The enhancement of high school students’ mathematical reasoning through team-assisted individualization

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Abstract. In this study, the author had used Team-Assisted Individualization (TAI). It was as an alternative Cooperative Learning to enhance students' mathematical reasoning ability. The population was the tenth grade students of SMA Negeri 1 Parongpong West-Java, and the sample was two classes of grade X students. Design research was a randomized pretest-posttest control group design. The instrument was used in this study consisted of written tests in the form of description to measure mathematical reasoning. Normality test, homogeneity test and test the difference of two averages were used in analyzing data. Based on this research, it was known that 1) the enhancement of students’ mathematical reasoning who obtain TAI type of cooperative learning was in medium category, 2) the enhancement of students’ mathematical reasoning who obtain TAI type of cooperative learning was better than the students who obtain conventional learning.

1. Introduction
Mathematics is one of the important subjects to be study, because it is closely related to human life. Mathematics should be studied because in the context of everyday life, humans desperately need mathematical abilities in solving real-world problems. Mathematics are as subjects that equip students to have the ability to think logically, analytical, systematic, critical and creative and able to work together much less attractive to students. Mathematical reasoning is one part of the very necessary mathematical competencies developed by the students while studying mathematics. According to [13] In relation to the success in learning mathematics, the students are expected to master the competence of mathematics. The importance of students' mathematical competence is the goal of mathematics learning. Mathematical skills are not only used when studying mathematics, but can be utilized in solving problems in everyday life.

In preliminary study before conducting the research, researcher gave a question about students' views of mathematics and mathematics learning for grade tenth students where researcher conducted the research. I found there are many students who are afraid, unhappy and have difficulty in dealing with mathematics. Not infrequently, from students who complain that mathematics regarded as a boring lesson, saturating or many other designations is negative. The students lack of motivation and interest in learning, are passive, anxious, do not dare to express ideas, questions or answers, either orally or writtenly to solve problems. This problems lead to the assumption that it is difficult for students to learn mathematics, and some even do not like it.
School learning activity shows that many learning model was developed, but still rarely used in the learning process. There is a tendency to implement a teacher-centered learning (teacher-centered) is still the most dominant than student-centered learning (student-oriented). This is due to the feeling of complicated or too many things that need to be prepared or the lack of teacher knowledge about models of learning that is appropriate for use. To achieve optimal learning should be remembered by the teacher is no learning model that is most appropriate for all situations and conditions. Therefore, in selecting appropriate learning models should pay attention to the condition of the students, the nature of teaching materials, media facilities are available, and the conditions of teachers themselves.

Cooperative Learning selected as one model of learning that can be done in the learning process is a learning model that can be used as alternative measures to address the above problems. All cooperative learning method contribute ideas that students who work together in learning and be responsible for his teammates were able to make them learn just as good. The success of the team depends on the individual learning of all team members, and all team members have the opportunity to improve the achievement of learning is better than they get before, and all the students of different abilities are challenged to do their best and give the contributions of all members will receive value [7].

One type of cooperative learning that researchers use in this study is Team-Assisted Individualization (TAI). TAI was developed by [8, 9, 10, and 11]. Further research About TAI has been done in various fields, especially in mathematics. TAI implementation in improving the communication skills of mathematics [14], enhance the problem solving and mathematics achievement [15].

Rationale of Implementing Team-Assisted Individualization (TAI) by [7, 8, 16, 17] are 1) TAI is Mathematical Learning that combines cooperative learning and individual learning, 2) To adapt teaching to individual differences with regard to the ability of students’ learning achievement, 2) Students are entering the class with diverse knowledge, ability and motivation, 4) Teach a lesson to a class of heterogeneous ability level raises certain inefficiency in the use of teaching time, 5) TAI is designed to minimize the involvement of teachers in assessment and routine of management class, 6) The students will be motivated to learn the material provided with fast and accurate, and will not able to cheat or find shortcut.

Based on these reasons above, researcher used TAI type of cooperative learning as an alternative solution to improve high school students’ mathematical reasoning. The research questions are “How are mathematical reasoning of students who obtain TAI type of cooperative learning and students who obtain conventional learning?” and “does the enhancement of students’ mathematical understanding who obtain Team-Assisted Individualization are better than the students who obtain conventional learning?”.

2. Mathematical reasoning

According to [1], reasoning is a central component in mathematics and especially in problem solving. The foundations of mathematics are reasoning. If reasoning abilities are not developed by the students, then mathematics is only a matter of following a series of procedures and imitating the example without thinking about why mathematics means.

[4] stated that the aim of reasoning learning are that students can (1) test patterns and structures to detect regularity, (2) formulate generalizations and conjectures of observations of regularity, (3) evaluate conjecture, and (4) create and evaluate mathematical arguments.

Director General of Higher Education Regulation no. 506/C/PP 2004 [2] formulated the mathematical reasoning indicators to be achieved by the students as follows:
1. Present mathematics statements orally, in writing, drawings and diagrams.
2. Ability to file allegations.
3. Ability to perform mathematical manipulation.
4. Ability to compile evidence, provide a justification for truth solutions.
5. The ability to explain conclusions from statements.
6. Check the validity of an argument.
7. Find the pattern or nature of mathematical phenomena to make generalizations.

Some indicators of mathematical reasoning by [12] namely, students can:
1. Drawing logical conclusions.
2. Provide an explanation with models, facts, traits and relationships.
3. Estimate answers and process solutions.
4. Using patterns and relationships to analyze mathematical situations.
5. Construct and test conjecture.
6. Formulate the counter example (counter example).
7. Following the rules of inference; check the validity of the argument.
8. Compose valid arguments.
9. Establish direct and indirect use of mathematical induction.

3. Team-assisted individualization (TAI)

TAI Program is the development program, which are used to solve the problems of theoretical and practical individual learning system. According to [7], TAI is designed to minimize the involvement of teachers in routine management and examination, teachers use only a portion of time to teach in small groups as facilitator, the students will be motivated to learn the subject matter quickly, and will not be able to cheat and find away shortcuts. Students can check each other’s worksheet by making the students work in cooperative group; they have equal status and foster positive attitudes toward students who have less academic achievement and the students who have a different racial, ethnic and gender [14].

The steps in Cooperative Learning Type TAI that are as follows:

1. Placement Test
   Teacher gives the students a test in the topic of mathematical operations in the beginning of implementation of the pre-TAI program, so that teacher knows the students’ weaknesses in the particular topics.

2. Teams
   Teacher divides heterogeneous groups of 4-6 students.

3. Teaching Group
   Teacher provides materials briefly or gives preliminary lesson, before the groups work.

4. Student Creative
   The students carry out tasks within groups by creating a situation where individual success is influenced by the success of the group.

5. Team Study
   The students are given the opportunity to start training in mathematics unit stated on the package of books/worksheet in their groups, discuss and correct what they have done, and they can ask the teacher if they really need. If there are students of students who have the problem with the formative test questions, the teacher will respond and accommodate all their problems after the answer sheets have collected.

6. Facts Test
   The students work on small tests based on facts obtained by them. They are given the individual skills test to determine the extent of their understanding of the material provided and discussed. When students have completed the skills test questions, then the students can continue working on formative tests.

7. Team Scores and Team Recognition
   Teacher provide a score and a reward for each of groups that they have done their assignment, test of individual skill and formative successfully, and also the groups have considered less successfully. Teacher gives reward motivation in the form of words such as “super team”, “very good team”, “good team”, and etc.
8. Whole Class Unit
Discussing what are the problems of students in completing tasks, individual skills test or formative test. Teachers and students will make a summary of the subject matter of newly learned.

4. Method
The research was quasi-experimental research. The design used in this study was randomized pre-test post-test control group design. This research was conducted in SMA Negeri 1 Parongpong, West Bandung. The populations in this study were students of class X. The samples in this study were grouped into two classes, namely class X-G as an experimental class and class X-F as the control class. Implementation phase of the study is to choose two classes from the class to be used as the experimental class and the control class, providing pretest to determine students' prior knowledge, learning activities carried out by the schedule and hours of mathematics set, giving the posttest carried out after all the learning activities ended. To measure mathematical reasoning of students, the instrument used in this study is written test. Indicators of mathematical reasoning in this study are The ability to justify the validity of the solution, using patterns to analyze mathematical situations and make generalizations, mathematical manipulations, and estimating answers and solution processes, and explain conclusions from statements.

The data analysis phase is carried out to analyze quantitative and provide conclusions and recommendations. On the pretest and posttest scores of data analysis to determine the normalized gain an increased mathematical reasoning of students in the experimental class and the control class. Furthermore, normality and homogeneity test are done first, before performing the test of two different mean. Analysis were performed using SPSS software with level of significant (α) = 0.05.

Learning device used in this study refer to the purpose of research is to determine whether there is an enhancement of students’ mathematical reasoning who obtain TAI. The learning device includes learning implementation plan and teaching materials in the form of Student Worksheet. The teaching materials developed subject matter contained in the applicable curriculum in school. The subject chosen in learning are Three Dimensional. Researcher used the time for five weeks to implement the learning TAI, which consists of ten meetings including pretest and posttest.

5. Result
To answer the first research question, author uses the criteria of normalized-gain as shown in the following table:

| Learning     | N  | Pretest Score | Posttest Score | Normalized Gain |
|--------------|----|---------------|----------------|-----------------|
|              |    | \( \bar{x} \) | \( S \)         | \( \bar{x} \) | \( S \)          |
| TAI          | 30 | 4,967         | 2,008          | 17,467         | 3,441           | 0,654   | 0,188   |
| Conventional | 30 | 4,367         | 3,023          | 14,667         | 2,669           | 0,520   | 0,155   |

The means of normalized-gain show that enhancement of students’ mathematical reasoning who obtained TAI is a medium category (0.654) and means Of normalize gain Conventional Class is 0.520 (medium category). The means score obtained is from the ideal maximum score equal to 24.
To answer the second question, researcher uses t-test (test of two means different) as shown in the following table:

**Table 2. T-test results of normalized-gain.**

| Explanation | t-test for Equality of | 95% Confidence Interval of the Difference |  |
|-------------|------------------------|------------------------------------------|---|
|             | T | df | Sig. P (2tailed) | Mean Difference | Std. Error Difference | Lower | Upper |     |
| Equal variances assumed | 3.004 | 58 | 0.004 | 0.234 | 0.045 | 0.045 | 0.223 | H₀ is rejected |

Based on the table, it shows that H₀: “The enhancement of students’ mathematical reasoning who obtain TAI type of cooperative learning was not better than the students who obtain conventional learning” is rejected. It means that the enhancement of students’ mathematical reasoning who obtained Team-Assisted Individualization was better than the students who obtain conventional learning.

6. Discussion

The results of the hypothesis test suggest that students who learn through TAI have better mathematical reasoning abilities than students who have received conventional learning. Descriptive seen that the mean score of the two classes are in the medium category.

Conventional learning has been done is the researchers explain the material, gives some examples of questions, and students do individual exercises from existing textbooks. For students who are smart, they easily understand and reasoning given problems, while students with the ability of understanding and reasoning mathematically less, they are slow and some even do not do the questions given.

TAI provides an opportunity for each student to develop at the appropriate level of teaching with the individual or group. Students who did not like mathematics before, by getting TAI, they were able to work on the problems at their own level and successfully solve them. As stated by [7] that the students help each other to work hard because they want team to succeed. They get the same chance of success because they have been placed based on the level of abilities previously owned.

The team received awards and felt satisfied that they could complete the task well and get support from the teachers and also from their team. Every student in the group understands that the best way to improve a team’s score is to complete a test. For this reason, they encourage each other to work quickly in order to complete class assignments and tests. Team recognition is an important part of TAI. As stated by [3] that rewards can fulfill the students’ positive psychological needs, [6] stated that teachers should give praise to motivate students in learning more than criticize and criticize, and [5] state that one way of active learning is to make notes with guidance.

In the implementation of TAI there are still some weak students who depend on clever students. There is no competition between groups. In general, the author find the advantages of TAI. These are weak student can be helpful in solving the problem, clever students can develop their skills and abilities, the responsibility of the group in solving the problem; students are taught how to work together in a group, students are motivated to learn, students receive reward for group achievement, and their mathematical reasoning ability will increase. This is similar to [14] who stated that TAI emphasis more on group awards, individual responsibility, and equal opportunities to share the results for each group member. They admitted when learning in teams, the difficult problem will be more easily solved.
7. Conclusion and Recommendation

Based on results of data analysis, then it can be concluded that the enhancement of students’ mathematical reasoning who obtained TAI type of cooperative learning was in medium category. The enhancement of students’ mathematical reasoning who obtain TAI type of cooperative learning was better than the students who obtain conventional learning.

Based on the above conclusions, the author propose some suggestions as follows: (1) Learning by Team-Assisted Individualization can be used as an alternative to mathematics learning in an effort to enhance high school students' mathematical reasoning, (2) For the future research, prospective researchers can use TAI to enhance other mathematical ability, such as mathematical representation, critical thinking skills and mathematical creative.

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