The effectiveness of module based on guided inquiry method to improve students’ logical thinking ability

M H Ash-Shiddieqy*, A Suparmi and W Sunarno

Sebelas Maret University, Indonesia

*Email: hidupcumasekali@student.uns.ac.id

Abstract. The purpose of this research is to understand the effectiveness of module based on guided inquiry method to improve students’ logical thinking ability. This research only evaluate the students' logical ability after follows the learning activities that used developed physics module based on guided inquiry method. After the learning activities, students This research method uses a test instrument that adapts TOLT instrument. There are samples of 68 students of grade XI taken from SMA Negeri 4 Surakarta. Based on the results of the research can be seen that in the experimental class and control class, the posttest value aspect of probabilistic reasoning has the highest value than other aspects, whereas the posttest value of the proportional reasoning aspect has the lowest value. The average value of N-gain in the experimental class is 0.39, while in the control class is 0.30. Nevertheless, the N-gain values obtained in the experimental class are larger than the control class, so the guided inquiry-based module is considered more effective for improving students' logical thinking. Based on the data obtained from the research shows the modules available to help teachers and students in learning activities. The developed Physics module is integrated with every syntax present in guided inquiry method, so it can be used to improve students' logical thinking ability.

1. Introduction

The ability to think logically is the ability determined in the period of the abstract process in Piaget's cognitive development phase [1]. The ability to think logically allows one to solve problems by generalizing, thus solving a complex problem [2]. Logical thinking implies a reasonable, understandable, reasoned, reasoned, an analytical, and interrelated way of thinking [3]. Many discussions and research are conducted to study students' logical thinking ability because of logical thinking ability influences student learning outcomes [4,2]. There are still many high school students who have not developed their logical thinking skills and many high school students have their thinking ability at the formal thinking stage [5,6]. The students' logical thinking ability is still low because teachers are less precise in choosing learning strategies and students are less accustomed to logical and critical thinking [7].

Learning that focuses only on teachers and students is only concerned, causing students to tend to be passive, thus causing students' logical thinking skills to be less than optimal [8]. A learning strategy that is more focused on student activities is required to improve students' logical thinking ability, one of the solutions by using inquiry approach [9]. The inquiry approach includes one of the contextual learning innovations that prioritize the learning process based on the search and discovery through the systematic thinking process. Guided inquiry approach can improve the ability of critical thinking and student learning outcomes because the inquiry approach can improve students' understanding. Some of the advantages of guided inquiry method, i.e students are more active in learning activities and help students to gain knowledge from the environment so that students are not always dependent on teachers in taking
knowledge [10], both student and instructor become critical in the teaching and learning process; a cycle of guidance, problem-solving and collaboration that continues between students and between students and instructors.

In its development, the guided inquiry approach is integrated into the learning module, so that students can build their knowledge independently according to the ability they have [11-13]. Learning modules based on guided inquiry approaches can improve students' science literacy on process dimensions, improve students' cognitive skills, enhance student character and conceptual understanding [11-15].

Based on the background explanation, the purpose of this research is to understand the level of students' logical thinking skills in the learning activities.

2. Experimental Method

This research was conducted in SMA Negeri 4 Surakarta in the odd semester of lesson 2017/2018. The study involved 32 students of class XI MIA 4 and 32 students of MIA class 5 as respondents. The learning activities used physics module based on guided inquiry method. The developed Physics module consists of 3 learning activities that are divided based on Rotational Dynamics and Equilibrium materials for students grade XI. The developed module consists of 2 related books, namely LKS (practice manual) and enrichment. Each guided inquiry method in physics module is also adapted to indicators of logical thinking ability, so that in each learning activity it supports the development of students' logical thinking ability. Overall, the resulting Physics module consists of 3 main parts, there are introduction, content, and cover. There are several examples of problems and exercises that can be used as a reinforcement of students in understanding the material, as well as a matter of competency test that can be used to measure student learning outcomes from learning activities using Physics module that has been done. The developed Physics module is appropriate to be used as a learning media, both in material aspect, language aspect, and media aspect. This research method uses a test instrument that adapts TOLT instrument developed by Tobin and Capie [16]. Tobin and Capie [16] developed TOLT instruments based on the development theory proposed by Piaget. The instrument used to measure the level of logical thinking ability contains 5 aspects assessed as shown in Table 1.

| Number | Rated aspect          | Problem Number |
|--------|-----------------------|----------------|
| 1      | Probabilistic Reasoning| 1, 2           |
| 2      | Controlling Variable  | 3, 4           |
| 3      | Proportional Reasoning| 5, 6           |
| 4      | Correlational Reasoning| 7, 8          |
| 5      | Combinatorial Reasoning| 9, 10         |

The TOLT instrument consists of 10 questions consisting of 8 multiple choice questions and choice of reasons and 2 short questions for no reason. Problems in the form of multiple choice are declared true if the answer and the reason chosen by the student is true, while the question in the form of short form is stated correctly if the student answer is true. Any number of students correctly answered will be worth 1, whereas every number that is answered by students will be 0. The maximum value obtained by the student if the answer the whole question correctly is 10, while the minimum value obtained by the students is 0. The result of the assessment obtained separated by logical thinking, then processed into qualitative data and divided into 5 criteria, as shown in Table 2 [17]. Assessment results obtained from the experimental class and control class were also analyzed using. Based on the analysis using N-gain can be known to improve students' logical thinking ability as shown in table 3.

| No  | Value Interval                     | Criteria   |
|-----|-----------------------------------|------------|
| 1   | Mi + 1,5 SDi < X ≤ Mi + 0,5 SDi  | Very good  |
| 2   | Mi + 0,5 SDi < X ≤ Mi + 1,5 SDi  | Good       |
| 3   | Mi - 0,5 SDi < X ≤ Mi - 0,5 SDi  | Enough     |
3. Result and Discussion

The written test instrument given to the experimental class is the same as the instrument given in the control class. Assessment of the level of understanding of student concepts based on the answers and reasons presented students. The percentage of the number of students of written test results is given in Table 4.

| No | Aspect                  | The percentage of student in the experimental class | The percentage of student in the control class |
|----|-------------------------|-----------------------------------------------------|--------------------------------------------------|
|    |                         | Pretest   | Posttest | N-Gain | Pretest   | Posttest | N-Gain |
| 1  | Probabilistic Reasoning | 71.88 %   | 84.38 %  | 0.44   | 56.25 %   | 71.88 %  | 0.36   |
| 2  | Controlling Variable   | 46.88 %   | 68.75 %  | 0.41   | 37.50 %   | 56.25 %  | 0.30   |
| 3  | Proportional Reasoning | 37.50 %   | 62.50 %  | 0.40   | 28.13 %   | 43.75 %  | 0.22   |
| 4  | Correllational Reasoning| 53.13 %   | 68.75 %  | 0.33   | 43.75 %   | 62.50 %  | 0.33   |
| 5  | Combinatorial Reasoning| 59.38 %   | 75.00 %  | 0.38   | 40.63 %   | 59.38 %  | 0.32   |
|    | Average                 | 53.75 %   | 71.88 %  | 0.39   | 41.25 %   | 58.75 %  | 0.30   |

Based on Table 4, the probabilistic reasoning ability has the highest percentage value than any other aspect in the experimental class or in the control class. The posttest value of the probabilistic reasoning aspects in the experimental class belongs to a very good category, whereas in the control class belongs to a good category. In addition to having the highest percentage of values, the probabilistic aspect also has the highest N-Gain value when compared to other N-gain aspects. In the control class and experimental class, the obtained N-gain values fall into the moderate category, so the guided inquiry-based module can be used to improve students' logical thinking in the aspect of probabilistic reasoning. Probabilistic reasoning is the ability to think to solve uncertain circumstances by considering the variables associated with the final outcome [18, 19]. Teachers should understand the strategies students use to solve probabilistic problems as a step to improve students' probabilistic reasoning [20].

The posttest value of the controlling aspects of the variables in the experimental class belongs to either category, whereas in the control class belongs to the sufficient category. In the control class and experimental class, the obtained N-gain values fall into the moderate category, so guided inquiry-based modules can be used to improve students' logical thinking in the controlling aspects of variables. Controlling variables relates to students' ability to know and manage relationships between interrelated variables of an event and can help students understand and develop scientific knowledge and scientific thought [21]. The ability to control variables can be enhanced by guiding students explicitly in reasoning contexts based on factors that exist [22, 23].
Proportional reasoning relates to students’ ability in determining functional relationships in the form of mathematical calculations [21]. The ability of proportional reasoning has the lowest percentage value than any other aspect, either in the experimental class or in the control class. In the experimental class, the obtained N-gain values fall into the medium category, so guided inquiry-based modules can be used to improve students' logical thinking skills on aspects of proportional reasoning. In the control class, the N-gain values obtained on the proportional reasoning aspect fall into the less category. Proportional reasoning abilities include less than once, so they need to be improved. Teachers should be more often to lead students independently to find a solution to a problem so that students' proportional reasoning abilities can be improved [19]. The students’ proportional reasoning abilities can be increased by providing regular proportional types of questions with various forms of questions and various forms of non-integer numbers [24].

The posttest values of the aspects of correlational reasoning in the experimental class and in the control class fall into either category. In the control class and experimental class, the obtained N-gain values fall into the medium category, so guided inquiry-based modules can be used to improve students' logical thinking in aspects of correlational reasoning. The correlational reasoning is concerned with the ability to determine relationships between variables in an event [21]. The ability of correlational reasoning can be increased by focusing on improving proportional and probabilistic reasoning of students since proportional reasoning and probabilistic reasoning have an effect on correlational reasoning [25].

The posttest value of aspects of combinatorial reasoning in the experimental class and in the control class fall into either category. In the control class and experimental class, the obtained N-gain values fall into the medium category, so guided inquiry-based modules can be used to improve students' logical thinking in combinatoric reasoning aspects. The combinatorial reasoning is concerned with the ability to identify all possible combinations of events [21]. Combinatorial reasoning can be enhanced by visuospatial-based learning [26]. Overall, the mean posttest scores of logical thinking students in the experimental class and control classes fall into either category. The average N-Gain values in the experimental and control classes are also classified as moderate, but the N-Gain values in the experimental class are larger than in the control class, so the guided inquiry-based module can be used to improve students' logical thinking.

4. Conclusion

Based on the results of the research can be seen that in the experimental class and control class, the posttest value aspect of probabilistic reasoning has the highest value than other aspects, whereas the posttest value of the proportional reasoning aspect has the lowest value. The average value of N-gain in the experimental class is 0.39, while in the control class is 0.30. Both N-gain values are included in the medium criteria. Nevertheless, the N-gain values obtained in the experimental class are larger than the control class, so the guided inquiry-based module is considered more effective for improving students' logical thinking.

The results obtained from this research are expected to be a suggestion to further improve students' logical thinking ability. Some suggestions for improving students' logical thinking include:
1. Learning activities in schools using a model or approach that focuses more on student activeness, such as problem-based learning, inquiry, constructivism, and scientific.
2. Teachers often provide varying enrichment and have different levels of difficulty, so as to improve students' logical thinking ability.

Acknowledgement

References

[1] Yaman S 2005 J. Turk. Sci. Educ. 2 31
[2] Sezen N and Bülbül A 2011 Proc. Soc. Behav. Sci. 15 2476
[3] Sobur A K 2015 Tajdid 14 387
[4] Fitriana S, Ihsan H and Annas S 2015 J. Educ. Sci. Tech. 1 86
[5] Aminah S and Derlina 2015 *J. Pendidik. Fis.* 463
[6] Amirulloh D, Rustaman N, Sriyati S 2014 *Formica Educ.* 11
[7] Nugraha T S, Mahmudi A 2015 *J. Ris. Pendidik. Mat.* 2107
[8] Setiawati R, Fatmarryanti S D and Ngazizah N 2013 *J. Radiasi* 324
[9] Nurdel 2010 *Pembelajaran fisika dengan pendekatan inkuiri terbimbing menggunakan metode eksperimen dan demonstrasi ditinjau dari kreativitas dan motivasi berprestasi* Tesis Surakarta: Universitas Sebelas Maret
[10] Nurhidayati S, Zubaidah, S, Indriwati S E 2014 *J. Kependidik.* 14285
[11] Cho C S, Cottrell D S, Mazze C and Dika S L 2013 *Am. Soc. Eng. Educ. Annu. Conf. Expos.* 13927
[12] Novilia L, Iskandar S M, Fajaroh F 2016 *Int. J. Educ.* 917
[13] Ali R., Ghazi S R., Khan M S, Hussain S and Faitma Z T 2010 *Can. Cent. Sci. Educ.* 649
[14] Wardani S, Nurhayati S and Safitri A 2013 *Int. J. Sci. Res.* 51589
[15] Natalia P M., Maridi and Suciati 2016 *J. Inkuiri* 552
[16] Tobin K. G and Capie W 1981 *Educ. Psychol. Meas.* 41413
[17] Azwar S 2007 *Tes Prestasi : Fungsi dan Pengembangan Pengukuran Prestasi Belajar* (Yogyakarta: Pustaka Pelajar)
[18] Savard A 2013 *Developing Probabilistic Thinking : What About People’s Conception?*.
[19] Sari I P and Sufri 2014 *J. Pendidik. Mat.* 448
[20] Heyvaert M., Deleye M., Saenen L., Dooreen W V, Onghena P 2017 *Int. J. Res. Method Educ.* 11
[21] Bello A 2014 *Int. J. Educ. Res.* 2613
[22] Boudreaux A, Shaffer P S, Heron P R L and McDermott L C 2008 *Am. J. Phys.* 76163
[23] Keselman A 2003 *J. Res. Sci. Teach.* 40898
[24] Bock D D, Dooren W V and Verschaffel L 2010 *From Addition To Multiplication...Back: The Development of Students’ Additive and Multiplicative Reasoning Skills.* Hub Research Paper p37
[25] Vass E, Schiller D, and Nappi A J 2000 *J. Res. Sci. Teach.* 37981
[26] Suprapto P K 2012 *Pengembangan Program Perkuliahan Anatomi Tumbuhan Berbasis Visusospasial Representasi Mikroskopi Sistem Jaringan Tumbuhan untuk Meningkatkan Penalaran dan Penguasaan Konsep Calon Guru Biologi* Doctoral dissertation http://repository.upi.edu/id/eprint/8563