativity and especially the value of curiosity [9].

One of the competencies in learning outcomes in applied mathematics courses is cadets to be able to solve math problems related to trigonometry. Trigonometry is one of the materials in mathematics that is important to study because it has wide applications [10]. Students must have knowledge of trigonometry because trigonometric applications are often found in everyday life, such as determining distances that are difficult to reach and height that cannot be measured directly [11]. However, previous research illustrates that the ability of cadets to solve non-routine problems is still not good enough so that problem-based learning is needed so that they are familiar with these types of questions [12].

Based on the description above regarding the various abilities and skills that cadets must possess, a more effective and efficient learning design and teaching materials are needed. Moreover, Indonesia is currently experiencing a national pandemic of the Corona Virus Disease (Covid-19) so that the Government of the Republic of Indonesia takes action related to technical learning from elementary school to university level. This is stated in the Minister of Education and Culture Number: 3692 / MPK.A / HK / 2020 regarding online learning and working from home in order to prevent the spread of Covid-19 [13]. This makes educators required to prepare various teaching materials that are in accordance with online learning methods so that learning objectives can be achieved.

2. METHODS

This research used a design research approach, which is an appropriate way to answer the research items and achieve the research objectives that start from Preparing for experiment and preliminary design, design experiments, and retrospective analysis [14]. Design research aims to develop Hypothetical Learning Trajectory (HLT) and also develop Local Instruction Theory (LIT) with the cooperation between researcher and teacher to improve the quality of learning [15] &[16].

After studied the literature, researcher formulated a Hypothetical Learning Trajectory (HLT) consisting of three components: (a) learning objectives, (b) planning learning activities (made the lesson plan, teacher's guide, and activity sheets), (c) Made conjecture or hypothesis (conjecture of student thinking). That conjecture was about the process of learning where teacher and researcher can anticipate the development of mathematics collectively and how the development of students' understanding, because learning activities in the classroom based on the design of learning that has been designed [17]&[18].

The data collection in this research is done through several activities such as observation, interview, pre-test, documentation collected through scan result of student activity sheet and post-test. The technique of data analysis of this research will be conducted qualitatively. The analysis will be done is to compare the results of observations during the learning process with the predicted learning trajectory which has been designed in the preliminary design. The analysis done at the preliminary design is the analysis of observation result and the result of interview with the teacher [19]. Further, data on the pilot step and teaching experiments were analysed to answer the research problem formulation and compared with the designed HLT.

3. RESULT AND DISCUSSION

Based on data analysis, the results show that learning trajectory of trigonometry problem solving approach can help students understand about how to solve the trigonometry problems systematically.

3.1 Preliminary Design

The researcher conducted a literature review regarding the material in the curriculum, trigonometric material, existing problems, learning approaches and contexts that could be used, the relationship between context and material and the research methods used. After that the researchers discussed with each other about the instruments to be used in the research series. From the discussion process, the initial HLT design was obtained, student activity sheets, test questions: pre-test and post-test, lesson plans, teacher / lecturer instructions and trigonometry modules.

Furthermore, the researcher discussed with two mathematics teachers as experts on the analysis of learning device needs. The discussion discussed technical alternatives for implementing learning when normal life was just facing the Covid-19 pandemic where the government gave directions that learning must be carried out online.

One of the learning in accordance with this condition is blended learning, where the learning space consists of face-to-face, virtual face-to-face, independent learning and collaborative learning [20]. However, face-to-face learning is very difficult to do because the teacher and students are no longer in the same room. One of the lessons that can be done to maximize face-to-face, independent and collaborative learning spaces is flipped classrooms [21].

After discussing the implementation of learning, it was concluded that learning would be carried out online by utilizing face-to-face, independent and collaborative learning spaces. The lesson plan, HLT, student activity sheets, learning media, and modules that have been given suggestions and input by the experts are then revised and used as instruments for testing at the teaching experiment stage. The revised cadet activity sheet consists of two activities, each of which consists

of two contextual problems along with a column of problem-solving steps. In Figure 1, you can see the revised results of the cadets' activity sheets adjusted to the suggestions of the validators.

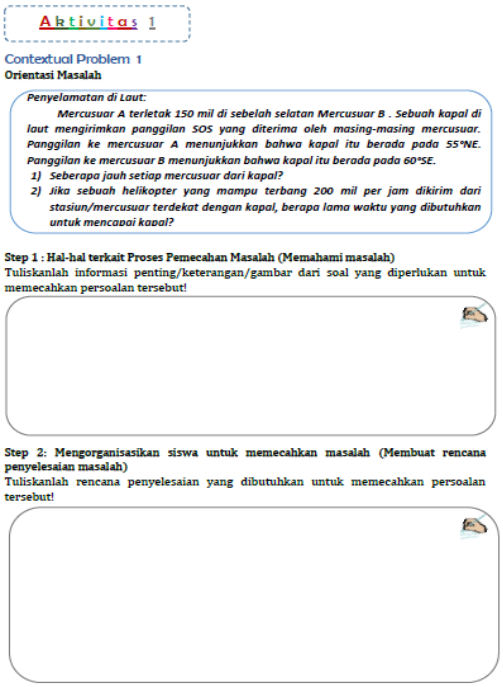

Figure 1. Activity 1 of Students' Sheets.

The results of Cycle I are that there is an improvement on the activity sheet, namely in the formulation of problem solving sentences that still have errors in typing and there are also improvements in post test.

3.2 The Design Experiment

At this stage, there are two cycles. Cycle I is called the Pilot Experiment and Cycle II is called the teaching experiment. In cycle 1, the research instrument was tested on 6 students. At this stage the data at this stage are also needed to adjust and revise the HLT before it is implemented at the next stage or the teaching experiment stage.

Furthermore, the teaching experiment stage (cycle II teaching experiment) is an implementation of the HLT that has been designed and improved in the previous stage. HLT is piloted in a class that is the research subject. Figure 2 and Figure 3 are the answers of students who can solve the problem correctly.

In the picture, it can be seen that students can write steps 2 to step 4. Students can also make interpretations of the questions in the form of pictures. The researcher analyzed that students can also do step 3, which is to make a completion plan. This can be seen from the steps taken by students in finding the angle from the direction of the ship first. However, all students had difficulty answering questions in part b, so they did not answer questions in section b.

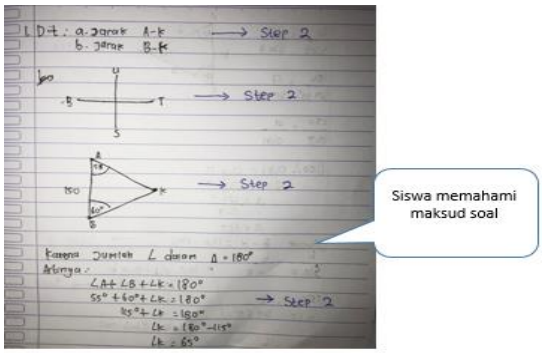

Figure 2. Students' Answer.

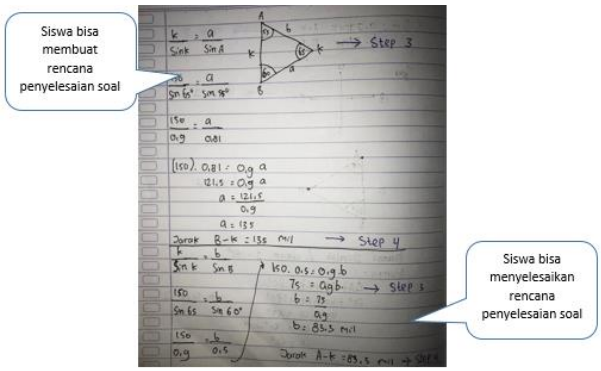

Figure 3. Students' Answer.

Research results from this stage are used to answer research questions. The lecturer acts as a teacher while the researcher observes the learning activities of the cadets. Before the teaching experiment begins, researchers and lecturers discuss learning activities on that day. During the learning process, ideas and conjectures can be modified as revisions for the next activity. In Figure 4, you can see the opinions of cadets regarding routine questions and non-routine questions.

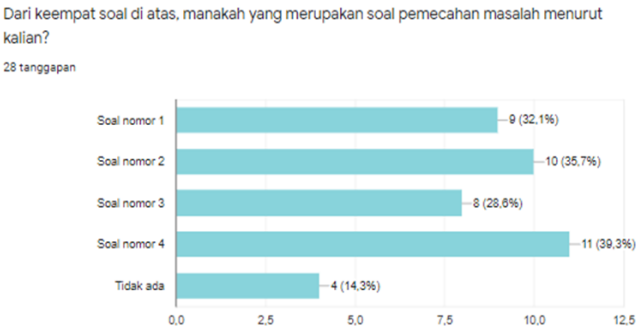

Figure 4. Opinions of cadets regarding problem solving problems

The results of the question analysis and the presentation of the cadets 'answers to the pretest and posttest questions were in accordance with the researchers' expectations, that the questions tested were in accordance with the characteristics of the question

problems solving. Problems number 1 and 3 are routine questions or problems that are commonly encountered by students / cadets and are solved using the routine procedure for the rules of sines and cosines. However, based on the test results, only about 42.9% of cadets can solve these questions. Meanwhile, questions 2 and 4 are non-routine questions because the solution does not only use routine procedures but required further thought, which can be seen in table 1.

Table 1. Question analysis

Problem on Pretest and Posttest	Cadets' answered correctly
• Jika pada segitiga ABC, diketahui AB = 5, AC = 10 dan sudut BAC = 120° maka BC = …	• 42,9%
• Sebuah kapal berlayar kearah timur sejauh 15 mil. Kapal tersebut kemudian melanjutkan perjalanan dengan arah 30° sejauh 20 mil. Jarak kapal terhadap posisi saat kapal berangkat adalah … mil	• 28,6%
• Pada ΔABC, diketahui b=15,c=20,dan B=29°. Berapakah panjang a ?	• 42,9%
• Dua stasiun radar yang terpisah sejauh 20 mil, masing-masing mendeteksi pesawat yang berada di antara mereka. Dari hasil deteksi didapati bahwa sudut ketinggian pesawat yang diukur dari stasiun pertama adalah 35 derajat, sedangkan sudut ketinggian pesawat yang diukur dari stasiun kedua adalah 15 derajat. Berapakah ketinggian pesawat sebenarnya?	• 14,3%

During the learning process, students are allowed to discuss and ask questions with the lecturer through the WhatsApp group virtual face-to-face room. All contextual problems presented on the activity sheet are types of non-routine questions so that students become accustomed to facing such problems. In the learning process, there are obstacles not only from a technical point of view, namely face to face, but also in terms of students' ability to be able to solve these problems. Through problem solving steps and directions from the lecturer, students can solve the problems contained in the activity sheet. This can be seen in Figure 5.

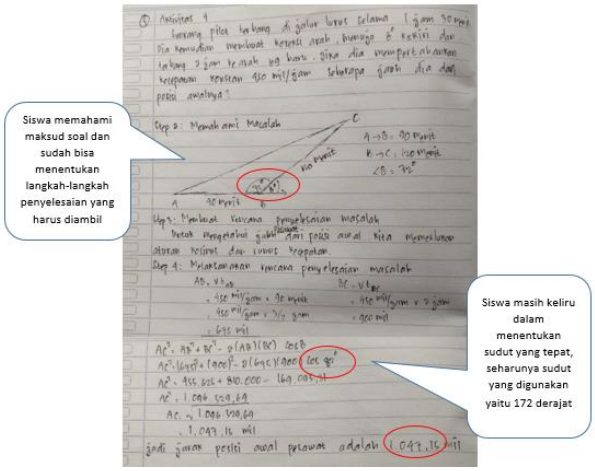

Figure 5. Students Answer Sheets

3.2 The Retrospective Analysis

At this stage the data obtained from the teaching experiment stage will be analyzed for later use in developing designs for the next learning activity. Researchers compared HLT with learning activities that have been carried out and then used to answer the formulation of research problems.

In general, the purpose of retrospective analysis is to develop a local instructional theory. Therefore, feedback from lecturers who teach is also very much needed to provide further information to researchers about different ways of teaching in theory so that it can be adjusted and implemented in general..

The learning objective in each activity is for students to apply and solve contextual problems related to the sine and cosine rules. Students work according to predicted conjectures. Based on the results of the discussion in the WA group online class, there are still students who are confused about understanding the meaning of the questions and looking for problem solving, namely in activities 1 and 3.But after discussing together, students can complete activity 3 well, but there are still questions in activity 1 which has not been answered by students.

From this activity it can be concluded that students can solve problems related to the rules of sinus and cosines through problem-based learning. The results of the HLT can be seen in Figure 6.

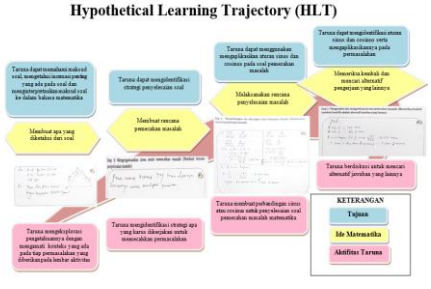

Figure 6 Result of Hypothetical Learning Trajectory

The comparison between initial HLT and actual learning in activities 1 and 2 can be seen in Table 2.

Table 2. Comparison of HLT and Actual Learning

Hypothetical Learning Trajectory (HLT)	Actual Learning
1) Students can understand the questions and fill in each step column of the problem solving process according to the questions given	2) Students do the questions directly, not in a step-by-step manner, but some can determine the steps even though the work is not in the boxes or columns provided 3) There are still students who have difficulty understanding the questions and determining the steps referred to on the activity sheet

Based on the results of the research and retrospective analysis that has been done, this study is designed to produce a learning path that can support students in understanding and applying the concept of the sine and cosine rules and solving problems related to the sine and cosine rules. In this study several aspects were discussed, namely:

1) The role of problem-based learning in trigonometric material

Based on the design of the learning path that has been designed and implemented previously, there are four trigonometric learning activities at the pilot experiment stage. This series of activities includes mathematical problem solving activities guided by the four steps of solving mathematical problems. In the first and third activities, students experienced a little difficulty in interpreting the meaning of the questions.

The problem in the next activity can be solved by students after discussing it with the teacher. This activity makes students think more actively in solving non-routine problems. This is where there is a role for problem solving learning to guide students to better understand and apply the rules of sines and cosines in solving mathematical problems. The use of problem-solving approaches in trigonometric learning has also been carried out and the results of this study recommend that teachers be able to provide non-routine questions to students because non-routine problems can trigger the emergence of happy characters such as honesty, hard work, creativity and especially the value of curiosity [9]. Furthermore, based on the results of the analysis, learning using the Problem Based Learning model is quite effective to be applied in trigonometric learning [22].

2) The design of learning activities is based on a mathematical problem solving approach

A series of learning implemented using a problem-based learning approach shows how the characteristics of problem solving in each learning process activity.

The learning syntax in the problem based learning model lay the foundation and develop natural ways of thinking that can be applied, namely: Contextual Problem Orientation; Matters related to Problem Solving Process; Organizing students to solve problems; Developing and Presenting Problem Solving Results; Analyze and evaluate the problem solving process [23].

Learning syntax with problem based learning that can be applied to make learning more effective, namely: Providing problem orientation to students; Organizing students for inquiry; Carry out investigations; Develop and present the results [22].

If it were viewed from several previous studies, it can be concluded that even though each sentence in the syntax or learning step is not exactly the same, it still has the same meaning. This model places cadets to learn more on their own and develop their creativity in problem solving. The purpose of this model is to train cadets' ability to research, explain phenomena, and solve problems naturally. The problem based learning model places cadets as learning subjects. The role of the lecturer in this model is as a learning guide and learning facilitator. With this model, cadets learn to analyze and try to solve problems they face through a designed activity sheet.

Next, in the implementation of learning or research data collection, the researcher hopes that learning can take place in accordance with the first design, but there are several obstacles encountered during the learning process in cycle II. This is related to the condition of students who are less disciplined in participating in learning activities. The researchers realize that there are still many deficiencies in the implementation of the research, so that further research is expected to be planned and implemented even better.

4. CONCLUSION

Based on the results and discussion that has been described, the conclusions of the HLT that have been implemented in this study are as follows.

(1) In trigonometric material, problem solving-based learning has an important role in helping deepen students' understanding of concepts through activities, namely:

a) The first and second activities aim to enable students to identify problems related to the concept of sine rules and apply these concepts in problem solving.

b) The third and fourth activities aim so that students can identify problems related to the cosine rule and apply the concept in problem solving.

(2) The resulting learning trajectory is in the form of trajectories that help students in the learning process starting from the exploration and problem identification process, selecting the completion plan, implementing the completion plan and checking the results of the answers obtained in solving non-routine questions.

(3) In the implementation of trigonometric learning using a problem-solving approach, there are several obstacles faced, namely less time efficiency at virtual face-to-face or during class discussions. This is because students still need more time to study independently in completing the activity sheet.

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