Improving the Mathematical Comprehension and Learning Independency through Discovery Learning Model on Trigonometry for High School Students

[1*]Nelliani, [1]Anwar and [2]Anizar Ahmad

[1]Master Program of Mathematics Education, Faculty of Teacher Training Education, University of Syiah Kuala, Banda Aceh 23111, Indonesia
[2]Department of Early Childhood Education, Faculty of Teacher Training Education, University of Syiah Kuala, Banda Aceh 23111, Indonesia;

[*]*Corresponding author*: nellianimnur@gmail.com

Abstract

The background study of this research was based on the lack of mathematical understanding and students' learning independency of Class X at one of the senior high schools in Aceh Besar. The test results on the trigonometry subject showed that only 3 out of 10 students (30%) passed the minimum score. This condition was also found during the observation of student activities in their learning process. Students tended to rely on teachers and friends to cope with the problems, such as lack of initiative, have poor learning management and easy to feel discouraged. The main objectives of this research were (1) to improve students' mathematical comprehension, and (2) to improve students' learning independency through discovery learning model on the trigonometry subject. This is a classroom action research. The subjects of this study were ten students at Class X of science class. The research instruments consisted of a set of mathematical comprehension test and students independent learning questionnaire. The technique of data collection used was a qualitative approach, and the collected data was described in descriptive form. The results show that there was an improvement of the learning process through the discovery of learning model, based on the mathematical comprehension test results (from 68.3% in cycle I to 71.7% in cycle II), and the improvement of student's independent learning (from 42.2% in cycle I to 47.1% in cycle II). Therefore, Discovery learning model effectively improves students' understanding ability, encourage student-learning independency and enlarge students' mathematical comprehension.

Keywords: mathematical comprehension, learning independence, discovery learning.

Introduction

Mathematics is a subject that requires various competencies to master it. Those competencies are explained in NCTM (National Council of Teachers of Mathematics) principle which contains five standardize the process of mathematics. Those are mathematical comprehension, communication, representation, connection and problem solving (NCTM, 2000). One of the most fundamental competencies in mathematics is mathematical comprehension (Bani, 2011; Saragih & Yuliani, 2016).

Because mathematical comprehension is one of the main compulsory objectives in the Curriculum 2013, it needs to be mastered by students (Nurina, 2014). Therefore, teachers are expected to improve students' mathematical comprehension for every mathematics material that being taught to learners.

Besides having a good mathematical comprehension, mathematics subject also requires independent learning (Soemarmo & Sumarni, 2016). Independent learning is a self-driven learning activity, self-initiative, self-choice and self-responsibility (Abdullah, 2016; Qohar & Soemarmo, 2013). Learning independently is essential in mathematics teaching. Students with good independent learning will be able to complete each of their learning task on their initiative, decision, and responsibility without any friend's interference. Students are expected to be excited with the challenges, confident and willing to achieve success during the learning process, as Zimmerman stated that independent students are those who are always motivated to get better improvement in the learning process (Steiner, 2016).

As a Mathematics teacher in high school, the researcher concerned about the condition of the learning process at the school, especially in learning Mathematics. It had been shown that during the learning process, the mathematical comprehension was very low. When the teacher asked the students to conclude the subject in their own words, they found it difficult and could not find an appropriate answer or explanation about it. Students were lack of skills in solving the questions. Moreover, they were unable to complete the questions, but somehow, they could solve the similar form of questions that were provided in the previous discussions. This phenomenon kept happening toward students when they were faced to contextual questions that require several completion concepts. Students were not able to associate with various mathematical concepts to find solutions. Students gave up easily for reasons that were too difficult.

The low ability of students' mathematical comprehension also occurred in learning trigonometry. Students had difficulty understanding sine and cosine rules. Most students were unable to solve problems correctly. Students also had difficulty in applying sine and cosine rules in accordance with the steps of completion. It was indicated by the low results of the students' mathematical comprehension testability on trigonometry. Based on these results, it was known that only three students from 10 students (30%) had achieved minimal mastery. While seven students had not met the minimum completeness criteria.

During learning, researchers also found the low independency of students in learning. When the teacher gives assignments, students are happy to wait for answers from their friends. Students do not have the initiative to complete their tasks, easily give up when dealing with complicated problems, inactive in finding relevant sources and always not ready to face a test.

Therefore, one of the learning models that can improve mathematical comprehension and student learning independence is a discovery-learning model. Discovery Learning is a learning model that provides students chances to explore on their own about the subject being learned (Hanafi, 2016; In'am, 2016). Regarding this model, McDonald (2016) stated that learning through finding could stimulate students' learning independence as the students involved in their self-development. Also, Dahar (2011) argued that the learning through finding would create some advantages like the knowledge would last longer and could be easily retrieved by students themselves and comparing to other technique, the result of this learning technique had a better impact toward the students.

Research Methods

This research was a Classroom Action Research which aimed to improve the students' abilities of mathematical comprehension and student learning independently through discovery learning model. This research was conducted in 2 cycles where each cycle consisted of four stages namely planning, implementation, observation and reflection (Arikunto, 2010).

The subject of this research was students of class 10 IPA. The numbers of students were ten students which consisted of 3 men and seven women. This research was conducted in the second semester (even) of the academic year 2017/2018, March to April 2018. The material used in this research was trigonometry which focuses on discussion on sinus and cosine rules. Data collection techniques used were tests and questionnaires. The test was used to find out the improvement of mathematical comprehension ability, and the questionnaire was used to see the improvement of student's independent learning.

The data analyses used in this research were as follow:

1. Data analysis of mathematical comprehension ability
The results of the students' answers to the mathematical comprehension test were analyzed using percentage calculations as follow:

$$R = \frac{(\text{total score mathematical comprehension})}{(\text{number of maximum score per question})}\ x\ 100$$

R = percentage of students' mathematical comprehension

Based on Permendikbud number 23 of 2016 concerning guidelines for assessing learning outcomes, students are considered to be completed in learning if they obtain a value of ≥ 70 of the total score of the test results.

2. Analysis of student self-reliance data
To analyze the questionnaire data, the formula used is:

$$P = \frac{F}{N} \text{ x } 100\%$$

Which illustrates the percentage of answers (P), the frequency of answers (F) and many respondents (N). The percentage obtained on each item statement/question would be interpreted according to the criteria as in Table 1 below:

Table 1. Criteria Interpretation Percentage of Answer Questionnaire

Criteria	Interpretation
P = 0%	No One
0% < P < 25%	Small part
25% ≤ P ≤ 50%	Nearly half
P = 50%	Half
50% < P < 75%	Mostly
75% ≤ P < 100%	Almost entirely
P = 100%	All

Source: Zarkasyi (2015)

Results and Discussion

The research results were described in the form of learning cycles that conducted during the teaching and learning process in the classroom. The action research consisted of two cycles presented below.

Cycle I

The researcher described the results of the learning cycle I by analyzing the value of mathematical comprehension test skills. The analysis was needed to determine the ability of understanding of the material taught and mastery learning during the cycle I. The test value description of mathematical comprehension of the cycle I can be seen in Table 2 below:

Table 2. Mathematical Comprehension Test Value of Cycle I

Student	Item/Indicator			Value		Explanation
	1	2	3	Total	Percentage	
1	4	3	3	10	83.3%	Qualified
2	3	3	3	9	75%	Qualified
3	3	3	3	9	75%	Qualified
4	3	3	3	9	75%	Qualified
5	2	2	3	7	58.3%	Unqualified
6	3	2	3	8	66.7%	Unqualified
7	2	2	2	6	50%	Unqualified
8	2	2	2	6	50%	Unqualified
9	3	3	2	8	66.7%	Unqualified
10	3	4	3	10	83.3%	Qualified
	Average			**8.2**	**68.3%**	

Based on Table 2, it is shown that from 10 students who took the first cycle test only five students received the complete value with the percentage of mastery learning that is above 70%. While the value for the five other students is still below the minimum mastery criteria. The average classical achievement for the first cycle test is 68.3%. It means that classical learning cycle I have not reached the target completion of a minimum set of 70%. This result placed consideration of researcher with colleagues to continue the learning process to the next cycle. The results of data analysis of learning independence during the first cycle are presented by the researcher as in Table 3 below:

Table 3. Questionnaire Response to Learning Independence

No	An indicator of Learning Independence	P	Interpretation
1	Learning initiative	47.3%	Nearly Its Half
2	Diagnose the need for learning	46%	Nearly Its Half
3	Setting learning goals / targets	45%	Nearly Its Half
4	Choose, apply the learning strategy	52%	Nearly Its Half
5	Monitoring, organizing and controlling learning	46%	Nearly Its Half
6	Viewing adversity as a challenge	45%	Nearly Its Half
7	Utilizing and searching for relevant sources	49%	Nearly Its Half
8	Evaluating the learning process and results	47%	Nearly Its Half
	Average	**47.2%**	**Nearly Its Half**

Table 3 shows that the level of achievement of each indicator is still in the category of "Nearly Half" with criterion percentage 25% ≤ P <50%. Also, some aspects of learning independence are still low responded by the students, such as setting goals and learning targets only 45% and aspects of viewing diversity as a challenge responded by 45%. This result affected in low student learning independency with an average percentage is only 47.2%.

Based on the research result of the researcher with colleagues about the actions that have been implemented during the cycle I, the researcher found some things that still need improvement. Teacher's creativity in presenting material was still inadequate. Learning was still dominated by lecturing, where the teacher explained, and students spent a lot of time listening. Student's participation in each learning activity was defective. Only a few students were active both in discussions and in discovery activities. There were still students playing around, not thinking about their understanding of problems given to the LKS, there were still students who did not record their observations, there were still students who did not interact with the group and only a few students appear to present the results of their group work or respond to the results other group presentations.

During the cycle, I of learning, students' independence was not optimal. Students depended on their teachers or friends to solve their problems, students were often not ready to complete the tasks, and students often complained when faced with challenging questions. The low ability of mathematical comprehension and learning independence of students had implications for the achievement of learning objectives. Based on the results of the reflection, the researcher believed that learning must have been packaged to be more interesting so that it could increase student learning activities. Teachers could use learning media as their learning aids so that the materials delivered were more memorable. Students who are actively involved in each learning process would easily build an understanding of every new knowledge they have gained. Therefore, the researcher decided that learning needs to be continued into cycle II through a multimedia-assisted *discovery learning* model

Cycle II

The cycle II of the learning still carried out with discovery learning model with several improvements. The teacher presented material with more creative PowerPoint so that it could reduce students' boredom. The teacher also asked questions that encourage students' curiosity, encouraged their daring to express ideas or opinions, provided rewards for students who dared to present their work or are active in class discussions and group discussions. Thus, learning took place more interactive and lives. So that it could improve the ability of students' understanding and independence of learning. Stage in cycle II is the same as a cycle I, consists of planning, implementation, observation, and reflection. Implementation of cycle II was done as much as two meeting. The result of the students' mathematical comprehension of cycle II is presented in Table 4 below:

Table 4. Mathematical Comprehension Test Value of Cycle II

Student	Item/Indicator			Value		Explanation
	1	2	3	Total	Percentage	
1	3	4	3	10	83.3%	Qualified
2	4	3	3	10	83.3%	Qualified
3	3	3	3	9	75%	Qualified
4	3	3	3	9	75%	Qualified
5	3	3	3	9	75%	Qualified
6	3	3	3	9	75%	Qualified
7	2	2	3	7	58.3%	Unqualified
8	2	2	2	6	50%	Unqualified
9	3	2	2	7	58.3.7%	Unqualified
10	4	3	2	9	75%	Qualified
	Average			**8.6**	**71.7%**	

Table 4 shows that the number of students who completed the study in cycle II has been increased from Cycle I. In the first cycle, students who completed learning only 5 students with a complete classical average by 68.3%, while in the cycle II increased

to 7 students with mastery the average classically rose to 71.7%. As the criteria established by the school is called classical completion of learning if in the class there are ≥ 70% of students have completed learning, and then the effort of teachers to improve student-learning outcomes can be said that has been achieved. Increasing student independency was also shown through the response of student learning independence in cycle II. In the cycle I, the average percentage was 47.2%, while in the cycle II the average percentage of the overall indicator was 50.6%. The response independency of students learning as a whole is presented in table 5.

Table 5. Questionnaire Response to Learning Independence

No	An indicator of Learning Independence	P	Interpretation
1	Learning initiative	52%	Mostly
2	Diagnose the need for learning	50%	Half
3	Setting learning goals / targets	52%	Mostly
4	Choose, apply the learning strategy	52%	Mostly
5	Monitoring, organizing and controlling learning	52%	Mostly
6	Viewing adversity as a challenge	45%	Nearly Its Half
7	Utilizing and searching for relevant sources	52%	Mostly
8	Evaluating the learning process and results	50%	Half
	Average	**50.6%**	**Mostly**

Based on the reflection of cycle II, it was shown that learning through multimedia-assisted discovery learning models could improve students' mathematical comprehension ability. Students were actively involved in the learning process, and the teacher has not dominated much of the learning, students were able to explain the concepts learned, able to link various mathematical concepts in problem-solving, and students were able to apply algorithms in problem solving.

Learning through discovery learning models also helped students to be independent in learning. Independence in learning was grown through activities that students must carry out during the learning process. Through the stages of data collection and data analysis, students did activities of recognizing, identifying, reviewing, observing so that the students were getting used to doing the learning tasks without other help, having their initiative to learn from various sources to increase knowledge and students were willing to evaluate learning outcomes as feedback.

Conclusions

Based on the results of research and discussion, can be concluded that the ability of students' mathematical comprehension on trigonometry subject can be improved through discovery learning model. It was indicated by the increase in student learning completeness from 68.3% in the first cycle to 71.7% in the second cycle. Then, student learning independence in trigonometry subjects can be improved through discovery learning models. This could be seen from the increase in student learning independence from cycle I by 47.2% to 50.6% in cycle II.

Discovery learning model effectively improves students' understanding ability, because it requires students' involvement in building their new knowledge. The knowledge that constructed by students will be meaningful and long-lasting in students' memories. Furthermore, learning with discovery learning models can also encourage student-learning independence. Discovery activities familiarize students to recognize, identify, assess, and examine which are indirect shapes student-learning independence.

The recommendation of this study is teachers can apply discovery learning to other materials, especially on concepts that are in accordance with the characteristics of the discovery-learning model.

References

Abdullah, M.Ng. (2016). Interaction effects of gender and motivational beliefs on self regulated learning: a study at ICT-integrated schools. *Malaysian Journal of learning and Instruction*, 13(1), 25-41

Afgani, D.J. (2011). *Analisis Kurikulum Matematika*. Jakarta: Universitas Terbuka

Arikunto, S. (2006). *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta.

Bani, A. (2011). *Meningkatkan Kemampuan Pemahaman dan Penalaran Matematik Siswa Sekolah Menengah Pertama melalui Pembelajaran Penemuan Terbimbing*. Tesis, tidak diterbitkan, Program Pascasarjana Universitas Pendidikan Indonesia: Bandung.

Dahar, R.W. (2011). *Teori-teori Belajar dan Pembelajaran*. Jakarta: Erlangga.

Depdikbud. (2016). *Peraturan Menteri Pendidikan dan Kebudayaan No. 24 tahun 2016 tentang Kompetensi Inti dan Kompetensi Dasar Pelajaran pada Kurikulum 2013 untuk Pendidikan Dasar dan Menengah*. Jakarta: Depdikbud.

Gur & Hulya. (2009). Trigonometry Learning. *New Horizons in Education*. ERIC, 57(1).

Hanafi. (2016). The effect of discovery learning method application on increasing student's listening outcome and social attitude. *Dinamika Ilmu*, 16(2), 291-305.

In'am, A. & Hajar, S. (2017). Learning geometry through discovery learning using a scientific approach. *International Journal of Instruction*, 10(1), 55-70.

McDonald, B. (2011). *Self-assessment and discovery learning*. Trinidad: West Indies.

NCTM. (2000). *Principles and Standards for Scholl Mathematics*. USA: NCTM.

Nurina, L.A. (2014). "Strategi *Everyone is a Teacher here"* untuk Meningkatkan Pemahaman Matematis dan Kemandirian Belajar Siswa SMP. *Repository UPI*. Retrieved from http://repository.upi.edu/11833/3/S_MTK_1201012_Abstract.pdf

Qohar, A. & Soemarmo, U. (2013). Improving mathematical communication ability and self regulation learning of junior high students by using reciprocal teaching. *Indo MS J.M.E*, 4(1), 59-74.

Saragih, S. & Yuliani, K. (2015). The development of learning devices based guide discovery model to improve understanding concept and critical thinking mathematically ability of students at Islamic junior high school of Medan. *Journal of Education and Practice*, 6(24), 116-128.

Steiner, H. (2016). The strategy project: promoting self-regulated learning through an authentic assignment. *International Journal of Teaching and Learning in Higher Education*, 28(2), 271-282.

Sumarni, C. & Soemarmo, U. (2016). Penalaran Matematika dan Kemandirian Siswa SMP melalui Pembelajaran Generatif. *Jurnal Ilmu Pendidikan dan Pengajaran*, 3(3), 290-299.

Zarkasyi, M.W. (2015). *Penelitian Pendidikan Matematika*. Bandung: Refika Aditama.