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⁴Improving Students' Mathematical Problem Posing Ability Using PACE Model

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Abstract. *Mathematical problem posing* ability is considered as a necessity for students to support their learning achievement. Some students are good at mathematical problem posing ability; some others are not. To foster *mathematical problem posing* in students, it is required that an innovative learning model is applied. From so many innovative learning models, one that is considered appropriate to increase the *mathematical problem posing* if the student is *project-activity-cooperative learning-exercise* learning model. This is an experimental study using pretest and posttest control groups design. The instrument used tests. The research was conducted in three regular classes of 5th-semester students of mathematics education who involved in a calculus course at IKIP Siliwangi, at a local university in Cimahi. A total of 123 students comprises three classes A1, A2, and A3. A purposive sampling technique was used to collect data. Based on data analysis, it can be concluded that there exists a different in the improvement of student's *mathematical problem posing* ability among those who received PACE model with GeoGebra (PACE-G), PACE model, and direct learning.

1. Introduction

Teaching materials of mathematics in college-level are generally more complicated than that of mathematics in school level. This is mainly because the materials are more abstract. One of the demands for students of Mathematics Education Department is actually that they have to possess the skill of constructing or defining mathematical concepts independently, that of conducting verification processes logically, and that of developing mathematical ability furthermore. This is important for them so that they can solve their mathematic subject assignments of college-level, especially their follow-up mathematic course subject [1].

For those reasons, the students need appropriate supporting learning activities. Learning activities with PACE models is highly expected to be able to push them in developing knowledge. The students can construct knowledge already acquired because it comprises construction results of new knowledge and efforts to gain new knowledge so that it cannot be transferred to passive receivers.

It, however, appears that some learning activities are still teacher-centered type and, in the meantime, the students are only to listen and write. This kind of activity does not make them more active and does not develop their learning autonomy because they are not asked to learn the materials in advance. So, when the teacher is giving the materials, they do not have enough knowledge supplies

to be discussed with their peers in the class. According to Putra [2], it is better for students to learn the materials first, and then present them in front of the course and to be involved furthermore with other people so, the atmosphere of learning becomes more active and dynamic guided by the teacher.

The students of Mathematics Education Department, especially in the Educational Department for Teaching Staff (LPTK), are expected to have the ability of *mathematical problem posing*. This is because the activity to pose mathematical problems is better than to solve them only. This, of course, is beneficial for the students in thinking mathematically. To increase their understanding of learning mathematics, the ability and activity to pose problems as a manifestation of curiosity and media to develop various strategies in solving given mathematic problems are needed. This ability will, in turn, enable the students when they already become teachers in years to come, to have capabilities in guiding their future pupils to be successful in their learning.

The mathematical ability has the potential to be developed when students learn and solve problems that exist or that are raised intentionally, and they want to find answers. The activity of posing problems in mathematics learning is so important, this is because of the heart of mathematics is to raise problems and solve them [3]. Therefore, problem-posing is an activity that plays a role in mathematical thinking and becomes an important part of problem-solving. Brown & Walter [4] argued that in thinking mathematically, asking for a problem will be better than just solving it.

Based on the results of the study, it is suggested that giving assignments for students to make or compile questions can improve their ability to solve problems and attitudes towards mathematics [5], the importance of the role of problem posing in mathematics learning has been known for a long time [6]. This problem-posing has been used as a measure of conceptual understanding and also as a pedagogical tool [7]. English [8] stated that problem-posing could improve the ability to think, solve problems, attitudes, be confident in solving problems, and generally contribute to understanding mathematical concepts.

Develop the ability to pose mathematical problems (mathematical problem posing), and integrated creative thinking ability is needed in raising new questions, creating new opportunities, and looking at old questions from a new perspective [9]. Facilitating students by allowing them to pose problems can enable them to better master flexible and diverse thinking, facilitate their problem-solving skills, expand and enrich their perceptions of mathematics, and consolidate their basic concepts [10]. In general, problem-posing can reduce student dependence on lecturers and source books and provide a feeling of being more involved in learning and problem-posing can be facilitating the students to pose problems can increase their ability of reasoning and reflection [11, 12].

Learning can be said to be successful, one of which can be seen from classroom learning activities [13]. The higher learning activities students interact with asking questions, the higher the chances of learning success. While students who tend to be passive will lack motivation in learning, the activity of asking and solving questions is also still limited. Therefore, teachers are required to be able to overcome these findings by considering appropriate learning, so that learning activities in lectures can encourage the achievement of certain mathematical abilities that students must possess. Independent students will be able to find the learning resources needed. They will try to overcome various obstacles in learning, such as unfavorable learning conditions, unclear material delivery from lecturers, and difficult subject matter but solutions can be sought, so that student learning achievements become better.

Given the importance of improving the mathematical ability of students' posing problems, an innovative learning model needs to be pursued. From so many innovative learning models, one of the right ones is learning with the Project-Activity-Cooperative Learning (PACE) model. The PACE model was developed for statistical learning [14]. This model has 4 stages of learning, namely, project, activity, cooperative learning, and exercise. Furthermore, the results of previous studies revealed that students taught using PACE model learning were more active through group work or class discussions [13], the PACE model is based on the following principles: Prioritizing the construction of knowledge independently with the direction of the lecturer, Practice and feedback are important elements in understanding new concepts, and Prioritizing active learning in solve problems [14]. Based on this, the purpose of this study was to determine differences in the ability to problem posing in mathematical between students who received the PACE model with Geogebra (PACE-G), PACE, and direct learning.

2. Method

This study applies to the experiment method. Therefore it uses pretest and posttest experiment and control groups. The experiment group obtained treatment in the form of a PACE model with Geogebra (experiment 1), PACE model (experiment 2), and direct learning / PL (experiment 3). The research is conducted in three regular classes of 5th-semester students of mathematics education who are involved in calculating courses at IKIP Siliwangi, at a local university in Cimahi. A total of 123 students, comprises three classes A1, A2, and A3. A purposive sampling technique was used to collect data. The instrument used is a descriptive test that measured mathematical problem posing.

3. Result and Discussion

3.1 Result

Table 1 is the results of normality tests for pretest data that are presented. The results of the normality test from the three classes, based on the pretest, obtained a significance value of less than 0.05, so, H_0 was rejected. Thus the data is not normally distributed for the three classes.

Table 1. Pretest Data Normality Test Mathematical Problem Posing Ability

Pretest	Kolmogorov-Smirnov		
	Statistic	Df	Sig.
Experimen 1	0,210	46	0,000
Experimen 2	0,365	39	0,000
Experimen 3	0,218	38	0,000

After it was known that the data was not normally distributed, the Kruskal-Wallis test was used to see whether there were differences in *mathematical problem posing* (MPP) ability of students between classes who would use PACE model learning with Geogebra (experiment 1), PACE model (experiment 2), and PL (experimental 3) as a whole. A summary of the test for differences in MPP ability, based on the pretest, is presented in table 2.

Table 2. Pretest Data Kruskal-Wallis Test of MPP Ability Based on Learning

Mean			Sig.	H_0
PACE-G	PACE	PL		
3,39	3,74	3,34	0,095	Accepted

H_0 : There is no difference in MPP ability

The Kruskal-Wallis test results in Table 2 show that the significance values obtained are more than 0.05, equal to 0.095, then H_0 is accepted. Therefore, it is concluded that, based on the pretest, there are no differences in mathematical abilities of problem-posing of students between the three classes.

Table 3. Posttest Data Normality test of Mathematical Problem Posing Ability

Learning	Kolmogorov-Smirnov Statistic	N	Sig.	H_0
PACE-G	0,110	46	0,200	Accepted
PACE	0,193	39	0,001	Rejected
PL	0,097	38	0,200	Accepted

H_0 : Data distributed normally

The results of the normality test of one class that received PACE learning obtained a significance value of 0.001 or less than 0.05, so, H_0 was rejected. Thus the data is not normally distributed for that class that learns by using the PACE model, while for the other two classes a significance value of more than 0.05 is obtained, so H_0 is accepted. Thus the data are normally distributed for classes that

learn by using PACE model with Geogebra, and those who learn by using direct learning (PL). After it was discovered that there were data that were not normally distributed, the Kruskal-Wallis test was used to see whether there were differences in the mathematical ability of problem-posing between classes using PACE model learning with Geogebra (experiment 1), PACE model (experiment 2), and PL (experimental 3) as a whole. A summary of the test for differences in MPP abilities, based on the posttest, is presented in Table 4.

Table 4. Kruskal-Wallis Test of MPP Ability Posttest Data Based on Learning

PACE-G	Mean		Sig.	H ₀
	PACE	PL		
12,37	11,51	7,23	0,000	Rejected

H₀: No differences in the increase of MPP ability

The Kruskal-Wallis test results in Table 4 show a significance value of less than 0.05, so H₀ is rejected. In other words, in this study, there are differences in mathematical problem posing abilities among groups of students (population) who learned using the PACE-G, PACE, and PL models. If we take a look at the mean of MPP ranking in students with PACE-G, PACE, and PL learning, it can be concluded that overall mathematical problem posing abilities of students who received PACE model learning with Geogebra, and students who get PACE model learning are better than those who received direct learning. However, there is a tendency that the PACE-G group is better (currently) compared to the group of students who studied using PACE only. There is a possibility, in the long run, these two groups may have no significant differences.

Table 5. N-Gain Data Normality Test of Mathematical Problem Posing Ability

Learning	Kolmogorov-Smirnov Statistic	N	Sig.	H ₀
PACE-G	0,091	46	0,200	Accepted
PACE	0,168	39	0,007	Rejected
PL	0,091	38	0,200	Accepted

H₀: Data distributed normally

That is why, the data is not normally distributed for the group of students that applied the PACE model, whereas for the two other groups of students their H₀ were accepted since the significance value is 0.05. From table 5, the results of the normality test of one class that received PACE learning obtained a significance value of 0.007 or less than 0.05, so H₀ was rejected. Thus, the data is not normally distributed for the class that learned using the PACE model; while for the other two classes a significance value of more than 0.05 was obtained, so H₀ was accepted. Thus, the data are normally distributed for the class that learned using the PACE model with Geogebra, and those who learned using direct learning (PL).

After it was discovered that the data were not normally distributed, the Kruskal-Wallis test was used to see whether there were differences in the improvement of mathematical problem posing skills among these classes, each of which using PACE model with Geogebra (experiment 1), PACE model (experiment 2), and Knv learning. (experiment 3) As a whole. A summary of the difference test for increasing MPP capability, based on the posttest, is presented in Table 6.

Table 6. N-Gain Data Kruskal-Wallis Test of MPP Ability Based on Learning

Mean	Sig.	H ₀
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PACE-G	PACE	PL		
0,720	0,643	0,314	0,000	Rejected

H₀: No differences in the increase of MPP ability

The Kruskal-Wallis test results in table 6 show a significance value of less than 0.05, so H₀ is rejected. In other words, in this study, there are differences in the increase of mathematical problem posing skills among groups of students (population) who learned using the PACE-G, PACE, and PL models.

Observed from the mean of MPP ranking for students with PACE-G, PACE, and PL learning, it can be concluded that overall improvement in the mathematical ability of problem-posing students who received PACE model learning with Geogebra, and students who received PACE model learning are better than those who received direct learning.

3.2 Discussion

PACE Models, contains four main components, namely project, activity, cooperative learning, and exercise. Projects are an important component of PACE Model learning [12]. A project is a form of innovative learning based on inquiry activities to solve problems. Activities in the PACE model aim to introduce students to new information or concepts [15]. Cooperative learning in the PACE model aims to transform student knowledge that has been obtained at the activity stage. Exercises in the PACE Model aim to strengthen the concepts that have been constructed at the stage of cooperative learning and activities through solving questions

Students' mathematical problem posing abilities before having obtaining the PACE model in the experiment class and having direct learning / PL in the control class, relatively have the same pretest scores. The average pretest score for three classes is 3,49, so it is still considered low because the ideal maximum score is 16. This condition is because the students have not yet accustomed to completing tests of mathematical problem posing abilities. However, they continue to work on the test questions based on their initial abilities related to the previous prerequisite material.

The pretest results showed that, based on the pretest, there were no differences in mathematical problem posing abilities students among the class of PACE-G, PACE, and PL. This condition serves as a basis for in comparing the improvement of students mathematical problem posing abilities among the students who learned using the PACE model, and direct learning.

Mathematical problem posing skills determined by the students' posttest results after learning. The results of posttest analysis showed that there were differences in mathematical problem posing abilities among groups of students who learned using PACE-G, PACE, and PL models.

Overall, mathematical problem posing abilities of the students who received PACE model learning with Geogebra, and those who received learning with the PACE model are better than those who received direct learning (PL). However, there were no differences between the two groups that received learning with the PACE model, PACE-G, and PACE.

Students who received learning with the PACE model possess better mathematical problem posing skills than those with direct learning. This condition occurs because learning with the PACE model accommodates them in observing problems, asking questions about problems, trying to solve problems, reasoning about solutions, and concluding the results of answers.

Mathematical problem posing is one of the highest levels of mathematical thinking skill. This statement is in line with the opinion [16] that the problem-posing task has all the criteria used in the task of high order-level thinking skills. Students can complete tests of mathematical problem posing skills if they have high mathematical abilities.

Direct learning, such as lecturing that applied to the students in one of the classes, can also improve their mathematical ability in problem posing. When the lecturer explains the material, students must focus on what the lecturer conveys. Good class management of a lecturer creates a conducive learning atmosphere, so that most of the students can freely express their opinions, as well as asking good questions, and show their understanding of the lecturers' explanations. When the students face problems, lecturer guidance is considered as a necessity for overcoming their difficulties.

When the students are asked for compiling new questions from problems, the lecturer always gives direction to them about the steps needed to make questions. For those succeeding in obtaining this strategy can arrange new questions given by the lecturer. It is this kind of activity that can increase mathematical problem posing abilities of the students who use various direct learning. This opinion is in line with what was stated by [17] that initial knowledge influences the mastery of the material being studied.

6 Conclusion

3 This study concludes that there are differences in the improvement of mathematical problem posing abilities among the students who get the PACE model learning with Geogebra (PACE-G), the PACE model (PACE), and direct learning (PL).

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