THE DEVELOPMENT OF HIGHER-ORDER THINKING SKILLS ON JUNIOR HIGH SCHOOL STUDENTS THROUGH GUIDED INQUIRY-BASED LEARNING APPROACH

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Abstract

This study was aimed to *determine the development levels of higher-order thinking skills on students through the guided inquiry-based learning approach. The research method used was experimental, with true empirical design research. The sample selection was performed by random sampling technique. Data was collected through five tests of essay forms in accordance with various indicators of higher-order thinking abilities, including analysing (C4), evaluating (C5) and creating (C6). The results of this study indicated that the percentage of higher-order thinking ability in the experimental class was 86%, while in the control class was lower, at 79.3%. Based on the results of the study, it was concluded that students with higher-order thinking skills taught through this guided inquiry-based learning were superior compared to those taught by conventional learning.*

Keywords: *Guided Inquiry-Based Learning, Conventional Learning, Higher-Order Thinking Skills*

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Mathematics learning in the 21st-century has been presenting challenges for educators to continually create innovations in optimising their excellent quality in learning in class. The 2013 curriculum strictly emphasises learning style that involves the ability of students whose *higher-order thinking skills* (HOTS). According to Sumarno, et al. (2019) regarding the implications of the 2013 curriculum, mathematics teachers and scientists need to be fully skilled in developing all mathematical instruments that demand students to think and perform mathematics at any HOTS levels. However, using HOTS as teaching problem materials during learning in class is still rare; while Indonesia achievements in mathematics subject at international reputation are also even low (Tonra, et al. 2019). This can be seen from the results of the scores obtained in *Trend International Mathematics and Science Study* (TIMSS) and *Programme for International Student Assessment* (PISA). According to Nizam (2016), TIMSS survey resulting in 2015 demonstrated that Indonesia ranked 44th of 49 countries. With TIMSS criteria, the achievements of survey participants could be divided into four levels: *low* (400), *intermediate* (475), *high* (550) and *advanced* (625), which results in Indonesia's position at a low level. Other data were also shown by Tohir (2019) from the results of the PISA

survey (*Programme for International Student Assessment*) for the Mathematics category, where Indonesia ranked 7th from the bottom, with a score of 73 out of an average rating of 379. Also, Indonesia takes place above Saudi Arabia, which has an average score of 373. Then for the first rank, China is still taken place with an average rating of 591. Performance of Indonesia seemed to decline in comparison to the report of PISA 2015 by receiving a score of 386. The low outcomes indicated that the quality of the ability to think and analyse in students, especially in Mathematics tests, is still relatively small.

According to Syahlan (2015), the causes of the poor quality of thinking and analysing skills against Mathematics in students are as follows: 1) a direct process of learning Mathematics which runs spontaneously to the abstract materials, in results skipping the process flow, beginning from the observation of a concrete problem, then to the semi-concrete, and finally, abstraction; 2) many formulas which students must memorise in order to resolve issues, which this leads in taking a significant amount of time concentrating on exercises only to solve problems that are still procedural and mechanistic; 3) the uncommon habit in accustoming students to think in a higher-order reasoning, which is against with the goal to create students

with a practice of the process of learning designing students to get used in resolving problems of higher-level study; 4) Mathematical problems are continually associated with numbers reduction, which is supposed to evaluate Mathematics without numbers such as figures, charts, patterns, and so on; 5) Unstructured of problem-solving methods drives in non-customization of algorithmic thinking way in students. The 2013 curriculum design with the revised version demonstrated that SKL (Completeness Competency Standard) of Education Unit (SD, SMP, and SMA) have been emphasised on each activity of core knowledge aspects that includes the indicators of understanding, applying, analysing, and evaluating. These indicators are compartments of a higher-order thinking skill (Kratwohl, 2002; Brookhart, 2010; Lewy, et al. 2009, Tanujaya, et al. 2017).

According to Tanujaya (2016), it exhibited that the ability to think, especially HOTS, is one of the critical indicators in determining success in Mathematics learning. Saputra (2016) also confirmed that HOTS is a process of thinking of students in the higher cognitive level developed from various concepts and cognitive methods as well as taxonomy learning such as the method of *solving problem* and taxonomy of bloom, learning, teaching, and evaluation. In the implementation of education, HOTS cannot be taught directly to students. They must be trained with HOTS, as a soft-skill, through learning activities that support their development processes, which is through inquiry-based learning (Retnawati, et al. 2018).

There are three types of inquiry-based learning approaches, namely guided inquiry-based, independent inquiry-based, and modified independent-inquiry-based (Setiawan & Royani, 2013). The inquiry type used in this research was a guided inquiry-based, which the election of this approach was students do not have any learning experience with the method. According to Nasution (2018), the guided inquiry-based approach is one of the models emphasising at science skills, thinking ability, and scientific research. Widiarta, et al. (2019) also revealed that the inquiry-based learning is one of the learning models occupying the intellectual capacity of the students in resolving a problem maximally through systematic, critical, logical, and analytic activities. Based on the observation and interview with Mathematics teachers and students from Class VIII in Integrated Muhammadiyah Middle School (SMP), it was identified that students did not have a strong understanding in comprehending and resolving *uncommon* problems. The mathematics learning process still tends to use conventional learning. During the class, the teachers actively provided with material explanations, whereas students recorded, memorised formula, and executed exercises, and then many did not respond appropriately to the described materials.

Moreover, the provision of teaching materials to facilitate students in training HOTS was still lacking. Besides that, the Mathematics grades obtained by students were still unsatisfied; many received unsatisfactory grades from daily and

semester evaluations which were not reaching up to the minimum completeness criteria (KKM) set by the school, which was 70. Through the presentation of *uncommon* problems and inquiry-based activity process in learning, it was expected to increase the skills of higher-order thinking ability of students. The objective of this study was to investigate the development of higher-order thinking ability through the guided inquiry-based learning approach to students in Class VIII of Integrated Muhammadiyah Middle School (SMP) in Bengkulu.

METHODS

The research method used was experimental, with *true empirical design research*. This was based on sample collection with *random sampling technique*. A *pretest-posttest control group design* was used in this study design. The description of the *pretest-posttest control group study design* was shown below.

Table 1. Research design

R ₁	O ₁	X	O ₂
R ₂	O ₁	-	O ₂

Information:

R₁: Experimental Group

R₂: Control Group

O₁: HOTS Pretest

O₂: HOTS Posttest

X: Treatment with the Inquiry-based Learning Approach

- : Treatment with Conventional Learning

The population in the study was the entire eighth-grade students in Integrated Muhammadiyah Middle

School (SMP) in Bengkulu. This population was divided into four classes: 1) Class A with 28 students, 2) Class B with 28 students, 3) Class C with 30 students, and 4) Class D with 28 students. The sample was selected by *random sampling*. The chosen sample of Class A as an experiment class was a total of 28 students, while Class D was classified as control class. Data was then gathered with an essay tests technique of five question types containing HOTS elements: 1) Analysis (C4), 2) Evaluation (C5), and 3) Creation (C6). Data results of the high-level thinking ability were later analysed with mixed Anova (2x2 *mixed factorial design*). *Mixed-design Analysis of Variance (ANOVA)* is a combination of two sub-analysis tests encompassing: (a) *Within-subject test* is an examination of score differences in one group (*pre vs post*), (b) *Between-subject test* is an examination of score testing differences between groups (*experimental vs control*) (Widhiarso, 2011). As for the research procedure was done through several stages as follows:

Preparation Stage

At the stage of preparation, those were done as follows: (a) preparing and arranging learning tools that are adapted to HOTS. Supadma, et al. (2019) also suggested that the 21st-century learning characteristics and the purpose of the 2013 curriculum were for learning tools that should be developed to reach HOTS values. Learning tools were arranged in the form of RPP, teaching materials, HOTS test questions, expert's approval sheets, and research site recommendation, in order to lead to successful planning-based research

and (b) Implementing the trial tests of validity, reliability, difficulty levels, and difference-ability tests from using HOTS questions, in which expected to the use of question tests that are eligible in each study.

Treatment Stage

At this level, those were done as follows: (a) Conducting the *pretest* HOTS with the questions that have been testified its true eligibility in the trial class. (b) Implementing study through the guided inquiry-based learning approach at the experimental class and the conventional learning at the control class. According to the Triyuni, et al. (2019), the process of learning by guided inquiry-based HOTS activity followed the following steps: (1) Orientation of students on the problem situations, to condition students to be ready to support the learning. Students were allowed to do familiarisation to a case of problems, (2) Formulation of the problem; students were redirected to a question to formulate the problem, (3) Creation of hypothesis; students were provided with an opportunity to argue hypothesis produced, (4) Data collection; students collected and explored information through inquiry-based activities with HOTS values, (5) Hypothesis testing; students determined correct answers following the data and information obtained through the inquiry-based activities of HOTS values, (6) Conclusion, students formulated a conclusion systematically and logically about the

problems given. (c) After completion of the treatments, both the experimental class and control class have then conducted a *posttest* to investigate the HOTS value development.

Analysis Stage

At the stage of analysis, HOTS values were then analysed from the *pretest* and *posttest* of experimental and control classes. Then, the data were tested to investigate the differences and improvements that occurred in a class of experiment or control class as well as intra-class between experimental and control class.

Completion Stage

Overall, all data were analysed and discussed, and then it was continued with the final stage of the completion of study results.

RESULTS AND DISCUSSION

After implementing the normality and homogeneity test by using *SPSS* software, it was obtained that both classes were normally distributed and the variance of them was homogeneous. Furthermore, the hypothesis testing was performed by using *ANOVA 2x2 mixed-factorial design*. *ANOVA* test was calculated using *SPSS software*.

Based on the calculation of the hypothesis test using the *ANOVA Mixed-Design* at *SPSS* software, it was obtained data shown below.

Table 2. Descriptive Statistics Pre-Post HOTS

Test	Class	Mean	Std. Deviation	N
Pretest	Experimental	4.86	2.606	28
	Control	4.89	2.514	28
	Total	4.88	2.537	56
Posttest	Experimental	16.68	1.847	28
	Control	14.21	2.283	28
	Total	15.45	2.404	56

Table 2 showed the average results of the *pretest* of high-order thinking ability in students, which was nearly the same as that in the experimental class $\bar{x}_{ke}$ of 4,86 and in the control class $\bar{x}_{kk}$ of 4,89. On average, the high level of thinking of students was not much different. As seen from the standard of deviation to *pretest* HOTS, the experimental class was much higher S_{ke} (2,606) than the control class S_{kk} (2,578). Based on the answer given by the students, generally, students did not have meaningful initial capabilities. The differences in pretest results mostly occurred in the writing of what is known and what is asked at the beginning of the solution. While students who earned low scores, generally lacked effort by still letting the answers sheets empty. From the average results of the pretest, it seemed that the initial ability of students at the experimental class was averagely the same as those in the control class.

The results of data score of the *posttest* at experimental class $\bar{x}_{ke}$ was higher (16.68) than control class $\bar{x}_{kk}$ (14,21). This indicated that after the treatment, there were differences between class experiment and control class. The average score of *posttest* of

both classes has increased from the average score of the *pretest*. As a result, it was concluded that guided inquiry-based learning could increase HOTS values in students. The reason for this conclusion was that students enabled to engage in discussion and put forward their hypothesis, in which accustoming students to always actively participate in learning, in resulting with the thought process of students would become better. Following the opinion of Triyuni, et al. (2019), guided inquiry-based learning can be synergised with HOTS activities to develop critical, logical, and systematic thinking. Furthermore, Tanujaya, et al. (2017) stated that students with good HOTS values tended to succeed in Mathematics learning compared to students who have low values.

The standard deviation of the *posttest* in the experimental class was S_{ke} 1,847 lower compared to the control class of S_{kk} 2,283. Changes in the value of the standard deviation score of HOTS in the experimental class more varied compared with the control class. Changes of standard deviation scores of *pretest* and *posttest* on the HOTS was quite significant; it suggested that the increase in the HOTS values in the experimental class

was quite varied. It means some subjects experienced small improvements, while on the other

hand, some experienced a significant increase in HOTS value.

Table 3. Mauchly's Test of Sphericity^a

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	.000	0	.	1.000	1.000	1.000

Based on *Mauchly's Test of Sphericity* in Table 3 with the following interpretation: 1) If the result showed insignificance ($sig > 0.05$) then refer to Table 4 on the line *Sphericity Assumed*, and 2) If the

result showed significant ($sig < 0.05$) then recommended to see to a line *greenhouse-geisser*, *Huynh-Feldt* or *lower-bound* (Widiarsho, 2011). The value of $sig < 0.05$ demonstrated a significant meaning.

Table 4. Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
time * class *	Sphericity Assumed	43.750	1	43.750	7.427	.009	.121
	Greenhouse-Geisser	43.750	1.000	43.750	7.427	.009	.121
	Huynh-Feldt	43.750	1.000	43.750	7.427	.009	.121
	Lower-bound	43.750	1.000	43.750	7.427	.009	.121

In Table 4. *Test of Within-Subjects Effects* looked at the rows of time*class and sub-rows of *greenhouse-geisser*. The result was $F = 7,427$ with $sig = 0.009$ (resulting in the value of $0.009 < 0.05$) indicated that there was an interaction between time (*pretest-posttest*) and the experimental and control class. The interaction revealed that the change in scores of *pretest* towards *posttest* in both of the experimental and control class was significantly different. This exhibited that there was a meaningful influence on the approach of guided

inquiry-based learning towards HOTS values. Confirmed with the studies by Hugerat & Kortam (2014), *inquiry-based learning* methods have a significant influence on the development of HOTS among the study participants. The students also showed a positive attitude, both emotionally and cognitively. The results of the research Ertikanto, et al. (2015); Malik, et al. (2015) showed the differences in the ability to think high-level in students between inquiry-based and conventional learning.

Table 5. Pairwise Comparisons

group	(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig. ^a	95% Confidence intervals for Difference ^a	
						Lower Bound	Upper bound
1	1	2	-11.821*	.649	.000	-13,122	-10,521
	2	1	11.821*	.649	.000	10.521	13.122
2	1	2	-9.321*	.649	.000	-10,622	-8.021
	2	1	9.321*	.649	.000	8.021	10.622

Table 5 demonstrated that the HOTS changes in the experimental class was significant, where (MD) = -11.821; $p < 0.05$), while the HOTS changes in the control class was also significant (MD = -9,321; $p < 0.05$). Despite both classes have significantly increasing HOTS values, yet experimental class was superior compared to the control class in terms of those values. The main purpose of the inquiry-based learning model is the development of the thinking ability of students. Our results revealed that the guided inquiry-based learning model could improve students' critical thinking skills (Azizmalayeri, et al., 2012; Fuad, et al., 2017; Nuryanti, et al., 2018).

HOTS values in students can be trained through activities in this learning model. One of the factors causing the expansion of HOTS values in students was the presence of learning activities that were meaningful, where students were actively involved in the process of discussions to build knowledge and utilising a variety of sources relevant to explore the desired experience (Apino & Retnawati, 2017). Guided inquiry-based learning approach presented in the experimental class was effective to improve the ability to think high-level in students. Hendryarto & Amaria (2013) exhibited that the high-level thinking ability of students increased by 92.8% through inquiry-based learning.

Table 6. Multivariate Test

Class	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
1 Wilks' lambda	.140	3.321E2 ^a	1.000	54.000	.000	.860
2 Wilks' lambda	.207	2.065E2 ^a	1.000	54.000	.000	.793

Table 6 at the rows of *Wilks' lambda* in the experimental group showed the value of *Partial Eta Squared* of 0,86. This means the approach of guided inquiry-based

learning, with the use of a textbook based on *open-ended problems*, enabled to improve the high-level thinking skill to students by 86%, while the increase in the control group

at merely 79%. This indicated the development in high-level thinking skill of students in the experimental class was higher compared to the control class. Several studies that performed before confirmed that the ability to think higher level positively increased through inquiry-based learning (Madhuri et al., 2012; Mubarok, et al., 2019; Hendryarto & Amaria, 2013; Syarqiy & Admoko, 2017).

The application of guided inquiry-based learning provided students with opportunities to become more active participants in finding existing knowledge either by themselves or groups, connecting new knowledge with existing ones and directly experiencing each learning process takes place. In inquiry-based learning, students are engaged mentally and physically to solve the problem given by the teacher. In accordance with the opinion of Anggareni, et al. (2013), inquiries give students real and active learning experiences. Students get trained on how to solve problems, make decisions, and acquire the skills. In addition, according to Trisnayanti (2017), suggested that inquiry-based learning is the learning model emphasising on critical and analytical thinking skills through solving a problem scientifically.

CONCLUSION AND SUGGESTIONS

Our current results of the study revealed a significant increase in HOTS values by 86% through the approach of guided inquiry-based learning. Based on the findings, it was obtained two conclusions as follows: 1) due to the demands of various skills

from students knowingly with Mathematics and language skill, self-learning and self-management, teachers will need to compose independently teaching materials adapting to the characteristics of a guided inquiry-based approach that can develop the ability to think higher-level in students, 2) The inquiry-based learning model will take much more time in learning activities. The teacher should pay more attention to the time allocation provided, and 3) As a facilitator, the teacher should put more extra care in guiding students, especially those who are experiencing difficulty in generating a hypothesis or opinion.

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