Effectiveness of The Jigsaw Strategy on Students Achievement in Mathematical Statistics I Course

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Abstract: Mathematical Statistics I is a compulsory course for the 4th term students in the Mathematics Department, Andalas University. The main problem faced in this course is the lack of students involvement which then affects their academic achievement. This research is concerned about the effectiveness of the jigsaw strategy, a cooperative learning approach, on the learning achievement of undergraduate students who took this course in the academic year 2017/2018. The classroom action research was conducted in two cycles. By comparing the final grade for the academic years 2016/2017 and 2017/2018 it was found that the jigsaw approach worked successfully to enhance student's learning achievement. It was also found that this strategy can increase student's involvement while improving teamwork and independence in the learning process and enhance students' understanding of the material being studied..

1 INTRODUCTION

At present, learning that makes lecturers as the center of knowledge transfer is still a hallmark of learning in universities. With this approach, the lecturer will become a central figure in the transfer of knowledge while students passively listen to lecturers and are not too involved in the learning process they undergo. On the other hand, the world of work requires university graduates who not only have good hard skills but are also able to think logically, analytically, critically and creatively, are able to work in a team, have excellent communication skills and other soft skills. As a result, there is an imbalance between the competencies possessed by university graduates and the expected competencies in the world of work.

For this reason, a paradigm shift is needed in the learning process from traditional learning to a learning approach that can place students in the center of the learning process, usually known as student-centered learning. This learning strategy puts all students as active and independent adult learners with responsibility for their learning. With these principles, a university graduate can be expected to become a long-life learner with a balanced ability of hard skills and soft skills. Meta-analysis shows that various approaches of student-centered learning effectively enhances students' academic achievement, is more suitable in forming the attitudes that are expected in the learning objectives and furthermore, improve the retention of the lecture material being studied (Afrizal et.al., 2014)

Mathematical Statistics I is a compulsory course in the 4th term in the Department of Mathematics of Andalas University. This course covers how to apply mathematical principles to statistics and provides a theoretical foundation for studying and developing various statistical methods used to analyze data. At present, most of the meetings in this course are carried out using a teacher-centered learning approach. With this approach, learning outcomes are still not satisfactory, because more than 40% of students fail or gain unsatisfactory grades.

Therefore, another learning approach is needed that can enhance students' learning outcome in this course. One strategy that can be used is the jigsaw strategy. This research aims to evaluate the impact of using cooperative learning based on a jigsaw strategy on students' learning achievement in the Mathematical Statistics I course.

At present, there is a paradigm shift in learning, especially in higher education, from a teaching paradigm to learning paradigm. With this new paradigm, students are placed as a center in the learning process. One type of student-centered learning is cooperative learning. This learning strategy is defined as an instructional method where

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the students need to work collaboratively in small and heterogeneous groups, helping each other to learn a specific assignment to achieve a common goal (Strother, 1990; Kagan, 1994). Compared to individualistic learning, this approach is proven to improve students' performance (Johnson and Johnson, 1999; Slavin, 1999). To be effective; the cooperative learning must be well-planned and structured with learning materials available to all participants (Azmin, 2015). There are several types of cooperative learning. The Jigsaw strategy is one of them.

Elliot Aroston originally introduced and used the Jigsaw instructional procedure in 1971 in Austin, Texas to help the students develop their social and cooperative skills (Aronson and Bridgemen, 1979). With this approach, the content of the lesson is divided into several parts of information, just like in jigsaw puzzle. The students are also divided into several heterogenous groups consist of 5-6 students refered to as the 'jigsaw' group, where they are each given a specific subtopic. In the next step, students break out of their jigsaw groups and form 'expert' groups, where they focus on one subtopic, researching and discussing it and become experts on the subtopic that they have been assigned to. Next, the students return to their jigsaw groups and teach their peers based on their discussions in the expert group. Eventually, all the members of the jigsaw groups will have learnt from each expert group discussion and will have benefit from each other (Azmin, 2015). In this method, the lecturer acts as a motivator, facilitator and assesses students activities.

2 METHOD

The classroom action research conducted this study. Learning strategy used a combination of a Teacher-Centered Learning (TCL) approach and cooperative learning using a jigsaw strategy.

2.1 Population and Participants

The population of this study was all students who took Mathematical Statistics I in the academic year 2017/2018. The students were grouped into three classes labeled A, B and C, consisting of 33, 34 and 30 students respectively. All members of the population participated in this study.

2.2 Study Design

This classroom action research was carried out during the even semester of the academic year 2017/2018. This research was done in two cycles, each cycle consisting of 4 steps, as follows:

Step 1: Planning. At this stage, a strategy was designed to achieve the learning objectives, starting from identifying the problems that arose in the learning process of the Mathematics Statistics I course, analyzing the causes and then developing an action plan through the development of the Semester Learning Plan and students' worksheets for lectures and tutorials. In this activity, an indicator of the success of the action was also determined. This step was conducted through week 1-5.

Step 2: Implementation. At this stage, actions that had been planned were implemented. The chosen Jigsaw strategy was used. This strategy was applied to two specific topics (a) The Properties of Expectation Values, (b) Special Discrete Distribution and also applied to the tutorial class. This step was conducted through week 6-10.

Step 3: Observation. At this stage, observations were carried out to identify events encountered in the implementation of the action, which included obstacles encountered and activities carried out by students during the learning process. This activity was conducted in conjunction with the implementation step.

Step 4: Reflection. The last stage of this research was the evaluation of the results of actions taken based on predetermined indicators.

2.3 Data Collection and Analysis

Data were collected during the implementation step. The collected data were the scores of the exams, quizzes and students' perceptions of the effect of this learning method on the active involvement of students, motivation to learn material independently and teamwork improvement. The measurement of students' opinion was carried out by distributing questionnaires to all students. The questionnaire used a Likert scale. Data were analyzed using descriptive statistics (central tendency and variability measures) as well as statistical tables and graphs.

2.4 Performance Indicator

Indicators used to assess the success of teaching methods, and assessments developed in this Classroom Action Research activity were:

Learning Outcomes. Learning outcomes were measured from assignments, quizzes and exams. Distribution of students' final grade. The criteria for success was the percentage of students who get a score below B is lower than the previous academic year. Students' opinion of the learning method was measured from a questionaire. The criteria for success was more than 75% of the students expressed a positive opinion of this learning method.

3 RESULTS AND DISCUSSION

Here we will describe the development of the learning and assessment method as a solution to problems faced in Mathematical Statistics I learning process. We will also discuss the result of the action done.

3.1 Development of The Learning Method

In the previous academic year, the learning process of Mathematics Statistics I courses was carried out by combining the TCL, and SCL approaches with the Think Pair and Share (TPS) method. From the evaluation, this method was not sufficient to actively involve all students in the learning process. In addition, the large number of students made it difficult for lecturers to assess the activity of all students. Besides, the tutorial activities did not provide enough opportunities for all students to be active in learning activities.

From the learning outcomes of previous years, it was suspected that the learning outcomes of students in this course were related to their activeness in the learning process. Students who got good grades were generally students who participated actively in the learning process. Therefore, it was seen advantageous to improve the learning methods to encourage all students to particpate actively to further improve the quality of students learning outcomes.

The TCL and TPS methods were still used to ensure that all material could be completed in 14 weeks of class meetings. Also, quite a lot of material is not easy to present in other ways. Learning methods were developed for the part of the course most suitable for the Cooperative Learning method using Jigsaw Strategy: "Properties of Expected Value" and "Special Discrete Distributions".

The procedure performed is as described previously. The basis of the group division was the students' grade in Elementary Statistics, Calculus I and Calculus II courses. A modification was made by appointing one student from each group as a leader. He/she was responsible for learning all the material that would be discussed and to lead the discussion. Ideally, this student must have good academic abilities and be the most mature in the group. Thus, if students have difficulty explaining the parts they are responsible for, this leader can help him. Furthermore, several students were appointed by the lecturer to explain or rewrite the results of the discussion for all participants of the course while other students responded or asked questions about the presentation or answer given. In this approach, the lecturer only acts as a motivator, facilitator and assesses the course of the discussion. The jigsaw strategy was also applied in tutorial activities.

3.2 Development of Student Assessment Strategy

The assessment carried out in this course included results-assessment and process-assessment. The results-assessment was measured through 3 Exams and Quizzes while the process assessment was measured through assignments, tutorials and group discussions conducted using the jigsaw approach. Performance indicators were: logical, analytical and critical thinking skills; creativity, time management, teamwork and communication skills.

3.3 Development of The Semester Learning Plan

Furthermore, improvements were made to The Semester Learning Plan (SLP) of the Mathematics Statistics I course. Improvements were mainly made on the learning approach used, where the jigsaw strategy was applied to several topics. In addition, the assessment method was also proscribed in more detail. This SLP was also supplemented with a class discussion worksheet which was used as a guide to carrying out class discussions.

3.4 Result of The Classroom Action Research and Discussion

This Classroom Action Research was carried out in two cycles. The following will describe the actions and results of each cycle.

3.4.1 Cycle-1

In this cycle, a jigsaw strategy was applied to lecture activities on topics of 'Properties of Expectation Values' and 'Special Discrete' Distribution. For the first topic, the jigsaw approach was only applied to students in Class A and B, while class C still used the TCL approach. Evaluation of learning outcomes was measured in the form of a quiz. For Classes A and B, the average score was 81.5 with a standard deviation of 18.24 and for class C, the average was lower, namely 73.18 with a more substantial standard deviation of 19.18. Comparison of the distribution of student quiz scores between students in Class A/B and students in class C is shown in the following figure.

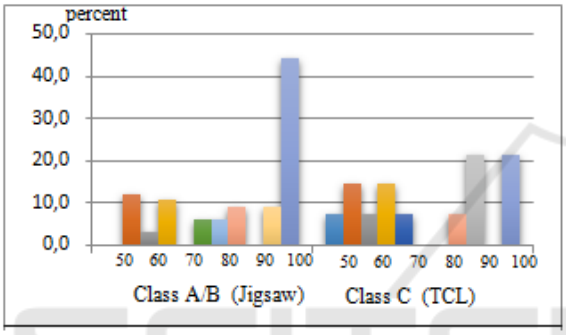

Figure 1: Comparison of Quiz 1 Distribution

It can be seen that the distribution of grades of A and B students (Jigsaw) is more encouraging than the distribution of students' grades in Class C (TCL). Nearly 50% of students in Class A / B scored grades 95 - 100 and only about 30% of students scored less than 75. Meanwhile, in class C only about 20% of students scored grades at 95-100 and 50 % of students scored below 75.

For the Special Discrete Distribution topic, the jigsaw strategy was applied to all classes. Assessment of learning outcomes was measured from the results of a second quiz, and the average score was 64.73 with a standard deviation of 22.27. The number of students scoring above 70 is quite significant, namely 42% of all students. However, this result is still unsatisfactory, because 30% of the students scored below 50.

The evaluation of the effect of this jigsaw strategy on student involvement in the learning process shows that this approach can increase the percentage of students who are actively involved in the learning process but is still not completely effective because there were many students who remained uninvolved in the learning process.

Several things might be the cause of this, namely:

- Lack of preparation. As with other SCL strategies, with this jigsaw approach, all students must study the discussed material before class. However, it was found the students did not prepare themselves well as might be expected. This might be because the course in Mathematics Statistics is theoretical and requires understanding of many new basic concepts and terms.
- Incompetent leaders.

3.4.2 Cycle-2

This cycle was done because the results obtained in the cycle -1 were unsatisfactory. Some of the method improvements made in this second cycle were:

1. The jigsaw strategy was applied to the tutorial activities. From experience, students are more enthusiastic about the completion of the exercise which they have learned about beforehand.
2. Change of some leaders who were considered to be less competent.
3. Motivation of students to learn the material.

Learning outcomes with the Jigsaw approach conducted in this tutorial activity can be seen from the grades in quiz 3. The results obtained are better than before with a higher average (66.20) and a lower standard deviation (16.03).

Another indicator is the active involvement of students in the lecture/tutorial activities. Table 1 illustrates the comparison of student involvement in learning that uses the TCL approach, jigsaw strategies on lecture activities and jigsaw strategies in tutorial activities.

Table 1 shows that the application of jigsaw strategies in this course is effective in increasing student involvement in lectures and tutorials activities. For tutorial activities, the application of this jigsaw method can involve almost all students actively in the learning process. This may be because the materials discussed were questions or exercises related to the material they had learned about beforehand in the lecture.

Table 1: Student Involvement

Learning Strategy	**Student Involvement (%)**		
	Active	***Moderate***	***Passive***
TCL	15	60	25
Jigsaw – class	26	56	18
Jigsaw – tutorial	41	56	3

From the table, it can be seen that the application of jigsaw strategies in this course was effective in increasing student involvement in lectures and tutorials activities. For tutorial activities, the application of this jigsaw method can involve almost all students actively in the learning process. This is thought to be due to the material related to the questions having been previously learnt in the lectures.

3.4.3 The final grade distribution

The student's final score is in the 0-100 range and is calculated based on the results- assessment and process-assessment. Furthermore, the academic grade for this course is based on the final score.

Fig. 2 shows a comparison of the academic grade distribution in the academic year 2016/2017 (using the TCL approach) and the academic year 2017/2018 (using the jigsaw approach).

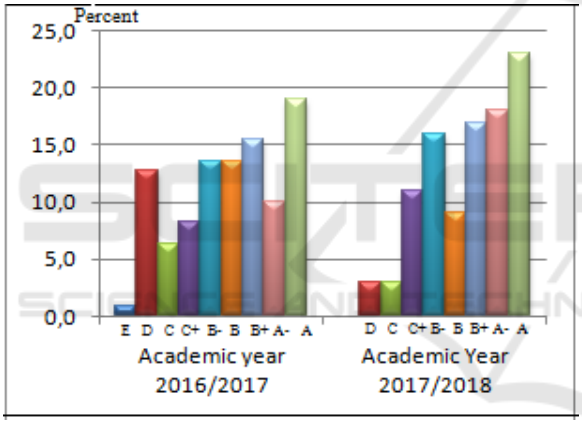

Figure 2: Comparison of final grade distribution

The distribution of student grades in these two academic years is right-skewed which means a larger number of higher scores. The distribution of students grades in the academic year 2017/2018 shows a higher percentage students have higher marks than the previous year with a higher percentage of A, A- and B + and a lower percentage of E, D and C values. In this academic year, there were no students who received E grades and only 3% of students received a D. The percentage of students who received grade B- or less also decreased from 42% to 33%.

3.4.4 Students' opinion of the jigsaw strategy:

The student's opinions toward the learning method conducted was collected by distributing questionnaires at the final meeting. In the questionnaire, students were asked to state the degree of approval of several statements related to the application of this jigsaw method. The degree of approval is expressed using a Likert scale (1 = strongly disagrees, 2=disagree, 3 = moderate, 4=agree, 5= strongly agree). Fig. 3 shows the average students' opinion scores in several areas.

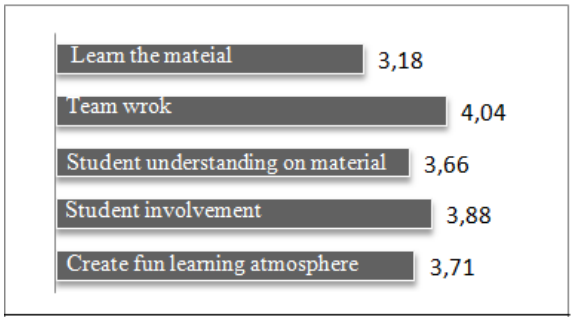

Figure 3: Likert scale scores from student feedback on the Jigsaw method's success in several areas

Fig, 3 shows that the students had positive opinions about the implementation of this jigsaw method. Students considered that this approach could create a fun learning atmosphere, increase student involvement in the learning process, increase team collaboration and enhance students' understanding of the material discussed. This method was generally considered helpful to motivate students to learn the material to be discussed before the discussion takes place.

Also, the students were also asked for their opinions about what activities this jigsaw method should be applied to. Almost all students wanted this approach to be applied in tutorial activities and part of lecture activities. Only about 4% of students preferred the TCL method to be fully implemented in all lecture activities.

4 CONCLUSION

In this study, classroom action research was conducted to determine the effect of a Cooperative Learning Method using a Jigsaw Strategy on student learning outcomes in Mathematics Statistics I. This study concluded that the jigsaw method is an effective approach to improve student learning outcomes and resulted in fewer students failing this course. In addition, students considered that this approach provided a fun learning atmosphere, was able to increase student involvement, enhance student understanding, improve teamwork and motivate

students to learn the material themselves before the class activity took place.

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