Use of Metacognition Questions, *Hands-On Activity*, and Fantasy Iron-wood Tree Metaphor for Trigonometry Learning

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Abstrak

Tantangan guru matematika SMAN-2 Palangka Raya munculnya kebosanan. Tujuan penelitian untuk (1) meningkatkan semangat siswa belajar trigonometri, (2) meningkatkan hasil belajar identitas perkalian ke penjumlahan dan pengurangan sine dan cosine, melalui penggunaan pertanyaan metakognisi dan metafora pohon ulin fantasi yang diintegrasikan dalam hands-on activity. Penelitian dilakisanakan dengan metode penelitian tindakan kelas dengan tiga siklus tindakan. Subjek penelitian 40 siswa kelas XI MIPA 4 Peminatan SMAN-2 Palangka Raya. Data berupa jurnal mengajar, rekaman foto-foto dan video, serta jawaban siswa, dikumpulkan dengan pengamatan dan wawancara yang dianalisis melalui reduksi dan tabulasi. Hasil penelitian menunjukkan perubahan suasana kelas sebagai dampak pelaksanaan tindakan, dimana (1) terjadi peningkatan jumlah jawaban benar; (2) teramati munculnya semangat belajar ; (3) produk kreativitas pohon ulin fantasi yang beragam dengan tempelan jawaban soal-soal identitas perkalian sinus dan cosinus.

Abstract

The challenge of mathematics teacher of SMAN-2 Palangka Raya was student boredom. The aim of research (1) increases the students' enthusiasm in learn trigonometry and (2) increase the learning outcome of multiplication to addition and subtraction identity of sine and cosine, used metacognition questions and fantasy ironwood tree metaphor integrated to *hands-on activity*. The research used the classroom action research method in three cycles of action. The subjects were 40 students of grade XI MIPA4 Specialization SMAN-2 Palangka Raya. Data comprised of learning journal, photos and video recording, and students' answer, collected through observation and interview, and analyzed through reduction and tabulation. The research result showed the classroom atmosphere change as the impact of action implementation, in which (1) the increase of right answers numbers; (2) the emerge of learning enthusiasm; (3) the variation product of the fantasy ironwood tree creation.

Keywords: hands-on activity, metacognition questions, metaphor, trigonometry

INTRODUCTION

It is important for students to be master trigonometry because trigonometry is the basis for understanding and solving problems in calculus and physics. Trigonometric functions are prerequisite knowledge in understanding pre-calculus

and calculus (Weber, 2005) and engineering (Siyepu, 2015). In the 2013 curriculum, trigonometry matter is taught in Senior High School (SMA). One indicator of achievement in learning trigonometry is able to determine the multiplication value of trigonometric functions related to the sum and difference of sine and cosine (Pembelajaran, 2019). This indicator contains two sub-matters, where students are expected to be able to find the identity formula of multiplication to addition and subtraction of sine and cosine and find the identity formula of addition and subtraction to multiplication of sine and cosine.

The 2013 curriculum recommends the use of the guided discovery method in mathematics learning, including learning trigonometry. Trigonometry learning with the guided discovery method is effective for learning the completeness of trigonometry (Ravikoh, 2018; Ishartono et al., 2016) and proving trigonometry (Hadi & Faradillah, 2020).

Mathematics teacher class XI Mathematics and Natural Sciences-4 (MIPA-4) Specialization at State Senior High School-2 (SMAN-2) Palangka Raya also applies the guided discovery method in learning trigonometry in that class. In the Lecturer Assignment at School (PDS) program, where lecturer and mathematics teacher collaborate to carry out learning in the classroom using the guided discovery method. While the math teacher carries out trigonometry learning in this class, students are generally having difficulty solving trigonometry problems with new formulas related to the basic concepts of sine and cosine. The reason is that students in junior high school did not understand well the basic concepts of trigonometry angles.

Difficulty understanding trigonometry matter is also found in the results of research by Siyepu (2015), Usman and Hussaini (2017), where students find it difficult to operate trigonometry calculations in problem solving. Even Gür (2009) found a misconception in the simplification of trigonometric functions in students. Likewise, Brown (2006) found that there is an incomplete or fragmented understanding of the concept of sine and cosine in trigonometric connection.

The obstacles experienced by students were observed in class XI MIPA Specialization at SMAN-2 Palangka Raya, when the lecturer and mathematics teacher collaborated to carry out learning with the guided discovery method. These obstacles are described in depth in the following. When trigonometry learning with the guided discovery method is implemented, the lecturer acts as a learner, and the math teacher accompanies students during learning. Before entering the subject matter, the lesson begins by reminding the difference formula for sine and cosine, namely (1) sin (α+β) = sin α cos β + cos α sin β; (2) sin (α-β) = sin α cos β - cos α sin β; (3) cos (α+β) = cos α cos β - sin α sin β; and (4) sin (α − β) = cos α cos β - sin α sin β. The next step provides the procedure for finding the multiplication formula by adding the difference formula for sine and cosine (1) and (2) with the elimination method to find the formula sin α cos β = $\frac{1}{2}$[sin (α+β)–sin(α-β)]. Then students are asked to try on their own to find the other multiplication formula of sine and cosine.

Students succeed in finding the multiplication to addition and subtraction formula of sine and cosine with the guided discovery method with the help of the Student Worksheet (LKS). For example, students are asked to find the formula sin α sin β = $\frac{1}{2}$[sin (α+β) + sin (α-β)]. In the same way, the teacher asks students to find the multiplication formulas cos α sin β, cos α cos β and sin α sin β.

The next activity, learning, was continued by providing examples of the application of these formulas with the angle values α and β replaced by variation values. For example, solving the multiplication form of sine and cosine

$$\sin 7 \frac{1}{2}^o \cos 37 \frac{1}{2}^o$$

and

$$\sin 10^o \sin 50^o \sin 70^o$$

in the form of sum or difference of cosine. Student response, it looks good. They understand. However, when the angles were changed in varying degrees, the students looked difficult. Students are only able to complete one question in about 10 minutes. After being asked to solve the second question, the students' faces began to look bored and anxious. The lecturer and teacher interviewed two students, IK and EL, asking what they felt when learning the matter. Both students answered that the lecturer's method of teaching was the same as their teacher, and it felt boring. This boredom is increasingly felt in class situations where the size of the room is insufficient to accommodate 40 students and is not equipped with air conditioning. The hot air temperature in the room makes students feel uncomfortable and often go to the toilet.

It can be concluded that the obstacles faced by students in studying the identity of multiplication to addition and subtraction matter in class XI MIPA Specialization at SMAN 2 Palangka Raya, are the weakness of reasoning in solving problems with varying angles and the emergence of boredom which weakens the enthusiasm and motivation of student learning.

Lecturer and mathematics teacher discuss solving problems experienced by students and decide to use *hands-on activity* and the fantasy ironwood tree metaphor to eliminate boredom and spur students' enthusiasm in learning. Research results related to the application of *hands-on activity* have been proven to be able to strengthen students' seriousness in learning mathematics (O Ekwueme, et al., 2015) and mathematical problem solving ability (Pambudiarso et al., 2016).

Strengthening the learning enthusiasm can be done through the use of metaphors which are believed to be able to create a meaningful mathematics learning process. Research results by Thibodi (2017) found that metaphors in learning mathematics affect students' perceptions, persistence, and mental image. According to Setiawan (2016) metaphorical thinking ability has been formed since students were in junior high school. Erdogan et al. (2014) found that the use of metaphors has formed learners' perceptions of mathematical concepts.

Kalra and Baveja (2012) define metaphor as a figure of speech that is presented with a picture, story, or anything that describes something less clear in its form. Metaphor is used to express something that is not known in a known term. The metaphor used in this study is a communication metaphor. According to Boero et al. (2001) communication metaphor is a figure of speech used to relate colloquial terms.

According to Ernest (2010), metaphors in learning support the creation of meaningful understanding and can be developed from various rich sources. Based on this opinion, metaphors can be created from the natural environment around students, such as local wisdom factors. The local wisdom factor in the research by Nkopodi & Mosimege (2009) was used to increase students' interac-

tion in learning.

In Central Kalimantan, one form that can be seen as local wisdom is a rare plant from the Kalimantan forest (Pradjadinata & Murniati, 2014). From the growth of ironwood (*eusideoxylon zwageri*), from seeds to being cut down to be used as raw material for building houses and ports in Kalimantan, can be taken a figure of speech to the mathematics learning motto. The learning motto that students can learn and live by is persistence, never giving up, and believing that learning trigonometry is beneficial for students and others, such as the ironwood tree. This learning motto is used as a metaphor to arouse students in learning trigonometry.

Weak students' mathematical reasoning can be developed by increasing their metacognition ability. In the research results by Schneider and Artelt (2010), Van der Stel et al. (2010), Ohtani and Hisasaka (2018), metacognition has a significant effect on mathematical reasoning. Metacognition is the ability to regulate a thinking activity by reflecting on what a person thinks themself in the learning process (Tachie, 2019; Veenman et al., 2006). In senior high school students' cognition, metacognition ability has been formed to solve mathematics problems (Zakiah, 2020; Van der Stel et al., 2010). It is in line with the research results by Amin and Sukestiyarno (2015) that senior high school students have metacognitive awareness, which affects metacognition skills.

These studies indicate that mathematical reasoning can be carried out through strengthening of metacognition ability. According to the research results by Pennequin et al. (2010), Mevarech and Fridkin (2006), metacognition ability developed through metacognition questions strategies have succeeded in developing mathematical reasoning ability.

The results of the above research can be used in solving the problem of learning the identity of multiplication to the addition and subtraction of sine and cosine experienced by students of class XI MIPA-4 Specialization at SMAN-2 Palangka Raya. This problem was solved by taking learning corrective actions to give metacognition questions and fantasy ironwood tree metaphor that were integrated into a *hands-on activity* in solving the problems of multiplication of sine and cosine.

The purpose of this study was to (1) increase the students' enthusiasm in learning trigonometry and (2) increase the learning outcomes of the identity of multiplication to addition and subtraction of sine and cosine, used metacognition questions and fantasy ironwood tree metaphor integrated in *hands-on activity*.

METHODS

This research is a classroom action research (Arikunto, et al, 2015; Kemmis et al., 2014) which was conducted in two cycles of action. These two cycles of action are carried out gradually. The first cycle was taught with a *hands-on activity* and the second cycle was taught with *hands-on activity* mediated by metacognition questions and the fantasy ironwood tree metaphor. Each cycle is carried out by the teacher and lecturer with the following steps: (1) reminding the prerequisite material, namely the formulas for the difference of sine and cosine, (2) guiding students to find the identity formulas of multiplication to the addition of sine and cosine, (3) guiding students to use the identity formulas of multiplication to the addition of sine and cosine in solving problems through hand-on activity writing and pasting formulas with colored paper in the student exercise book, (4) elaborating questions equipped with

metacognition questions guides, doing *hands-on activity* integrated with the fantasy ironwood tree metaphor.

The planning stage involves making a Lesson Plan (RPP), collecting teaching materials in textbooks and students' worksheet (LKS), preparing recording devices, and teaching journals.

The research data were collected by observation and interview, making teaching journals, collecting learning tools of question cards equipped with metacognition questions, *power point* slide templates, students' work of fantasy ironwood tree products, and learning documentation with video recordings and photos.

The data were analyzed through evaluation and reflection activities in the focus group discussion by the Mathematics teacher and lecturer of class XI MIPA-4 Specialization at SMAN-2 Palangka Raya. The results of the analysis are presented in the form of tabulations, documentation of photos of activities, and the meaning of the data qualitatively.

The indicator of achievement for the increase of the learning enthusiasm is a change in behavior from being bored to being full of enthusiasm which is observed in completing the task of solving the identity of multiplication of sine and cosine questions. The indicator of achievement for the increase in learning outcomes is the increase in number and variations of the difficulty level of the identity of multiplication to addition and subtraction of sine and cosine questions.

Classroom action research methods are very dependent on the learning time allocation in schools. It is impossible to repeat the same action until it reaches a saturation point due to the limited time allocation specified in the Syllabus. Meanwhile, lecturers are also limited by the schedule for implementing the Lecturer Assignment at School (PDS) pro-gram from the Ministry of Research, Technology, and Higher Education. The lecturer experience problems when collecting research data at the end of learning the identity of multiplication because there was no time for formative tests related to this matter.

RESULTS AND DISCUSSIONS

Research setting

Learning is carried out in a setting of class XI MIPA 4 at SMAN-2 Palangka Raya. The classroom is 7 m x 8 m in size to accommodate 40 students with classical students' desks and chairs, but it is easy to modify for group learning. There is a whiteboard, a large fan, a bookcase and a table and chair for the teacher. This classroom is located in the west corner of the school building, equipped with glass windows and air vents. When studying mathematics, the sunlight passes this room, which makes the air temperature in the classroom increase. A crowded classroom atmosphere with a high enough air temperature creates an uncomfortable atmosphere for learning mathematics, gets tired quickly, and reinforces boredom.

Action Implementation

Learning corrective actions to eliminate boredom and increase students' learning enthusiasm and improve learning outcomes of the identity of multiplication of sine and cosine matter are carried out in two cycles. The action was carried out gradually in the first and second cycles. In the first cycle, the teacher and lecturer used a *hands-on activity* by simply writing and pasting formulas on colored paper. Then in the second cycle, the teacher and lecturer taught with *hands-on activity* integrated with metacognition questions

and the fantasy ironwood tree metaphor. The following describes the results of the action implementation in the first and second cycles.

The first cycle: learning with hands-on activity

Learning in the first cycle was carried out using a *hands-on activity*. The details of the action activities in the first cycle are presented in Table 1.

Table 1. Action activities in the first cycle

Sub-matter: the identity of multiplication to the addition of sine and cosine
Activities

Planning:
- ✓ Focus group discussion about problems and steps to improve learning by modifying learning activities by including *hands-on activity* (writing, cutting, and pasting) in the lesson plan.
- ✓ Choose questions with easy and medium difficulty levels.
- ✓ Prepare materials such as colored hvs paper, scissors, and paper glue for *hands-on activity*.

Action implementation:
- ✓ Give individual task to do the problems by *hands-on activity*.
- ✓ Guide students to solve the problems.

Observation:
- ✓ Observe students' gesture responses, pay attention to students' difficulties and errors that arise.
- ✓ Take photos when students are completing the task with *hands-on activity* individually.
- ✓ Write down students' behavior and the process of completing the task in class during learning.
- ✓ Conduct interviews related to students' responses to learning.

Evaluation/reflection:
The lecturer and teacher team conducted a focus group discussion with the following activities:
- ✓ Review the results of observations and reflect on achievements and obstacles (problems that arise) faced by teachers and students.
- ✓ Review the photos of students' facial expressions and behavior and match them with observations.
- ✓ Determine learning problems that still arise and need immediate solutions.

At the beginning of the lesson, the teacher distributes colored paper (red, blue, yellow, green), where students are asked to choose the preferred color. Students are asked to write four formulas of multiplication of sine and cosine on colored paper. They were given the opportunity to make their writing creations and then paste it into their notebooks. Students are asked to do the questions and write their answers on the same page with the formulas attached. The teacher gives the task of solving two questions $\sin 7\frac{1}{2}^o \cos 37\frac{1}{2}^o$ and $\sin 10^o \sin 50^o \sin 70^o$ individually.

Students seem to like the *hands-on activity* like this. When asked to write the formula on colored paper, all students immediately do it with a cheerful face. The results of the interview related to this activity, student EL responded that:

"with these activities, there is something different in the learning that we live in, compared to the previous lessons".

Then the students started to do the questions in their notebooks, observing the form of the questions and then matching them with the four formulas written on the colored paper. After that, students are asked to choose one of the appropriate formulas and use the formula chosen to solve the question $\sin 7\frac{1}{2}^o \cos 37\frac{1}{2}^o$. Students have the opportunity to think critically in choosing the right formula for solving this question. The result was that the students were able to solve these questions well.

However, when students have a problem that is a little difficult compared to previous trigonometry problems, for example, determine the value of $\sin 10^o \sin 50^o \sin 70^o$, the student begins to seem to have difficulties. The teacher reminds students about the associative

property of multiplication a x b x c = (a x b) x c or a x (b x c), and the formula sin $(180^\circ - \alpha)$.

Then the students apply the associative property of multiplication by putting brackets on $\sin 10^\circ \sin 50^\circ \sin 70^\circ$ to become $(\sin 10^\circ \sin 50^\circ) \sin 70^\circ$ or written as $\sin 10^\circ \sin 50^\circ \sin 70^\circ = (\sin 10^\circ \sin 50^\circ) \sin 70^\circ$. Of the 40 students, only 3 were able to describe $\sin 10^\circ (\sin 50^\circ \sin 70^\circ)$ using the formula $\sin \alpha \sin \beta$ correctly. There was a grammatical error in describing the problem solving, where students were able to describe the trigonometry multiplication in brackets $(\sin 50^\circ \sin 70^\circ)$, but $\sin 10^\circ$ was not written in the description. Therefore, the written answer is incomplete.

The learning atmosphere observed was the emergence of learning boredom, resulting in weak students' interest in doing practice tasks on trigonometry questions. Where among the 40 students who are unable to link the concept of associative property of multiplication. Students do not complete their tasks and seem to give up, and have no effort to ask friends or teachers. They were not trying to study the matter in order to be able to do the questions well. The time used to find solutions to the two forms of trigonometry problems for 90 minutes is very long and very inefficient because of the students' surrender attitude. Students with less mathematical abilities are unable to understand the teacher's instructions in solving the questions. A passive student with a silent face, not excited. Signs of boredom are not only visible through the face but in the behavior of asking permission to go to the toilet, in turn.

The second cycle: learning with metacognition questions and the fantasy ironwood tree metaphor integrated with hands-on activity

Reflection on the results of learning observations in the first cycle is seen from the students' physical, cognitive, and attitude aspects. The results of these reflections are used as references in formulating learning action in the second cycle. The results of reflections on the physical, cognitive, and affective aspects and the formulation of actions are presented in Tables 2, 3 and 4.

Table 2. The observation results of the physical aspect

Observation results
✓ The condition of students in general, physically there are no obstacles.
✓ The physical condition of the classroom, with the classical arrangement of 40 students and teacher's desks and chairs, the walls are decorated with paintings, colored paper fold decorations, and the decoration of moral messages writing with ornaments created by students.

Reflection
✓ Students in Class XI MIPA 4 Specialization at SMAN-2 Palangka Raya have a passion for making colored paper creations, painting, and making unique ornaments.

Action formulation
✓ Giving task by making drawing creations, *hands-on activity* by writing, cutting, and pasting various colored papers with material: 80 cm x 60 cm white cardboard, origami paper, glue, and scissors.

Table 3. The observation results of the cognitive aspect

Observation results
✓ Difficulties faced by students in solving questions that have a medium difficulty level, for example, determining the value of $\sin 10^\circ \sin 50^\circ \sin 70^\circ$.
✓ The students seemed confused in solving the question.

Reflection
✓ Students seemed to have difficulty applying the multiplication formula of sine and cosine

Action formulation

- ✓ Make easy and medium questions with the same pattern but varying the magnitude of the angles α and β both in the form of numbers, other angle symbols such as x^o, A^o, B^o, or π, and equation, for example $(A^o + B^o)$ and $(A^o - B^o)$.
- ✓ The questions are typed in the form of question cards and accompanied by metacognition questions as guiding questions for reasoning, understanding and answering questions.

Table 4. The observation results of the attitude aspect

Observation results
- ✓ As time passed, the bored behaviour in solving the questions arises, and the students' attention is no longer focused on the process of solving the questions, and students become noisy themselves.
- ✓ Students give up on their inability to solve the questions.

Reflection
- ✓ Boredom because of the learning mode that is felt to be monotonous, the surrendering attitude, and being passive.
- ✓ Get into the students' world through the favorite window making decorative creations in the classroom with colored paper.
- ✓ Destroy the surrender behavior by providing the ironwood tree metaphor (local wisdom).

Action formulation
- ✓ Provide an understanding of the meaning and important lessons of ironwood plant growth, which are associated with "persistence leads to good quality mathematics learning outcomes". Presentation through ironwood plant *power point template*.
- ✓ Using a *hands-on activity* with cardboard and colored origami paper, create an "fantasy ironwood tree" creation.

The reflection and action formulation presented in Tables 2, 3, and 4 serve as a reference for lecturer and teacher in deciding the form of learning corrective actions that must be carried out in the second cycle. The form of action in the second cycle is formulated as follows. The use of metacognition questions and giving the fantasy ironwood tree metaphor can be integrated into a *hands-on activity* when completing the task of solving the identity of multiplication of sine

and cosine questions.

Learning in the second cycle is gradually added by adding the ironwood tree metaphor. The teacher presents a PPT about the growth of ironwood tree (*eusideoxylon zwageri*). Then the students in groups were given the task of doing the questions made on the question cards, where the question cards contained metacognition questions. Metacognition questions to direct students' reasoning about the questions and how to solve them. Examples of metacognition questions, "which formula of multiplication of sine and cosine is the most appropriate used for this question?" "By the associative property of multiplication, which of the problem is bracketed?" The results of solving the identity of multiplication of sine and cosine questions are written on colored paper and attached to the fantasy ironwood tree creation. The second cycle action activities are presented in Table 5.

Table 5. Action activities in the second cycle

Sub matter: solving the identity of multiplication of sine and cosine questions
Activities

Planning:
- ✓ Lesson plan prepared by the teacher, and modifying learning activities by providing metaphors, *hands-on activity*, doing the questions with metacognition questions instructions.
- ✓ Collect materials and put the fantasy ironwood tree metaphor in PPT.
- ✓ Prepare materials for *hands-on activity* (origami paper, white manila cardboard size 80 cm x 60 cm, paper glue, and scissors).
- ✓ Choose questions about the multiplication of sine and cosine, supplemented by metacognition questions.
- ✓ Prepare a recording device for learning activities.
- ✓ Arranging the position of O-shaped students' chairs and desks for group work of 9-10 peoples.

Action implementation:
- ✓ Ask students to sit in groups with heterogeneous students and distribute materials and question cards.

✓ Provide the ironwood tree metaphor, and lead students to learn the lessons about persistence in learning, such as the growth of the ironwood tree.

✓ Give the task of doing the questions and organize the results in a fantasy ironwood tree. Provide procedures and use of metacognition questions in solving questions.

✓ Observe students' motivational behavior while walking around between groups.

✓ Collecting the task and assessing results, and interviewing students to obtain information about students' responses to learning.

Observation:

✓ Observe students' behavior while walking around between groups in the classroom.

✓ Collect and assess work results and interview students to get students' responses to learning.

Evaluation/reflection:

✓ Assess the students' answers written on origami paper and pasted on the leaves of the fantasy ironwood tree.

✓ Analyze photos of recorded lessons.

✓ Discuss with the teacher about the impressions felt by students.

✓ Conclude the results of the provision of the corrective learning action.

The PPT slides about the ironwood tree are presented in Figure 1. *Hands-on activity* with activities to create "fantasy ironwood tree" creation, making questions in various forms, reasoning guides with the help of metacognition questions are a form of active learning. This learning integrates local wisdom components of the use of ironwood tree as the source of metaphor.

Seed

Seedling

Fruit

Tree

Decades of growing, getting bigger and stronger, useful for human life.

The growth of ironwood tree metaphor

Figure 1. Ironwood tree metaphor

The growing period of the ironwood plant takes a long time, from seed to tall, large trees. The benefits of ironwood trees is as raw material for building houses, ports, bridges, and household furniture that have high quality and durable. That sentence full of meaning is used as a source of the formulation of metaphor. The growth, the shape of the tree, the lush leaves on the top of the tree, and the use of the ironwood plants are associated with the mathematics learning process. This sentence is associated with the students' experience, where learning mathematics which they have spent years in school, is like the growth of an ironwood tree and is beneficial for students and society. Student persistence is like the growth of ironwood, associated with the formation of the mastery of mathematics matter which has become increasingly complex in a long time, which will produce a mathematical ability that is complex and beneficial to others. This figure of speech of the growth and use of ironwood plants serves as a metaphor to get rid of boredom and foster learning enthusiasm.

Learning is carried out according to the action plan. There are four groups of

students consist of 10 members each group working together on a fantasy ironwood tree creation. The number of questions distributed to four groups of students; 8 items with easy (E) difficulty level and 4 items with medium (M) difficulty level.

One easy question is given a maximum score of 10, while one medium question is given a maximum score of 15. Therefore, the total score of 12 items is 140.

Table 6. Distribution of the number of answers to the questions according to the level of difficulty

Groups	Number of questions			Groups' score	
	C	LD	%	Total	%
1	7	E	58,33	70	50
2	9	E	83,33	105	75,00
	1	M			
3	8	E	75,00	95	67,85
	1	M			
4	7	E	83,33	115	82,14
	3	M			

Information:
C = number of correct answers
LD = justification of the level of difficulty of the question
E = the question with easy difficulty level
M = the question with medium difficulty level

Table 6 the distribution of the number of correct answers and the variety of questions that students were able to do in the second cycle. When it is compared to the first cycle, there is an increase in the number and variation of the level of difficulty of the questions. At first, the number of questions with an easy level in the first cycle was completed by 1 student. After the second cycle increased to 31 students, the medium difficulty level questions in the first cycle can only be done by 3 students. In the second cycle, the number of questions with medium difficulty justification was done correctly by 5 students. There was an increase in the number of students who answered correctly and the level of difficulty of the questions from the first cycle

to the second cycle.

Along with this, there was an increase in the questions being worked on. Where of the 12 questions given, in the first cycle the number of questions worked on was only 1 question and increased in the second cycle in the range of 7 – 9 questions. The highest possible total score of the 12 questions is 140. The total score for the groups in the second cycle is only in the range 0 – 10, after increasing in the range 70 – 115. There was an increase in the number of students who answered correctly and the total score. The results of this study show an increase in the student's ability to understand the identity of multiplication to the addition and subtraction of sine and cosine matter.

Students write their answers on origami paper with their favorite colors and then combine them with a fantasy ironwood tree trunk sketch. According to their respective imaginations, the sketch of ironwood tree trunk was described by the students when listening to the slide show of the ironwood tree picture. Snippets of creative products of fantasy ironwood tree made by students are presented in Figures 2 and 3.
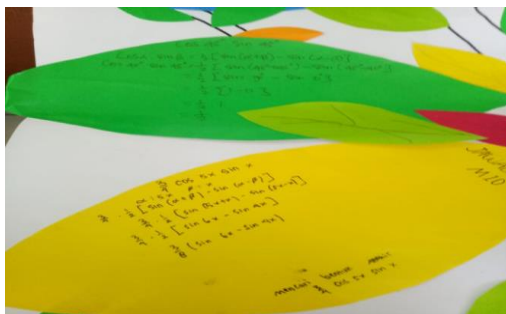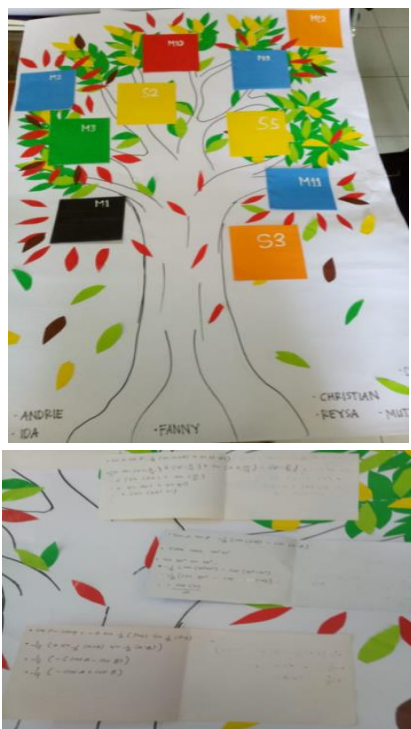
Figure 2. Group 2's fantasy ironwood tree creation

Figure 3. Group 4's fantasy ironwood tree creation.

Meanwhile, student EL gave a response:

"learning by making fantasy ironwood tree make us happy ... to gain our creativity, we are looking for new ideas to make the trees even more beautiful. Besides increasing our mastery of science, our creativity also increases."

Students' responses in the interview showed that the problem of boredom in learning trigonometry had been solved. Students feel their creativity is also channeled through the creation of a fantasy ironwood tree.

Discussion

The findings obtained from the learning outcomes are as follows. *First*, the use of *hands-on activity* and the creation of fantasy ironwood tree can increase students' learning enthusiasm. Students seemed more eager to complete the task of doing the questions of the identity of multiplication to addition and subtraction of sine and cosine. Boredom is no longer visible. The students' faces were full of enthusiasm and joy during the *hands-on activity*. In other words, there is a change in students' learning enthusiasm, who at the previous meeting seemed bored to become full of enthusiasm. *Hands-on activity* in this learning forms a positive behavior where students learn in earnest and fun. The results of this study are relevant to Holstermann et al. (2010) who also found that giving *hands-on activity* increased learning interest and seriousness in learning mathematics (O. Ekwueme et al. (2015) affect the formation of mathematics learning attitude (Thuneberg et al., 2017).

The creation of the fantasy ironwood tree stimulates the functioning of the right brain. Art creativity develops, and the right brain tasked with the reasoning in learning mathematics can run on its own without feeling pressured and bored. This condition shows that the students are in a *flow* condition. *Flow* condition occurs when a person is able to motivate themselves, control themselves and be able to be creative (Goleman, 2000).

Hands-on activity is integrated in creating fantasy ironwood tree, making learning the identity of multiplication to the addition of sine and cosine matter meaningful. The results of the evaluation and reflection of learning as a whole in the first cycle and the second cycle show the simultaneous development of the students' affective, cognitive and psy-

chomotor aspects. The results of evaluation and reflection are also found in research by Kartono (2010).

Second, the increase in the number and level of difficulty of questions of the identity of multiplication to addition and subtraction achieved in the third cycle indicates an increase in learning outcomes. The use of metacognition questions and the fantasy ironwood tree metaphor integrated in the *hands-on activity* can improve students' learning outcomes. Research results relevant to this were conducted by Pfaff & Weinberg (2009) who used *hands-on activity* to increase mastery of statistics matter. According to Riley et al. (2017) *hands-on activity* facilitates students to understand mathematical concepts.

Third, the importance of giving metacognition questions to help students analyze the form of questions, find a solution plan and solve and find the final result correctly. The results of this study are relevant to Mevarech and Fridkin (2006), Kramarski and Mevarech (2003), as well as Verschaffel et al. (2019) which shows that giving metacognition questions can help students analyze mathematical formulas or principles that are appropriate in solving problems of rational exponent and algebra.

Fourth, the metaphor to arouse students' learning enthusiasm can be extracted from the student's life environment related to local wisdom knowledge about the growth of ironwood tree from Kalimantan forests. The metaphor in the form of a learning motto, which is reflected in the growth of ironwood tree, becomes the driving force for students' learning enthusiasm. The ironwood tree metaphor is similar to the metaphor found by Thibodi (2017), which associates learning mathematics with fun activities in everyday life. The metaphor of the fantasy ironwood tree refers to Boero et al.

(2001) classified as the communication metaphor type, where the fantasy ironwood tree and its motto conveyed to students is a means of communication to create a student learning atmosphere thoroughly.

Fifth, the mathematics teacher gets important lessons from this activity. The mathematics teacher got a solution about how to enable students to learn trigonometry. Furthermore, the teacher adopts this learning for learning other mathematics matter. This method can develop the quality of teachers' professional competence. According to Kukey et al. (2019), the professional ability of teachers can be done through the use of *hands-on activity*, and according to Hendriana et al. (2017), through the use of metaphors in learning.

This research has had a positive effect on improving trigonometry learning. However, it is still limited to changes in learning enthusiasm and changes in the process of doing the trigonometry multiplication identity questions. Due to the limited time for implementing the Lecturer Assignment at School (PDS) program, guest teachers have limited time to finish until the end of the semester to evaluate learning outcomes thoroughly. Further research can be carried out thoroughly with experimental research methods, which will provide another color in mathematics learning research.

CONCLUSIONS

The results of this classroom action research indicate that the use of the ironwood tree metaphor integrated with *hands-on activity* and metacognition questions can arouse students' learning enthusiasm. The students looked enthusiastic and diligent in solving quite difficult questions of the identity of multiplication of sine and cosine. Boredom did

not appear on the faces of the students.

Indicators of the success of action implementation that were achieved were (1) an increase in the number and level of difficulty of correct answers; (2) it is observed that the learning enthusiasm emerges; (3) creative products of various fantasy ironwood trees with the attachment of answers to the identity of multiplication of sine and cosine questions.

The application of metacognition questions requires teachers to make reflective questions and lead students' cognition in choosing the right formula of the multiplication of sine and cosine. The development of metaphors can be elaborated using other rare plants that exist in the environment of students' lives.

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