Infinity Journal of Mathematics Education
Volume 11, No. 2, September 2022

p-ISSN 2089-6867
e–ISSN 2460-9285

https://doi.org/10.22460/infinity.v11i2.p285-296

PROJECT-ACTIVITY-COOPERATIVE LEARNING-EXERCISE MODEL IN IMPROVING STUDENTS' CREATIVE THINKING ABILITY IN MATHEMATICS

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Article Info

Article history:

Received Feb 13, 2022
Revised Sep 19, 2022
Accepted Sep 20, 2022

Keywords:

Mathematical creative thinking, PACE

ABSTRACT

Mathematical creative thinking ability is essential to be mastered by students to create good learning results and achievement. To install creative thinking in students' minds, they are highly requested to apply an innovative learning model. Among innovative learning models, project-activity-cooperative learning-exercise (PACE) is the one to be considered suitable for improving the students' mathematical creative thinking. This study is an experimental research using a pretest-posttest control group design. It was conducted in three classes of IKIP Siliwangi students by applying different learning models. The first class was given the PACE model treatment with Geogebra, the second class was given the PACE model treatment, and the third class was given direct learning. The instrument used tests. Based on the data analysis, we can conclude that there are differences in improving creative thinking abilities among the students who get the PACE model learning with Geogebra (PACE-G), the PACE model, and direct learning (DL). The improvement of creative students who get PACE and PACE-G models is better than those who get DL. The progress of students' mathematical creative thinking abilities obtained from PACE and PACE-G models is a high category. In contrast, improving students' creative thinking abilities who acquire DL is categorized as a medium.

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How to Cite:

Afrilianto, M., Rosyana, T., Linda, L., & Wijaya, T. T. (2022). Project-activity-cooperative learning-exercise model in improving students' creative thinking ability in mathematics. *Infinity*, *11*(2), 285-296.

1. INTRODUCTION

Science, technology, engineering, and mathematics are important terms in mathematics education. As one of the implications of the statement, analyzing the four terms above simultaneously can help achieve meaningful knowledge needed in dealing with the development of science in this digital era.

According to Afrilianto et al. (2019), The teaching materials for mathematics at the college level are typically more difficult than those for mathematics at the school level. It is crucial for the students to be able to complete their math assignments at the college level, especially for their subsequent math course subject (Luttenberger et al., 2018; Sun et al., 2018; Xu & Dadgar, 2018). Mastering arithmetic can benefit children in a variety of ways to shape their character or personality (Rosyana et al., 2018).

As a result, the student required learning activities that are appropriate. With PACE learning activities, it is intended that the model will strongly motivate individuals to grow their knowledge. Since this knowledge can only be communicated to active receivers, it is possible for individuals to construct knowledge that they have already learned. It is preferable for students to acquire the content first, present it in front of the class, and engage further with other peers (Konopka et al., 2015; Litster et al., 2020; Lopez-Caudana et al., 2020; Maass et al., 2019). This way, the learning environment will be more active and dynamic under the direction of the teacher. As a result, when the teacher distributes the materials, they lack the necessary expertise to engage in class discussion with their classmates.

Students are obliged to have mathematical creative thinking skills. Garrison et al. (2001) said that when creative and reflective thinking skills are developed, people tend to seek the truth, open minded, be tolerant of new ideas, and be able to analyze problems well, big, systematically, and individually critical thinking. Creative thinking skill develops in someone, it produces a lot of ideas, making connections, has a lot of perspective on things, makes and does imagination, and cares about results (Garrison et al., 2001).

Creative thinking is required to produce something relatively new. Evans (1991) said that creative thinking looks at how we perceive things from a different perspective. Briggs (2007) suggests that creative thinking can be identified by its aspects of novelty, productivity, and impact or benefit. Novelty refers to the problems solving strategy used is relatively unique. Productivity refers to the construction of the ideas or approaches that are generated as much as possible, while the impact or benefit refers to the benefit of the ideas that have been generated.

This mathematical thinking skill is very relevant, considering that real-world problems are generally not simple and convergent, but are often complex and divergent, even unpredictable. The creative thinking skill is important in analyzing, synthesizing, and evaluating all arguments needed to make rational and responsible decisions (Aizikovitsh-Udi & Amit, 2011; Ersoy & Başer, 2014; Krisdiana et al., 2019; Ülger, 2016). Students should be directed to achieve this high level competence through varying, contextual, and open learning activities.

Based on the factors analysis, Guilford (Carbonell-Carrera et al., 2019; Nurdiana et al., 2020) found that there are five characteristics of creative thinking: (a) Fluency, the ability to produce multiple ideas; (b) Flexibility, is the ability to propound some solution or approach to the problems; (c) Originality, is the ability to making decision of the ideas in originality, not cliche; (d) Elaboration, is the ability to elaborate things in detail; and (e) Redefinition, is the ability to review the problems from different perspective to what many already know.

As for indicators of mathematical creative thinking skill used in research by Tandiseru (2015), are fluency, simplicity, originality, and elaboration. The indicator of the mathematical creative thinking skills used are eloquence, flexibility, and novelty (Hidayat et al., 2018). Based on the description, the indicators used to measure mathematical creative thinking in this study are fluency, simplicity, originality, and elaboration.

According to Afrilianto et al. (2019), independent students will be able to locate the necessary learning resources. The student will look for a variety of learning barriers, such as poor learning environments, unclear content, and challenging subject matter, but these can be overcome so that student learning outcomes improve.

Lee (1999) created the PACE model for statistical learning. There are four learning stages in this model: project (project), activity (activity), cooperative learning (cooperative learning), and exercise (exercise). Additionally, Lee (1999) found that PACE model learners were more engaged in group projects and class discussions. The PACE paradigm is built on the following tenets. Lee (1999) said that prioritizing active learning when solving problems, (2) Practice and feedback are crucial components in grasping new concepts, and (3) Independent knowledge production under the lecturer's guidance. Exercising a model project, activity, and cooperative learning (PACE). PACE Model Learning consists of four essential parts, specifically: (1) Project. It is crucial to learning using the PACE Model (Lee et al., 2000). According to Laviatan (2008), the project is an example of creative learning that relies on problem-solving activities; (2) Activity. The PACE model's activities are designed to introduce students to new knowledge or ideas (Lee et al., 2000). Cooperative Learning. Through cooperative learning, there is a complementary exchange of information between students; and (3) Exercise. Through practicing, students can strengthen the concepts that have been constructed at the activity and cooperative learning stages.

PACE model will be good in collaboration using Geogebra application. GeoGebra is software that is freely available for teaching and learning mathematics with features suitable for topics such as geometry and algebra (Azizul & Din, 2018). GeoGebra software is an interactive media that allows students to explore various mathematical concepts (Kusumah et al., 2020). The use of GeoGebra in learning can help teachers improve student understanding of mathematical concepts and procedures (Zulnaidi & Zamri, 2017). Kusumah et al. (2020) the use of GeoGebra can improve students' mathematical communication skills, it is recommended for mathematics teachers to use GeoGebra in Geometry learning, especially in probability concept material.

2. METHOD

This study employs experimental research that uses pretest and posttest control groups design. It is conducted in three classes of IKIP Siliwangi students by applying different learning methods. The first class (experiment 1) is given the PACE model treatment with Geogebra software, the second class (experiment 2) is given the PACE model treatment, and the third class (control) is given direct learning (direct instruction).

Quantitative data is collected through test giving. Observations are done twice, the first one is before the learning process, which is called pretest and the second one is after the learning process, which is called posttest. In this study, the independent variables are learning (PACE-G Model, PACE Model, and DL), while the dependent variable is the mathematical creative thinking ability.

3. RESULT AND DISCUSSION

3.1. Result

Table 1 shows the results of normality test for pretest data are presented.

Table 1. Pretest data of normality test mathematical creative thinking ability

Grades	Kolmogorov-Smirnov		
	Statistic	Df	Sig.
PACE-G	0.171	46	0.002
PACE	0.145	39	0.039
DL	0.214	38	0.000

The results of the normality test showed that the three classes were not normally distributed (see Table 1), this resulted in further testing using the Kruskal-Wallis test. The Kruskal-Wallis test was conducted to see if there was a difference in overall mathematical creative thinking ability between classes using the PACE and Geogebra models (experiment 1), PACE model (experiment 2), and DL (control). The summary of the Kruskal-Wallis test on increasing MCT ability is presented in Table 2.

Table 2. Pretest data of kruskal-wallis test of MCT ability based on learning

Mean			Sig.	H_0
PACE-G	PACE	DL		
2.36	2.35	2.10	0.715	Accepted

Table 2 show that the significance values obtained are more than 0.05, then H0 is accepted. Therefore, as the result, based on the pretest, there are no differences in mathematical abilities of creative thinking of students between the three classes.

The results of testing the pretest data showed that there was no difference in students' initial mathematical creative thinking abilities, then analyzed the posttest data for mathematical creative thinking abilities with the results of the normality test presented in Table 3.

Table 3. posttest data normality test of mathematical creative thinking ability

Class	Kolmogorov-Smirnov Statistic	N	Sig.	H_0
Experiment-1	0.123	46	0.080	Accepted
Experiment-2	0.159	39	0.015	Rejected
Control	0.215	38	0.000	Rejected

The results of the normality test of two classes that received PACE (Experiment 2) and Direct Learning (DL) learning obtained a significance value of 0.015 and 0.000 (see Table 3). Thus, the data is not normally distributed for classes taught using the PACE model and direct learning (DL), while for other classes (Experiment 1), the results obtained a significance value of more than 0.05. Thus, the data is normally distributed for the class that learns using the PACE model with Geogebra (PACE-G). Because there are data that are not normally distributed, it is continued with the Kruskal-Wallis test to see whether there are differences in the mathematical ability of creative thinking between classes using the PACE and Geogebra (PACE-G) learning model, the PACE model, and Direct Learning (DL) as a whole. The summary of the MCT ability difference test based on the posttest is presented in Table 4.

Table 4. Posttest data of kruskal-wallis test of MCT ability based on learning

Mean			Sig.	H_0
PACE-G	**PACE**	**DL**		
12.10	10.84	7.21	0.000	Rejected

The results of the posttest data show that there are differences in students' initial mathematical creative thinking abilities (see Table 4), then the data on the gain of mathematical creative thinking abilities with the results of the normality test is presented in Table 5.

Table 5. Gain data normality test of mathematical creative thinking ability

Learning	Kolmogorov-Smirnov Statistic	N	Sig.	H_0
PACE-G	0.073	46	0.200	Accepted
PACE	0.099	39	0.200	Accepted
DL	0.151	38	0.028	Rejected

Based on the results of the normality test (see Table 5), it was found that there was one class that was not normally distributed (DL), this resulted in further testing using the Kruskal-Wallis test. The Kruskal-Wallis test was conducted to see whether there was a difference in the overall increase in mathematical creative thinking skills between the classes using the PACE model with Geogebra (experiment 1), PACE model (experiment 2), and DL (control). The summary of the Kruskal-Wallis test on increasing MCT ability is presented in Table 6.

Table 6. Gain data kruskal-wallis test of mct ability based on learning

Mean			Sig.	H_0
PACE-G	**PACE**	**DL**		
0.718	0.623	0.367	0.000	Rejected

Table 6 show a significance value of less than 0.05. To put it another way, groups of students (population) that learnt using the PACE-G, PACE, and DL models showed varying increases in their mathematics creative thinking abilities in this study.

Then, obtained student responses in learning PACE learning. Supporting findings related to student opinions about the implementation of PACE model learning were obtained from questionnaires and interviews. Based on the results of the interviews, it was revealed that the PACE and PACE-G models generally made a positive contribution in improving students' mathematical problem posing and creative thinking skills. Students admitted that learning the PACE and PACE-G models actually helped in improving their understanding of the Cone Slice material. They are very enthusiastic in participating in every stage of learning the model which is supported by the existence of the LKM.

The learning role of the PACE model, which has a positive contribution to understanding the Cone Slice material, is also strengthened by the results of an open questionnaire. The results of the study of open questionnaires (free comments) showed that all students had feelings of pleasure towards the lectures they attended. Students feel that PACE model learning provides opportunities for them to complete projects through learning activities with cooperative learning and individual and group exercises, thus making it easier for them to understand the material. Likewise, the impression of students in learning the PACE model with Geogebra (PACE-G) turned out to be student interest and it was seen both while studying and after lectures. These results can be seen from the student's comments, one of which is revealed in Figure 1.

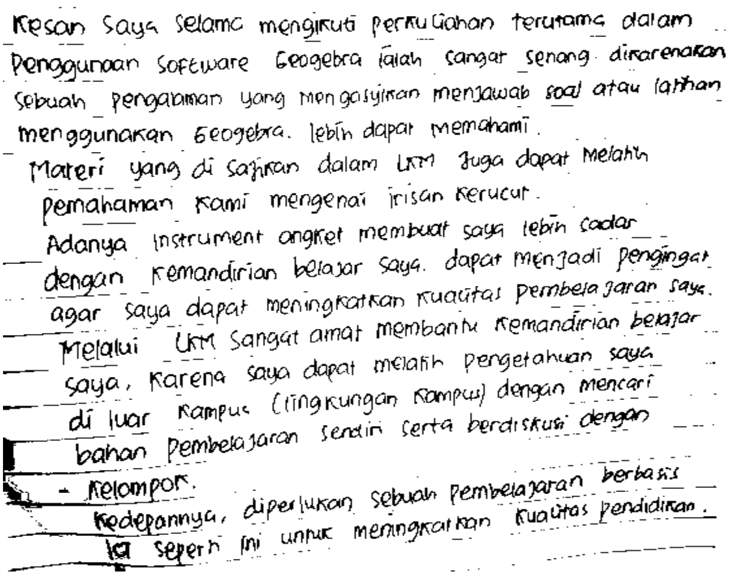
Kesan saya selama mengikuti perkuliahan terutama dalam
penggunaan software Geogebra ialah sangat senang dikarenakan
sebuah pengalaman yang mengasyikan menjawab soal atau latihan
menggunakan Geogebra. lebih dapat memahami.
Materi yang di sajikan dalam LKM juga dapat melatih
pemahaman kami mengenai irisan kerucut.
Adanya instrument angket membuat saya lebih sadar
dengan kemandirian belajar saya. dapat menjadi pengingat
agar saya dapat meningkatkan kualitas pembelajaran saya.
Melalui LKM sangat amat membantu kemandirian belajar
saya, karena saya dapat melatih pengetahuan saya
di luar kampus (lingkungan kampus) dengan mencari
bahan pembelajaran sendiri serta berdiskusi dengan
kelompok.
kedepannya, diperlukan sebuah pembelajaran berbasis
ICT seperti ini untuk meningkatkan kualitas pendidikan.

Figure 1. Student comments on learning

Besides that, obtained of student responses from closed questionnaires that were filled directly by students were also obtained by choosing answers very agree (SS), agree (S), disagree (TS), and very disagree (STS), can be presented in Figure 2.

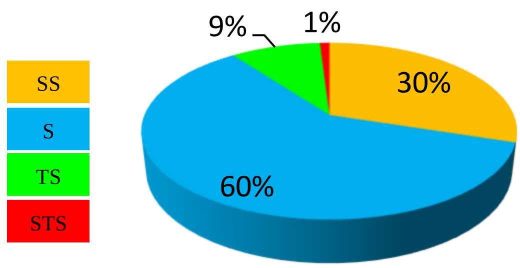

Figure 2. Recapitulation of student opinions related to PACE and PACE-G

Figure 2 shows that the percentage of students who give a very high agree response is 60%, meaning that students are interested in learning with the PACE and PACE-G models. In addition, there are also the working on mathematics problem from students who have learned PACE, PACE-G, and DL. For indicators of mathematical creative thinking ability, namely fluency. The overall average achievement of students' mathematical creative thinking skills who received PACE-G and PACE learning models was higher than students who received direct learning (DL). In other words, students who received the overall PACE-G and PACE model learning on the "fluency" indicator experienced lower difficulties in solving mathematical creative thinking skills than students who received direct learning (DL).

To strengthen the descriptive results, it is necessary to analyze student answers next. In order to obtain further analysis related to the difficulties experienced by students in solving mathematical creative thinking skills on the "fluency" indicator, the analysis of student answers will be carried out based on the level of student learning independence. The question of mathematical creative thinking skills that reveals "fluency" is in Number 1, namely:

The equation of the parabola is
$x^2 + 8x - 4y - 16 = 0$
Determine the coordinates of the extreme poin,
focal point, directrix equation, and the lotus rectum.

For students with a high level of learning independence (TKB) who receive PACE-G and PACE learning models, generally do not experience significant difficulties, only the accuracy factor makes the answer wrong. For example, the following answers are presented by M-1 students (see Figures 3 and 4), as representatives of students with high early learning independence who received PACE-G and PACE learning models.

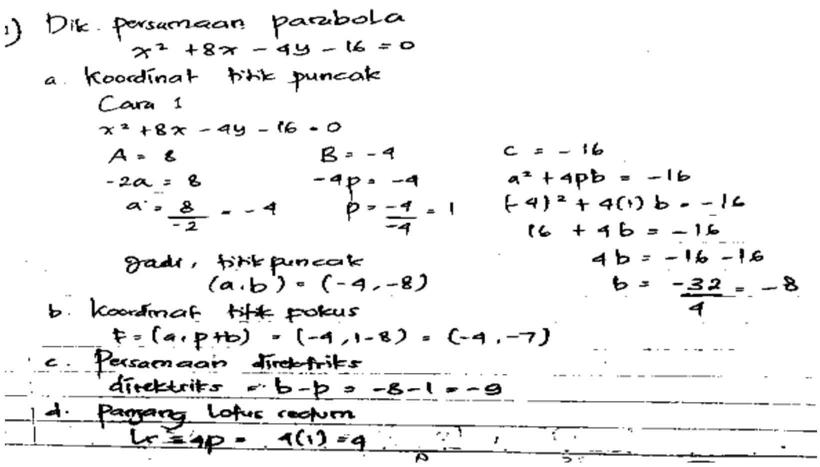

Figure 3. M-1 student answers on test about fluency indicator

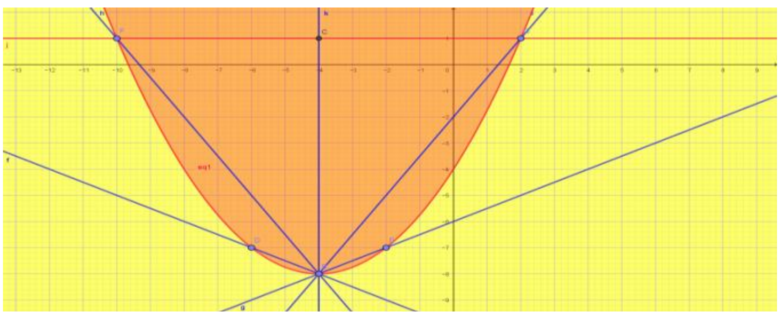

Figure 4. M-1 student answers based on Geogebra

For students with moderate TKB who receive PACE-G and PACE learning models, generally they do not experience significant difficulties, but sometimes they are not checked in detail. For example, in the following, the answers of students M-17 are presented as representatives of students with moderate TKB who are learning the PACE-G and PACE models.

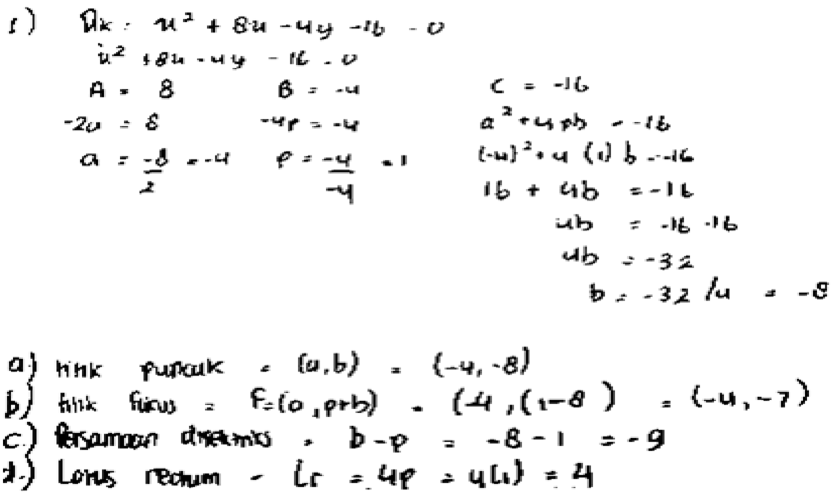

Figure 5. M-17 student answers related to fluency indicators

Figure 5 show that M-17 students did not experience too many difficulties, but they were not described in detail. After checking, it turned out that the answer was correct, but the score obtained was not optimal because it was not described or checked again.

This finding was strengthened by the results of interviews with representatives of students with moderate TKB who received PACE-G and PACE learning models, that they admitted that they did not experience too many difficulties, only that they wrote the answers directly on the answer sheet without elaborating or re-checking in detail. As a result, the score obtained by the student is not optimal.

Meanwhile, for students with TKB level who received DL, some were still confused in answering questions or were not careful in answering questions, so the answers were wrong. For example, in the following, the answers of students M-112 are presented as representatives of students with low TKB who received DL (see Figure 6).

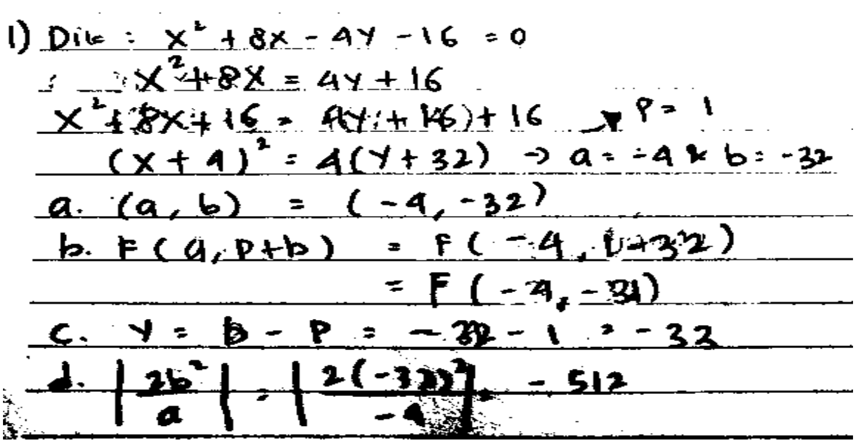

Figure 6. M-112 student answers related to fluency indicators

The students with low TKB who get the PACE-G model learning, and PACE on the "fluency" indicator, generally experience lower difficulties than students who get DL in solving mathematical creative thinking skills problems. This finding is supported by the achievement scores and the improvement of students' mathematical creative thinking skills with low TKB on the "fluency" indicators of learning (PACE-G, PACE, and DL models) which concludes that students with low TKB who get learning the PACE-G and PACE models have a higher average of achievement and improvement than students who received DL.

Based on the overall analysis, it can be seen that most of the students who received the PACE and PACE-G models did not experience difficulties in working on mathematical creative thinking skills on the "fluency" indicator, both students with high, medium, and low TKB. It's just that it still requires better accuracy. For students who received DL varied, namely students with high and medium TKB, in general they did not experience difficulties, although they had to be more careful. Meanwhile, for students with low TKB who received DL, some students were still confused in answering questions or were not careful in answering questions, so the answers were wrong. This is of course the fact that the index/difficulty level of mathematical creative thinking skills for the “fluency” indicator is 0.287 and is categorized as difficult.

3.2. Discussion

Based on the analysis of research results about the achievement and improvement of students 'mathematical creative thinking abilities influenced by learning factors with the Project-Activity-Cooperative Learning-Exercise (PACE) and Direct Learning (DL) models, it was found that there are some differences. The achievement and improvement of mathematical creative thinking abilities of students who learn by learning the PACE and PACE-G models are better than those learning with DL. In addition, there are differences in the achievement and improvement of students' mathematical creative thinking abilities based on the level of learning independence. This invention is based on the average score of achievement and improvement of students' mathematical creative thinking abilities in terms of learning factors.

The results of this study indicate that students who learn by learning the PACE model are helped in developing mathematical creative thinking skills through stages: (a) Projects, (b) Activities, (c) Cooperative learning (cooperative learning), and (d) Exercise (exercise). For groups that receive PACE-G model learning, students are also helped by the use of Geogebra software in completing Student Worksheets / LKM at learning meetings. The effect of PACE model learning on the achievement and improvement of mathematical creative thinking abilities due to the characteristics of PACE model learning is also focused on fostering and developing students' mathematical creative thinking actively through project assignments, activities in cooperative learning, and exercises. Stages in learning the PACE model can develop mathematical creative thinking ability.

Creative thinking abilities need to be developed especially in facing the information age. Someone with creative thinking abilities will grow healthy and face challenges (Behnamnia et al., 2020; Yaniawati et al., 2020). To develop creative thinking abilities, lecturers must create class conditions that stimulate students' sensitivity through assignments by raising several questions, such as: "how if," "what is wrong," "what will you do," and to settle the problems with variety of ways (Krulik & Rudnick, 1999).

The implementation of Project-Activity-Cooperative Learning-Exercise (PACE) and PACE with Geogebra (PACE-G) learning models have a positive influence on mathematical creative thinking abilities, so that they are worthy of being used as learning models at campus. These learning models can be used to improve mathematical creative thinking abilities.

Judging from the study, these findings are similar to the findings of previous studies. The finding is that the improvement of various mathematical abilities of students who received PACE model learning was overall better than students who received conventional learning (Lee et al., 2000; Pearce & Cline, 2006). The research findings of Lee (1999) suggest that the PACE model learning is able to train students to be able to construct new concepts by themselves by applying previously owned mathematical concepts (assimilation process) or even modifying other mathematical methods or concepts through the process. exploration in constructing new (accommodation process). Hartman (1997) explains the relationship between the concepts of assimilation and accommodation with cooperative learning. Assimilation is the entry of new information into an existing schema through a process of continuous exploration. Meanwhile, accommodation is a change to the previous schema or the creation of a new schema so that we are ready to adapt it to the new information.

The learning factor of the PACE model is more instrumental in developing students' mathematical creative thinking abilities. This shows that learning the PACE model makes different contributions to the level of ability called the Zone of Proximal Development (ZPD). Vygotsky and Cole (1978) defines the Zone of Proximal Development as the distance between the actual level of development determined by the individual's ability to solve problems independently and the level of potential development determined by the individual's ability to solve problems with the help of others who are more mature or by collaborating with a partner who is more capable.

4. CONCLUSION

The study's findings indicate that students who receive direct learning (DL) on the probability concept, the PACE model (PACE), or both exhibit disparities in the growth of their mathematics creative thinking skills. Students who use the Project-Activity-Cooperative Learning-Example (PACE) and PACE-G models for learning attain higher levels of mathematics creative thinking than students who use direct learning (DL). The success rate of students' mathematical creative thinking abilities as measured by the Project-Activity-Cooperative Learning-Example (PACE) and PACE-G models is high, whereas the success rate of students' direct learning (DL) abilities falls into the medium category.

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