Improving conceptual understanding through inquiry learning by using a jigsaw method in abstract algebra subject

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Abstract. This study was aimed at improving conceptual understanding through inquiry learning by using a jigsaw method. This cyclical classroom action research was conducted in four phases including planning, implementation, observation, and reflection. Thirty-seven bachelor degree students of semester 6 (even semester, academic year 2018-2019) of Mathematics Education, Faculty of Education and Teacher Training, University of Bengkulu were used as subjects of this study. Results showed that inquiry learning by using a jigsaw method improved students’ conceptual understanding. Average scores the students gained increased from 61.89 in cycle I to 78.37 in cycle II.

1. Introduction
Education plays an important role in individual and public knowledge and skill development. As formal educational institutions, schools conduct an educational program which is developed in a school curriculum and implemented through educational activities. These educational activities include learning, training, and supervision which are conducted purposively, evenly, wholly, on schedule, and systematically and compulsory for all students as an effort to develop the quality and basic potential of students in facing problems they face in daily life. In facing the competition in this global era, the government makes its efforts to improve the quality of human resources in a comprehensive way through the improvement of educational quality by developing and perfecting school curriculum [1,2].

Mathematics is a compulsory for all learners in all levels of educational since elementary schools. Mathematics subject is taught in order to equip learners/students with the ability to think logically, analytically, systematically, critically, and creatively and to work cooperatively [3]. This ability will be gained if the objectives of mathematics learning are obtained. However, learners/students seem to be less interested in the implementation of mathematics learning and find it hard to understand. The process of mathematics learning in universities is still dominated by lecturers as the main source of knowledge. Another finding shows that students’ interest in abstract algebra is still low. Lecturers play an important role in shaping the success of learners or students in their study. Therefore, it is expected that lecturers have an ability or skill to supervise students in the learning process and select an appropriate learning model as an alternative to optimize the results of learning by students. Dominant role of lecturers in class as demanded by the applied learning method makes students fewer active learners in the learning process. Students only listen to, pay attention to, and take note about the lectures so that they lack of training in developing their thinking skill to reinforce their understanding on a certain concept. This
notion is supported by the findings of a previous study showing that students in abstract algebra class still found it difficult to prove the theorems they get in the lectures.

Students tended to have no understanding in what they have to do with the characteristics of a theorem. This condition made them have less curiosity and care about the learning process they had to follow. Consequently, their study results were unsatisfactory. Students way of thinking can be improved through an open-ended learning [4]. Mathematics lessons in schools today are focused on teachers explaining the materials and giving examples and assignments [5]. In colleges, lecturers’ explanation is accepted without reserve by the students. In order to develop students’ critical thinking in solving problems, an appropriate learning method is required. It is shown that in giving lectures, lecturers today seem to stick on one learning method which is used continuously without any modification regardless the fact that every lecture may have different learning objectives. This practice may make learning objectives not optimally reached. In case of bachelor degree students of semester 6 (even semester, academic year 2018-2019) of Mathematics Education, Faculty of Education and Teacher Training, University of Bengkulu, appropriate models and methods of learning should be prepared in order to improve the students’ conceptual understanding.

Based on the above notion, this study on the use of appropriate learning method that made students more active in class was conducted. It was expected that active and cooperative involvement of students in this inquiry learning model make them able to analyse and proof the theorems. Using this learning method, students were also expected to be responsible and independent learners who were ready to share materials they learned to the other group members [6]. The use of an inquiry learning model with a jigsaw method could be used to improve students’ understanding on an algebra concept.

Understanding comes from the word ‘understand’ meaning knowledgeably aware of the character or nature of something. In Bahasa Indonesia, the word ‘pemahaman’ as a translation of understanding has a meaning as the result of an act to fully understand something. Understanding is an aspect in learning used as a basis to develop a learning model [7]. Concept in mathematics is an abstract idea that can be in the form of examples or non-examples. The addition of integers is an example of concept [8]. There is no definition which can reveal the rich meaning of a concept or variety of concepts that can be obtained from students. Therefore, concepts are internal presentation of groups of stimuli, unobservable, and to be concluded from attitudes.

Conceptual understanding is important as it helps students in learning mathematics. Conceptual understanding is a level of study results by which students can solve a little varied problem or explain study materials by using their own words. According to Hendriana et al. [9] understanding mathematical concepts is a basic competency in mathematics learning which includes: the ability to absorb a material, remember mathematical formulas and concepts and apply them in simple cases or in similar cases, estimate the truth of a statement, and apply formulas and theorems in solving problems. Conceptual understanding is a student’s mastery of study materials, ability to express these materials in different formats which are easy to understand, and ability apply the concept according to the cognitive structure the student has [10]. This indicates that the ability gained by students is not only knowing but also applying the concept. One can be said as understand a certain thing if the person can explain and imitate it by using his/her own words.

Indicators of conceptual understanding include [11]: (a) able to do verbal explanation, (b) able to present mathematical situations, (c) able to classify objects, (d) able to implement the relation between concept and procedures, (e) able to give examples and contrast of the concept learned, (f) able to algorithmically implement concept, and (g) able to develop the concept learned.

The above indicators are in line with what is stated in the Regulation of Directorate General of Elementary and Secondary Education Number 506/C/Kep/PP/2004 that the indicator of students’ mathematical conceptual understanding is their ability to re-express a concept by: (a) classifying objects based on a certain concept, (b) giving examples and non-examples of a concept, (c) presenting concept in various forms of representatives, (d) developing necessary conditions and sufficient conditions of a concept, (e) using, utilizing, and selecting certain procedures or operation, and (f) implementing concept or algorithm in solving problems.
Based on the above notion, it can be concluded that conceptual understanding is a power which relates the information contained in the understood concept with the schemes owned previously and makes one able to re-express a concept, classify objects based on certain characteristics, give examples and non-examples of a concept, present a concept in various forms of mathematical representatives, select certain procedures and operation, and implement concept or algorithm in solving problems.

Inquiry comes from the word ‘to inquire’ meaning take part, get involved in posing questions, seeking for information, and conducting investigation. Inquiry learning is aimed at providing ways for students to develop intellectual skill (thinking skill) related to reflective thinking processes. If thinking becomes the main objective of education, ways to help individuals develop this intellectual skill need to be created. It can be concluded that inquiry learning is a learning activity which maximally involves all students’ skills to seek for and investigate something (thing, human, or event) systematically, critically, logically, analytically, so that they can formulate their findings in their own way with confidence [12].

A jigsaw method is a type of cooperative learning involving heterogeneous learning team consisting of 4-5 students. In this method, materials are presented by learners in the forms of texts and each learner is responsible for mastering the learning materials and being able to teach them the other members. Jigsaw method was developed and tested by Elliot Aronson and his colleagues in Texas University and John Hopkins University in 1978. A cooperative learning model of Jigsaw type consists of two groups including home group and expert group. Home group is the mother group of students with various abilities, origins, and family backgrounds. Expert group consisting of students of different home groups is tasked to deeply study a certain topic and explain their findings to home group.

The syntax of inquiry learning includes [13]:

- Orientation,
- Problem formulation,
- Hypothesis development,
- Data collection,
- Hypothesis test, and
- Conclusion drawing.

Meanwhile, syntax of Jigsaw Cooperative Learning Model includes:

- Presenting objectives and motivating students,
- Presenting information,
- Organizing students in learning groups,
- Supervising working and learning groups, and
- Evaluating.

An inquiry-jigsaw learning model is resulted from the merge between syntaxes of inquiry and jigsaw learning models. The implementation of learning process using an inquiry-jigsaw learning model consists of several stages. These stages include:

- Problem formulation,
- Hypothesis development,
- Student coordination in learning groups,
- Data collection, and
- Conclusion drawing.

Based on the above explanation, it is concluded that using an inquiry learning model with a Jigsaw method is a way to improve students’ conceptual understanding. This way, students are trained to not depend fully on learning activities provided by lecturer so that their independent learning ability rises. Students are encouraged to be actively involved in learning activities. This will challenge students to think logically and creatively to keep searching for and discover theorems. Based on this notion, a study on “Improving conceptual understanding through inquiry learning by using a jigsaw method in order to increase study results of students of Mathematic Education Department, University of Bengkulu” was conducted.
2. Methods
This study was conducted as a classroom action research. A classroom action research is an observation of learning activities in the form of action which is purposively taken together in order to improve the quality of learning in a class [12]. The study was conducted in the following cycles [13]:
- Planning,
- Implementation of action,
- Observation, and
- Reflection.

3. Results and discussion
Before learning process started, students were given a pretest in order to assess their readiness to study. A lecture adopting an inquiry learning model was then conducted. In cycle I, students were found to make mistakes in conducting the learning process. They seemed to be not fully understood about the characteristics and definition of groups so that their conceptual understanding was still low. The stages in Cycle I were conducted as follows.

3.1. Planning
Learning plan in Cycle I included:
- Preparing and reviewing learning syllabus to be done,
- Developing a Semester Lesson Plan (SLP) by using an inquiry learning model with a jigsaw method,
- Developing student assignments,
- Preparing observation sheets,
- Preparing fact test questions,
- Developing evaluation test of Cycle I,
- Preparing keys for evaluation test of Cycle I.

3.2. Implementation of action
- A pretest to assess the existing students’ conceptual understanding was given before action was implemented.
- Lesson plan was then implemented.
- A post-test as final evaluation was given.

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![Image](image.png)

**Figure 1.** Students’ study results assessed with a post test.
It is shown in Figure 1 that based on students’ average scores after action was implemented in Cycle I, students seemed to be less successful in following the lecture in abstract algebra. Therefore, it was decided to conduct Cycle II. Prior to action implementation in Cycle II, students formed groups of discussion. Lecturer distributed worksheets to be done by students to make them able to think critically, logically, and analytically.

3.3. Observation
Observation was conducted by researcher, colleagues, or lecturers of mathematics. Observation was conducted to assess the accordance of plan and implementation of action. In addition, all things happened during the learning process were recorded.

3.4. Reflection
This stage was conducted as an analysis on the results and weaknesses revealed during the learning process conducted in Cycle I. Results of this analysis were used as the basis to develop appropriate action to be conducted in the next stage. In this analysis, the level of success was measured and causes of this success were assessed. Solutions for betterment were sought and implemented in Cycle II. Results of students’ work are presented in the table below.

| Cycle | Average Score | Number of students completing the learning process | Completion of classical learning | Remarks |
|-------|---------------|---------------------------------------------------|---------------------------------|---------|
| Pretest | 22.56 | 18 | 48.64% | Not achieved |
| I | 61.89 | 29 | 78.37% | Good |
| II | 78.37 | 31 | 83.37% | Achieved |

It is shown in the above table that based on the average score and classical learning process completion; students’ study results were found to be increased in each cycle. The average score students got in pretest was 22.56. This average score increased to 61.89 in Cycle I and 78.37 in Cycle II. Improvement in students’ average scores is depicted in Figure 2.

![Figure 2](image-url)Students’ average scores in each cycle.

Improved study results were not only found in average scores but also in students’ classical learning process completion. Learning process completion was 22.56% with 19 students having no completed learning process in pretest. This completion score increased to 61.89% with 8 students having uncompleted learning process in Cycle I and 78.37% with 6 students having uncompleted learning process in Cycle II. Based on these improved scores of students’ study results in each cycle, it can be said that an inquiry learning model with a jigsaw method resulted in improving students’ conceptual understanding in each cycle.
4. Conclusions
An inquiry learning model with a jigsaw method implemented in a classroom action research conducted in semester 6 class of Mathematic Education, Faculty of Education and Teacher Training, University of Bengkulu improved students’ conceptual understanding. This improved conceptual understanding increased student’s study results in Cycle I and Cycle II. In Cycle I, student’s average score was 61.89 with classical learning process completion of 78.37%. In Cycle II, student’s average score increased to 61.89 and classical learning process completion increased to 78.37%.

5. Recommendations
Based on the results found in this study, the following recommendations were made for students, lecturers, and researchers.

5.1. For students
It was recommended that bachelor degree students of Mathematic Education, Faculty of Education and Teacher Training, University of Bengkulu develop and improve their conceptual understanding in other subjects having similar characteristics to the subject in this study.

5.2. For lecturers
It was recommended that lecturers in bachelor degree program of Mathematic Education, Faculty of Education and Teacher Training, University of Bengkulu improve their students’ conceptual understanding through inquiry learning model with jigsaw method in other subjects having similar characteristics to the subject in this study.

5.3. For researchers
It was recommended that further studies on the use of inquiry learning model with jigsaw method be conducted in other subjects having similar characteristics to the subject in this study.

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