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APPLICATION OF PROJECT-BASED LEARNING TO IMPROVE STUDENTS' CREATIVE THINKING ABILITY IN REAL ANALYSIS COURSES

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Abstract

Based on the preliminary research in the Real Analysis material, especially those related to limits, it was found that 83.37% of students had moderate and low mathematical reasoning abilities. This condition shows that students are not able to solve problems, because students' creative abilities are low. Developing of student's creative abilities can be done through Project-Based Learning. This study aims to improve students' creative thinking skills through Project-Based Learning. The approach used in this research is descriptive qualitative. Data analysis is in the form of valid project sheets, practical creative thinking skills using indicators of Fluency, Flexibility, and Novelty. Data was analyzed with the normalized gain score formula. The results showed that of 12 students who took the Real Analysis course, 75% of students' thinking skills were low, and 25% were moderate. When compared with the conditions before learning for the three indicators 1.25, 1.13, and 0 with after learning there was an increase of 2.17, 2.17 and 0.5.

Keywords: Project-Based Learning, creative thinking

Abstrak

Berdasarkan penelitian pendahuluan dalam materi Analisis Riil terutama yang berkaitan dengan limit ditemukan bahwa 83,37 % mahasiswa memiliki kemampuan penalaran matematis sedang dan rendah. Kondisi tersebut menunjukkan bahwa mahasiswa tidak mampu menyelesaikan masalah, karena kemampuan kreatifitas mahasiswa rendah. Menumbuhkembangkan kemampuan kreatifitas sesorang dapat dilakukan melalui Pembelajaran Berbasis Proyek (*Project-Based Learning*). Penelitian ini bertujuan untuk meningkatkan kemampuan berpikir kreatif mahasiswa melalui Pembelajaran Berbasis Proyek (*Project-Based Learning*) Pendekatan yang digunakan dalam penelitian ini adalah deskriptif kualitatif. Analisis data berupa lembaran proyek yang valid, praktis kemampuan berpikir kreatif menggunakan indikator Kefasihan (*fluency*), Fleksibilitas (*flexibility*), dan Kebaruan (*novelty*). Analisis data menggunakan rumus skor gain ternormalkan . Hasil penelitian menunjukkan bahwa dari 12 mahasiswa yang mengikuti perkuliahan Analisis Riil kemampuan berpikir mahasiswa 75% rendah, dan 25% sedang. Jika di bandingkan dengan kondisi sebelum pembelajaran untuk ketiga indikator 1,25, 1,13, dan 0 dengan setelah pembelajaran terjadi peningkatan 2,17, 2,17 dan 0,5.

Kata kunci: Pembelajaran Berbasis Project, Berpikir Kreatif

INTRODUCTION

This research is motivated by preliminary research conducted by Herawati and Amelia (2021) in the Real Analysis material, especially those related to limits, it was found that 83.37% of students had moderate and low mathematical reasoning abilities. According to Herawati and Amelia (2021) and Siregar (2018), with such student's ability, showed that students can not understand problem solving in the Real Analysis course, in other words, the level of student understanding was still at a level of understanding the problem and planning the solution. While Hasanah, et. al (2019) said that the character of students with low mathematical abilities were only able to understand problems. While at the stage of making

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a problem-solving plan, the stage of implementing the problem-solving plan, and the stage of re-examination the subject cannot solve it.

This condition describes that students have not been able to be at the analysis stage. This means that students still have many difficulties in solving problems that the difficulties experienced by students in the real number material include difficulties in constructing ideas or ideas to prove a statement. Furthermore, according to Adamura and Susanti (2018) analyzing intuitive abilities in solving real analytical problems, students with intuitive thinking skills are not able to carry out mathematical reasoning at the problem-solving stage, solving problems according to plan and re-checking. Meanwhile, Hasanah et al (2019) said that the character of students with low mathematical abilities were only able to understand problems. While at the stage of making a problem-solving plan, the stage of implementing the problem-solving plan, and the stage of re-examination the subject cannot solve it.

Real Analysis Learning is currently implementing Student Center Learning, students are mostly given assignments in groups and independently. Students are given the freedom to look for references in solving the problems given. However, the results of research on students' reasoning abilities show that students still have difficulty understanding and solving problems in the Real Analysis course. Especially in proving the deep theorems on the topic of Limits. This means that the learning model used has not been able to improve students' reasoning abilities.

In the current era, the government is making efforts to improve education in higher education by issuing the Independent Learning Campus (MBKM) policy, using the Case Study or Project-Based Learning model. In project-based learning, students are required to be able to develop their creative thinking skills. These skills are assets that students must have in facing this 21st century. According to Redhana (2019), these 21st century skills include critical thinking and problem solving, creativity and innovation, communication, and collaboration. According to Hidayat et al (2020) universities implementing learning tend to be limited to the transfer of knowledge and information, not yet touching on building student experiences.

Therefore, in the learning process, educators must be able to stimulate students' creative thinking skills through the learning models they use. Project-Based Learning Model to cultivate students' creative thinking skills in learning Mathematics. According to Ummah et al (2019) increasing student creativity can be through project-based learning.

According to Wulandari (2019) and Hidayati et al (2019), developing one's creative abilities can be done through learning the learning model. The learning model is a conceptual that has a systematic procedure and is applied in learning with the aim that learning can achieve maximum learning indicators, both indicators of learning aspects of cognitive, affective and psychomotor aspects. This opinion is supported by the ability to think critically and creatively a person can be seen through the ability to solve mathematical problems. Someone who thinks critically and creatively will be able to solve problems better because he is able to understand more deeply the problems at hand, plan more precisely and creatively, carry out plans in more detail and are better able to re-examine his work based on his ability to evaluate and self-regulation. Sumartini (2019) stated that Real Analysis is one of the fields of Mathematics providing problems with the solution using divergent thinking.

Fatimah (2019) states that divergent thinking is a combination of forming creative thinking patterns and creative thinking can be interpreted as a combination of logical thinking and divergent thinking based on intuition but still in awareness. When someone applies creative thinking in a problem solving practice, divergent thinking produces many useful ideas in solving problems. If so, then giving assignments in the form of problems designed as systematic projects will be able to familiarize students with intuition to think creatively. According to Ummah (2019), Sousa (2012) and Abidin et al (2018), one of the benefits of PjBL is showing higher student abilities. By using PjBL, we can observe students' creativity through various school mathematics learning media projects. Creativity is a process that produces novelty, which is useful, sustainable, or satisfying for people. Furthermore, Ummah (2019) and Fatmah (2019) stated that the increase in student creativity was related to aspects of originality, novelty and flexibility. The characteristics of the Project-based learning model include that students are faced with concrete problems, find solutions, and work on projects in teams to overcome these problems. According to Ariwibowo et al (2018) the steps of the Project-Based Learning learning model are as follows: (1) Opening the lesson with a challenging question (start with the big question); (2) Planning the project (design a plan for the project). Planning is done collaboratively between educators and students; (3) Develop a schedule of activities (create a schedule).

Based on the problems stated above, a learning model is needed to increase student creativity in solving math problems, namely a project-based learning model. The increase in

creativity is also based on the fulfillment of aspects of flexibility and novelty in good criteria, while aspects of originality meet the criteria of good enough. The project sheet to increase creativity is material for proving theorems related to limit material. Implementation of this model will begin with the formulation of learning objectives, preparation of project sheets and preparation of test sheets.

METHODS

The approach used in this research is descriptive qualitative with the steps (1) initial observation (2) studying the relevant literature, (3) preparing instruments, (4) designing project sheets (5) implementing project-based learning, (5) handling basic questions, (6) monitoring, (7) reviewing results, (8) evaluation, (9) interviewing, (10) data reduction, and (11) analyzing data.

Initial observations are carried out by studying the results of the initial tests given to students at the beginning of the semester. Test material is prerequisite material that has been studied by students. The results of the initial tests are used as guidelines in preparing project sheets.

Student project sheets are developed based on research development procedures. Student project sheets have been validated and practical in Puspa and Herawati's research (2021). The results of the validation and practicality are obtained that the project sheet is valid and practical. Development of project-based learning model design by studying research that has been done by researchers including; Hidayat (2020) developed a project based learning learning design on set material, Ummah (2019) developed a project based learning design for multimedia courses, and Sulistyaningrum (2019) developed a mathematics learning design on number pattern material.

The student project worksheets are divided into 2 parts, project activity 1 and project activity 2. The material for project 1 is an understanding of the definition of the limit of a sequence. As for project activity 2 is the theorem related to the Limit of the Sequence. Data collection techniques and instruments used in this study are as shown in Table 1.

Table 1. Data Collection and Research Instruments

No	Research Activity	Technique of collecting data	Learning Outcome
I	Pre-observation	Test , interview	To find out students' creative thinking skills before learning, use the project sheet
2	Implementation of project learning	Project Worksheet, Observation, Quotionaire Interview	Seeing the accuracy of students in completing the given project To find out how the steps taken by students in project completion

The test is carried out using student project sheets. Based on the indicators of creative thinking ability, as shown in table 2.

Table 2. Creative Thinking Ability Indicators and Assessment Scores

No.	Indicator	Score				
		0	1	2	3	4
1.	Eloquence	No answer	Giving one answer, but it has no reason	Gives one correct answer, but the reason is not right	Gives more than one correct answer, but the reason is not quite right	Giving more than one correct answer and complete reasons
2	Flexibility	No answer	Giving one answer, but it has no reason	Gives one correct answer, but the reason is not right	Gives more than one varied/different answer, but the reason is not quite right	Giving more than one varied/different answer accompanied by a complete reason
3	Renewal	No answer	Gives an answer in its own way but is incomprehensible	Gives an answer in its own way, but does not correspond to the concept in question and is not appropriate	Giving answers in their own way according to the concept in question, but less complete and precise	Giving answers in their own way according to the concept in question completely and precisely

Data on students' creative thinking ability were analyzed for each indicator using normalized gain scores<g>. Normalized gain score is a comparison of actual gain score with maximum gain score. The actual gain score is the gain score obtained by the student, while the maximum gain score is the highest gain score that the student may get. The formula of the normalized gain score is as follows :

$$< g >= \frac{T_1' - T_1}{T_{maks} - T_1}$$

Information :
<g> : *normalized gain score*
T1' : *postest score*
T1 : *pretest score*

Good learning if the normalized gain score is more than 0.4. According to Hake (2007) who was documented by Winata et al (2020), the normalized gain score is divided into three categories which can be seen in Table 3.

Tabel 3: Kriteria Skor Gain Ternormalisasi

Normalized gain score	Classification
0,00 < h ≤ 0,30	Low
0,30 < h ≤ 0,70	Moderate
0,70 < h ≤ 1,00	High

RESULTS AND DISCUSSION

The implementation of project-based learning takes place during the even semester of the 2021/2022 academic year. The subject is a student majoring in mathematics education who attends real analysis lectures. Students are given a test at the beginning of the lecture with test material on basic concepts in real analysis that they have learned before, namely: the properties of real numbers. The discussion should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Furthermore, project-based learning is carried out. Students work on projects in groups. Furthermore, the results of student project work are scored based on creative thinking indicators. Results can be seen in figure 1.

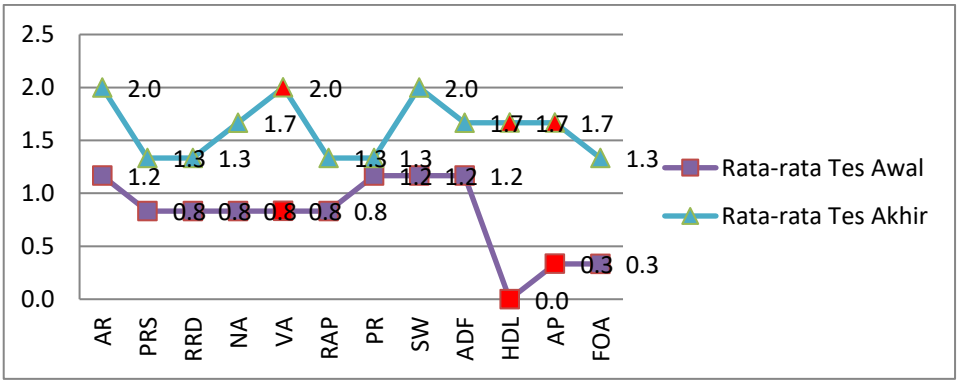

Figure 1. Students' Early and Final Test Scores of Creative Thinking Ability

From Figure 1, it can be seen that when compared, the average final test score of each student always increases from the average initial test score.

Furthermore, a normalized gain score was seen for the study sample as shown in Figure 2.

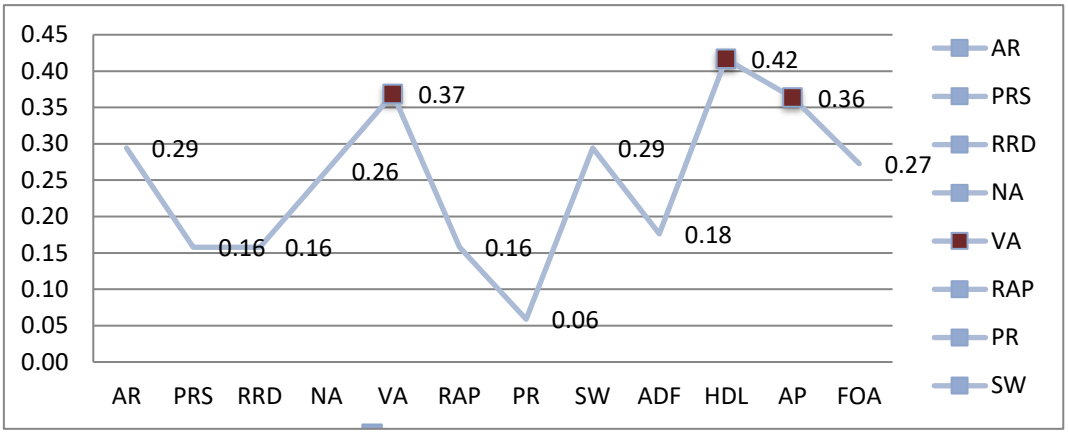

Figure 2. Normalized Gain Score for Each Sample

Based on Figure 2 students who are in the medium category, there are 3 people, namely students with dots on the red chart. For example, HDL students, although at first the student got the lowest score of 0, but because the score increased quite rapidly to 1.7, making the student fall into the medium category.

After being classified, the percentage of students who fall into the low, medium and high categories as shown in Figure 3 is obtained.

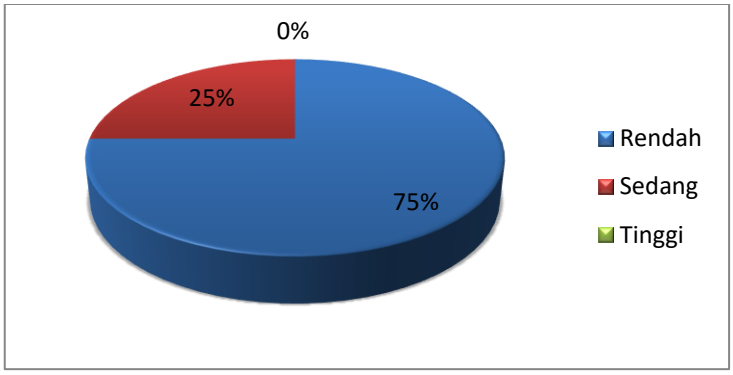

Figure 3. Percentage of Students Who Classified in the Low, Medium and High

From Figure 3, it can be seen that 75% of students are in the low category and the rest (25%) are in the medium category. It can also be seen that there is not one student who is in the high category.

The results of the calculation of normalized gain scores for each research sample such as figure 2 When compared the conditions before and after learning for the three indicators obtained results such as Figure 4.

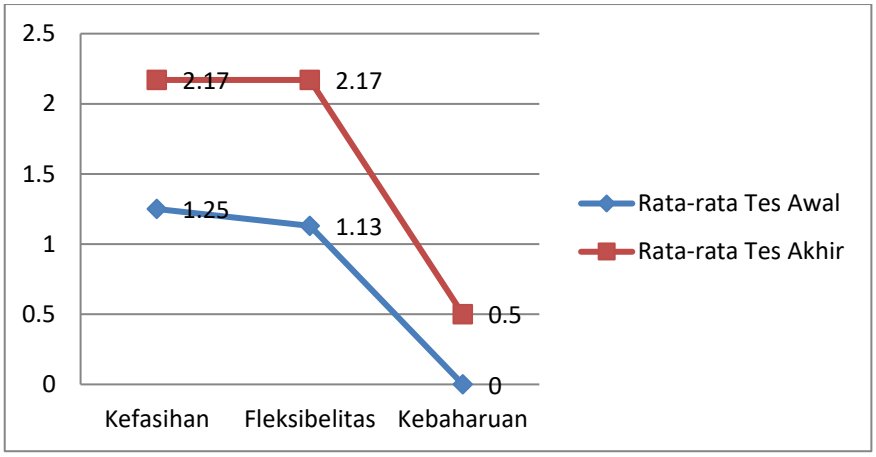

Figure 4. Comparison of Average Starts and Ending Tests for All Three Indicators

The Real Analysis course is one of the compulsory courses in the curriculum of the Mathematics Education Study Program. The expected competence after studying real analysis material is that students have the ability to analyze definitions. Properties and theorems.

The experience of researchers teaching in the Mathematics education study program in the real analysis course, students tend to choose to solve routine problem problems as previously done. This makes students unfamiliar with problem solving that can develop a more mindset.

Problem solving carried out by students is characterized by the student's ability to understand and plan its solution. Narrowly understand in the sense of knowing what is known and what is asked. Indicators of student success in solving given problems are not carried out numerically. Understanding and planning the resolution of a problem requires an adequate creative thinking ability, because this ability is a high-level thinking (reasoning) ability after basic thinking and critical thinking. This is in line with the opinion of Hasanah, Haerudin (2021) that in creative thinking students learn to see problem solving from various points of view and learn to find innovative answers and can solve problems in various ways. In addition, Siregar, Rama Nida (2021) also stated the relatively same thingthat in creative thinking a person will go through the stages of synthesizing ideas, also giving birth to new concepts that are much more perfect in planning ideas and implementing these ideas so as to produce something new.

Such circumstances as students can obtain through the project-based assignment completion process. Some of the things that are indicators of the habituation of students' creative thinking in completing this task are shown by the existence; a) students understand

problem information, namely showing what is known and what is asked, b) solving 1 problem given with various answers (fluency), c) solve the problem in 1 way, then in another way and the student gives an explanation of the various methods of solving it (flexible), d) checking the answers with various answers with various methods of solving, then creating new different methods.

Based on the results of solving the project problem, it was found that as many as 75% of students have the ability to think creatively in the low category. This is identified based on the indicators, students are still not fluent and flexible in answering the questions given. Most students are only able to give one answer or not give an answer at all. In addition, students have not been able to provide novelty for a settlement and tend to still imitate the completion described in sourcebooks and learning resources from the internet. This shows that students are still not creative in finding solutions to mathematical problems. This is similar to what was revealed by Hasanah M & Haerudin (2021) that students' creative thinking ability is still low in solving math problems.

Furthermore, from the results of the completion of the project that 25% of students or as many as 3 students are in the moderate category. In this category, students are quite fluent and flexible in providing answers. Students are able to give more than one answer, but cannot give an exact reason why the answer was chosen in the settlement. But for this category, students are also still unable to show a novelty in solving problems. This is also in line with the results of research by Hasanah M & Haerudin (2021) which found that students have not been able to find unique or new answers according to novelty indicators. According to Marliani (2015) the indicator of novelty means being able to create new and unique expressions and being able to choose other ways of thinking over others. This condition is due to the limitations of students in finding references that are in accordance with the material. The following is an overview of the types of references referred to by students in figure 5.

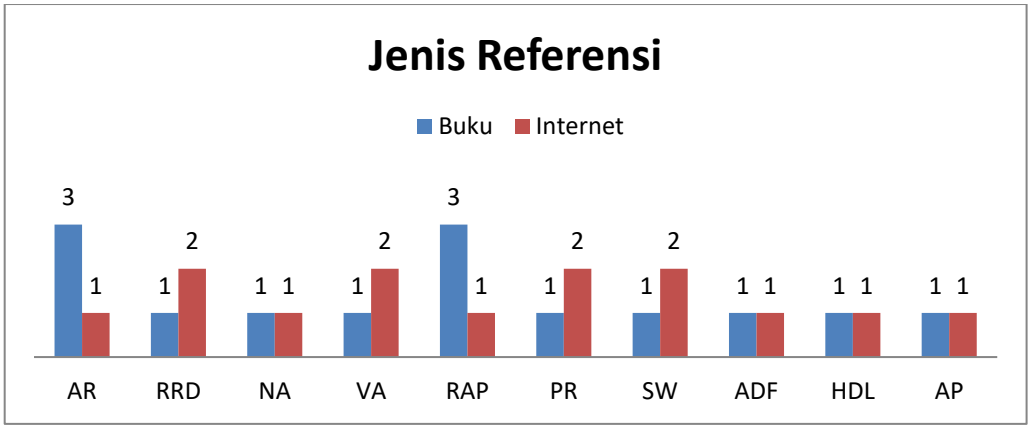

Figure 5. The type of Reference that students refer to.

In general, the application of PjBl in real analysis learning tends to increase from before and after the implementation of such learning. This can be measured by the results of the initial test and the final test given to test the competence and understanding of students in this course which can be seen in Figure 4. Based on the three indicators measured in analyzing the creative thinking ability of students, they still have weaknesses in showing a novelty in solving problems. Therefore, it is necessary to carry out a follow-up so that students' creative thinking skills will increase.

CONCLUSION

Based on the results of the study obtained conclusions: (1) From the 12 students who took part in the Real Analysis lecture, students' thinking ability was 75% low, and 25% moderate. 2. When compared with the conditions before learning for the three indicators, namely 1.25, 1.13, and 0 with after learning there was an increase of 2.17, 2.17 and 0.5.

Because of that it is hoped that further research will be carried out on the ability to think creatively and efforts to improve each indicator as measured by using varied learning models.

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