The effectiveness of collaborative learning model with challenging task on students mathematical problem-solving skills

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Abstract. This study aimed to examine the effectiveness of collaborative learning model with challenging task in terms of students’ mathematical problem solving skills. This study was a quasi-experimental with pre-test and post-test control group design. The population of this study was all the eighth-grade students in one of the state junior high school in Pontianak that consisted of nine classes, then randomly selected two classes as samples. One class as the experimental group was taught using collaborative learning model with challenging task, while another class as the control group was taught using collaborative learning model. The data were obtained by tests including a pre-test and a post-test to measure students’ problem solving skills. Data were analyzed using one-sample t-test and independent-samples t-test at a significance level of 5% on the normalized gain score. The result of the study shows that collaborative learning model with challenging task and collaborative learning model are both effective in terms of students’ mathematical problem solving skills. Furthermore, this study concludes that collaborative learning model with challenging task is more effective than the collaborative learning model in terms of students’ mathematical problem solving skills.

1. Introduction
Problem solving is one of the important skill in both primary and secondary school mathematics. Problem solving is considered as the heart of mathematics learning because that skill is not only for learning that subject, but it also emphasizes on developing thinking skill method as well [1]. By learning problem solving, students acquired ways of thinking [2], so they will have skills to overcome unfamiliar situations or problems in their daily lives [3]. Therefore, mathematical problem solving regarded as an important cognitive activity on human life, so students should be encouraged to develop their problem solving skills in mathematics learning.

Unfortunately, many students faced difficulties in mathematical problem solving. Several facts show that Indonesian students’ problem solving skill still belong to a low category. The complexity of mathematical problems that can be solved by Indonesian students were generally lower, with the average percentage of low complexity level problems 57%, medium complexity 40%, and with only 3% of the problems of high complexity level [4]. Furthermore, based on the results of PISA (Program for International Student Assessment) in 2015, Indonesia was ranked 63rd out of 72 participating countries.
with an average score on mathematics ability performance 386. This achievement was still below the international average that was 490 [5].

Based on the facts about students’ problem solving skills, the teachers need to be encouraged to plan their teaching effectively to promote students' problem solving skills. Furthermore, problem solving generally requires high cognitive processing, this can be facilitated by using group discussion [6]. Through discussion groups, all students can learn concepts and problem solving strategies [7]. One of group discussion models which commonly used by teachers is cooperative learning model. In a meta-analysis of the research on teaching problem solving, reported that the improvements in problem solving are dependent on using formally structured cooperative learning groups incorporating specific guidelines and feedback [8].

In cooperative learning where it has been observed across a range of samples, it showed that the lower ability student passivity and the upper ability students dominance in small groups [9]. In other words, the students who have upper ability contribute more than the others, so the mathematical understanding more obtained by students who have the upper ability. Although the cooperative learning has a number of advantages, it offers less opportunity for all students from various levels to develop their problem solving skills.

Another learning model based on the group work is collaborative learning. Research suggests that collaborative learning has quickly turned into a strong promoter of group work in educational institutions at all levels [7]. Collaborative learning is a learning that involves students in joint assignments, each student depends and responsible to each other [10]. The difference of collaborative and cooperative learning lies in its purpose. The purpose of cooperative learning is to cooperate in harmony and support each other to find a solution, whereas the purpose of collaborative learning is to build autonomous and good individual in articulating their mind [11]. Therefore, in collaborative learning, students are encouraged to participate, contribute, collaborate, share ideas with peers.

Many researchers have indicated that employing collaborative learning is effective to improve students’ problem solving skills. Although collaborative learning has a number of advantages, it doesn't mean this learning has no limitations. The types of tasks which used must be able to encourage students to collaborate. In addition, the collaborative tasks must not be decomposable, i.e can be divided into several parts which group members can complete their part alone or the task that can be completed by one of the group members while the others just wait for the answers [12]. Therefore, it can be concluded that not all types of task are suitable for collaborative learning.

Tasks that can support collaborative learning are often described as higher order thinking because they require a thoughtful approach and the negotiation of meaning [12]. The task should involve students in various completion strategies and decision making. The use of open-ended problems, discovery tasks, or complex problems was thought to be necessary in order to stimulate active interactions since they require multiple resources and can be solved using different strategies and methods [13]. One of the types of assignments that have the characteristics is challenging task.

Challenging task defined as a learning task that allows students to determine their own strategy, explore every possible answer, connect ideas, and consider ways to communicate their solution [14]. In other words, a mathematical task is called challenging task if the individual is not aware of procedural or algorithmic tools that are critical for solving the problem, and therefore, they have to build or otherwise invent a subset of mathematical actions to solve the problem [15]. So, challenging task is a task which has no direct procedure to complete it, so the students have to think by combining mathematical ideas to complete the task.

The advantage of challenging task in developing students’ problem solving skills is supported by previous research which concluded that posing challenging tasks can activate student thinking process in problem solving and reasoning [16]. Because many scholars who have argued that the choice of task is fundamental to opportunities for student problem solving [16], so this study focused to examine the effectiveness of collaborative learning model with challenging task in terms of students’ mathematical problem solving skills.
2. Experimental method
This study is a quasi-experimental research with pre-test post-test control groups design. This study used two groups of participants, namely the experimental group and control group. The experimental group was taught using collaborative learning model with challenging task, while the control group was taught using collaborative learning model without challenging task.

The study was conducted on the eighth grade students in a junior high school in Pontianak during the 2017-2018 academic year. The eighth grade students consisted of nine classes. The sample of this research was determined by using cluster random sampling because the researcher could not directly select a random sample of individuals. The study was carried out on two focused group samples, where one class randomly were selected as the experimental group and other one class as the control group. Each of group consisted of 35 students.

The material adopted in this study was the circle geometry for eighth grade students. This study used pre-test and post-test to measure students' problem solving skills in circle material. Each of pre-test and post-test consisted of three items where each item measures problem solving skills indicators which consists of understanding the problem, exploring the strategies, using the strategies, and looking back the solution. The proof of the validity of the instrument using content validity based on expert judgment. As for reliability, the researcher adopted an internal reliability, obtaining a Cronbach’s alpha coefficient of 0.843 with SEM 2.13.

Data analysis techniques consisted of descriptive analysis and inferential analysis. Descriptive analysis was used to describe the average, standard deviation, maximum score, and minimum score on the pre-test and post-test data. Meanwhile, the inferential analysis used to examine the hypotheses. Data were analyzed using one-sample t-test at a significance level of 5% on the normalized gain (N-gain) score to examine the effectiveness of each learning in terms of students’ problem solving skills. The learning model satisfied effectiveness criteria if the average of N-gain score reaches at least 0.7 or high criterion [17]. If both learnings are effective, the independent-samples t-test would employed to examine which learning is more effective in terms of problem solving skills. Before testing the hypotheses, a test for normality and homogeneity of variance was conducted.

3. Results and discussion
The descriptive statistic of students’ mathematical problem solving skills for experimental and control group are presented in Table 1.

| Table 1. Descriptive statistic of mathematical problem solving skills. |
|---------------------------------------------------------------|
|                                                                 |
| **Experimental Group (N=35)**                                |
| **Control Group (N=35)**                                    |
| Average | Standard Deviation | Max Score | Min Score | Average | Standard Deviation | Max Score | Min Score |
|----------|--------------------|-----------|-----------|----------|--------------------|-----------|-----------|
| **Pre-test** |                   |           |           |          |                    |           |           |
| 27.24    | 11.1               | 60        | 3.33      | 19.91    | 11.01              | 40        | 0         |
| **Post-test** |                 |           |           |          |                    |           |           |
| 83.05    | 10.8               | 100       | 56.67     | 67.33    | 14.75              | 93.33     | 33.33     |
| **N-gain** |                   |           |           |          |                    |           |           |
| 0.76     | 0.16               | 1         | 0.43      | 0.6      | 0.16               | 0.92      | 0.29      |

The statistical result in Table 1 indicated that the average score of the pretest on experimental group was higher than the control group. Furthermore, the independent-samples t-test was employed to examine the difference of the students’ initial problem solving skills in both groups. The result obtained sig value (2-tailed) is 0.007 less than the significant level $\alpha = 0.05$. Thus, $H_0$ is rejected. This means there is a difference of the students’ initial problem solving skills in both groups before treatment. Therefore, the effectiveness criteria of learning model were determined using N-gain score.

Before examining the effectiveness of each learning model, it is necessary to test the normality and homogeneity of the N-gain score data. The summary result of normality and homogeneity test at
significance level $\alpha = 0.05$ on the distribution of N-gain score data of both groups can be seen in Table 2.

| Group      | Normality (Shapiro Wilks) | Homogeneity (Levene Statistic) |
|------------|---------------------------|-------------------------------|
| Experimental | 0.073                     | 0.958                         |
| Control    | 0.218                     |                               |

Based on Table 2, it can be stated that both the N-gain score data were normally distributed. Furthermore, the homogeneity of the N-gain score data have homogeneous variance. Because of the assumption of normality and homogeneity of N-gain has been satisfied, then the next phase we examine the effectiveness of each learning method in experimental group and control group. The summary result of one-sample t-test for examine the effectiveness of each learning towards students’ problem solving skills can be seen in Table 3.

| Group      | t      | df | Sig. (2-tailed) |
|------------|--------|----|----------------|
| Experimental | 2.141  | 34 | 0.039          |
| Control    | 3.860  | 34 | 0.000          |

Based on Table 3, hypothesis testing in the experimental group using one-sample t-test shows that t-statistic $= 2.141$ higher than t-table $= 1.69$; sig value $= 0.039/2 = 0.019$ less than the significance level $\alpha = 0.05$. Thus, $H_0$ is rejected. In other words, collaborative learning model with challenging task effective in terms of students’ problem solving skills. Furthermore, hypothesis testing in the control group shows that t-statistic $= 3.860$ higher than t-table $= 1.69$; sig value $= 0.000/2 = 0.000$ less than the significance level $\alpha = 0.05$. Thus, $H_0$ is rejected. It means the collaborative learning model effective in terms of students’ problem solving skills. It can be concluded that both learnings effective in terms of students’ mathematical problem solving skills. Then, we examine the difference of N-gain score average of both groups using independent-samples t-test. The result can be seen in Table 4.

| t      | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|--------|----|----------------|-----------------|-----------------------|
| 4.233  | 68 | 0.000          | 0.16314         | 0.03854               |

Based on Table 4 showed that the sig value is 0.000 less than the significant level $\alpha = 0.05$. Thus, $H_0$ is rejected. It means there is a difference in the effectiveness between the experimental class and the control class in terms of students’ problem solving skills.

Furthermore, the results of the analysis with the independent-samples t-test in Table 4 obtained sig value (1-tailed) $= 0.000/2 = 0.000$ less than the significant level $\alpha = 0.05$ or if using the t-statistic results is 4.233 higher then t-table 1.9955. Thus, $H_0$ is rejected. It can conclude that collaborative learning model with challenging task is more effective than collaborative learning model in terms of students’ problem solving skills.
Based on the results, collaborative learning model is effective in terms of students’ mathematical problem solving skills. Collaborative learning ensures higher level of achievement and increases problem solving skills [18]. Previous experimental also argued that the use of collaborative learning has an impact on students’ achievement and also leading to several other skills as well such as communication skill and critical thinking [19]. One reason to use collaborative learning because it encourages students at various skill levels to work together, in small groups, to reach common goals [20] and allows students to provide explanations of their understanding, helps students elaborate and reorganize their knowledge [21].

Moreover, integrating the challenging task in collaborative learning also effective in terms of student problem solving skills. As many scholars who have argued that the choice of task is fundamental to opportunities for student problem solving [16]. Valle [22] also argues that discussion which focuses on cognitively challenging mathematical tasks, namely those promoting flexible thinking, reasoning and problem solving, is a primary mechanism promoting conceptual understanding of mathematics.

In this study, findings also reported that collaborative learning model with challenging task is more effective than the collaborative learning model without challenging task in terms of students’ mathematical problem solving skills. It may caused by the challenging task would necessarily involve students in variety, strategy, and decision-making [12]. Students also more interdependent each other by the task, so it can lead students to construct problem solving schemas effectively.

Moreover, the reason why collaborative learning with challenging task is more effective than collaborative learning model. It might caused by in this instruction there were two further additional elements of the lesson structure that facilitate the implementation of challenging tasks, i.e prompts which can support the learning of students who experience difficulty with the learning task and prompts that can extend the thinking of students who have completed the learning task [14]. For groups who have difficulty completing the challenging task, they would be given enabling prompts such as reducing the number of steps, simplifying the complexity of the numbers or varying the forms of representation. For groups who previously had no difficulty in solving the challenging task, they would be given extending prompts such as proofing the solution. The use of enabling and extending prompts made the experimental group have the upper ability in problem solving indicators such as exploring the strategies and looking back the solution. The Figure 1 and Figure 2 are the examples of students' answers to one of the problems in post-test.

Figure 1. Sample of student answer in experimental group.
Figure 1 shows that the experimental group students could write the strategies they used in more detail and used another strategies for looking back their solution. In this case, by engaging students in solving challenging mathematical problems also can lead them to construct effective and important problem solving schemas [15]. While Figure 2 shows that the control group tends to write the strategy succinctly and repeat the strategy that they have been used to looking back their solution. So, viewed from lesson structure, collaborative learning model with challenging task more promote students' problem solving skills compared to the collaborative learning model.

4. Conclusion
Based on results and discussion, it can be concluded that both of collaborative learning model with challenging task and collaborative learning are effective in terms of students’ mathematical problem solving skills. However, collaborative learning model with challenging task is more effective than the collaborative learning model in terms of students’ mathematical problem solving skills.

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