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EFFECTIVENESS OF USING CONCEPTUALIZED ACQUSITION WITH OPEN ENDED QUESSISTED MODEL TO IMPROVE STUDENT'S CRITICAL THINKING ABILITY

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ABSTRACT

In learning activities that are oriented to the needs and abilities of students, it is necessary to provide a variety of learning situations that are adequate for the material which is presented and this should be tailored to the abilities and characteristics of students. This study aims to describe the effectiveness of conceptualized acquisition with open ended question-assisted model in improving critical thinking ability of students. The research design is the control group of pre-test post-test to the students of mathematics education program at Muhammadiyah University in North Sumatra. Based on the results of data analysis, it is found that the critical thinking ability of students who are taught with Conceptualized Acquisition with Open Ended Question-Assisted Model is better than the critical thinking ability of students who are taught with conventional learning model on lectures of Algebra Structure II and Conceptualized Acquisition with Open Ended Question-Assisted Model are effective in improving the critical thinking ability of students in the lecture of Algebra Structure II.

KEYWORDS Effectiveness, Conceptualized Acquisition, Open-Ended Question, Assisted Model, Critical Thinking Ability

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INTRODUCTION

The Course of Algebra Structure II is one of the subjects in the field of pure mathematics expertise in the curriculum of mathematics education study program. The characteristics of algebra structures have a strict and concise axiomatic deductive structure, loaded with abstract concepts both on definition and theorem (Hijriati & Mardiana, 2014).

Because it is loaded with abstract concepts, the algebra structure is difficult to learn and also difficult to teach. The research findings of Dubinsky et al (in Mardiana, 2014) which is supported by Lajoie show that the understanding of students upon concepts in abstract algebra is far from satisfactory. Abstract algebra is still difficult to digest by most students. Furthermore, many lecturers have difficulty in teaching abstract algebra.

One of the learning models that can help students of all ages develop and strengthen their understanding of concepts and practice critical thinking, in the lesson is the conceptualized acquisition model (Schulz, Dehghani, & Stadelmann, n.d.). This model is also useful for giving students experience with scientific methods. Especially, it is also the experience with testing hypotheses, the experiences that are often difficult to give in the fields of matter other than science. This is supported by Bruning (in Eggen & Kauchak, 2012: 239) that "Conceptualized Acquisition activities can be used to enhance metacognition and self-regulation of students."

The activities of Conceptualized Acquisition can be used to improve the metacognition and self-regulation of students. Metacognition is the awareness of students about and control of their mental processes. Developing metacognitive abilities in students is important. Because, it can contribute to self-regulation, namely the conscious use on mental strategy of a person is designed to improve learning and thinking. Students who are self-disciplined are responsible for the progress of their learning to meet the demands of the task. Learning Activities of Conceptualized Acquisition can build self- regulation of students because the activities emphasize a lot of critical thinking.

The findings of (Panggabean, n.d.) show the application of conceptualized acquisition model influences the math concept of students. While (Ratnaningsih, Hermanto, & Kurniati, 2019) finds, there is improvement of critical and creative thinking ability of students after applying the conceptualized acquisition model. Furthermore, it is recommended that to increase the critical and creative thinking with the conceptualized acquisition model should be combined with other learning model so that the achievement of ability can be achieved maximally (Fuad, Zubaidah, Mahanal, & Suarsini, 2017).

(Lindeman, 2018) defines the conceptual acquisition as an inquiry on the number of attributes that can be used to distinguish samples and non-samples from different categories. In learning with this conceptualized acquisition model, the teacher shows the sample and non sample of a concept that he or she imagines (Kim, 2020). While students hypothesize what the probability of the concept might be, analyzing their hypotheses by looking at samples and non-samples, and ultimately coming up to the concept in question.

To assess thinking processes and reasoning of students, it needs strategies that encourage students to communicate completion in writing, mathematical statements, diagrams or combinations of both One of the strategies that can be used by lecturers is the open ended question.

Open-ended questions require students do not only provide answers but more importantly show the completion process (Romli & Riyadi, 2018). Students are not only given the opportunity to show the level of understanding but also communicate mathematically. As stated by Heddens & Speer in (Rohid & Rusmawati, 2019) that "Open-ended question is a technique that can be used effectively in the assessment of mathematics learning and is very useful in assessing student thinking". Through the questions like these, they are asked to answer questions by explaining, drawing graphs, showing or by proving. Variations of answers are desirable and there are not two answers in the class will be exactly the same (Capano, Howlett, Jarvis, Ramesh, & Goyal, 2020).

The need for open-ended questions which is considered to be applied in mathematics learning is as follow; 1) The desire to make mathematics learning more challenging. The success in challenging activities gives students concrete trust and this will increase their desire to work further in mathematics; 2) It needs activities that encourage autonomy and independence of students as a mathematical thinker. If students believe they have control over learning, they will set a higher standard for next learning. This will make them more responsible for what they do; 3) Preventing overuse of yes/no factual answers that often limit critical thinking opportunities.

The Conceptualized Acquisition model is designed to help students achieve two types of learning objectives, namely (1) Building and developing their understanding of concepts; (2) Developing their critical thinking skills. In learning with this model, the lecturer demonstrates the sample and non sample of a concept that he or she imagines. While students hypothesize about what the probability of the concept might be, analyzing their hypotheses by looking at samples and non-samples, and ultimately coming up to the intended concept. This analysis follows the simple rule that all samples must describe the concept and none of the non- samples can illustrate the concept.

Four essential steps in planning for the learning with the conceptualized acquisition model are as shown below.

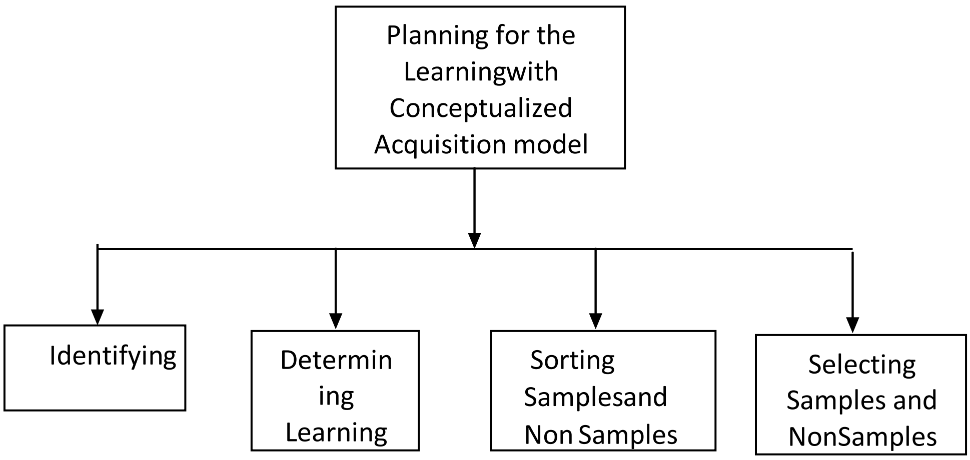

Figure 1. Planning Conceptualized Acquisition Learning

Identifying the topic is the first phase in planning the learning planning process with the conceptualized acquisition model. In this phase, the initial ability of students is one of the factors to be considered. When creating a plan, learning goals need to be very clear. Objectives will guide the mind of selecting a sample. The learning objectives for the Conceptualized Acquisition model include helping students develop and build concepts and relations between the concepts. Also, it provides critical thinking exercises by forming and testing hypotheses. Selecting samples and non-samples in principle is to help students develop and enrich their understanding. Samples should be arranged so that students get as much as possible critical thinking practice. In sorting the samples, they do not always have to be nested in samples and non-samples. Two or even three positive samples can be given in sequence then it is followed by two or more non-samples.

To make it easier to assess thinking processes and reasoning of students, the guidance should encourage communicating the resolution strategies in writing, mathematical statements, diagrams or combinations of both. Describe the data which is shown by the graph.

Critical thinking skills can result from the ability to form valid generalizations, explanations, predictions, hypotheses and comparisons. It is also generated from the ability to accept the validity of a statement as well as the ability to receive irrelevant information. Accordingly, Appelbaum (in Budiman, 2014) states that the development of critical thinking in mathematics can be done by doing activities such as comparing, making contradictions, inductions, generalizing, sorting, classifying, proving, linking, analyzing, evaluating and making patterns, coupled continuously.

Fisher (in Whardani, 2012) emphasizes indicators of critical thinking skills, including: (1) Stating the truth of questions or statements; (2) Analyzing questions or statements; (3) Thinking logically; (4) Sorting, for example temporally, logically, causally; (5) Classifying, for example, the idea of objects; (6) Deciding, for example, whether there is sufficient evidence; (7) Predicting (includes justifying prediction); (8) Making theory; (9) Understanding others and himself. While Glazer (in Budiman) uses 3 indicators of critical thinking, namely: (1) Proof is the ability to prove a statement deductively (using theories that have been studied previously); (2) Generalization is the ability to produce patterns of problems that are encountered for a broader category; (3) Problem solving is the ability to identify the discovered, asked elements, and to check the adequacy of the necessary elements in the problems, to construct mathematical models and to solve them, and to check the results or answers.

The phases in applying the Concept Acquisition with Open ended Questions Model can be seen in the following table:

Table 1 the Phases of Implementation on Conceptualized Acquisition with Open Ended Question model

Phase	Descriptions
Phase 1: Introduction	Lecturer introduces the learning topic and how the activities will be performed.
Phase 2: Samples dan Formulating Hypotheses	Students are given a sample (or perhaps two samples) and are non samples, and with an open ended question, lecturer asks students to hypothesize the possibility of designation for the concept based on the initial sample and non-sample.
Phase 3: Cycle of Analysis	With open ended questions, additional samples and non samples are provided. Students are asked to remove the existing hypotheses and add new hypotheses based on new samples (and non-samples).
Phase 4: Closing and Application	A single hypothesis is separated and defined. Also, additional samples are analyzed by definition

RESEARCH METHOD

This is an experimental research of Control Group Pre-test Post-test Design. The independent variables in this study are the use of Conceptualized Acquisition of open ended question-assisted model on the lecture of algebra structure II with Ring material, Ring characteristics, Ring Classification and Sub Ring. The dependent variables in this research are the improvement on critical thinking ability of students. The study is conducted in the odd semester in the 2015/2016 academic year.

The study population is the students of fifth (V) semester in Mathematics Education Program of FKIP-UMSU. Of the 8 classes, there are 2 randomly selected classes as the study sample. One class that becomes experimental class is VB and the other that becomes control class is VA. The experimental class is treated with conceptualized acquisition of open ended question-assisted model while control class by using conventional learning model. Before and after the learning, the initial test and the final test are done.
The design in this study is presented as in table 2 below.

Tabel 2. The design in this study

Class	Pre-test	Treatment	Post-test
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

Information:

O1 = Initial test (pre test) for experimental class and control class.

O2 = End test

X1 = Treatment of learning with the conceptualized acquisition model. X2 = Treatment of conventional learning.

The implementation of this study consists of the phase of preparation, implementation and results analysis. The study is designed for each class in 7 meetings. Post test is held at the 8th meeting. The data which is required in this study is the data about critical thinking ability of students. The learning tools that are needed: (1) The teaching materials of Algebra Structure II ie Ring, Ring characteristics, Ring Classification, Sub Ring; (2) Unit of Lecture Course (SAP) on Conceptualized acquisition model; (3) Test on Critical Thinking Ability of Student.

The technique of data collection is a test technique. This test is an essay for 5 questions that aims to measure critical thinking ability of students on mathematics with the indicators that are mentioned in the theoretical framework.

The collected data is analyzed descriptively and inferentially. Descriptive analysis is used to describe critical thinking ability of student by using Conceptual Acquisition of Open Ended Question-Assisted Learning and critical thinking ability of students by using Conceptualized Acquisition of Open Ended Question-Assisted Learning.

The technique of data analysis in this research is t-test. This test is used to describe the difference on critical thinking ability of students with the conceptualized acquisition of Open Ended Question-Assisted model and critical thinking ability of students with conventional model.

The indicators that show that Conceptualized Acquisition Open Ended Question-Assisted learning is effective are the test result data on critical thinking ability of students is better than critical thinking ability of students using conventional model. The improvement on critical thinking ability of students is calculated by gain score (N-gain). The N-gain test is formulated as follows.

$$< g > = \frac{T_f - T_i}{SI - T_i}$$

Information:
< g > = normalized gain
Tf = post test score
Ti = pre test score
SI = ideal score / maximum score

The gain interpretation of normalized score can be seen in table 3 below:

Table 3. Interpretation of normalized score

The Gain normalized Value <g>	Criteria
≥ 0,70	HighMidleLow
0,30 ≤ (<g>) < 0,69	
< 0,30	

(Hake, 1999)

RESULT AND DISCUSSION

The analysis results of the pre tests on both groups show the mean and standard deviation are as in table 4 below.

Table 4. The mean and standard deviation of the pre tests on both groups

Group	Mean	Standar Deviasi
Control	8,8461	9,9645
Experiment	8,875	9,9670

The variance similarity test is done before the selection of the appropriate t test formula. The analysis result on pre tests of experimental group and control group is obtained that F value is 0.9998. The value of F (0.9998) < F critical value (1.71), means there is no variant difference between both groups. Then the mean of the two samples are compared. The hypothesized formula:

Ho: $\mu 1 = \mu 2$, or the mean of both groups are the same.

Ha: $\mu 1 \neq \mu 2$, or the mean of both groups are different.

From the calculation results with the help of microsoft excel, it is obtained t count equal to 0.989771 while t-critical is 1.98 with the significance level of 0.05. Since t count < t critical then Ha is rejected means there is no difference between the mean of the experimental group and the control group.

Normality test is conducted to find out whether the research data is normally distributed by using Kolmogorov Smirnov and Shapiro Wilk test with the following results.

Table 5. Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
FT_Value	.092	80	.089	.980	80	.231

a. Lilliefors Significance Correction

Table 5 shows that the significance values of (p) Kilmogorov Smirnov are 0.089 and 0.231, both are greater than 0.05, so it can be concluded that the data is normally distributed. The results of this analysis are also confirmed by Figure 2 QQ plot as follow.

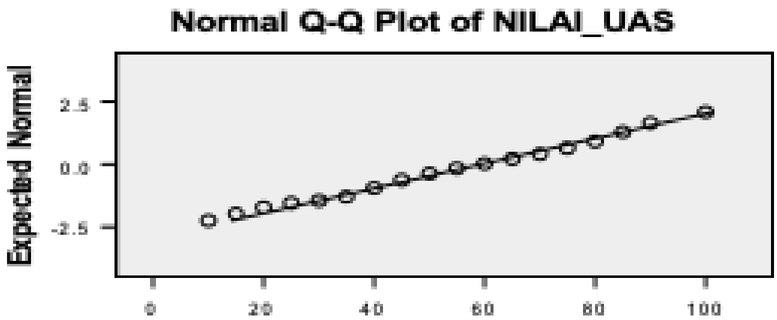

Figure 2 QQ plot from

The picture above shows that the data points are located along the diagonal line forming the left and right symmetric lines. This indicates that the research data is normally distributed.

The variance homogeneity test is conducted to find out whether the two study data groups have the same or equal variances (characteistics) with the provision if p > 0.05,

Table 6 Test of Homogeneity of Variances

XA

Levene Statistic	df1	df2	Sig.
.476	8	26	.862

Table 6 shows that the value of significance (p) = 0.862 is greater than 0.05. This means that both groups of data have the same variances. In other words, both groups of data have the same characteristics.

Different test is done to find out whether the two data groups are different or not with one sample t-test with the results, it can be seen in table 7 as follows.

Table 7. One-Sample Statistics

	N	Mean	Std. Deviation	Std. ErrorMean
XA	40	51.2500	19.03943	3.01040
XB	40	67.1250	18.04153	2.85262

The table shows that the mean value of class A = 51.25 and class B = 67.12. This shows that the average UAS value of group A is different from group B. Furthermore, to know whether the difference is significant or not, it can be seen from further test in table 8 below.

Table 8 One-Sample Test

	Test Value = 0					
					95% Confidence Interval of theDifference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
XA	17.024	39	.000	51.25000	45.1609	57.3391
XB	23.531	39	.000	67.12500	61.3550	72.8950

Table 8 shows that the significance value (p) = 0.000 is less than 0.05. This shows that the UAS score of Group A and the UAS score of group B are significantly different.

To find out whether the mean of experimental group is better than the mean of control group, the following hypotheses are formulated.

Ho: $\mu1 < \mu2$, or the mean of group A is less than the mean of group B.
Ha: $\mu1 \geq \mu2$, or the mean of group A is more than or equal to the mean of group B. With the help of mocrosoft exel, it is obtained the value of t arithmetic = 0.00013. Price of t table at df = 78 at the 0.05 significance level is 1.4571.
Because $t < t0.05$ then the hypothesis is accepted. In other words, the average critical thinking ability of students with conceptualized acquisition of open ended question-assisted model is better than the average thinking ability of students with conventional model.

To know the improvement of critical thinking ability of experiment class and control class, data analysis on gain index of each class is done. The Data Analysis on Gain Index is based on data analysis on initial and final tests. The gain which is referred to in this study is normalized gain of which the gain index of each class as in table 9 below.

Table 9. the gain index of each class

Group	Gain Index
control	0,4692
Experiment	0,6426

Based on the above table, it is clear that the average normalized gain on critical thinking ability of experimental class students is different from the average normalized gain of the control class. Based on the criteria which is previously mentioned, this increase is included in the ‘moderate’ criterion. This means that after the learning takes place, there is a significant increase in critical thinking ability of students in the experimental group and the control class. Although both are ‘moderate’, but the normalized gain of the experimental class is better than the average normalized gain of the control class. The difference is 0.1734. This means that the conceptualized acquisition of open ended question-assisted model is effective in improving critical thinking ability of students.

Learning activities with the Conceptualized Acquisition model indeed emphasizes critical thinking. Beginning in the first phase in which the lecturer presents a set of data to the students (Nusantari, Abdul, Damopolii, Alghafri, & Bakkar, 2021). Each set of sample and non sample data concept is presented separately. To the students, it is explained that there is only one idea (concept) which is shown by positive samples (Falloon, 2019). The task of the students is to develop a hypothesis about the characteristics of the concept. Students will compare and contrast the samples that contain the characteristics (attributes) of the concept and the samples that do not contain the attributes of the concept(Li, Eigen, Dodge, Zeiler, & Wang, 2019). Then they are asked to name the concept and declare the rules or definitions of the concept according to these attributes(Barricelli, Casiraghi, & Fogli, 2019). The hypothesis which is constructed by them has not been confirmed until the next phase.

In the second phase, students test the concept by identifying additional examples of both positive and negative. Thus, students will focus on these attributes.Then the students hypothesize possible appellations for concepts, analyze hypotheses and test hypotheses to obtain a single hypothesis (Scheel, Tiokhin, Isager, & Lakens, 2021). Based on that, the students make their own samples. Next lecturers and students together compose the attributes of the intended concept. Then the concept is defined and the characteristics of the concept are identified. The concepts can be linked to related concepts (Granstrand & Holgersson, 2020).

The next phase, the lecturer asks the students to analyze the strategies that are carried out in the conceptualized acquisition. Each student can describe the pattern what he is doing. In this phase, students are encouraged to share and to explain the thinking process that they use to arrive at their answers.

The above activities are included in the inquiry activities. Beginning with categorization process then testing the hypothesis and ending with the evaluation process of the steps that are undertaken during the conceptualized acquisition process. Indirectly, lecturers and students perform learning activities with scientific method, it is a pattern of thought that emphasizes the submission of questions, develops hypotheses to answer questions, and tests the hypothesis with the data.

As it is stated by (Bisra, Liu, Nesbit, Salimi, & Winne, 2018) the conceptualized acquisition model can be an effective tool for introducing students to the inquiry process because it does not take much time to complete a lesson. Students can see that the whole process is unfolding in one learning activity. However, it does not give a fully valid picture of the inquiry process because the lecturer provides all the data about the samples and non-samples. However, this can be an effective way to introduce students with an inquiry before they conduct their own actual inquiry research.

During the above conceptual activities, the lecturer also develops metacognitive ability within the learner. Metacognition is the awareness of students about and control of their mental processes because it can contribute to self-regulation, namely the conscious use of a person upon mental strategy which is designed to improve learning and thinking. Students who are self-disciplined are responsible for the progress of their learning to meet the demands of the task. The Activities of Conceptual Learning can build self-regulation of students because the activities emphasize a lot of critical thinking. As it is stated by Bruning, "The activities of Conceptual Acquisition can be used to improve the metacognition and the self-regulation of students."

Another thing that makes this learning is interesting is the questions that are asked. The types of questions that are asked and the sequence of questions that attract the attention of students strengthen the important things and encourage the occurrence of reflection. To improve the investigation ability of students, it uses the opening questions from the lecturers. This will stimulate students to create their own questions. The questions are placed in a sequence. The sequence of questions is chosen so that the question stimulates the earnings of ideas as much as possible, ranging from simple questions to those that require deeper thinking. The learning activity by asking questions like this would be, as (Martin & Collie, 2019) "the dynamics of asking questions and acceptance in questioning and answering questions are the central to learning and for achieving effective teaching."Another finding in this study is that most students are right in terms of expressing the truth of a statement. But they are less able to provide logical arguments. It is necessary to keep in mind that in providing logical arguments, it would require the ability to link the concepts in mathematics. This disability is shown by the students who participates the lectures of algebra structure II.

The ability of students in proving is also very inadequate. According to the researchers, on the ability to prove this, it is already contained the ability to analyze questions. If it is further studied, it must be admitted that the learning that has been done in all courses in the mathematics education program does not require or familiarize the students to prove the theorems of mathematics. This condition causes the students to be weak in terms of proving. Related to this, researchers suggest to do research on how to develop the ability of students in terms of proving. Through this study, overall, it can be said that learning by using Conceptualized Acquisition of Open Ended Question-assisted learning is quite effective in improving critical thinking ability of students in the lectures of Algebra Structure II.

CONCLUSION

Based on the study results and discussion previously, it can be concluded that the critical thinking ability of students who are taught with conceptualized acquisition of open ended question-assited models is better than the critical thinking ability of students who are taught with conventional learning model on the lectures of Algebra Structure II and conceptualized acquisition of open ended question-assited models is effective in improving critical thinking ability of students in the lectures of Algebra Structure II.

Some things that require to be suggested, (1) The teaching learning process needs to be oriented to the needs and the ability of students, in this activity, lecturers need to provide adequate learning situations for the material which is presented and adjust it with the ability and the characteristics of students. The characteristics of students are very important to know because it influences the learning process; (2) It is needed further research to analyze the ability of students in proving the theorems in mathematics and the research on how to develop the ability of students in proving theorems of mathematics.

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