Development of trigonometric visualization concepts to increase the study motivations of SMK students

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Abstract. The students of SMK Cendekia Madiun are not motivated to learn mathematics especially trigonometry because students do not understand the concepts. The alternative approach offered by the ITS and UNIPMA teams as a form of community service is to develop and apply visualization in learning. Activity implementation methods are adopted from research and development (R&D) methods, namely: initial analysis, development / implementation, and final analysis. The results of the activity addressed that visualization developed is quite effective to increase student’s learning motivation.

1. Introduction

Vocational High School students (SMK) have a different character from high school students (SMA). Most vocational students will work after graduating from vocational school so that they emphasize skills. Meanwhile, most high school students are more likely to continue their study to college after graduating from high school. These mindsets directly or indirectly influence the learning process, especially in mathematics learning which is considered frightening for most vocational students.

Based on the results of interviews with Madiun Scholar Vocational Teachers and supported by the results of direct discussions with students of multimedia majors, there were 97\% of students who did not like to learn mathematics. Students feel afraid or unable or there is no motivation to learn mathematics. Motivation is important in learning for students because it encourages students in every learning activity and determines the direction or purpose of learning activities so that learning objectives are achieved [1]. Motivation can be classified into two, namely: intrinsic motivation (internal motivation arising from within the individual without any encouragement from others) and extrinsic motivation (external motivation that arises as a result of external influence) [2]. The characteristics of motivated students are diligent, tenacious, and independent [3]. Without motivation, students will not have the enthusiasm to learn.

Based on the results of student interviews and supported by the statement of the teacher of SMK Cendekia Madiun, one of the mathematics material that was considered difficult to learn and teach was trigonometry. The assumption that trigonometry is difficult also occurs in students of mathematics education courses [4]. Trigonometry is important to learn because it
provides an explanation and assistance to solve several daily problems, such as calculating the height of the object, calculating the distance traveled or the length of the rope, etc.

The use of appropriate learning models can increase student learning motivation. The appropriate learning model to foster motivation is the Problem Based Learning (PBL) learning model. PBL learning model syntax has 5 stages, namely: the stage of orienting students to the problem (raising problems, explaining learning objectives, explaining activities to be carried out, and explaining the evaluation of the learning process to be carried out), the stage of organizing students to learn (problem selection and group formation), the stage of assisting independent and group investigations (data and experiment collection, hypotheses and explanations, problem solving), the stage of developing and presenting works (development of work, presentation of work, assessment of friends / teachers, and feedback / response), and stages analysis & evaluation of the problem solving process (reconstruction of thoughts and activities that have been carried out, analyzing and evaluating the processes used) [5, 6]. The PBL model attracts most educators because it is considered capable of delivering students to improve higher-order thinking skills (HOTS) of students.

For the implementation of optimal learning, the learning model must be equipped with learning tools, such as Learning Plans (RPP) and Student Worksheets (LKS). Some educators refer to LKS with LKPD (Student Worksheet). LKS is a supplementary learning tool sheet or supporting the implementation of RPP [7]. LKS is important because it helps teachers to carry out learning, activating students learning independently according to the learning process [8]. One form of LKS, namely LKS that helps students find, apply, and integrate various concepts [9].

Based on the results of the discussion and the team’s observations, the problems faced by vocational students occur because in learning, the teachers rarely use visualization. Visual media can be used to visualize themes / ideas of discussion material, as a media of stories and presented to provide an atmosphere and center of attention for students through the blackboard or other media [10]. Visualization is important because it is able to provide a clearer picture of a concept [11]. Likewise for high-level mathematics learning, visualization is needed [12]. Transition from the use of visualization through investigation and interesting manipulation is interesting to observe [13].

Following up on the existing problems, the LPPM ITS team together with the UNIPMA LPPM team conducted Community Service (PKM) at SMK Cendekia Madiun. Scholar Vocational School acts as a partner in community service activities entitled visualization of mathematical concepts to increase learning motivation of vocational students. The purpose of this PKM is to increase the learning motivation of vocational students.

2. Methods

This PKM implementation method was developed according to research and development (R&D) methods. R&D has define (initial analysis), design (design), develop (development), and disseminate (dissemination) stages. Development research (R&D) is a type of research that is used to produce a particular product and to test the effectiveness of the product [14]. The implementation of this PKM has the stages of initial analysis (developed from the define stage), the implementation of PKM (developed from the design and develop stages), and the measurement of students’ perceptions for publication (developed from the disseminate stage).

The schools that are partners of this activity are SMK Cendekia Madiun majoring in multimedia who have problems with student learning motivation in learning trigonometry. The initial analysis phase is done to get visualization that fits the needs and character of students and material so that the learning objectives are achieved, namely to increase student learning motivation. The implementation phase is carried out to provide treatment, namely using appropriate visualization by preparing the learning tools, such as: lesson plans, worksheets,
and assessment instruments. The final measurement or analysis stage is carried out to measure the success of the treatment given by visualization to improve student learning motivation. The indicator of the success of this activity is to get a practical and effective visualization of mathematical concepts (trigonometry). The visualization validity is guaranteed by the team because of the dedication carried out in accordance with the field of research team science. Visualization of mathematical concepts (trigonometry) is said to be effective if there is an increase in student responses at least 70%. Visualization of mathematical concepts (trigonometry) is said to be practical if there is an increase in students’ conceptual understanding of at least 70%.

3. Results
This community service activity is carried out according to the planned schedule. Visualization of trigonometric concepts is said to be feasible if it is effective and practical to use.

3.1. Results of Initial Analysis
The initial analysis phase began to be carried out for the preparation of proposals that were strengthened by the signatures of the partners’ willingness on Thursday, February 22, 2018. The initial analysis was continued more intensely to collect data about students’ initial perceptions on Friday, July 20, 2018. There were 20 students who participated in filling out the initial perception questionnaire student. Data collection was carried out for almost 2 hours of study. The results of the students’ initial perception questionnaire showed that all students (100% of students) did not have an overview of trigonometric concepts.

3.2. Results of PKM Development
Before implementation, the design was carried out by compiling and developing RPP and LKS according to the results of the initial analysis. In accordance with the distribution of material in the Trigonometry book, 4 (four) meetings were organized which were carried out by the UNIPMA team and the ITS team.

- The first learning was carried out on Friday, August 3, 2018. The implementation of learning was focused more on efforts to improve students’ ability in drawing right triangles where one of the angles is known. This focus is done because most students have not been able to draw a right triangle where one of the angles is known. Students still have difficulty and use the bow and use it to draw right triangles where one of the angles is known. The activity of drawing a right triangle where one of its angles is known is very important as a basis for visualization to understand the basic concepts of trigonometry. Because of these obstacles, the implementation of learning with PBL cannot be optimal.

- The second learning was held on Wednesday, August 8, 2018. The implementation of learning was focused more on efforts to improve students’ understanding of the basic concepts of trigonometry through visualization. Students are reminded again of the ratio of the length of the triangle side to the basic concepts of trigonometry and related to the images that have been made in the first learning for visualization. In accordance with the PBL learning model syntax, students conduct research and development. The obstacle is that students are too passive and inactive to investigate and develop their knowledge.

- The third learning was held on Friday, August 10, 2018. The implementation of learning focused more on efforts to improve understanding and application of the basic concepts of student trigonometry. Students are reminded of the basic concepts of trigonometry and use them to solve problems. In accordance with the PBL learning model syntax, students are asked to dare to appear in front of the class to present their work. The obstacle is that
students do not dare to appear because they feel they cannot trigger trigonometry until they have to be explained and motivated to dare to appear in front of the class.

- The fourth learning was held on Saturday, August 11, 2018. In this implementation, the ITS team was more dominant in learning while the UNIPMA team helped as team teaching. Learning is more focused on the introduction and use of geogebra for visualization, from drawing simple graphs to drawing graphs of trigonometric functions with animation and other features, as shown in Figures 1, 2, 3, 4. Through the introduction and training of geogebra it is expected to help students who still have difficulty in drawing manually. In addition, it is also expected that this learning can facilitate students to draw and add visualization skills so that they are more motivated to learn trigonometry.

![Figure 1. Sine function graph.](image1)

![Figure 2. Cosine function graph.](image2)

![Figure 3. Tangent function graph.](image3)

![Figure 4. Comparison of angles in a triangle graph.](image4)

3.3. Results of Final Analysis
The retrieval of students’ final perception data as a result of this activity was carried out on Wednesday, August 15, 2018 using a revised final student perception questionnaire. There were 20 students who participated giving the final data on students’ final perceptions. The results of the final student perception questionnaire obtained an overview data of basic concepts and trigonometric equations and students’ responses to mathematics learning with visualization.

The results of the student perception questionnaire showed that 100% of students (20 students) had an overview of the basic concepts of trigonometry. Students give a visualization of the concepts of sine, cosine, and tangent.

- There are 40% of students (8 students) giving a general description of the sine, cosine, and tangent concepts with appropriate explanations.
- There are 30% of students (6 students) giving a description of the concept of sine, cosine, and tangent with an explanation of number illustrations.
  - There are 4 students who provide illustrations that are not true all.
  - There is 1 student who gives illustrations correctly only 1 student.
  - There are 1 students who give illustrations correctly as many as 2 students.
- There are 30% of students (6 students) giving an idea of the sine, cosine, and tangent concepts only with pictures without a clear explanation.
The results of the final student perception questionnaire showed that 20% of students (4 students) gave an overview of the equation of sine trigonometry. However, the picture given by students is still not appropriate. Most students (80% of students (16 students)) said they did not know. The results of the final student perception questionnaire showed that 85% of students (17 students) were happy and felt easier to understand and get benefits after getting trigonometric learning with visualization. There are 15% of students (3 students) who still feel they understand.

4. Discussions
In accordance with the focus of the problem, this paper discusses the effectiveness and practicality of visualization given to motivate student learning.

4.1. Effectiveness of visualization
The effectiveness of visualization is measured based on the response data of students who have received trigonometric learning by visualization. The results of the students’ initial perception questionnaire showed that all students (100% of students) had an unfavorable response to mathematics learning, especially trigonometric material. In other words, there are no students (0% students) who feel like learning trigonometry. However, the results of the final student perception questionnaire showed that 85% of students felt happy and felt easier to understand and get benefits after getting trigonometric learning by visualization. This shows that there is an increase in students’ responses towards better trigonometric learning with visualization. Based on an increase in the positive response of students, visualization of the mathematical concepts provided is included in the high effective category [15].

4.2. Practicality of Visualization
The practical level of visualization is measured based on data on students’ level of understanding of concepts represented by images for visualization. The results of the students’ initial perception questionnaire showed that 100% of students (20 students) did not have an overview of the basic concepts of trigonometry. Meanwhile, the results of the final student perception questionnaire showed that 100% of students (20 students) had an overview of the basic concepts of trigonometry. However, only 40% of students observed have a description of the basic concepts of trigonometry correctly. This shows that the visualization given is less practical in improving students’ understanding.

At the first meeting in learning that was originally planned to use PBL models could not run optimally because of the technical symptoms, namely: students could not use the bow correctly so it was difficult to describe a large right triangle where one of the angles is known. In addition to previous learning that lacks visualization, it shows that the motor skills of students are less trained. According to Bloom’s opinion that in addition to considering cognitive and affective aspects, assessment in learning needs to involve psychomotoric aspects.

At the second meeting in student learning, it is still difficult to use visualization to learn. Students need to look for connecting the existing images with trigonometric concepts. In learning mathematics, there should be a connection between images as the visualization of a defined concept. The theory of mathematical development through visualization, symbols, and proof [16].

At the third meeting in the learning that was originally planned by students to present their work with presentations in front of the class according to PBL syntax constrained because students felt they did not master the material. This shows that mastering the material influences the students’ self-confidence to appear in front of the class to present their work. The images given by students and teachers on the blackboard are representations [17].
At a meeting with the ITS team, students were explained about the concept of trigonometry, but in explaining the students’ perceptions showed that students could not explain the meaning of the equations of sine trigonometry with pictures. Remembering $\pi = 3.14$ and the periodic nature of the sine function graph described below.

![Figure 5. Sine function graph.](image)

Students should know that solution of the equation $\sin x = \sin \alpha$ is $x_1 = \alpha + k2\pi$ or $x_2 = (180^\circ - \alpha) + k2\pi$ where $k$ any integer. It shows that students have not got a connection or visual relationship with the concept being studied, other than as an impact because previous learning did not use visualization so that students did not have the skills in visual thinking to learn. There is a relationship between visualization with symbols in mathematics [18].

5. Conclusions
Visualization of mathematical concepts is able to increase the learning motivation of vocational students because it meets the effective criteria. However, visualization of mathematical concepts meets the criteria of being less practical because they are less able to improve students’ understanding of concepts.

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