Mathematical representation ability through geogebra-assisted project-based learning models

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Abstract. The purpose of this study is to analyse the achievement, improvement, and achievement of indicators of mathematical representation ability between students who obtain a project-based learning model assisted by GeoGebra and students who get a project-based learning model. The research method used in this study is quasi-experimental with a non-equivalent comparison group design. The subjects in this study were students of the Department of Mathematics Education in the second semester of the academic year 2018-2019 at Universitas Suryakancana. The research instrument used was a mathematical representation ability test and the Group Embedded Numbers Test (GEFT). Analysis of the data used is the normality test, the Mann Whitney test, and the percentage of achievement indicators. As a result, the achievement and improvement of the mathematical representation ability of students who obtained a project-based learning model assisted by GeoGebra were better than students who obtained a project-based learning model, the achievement of the mathematical representation ability of students in the experimental group were good categorized, the control group was categorized sufficiently, the experimental group with field-independent and field-dependent cognitive style were categorized as good, the control group with field-independent and field-dependent cognitive styles was considered sufficient.

1. Introduction
The problems found when researching in the Department of Mathematics Education Universitas Suryakancana in 2017 namely (1) Students still experience difficulties and errors in solving integral calculus problems due to lack of mastery of concepts; (2) Students still make mistakes in drawing pictures/graphs of functions that explain Integral; and (3) Difficulties in solving mathematical problems relating to the application of integral calculus.

Some students are still weak in their ability to illustrate pictures [1]. Some students do not have the visual ability to rely more on the ability of memory/memorization so that it is low in algebraic and graphical representations as well as their effect on analytic abilities [2]. This is a serious problem in solving problems. Weaknesses in solving problems due to obstacles drawing graphics in calculus [3]. There are some similar difficulties in differential calculus, namely drawing graphs of incorrect functions/difficulties [4]. Specifically explained that the error in determining the upper and lower limits of the integral if the problem is not known the integral limit, so it must draw a graph in determining the area of the integral. The majority of students make mistakes determining the upper and lower limits of the integral [5]. The main focus in solving problems related to integral calculus is to focus on how to make students interpret the definition of integrals, understand the concept of integrals, use theorems, draw and calculate the area of integrals. This is considered to be able to solve the main problems experienced by students.
Some students experience difficulties with integral concepts [6]. This is similar to the problems experienced by students in the Department of Mathematics Education Universitas Suryakancana. The majority of students only use the formula directly in solving problems, regardless of understanding the concept of integral definition at the beginning [7]. Therefore, how to find ways for students to understand integral concepts in a meaningful way and not just memorize the formula.

Also, several approaches through visualization/representation in the form of images will facilitate students in understanding integral concepts [8,9]. This was stated in previous research. Problems that are often discussed in the world of education are related to visual abilities and mathematical analytic thinking [10]. In the research that have been carried out, students use very technically insufficient ways to understand the concepts of regional and integral area. Furthermore, to improve the understanding of concepts, other researchers recommend special attention to visualization [11]. So that it influences the resolution of problems about determining the area of the integral area.

The problem of visualization ability to the integral folding problem is the main thing. The link between visualization and representation is very important. The essence of integral concepts including other mathematical concepts is that process concepts and object concepts can be presented by connected but distinct representations [12]. Several research has shown that representations used by students to solve integral problems are related to the meaning of their attributes with integral concepts [13]. Certain integral graphical representations are usually used in calculations involving areas under the curve, whereas numerical representations are used for Riemann problems besides cumulative. Integral solving using general integration techniques indicates symbolic representation is needed.

The ability of students to use relationships between representations to solve problems is required [14–16]. Understanding of the concept of integral research is done by doing a representational approach. This needs to be highlighted as the cause of the lack of coordination between graphics and algebraic representations. This leads us to pay special attention to the use of graphical representations and visualizations. Therefore, the ability of mathematical representation is a major problem in understanding integral calculus courses.

Innovative learning models are needed in every integral calculus lecture[17]. Many of which are possible are Project-Based Learning Models assisted by GeoGebra. The Project-Based Learning model assisted by GeoGebra is a learning model that provides an opportunity for lecturers to manage to learn in the classroom by involving project work assisted by GeoGebra software. Project work contains complex tasks based on problems as the first step in gathering and integrating new knowledge based on experience in real activities and demanding students to design, solve problems, make decisions, conduct investigations, and provide students with opportunities [18,19] to work independently or in groups. The final result of the project work is a product in the form of project results in the form of GeoGebra.

The advantages of the Project-Based Learning Model assisted by GeoGebra are that it can make students more independent in learning, explore abilities in technology, facilitate solving problems, and assist in mathematical representation and connection abilities [7,20,21]. In several previous research, an improvement in mathematical representation ability was caused by the use of student center learning, including using a project-based learning model [17]. The combination of learning models with the use of media and multimedia with Macromedia flash applications and offline GeoGebra on some mathematics material in secondary schools can improve mathematical representation ability [22–24]. In this study, the application of GeoGebra is used as a tool, and Integral Calculus material in each lecture is rarely delivered and researched by lecturers. Research using the GeoGebra application is still rarely used by teachers/educators [25,26]. Likewise, the provision of material with GeoGebra is still rare by lecturers. The difference between this research and previous research is to use a merger of project-based learning with the help of GeoGebra. The material studied about integral calculus is still rarely studied.

Also, cognitive style factors serve as a differentiator of this study with previous research. One of the internal variables of students that need to be considered in any learning approach is the cognitive style that is a learning style that is influenced by the students' perceptual and intellectual views[27]. Witkin, Moore, Goodenough, and Cox classify two types of cognitive styles namely the global one called the field-dependent cognitive force (FD) and the analytic one called the independent field cognitive style (FI). Individuals with a cognitive style of FD tend to be bound by their surroundings or environment, whereas individuals with a cognitive style of FI can distinguish objects from the
surrounding context. Everyone has both kinds of cognitive styles namely FD and FI, however, one of them is always more dominant [28–30].

Also, the cognitive style is consistent and can affect almost all student activities related to cognitive and affective aspects. Thus, cognitive style is thought to influence student strategy in understanding the lesson or in how it is learned [31]. However, that does not mean that cognitive styles are superior to other cognitive styles. Knowledge of one's cognitive style tends to help students in their successful learning [32].

Based on the explanation above, the purpose of this research is to examine the achievement and improvement of mathematical representation capabilities between students who obtain GeoGebra-assisted project-based learning models and students who obtain project-based learning models, and analyze the achievement indicators of mathematical representation abilities of students who obtain project-based models GeoGebra-assisted learning and project-based learning models in terms of a) Overall; b) Cognitive Style (Field Independent (FI) and Field-dependent (FD)).

2. Method

This type of research is a quantitative method. The research method used in this research is quasi-experimental. The quasi-experimental research design used in this research took the form of non-equivalent comparison group design which involved two groups, namely the experimental group and the control group [33]. Before treatment, the two groups of students were categorized based on cognitive style namely independent and dependent fields using the Group Embedded Figures Test (GEFT). After that, a pre-test is conducted to determine the initial ability. After treatment, a post-test and questionnaire were given.

The subjects in this research were students in the Department of Mathematics Education semester 2 the academic year 2018-2019 at Universitas Suryakancana. There are 2 classes namely experimental group (N= 22) and control group (N=23). The sampling technique uses purposive sampling. On the subject of this research, both the experimental group and the control group will be classified based on cognitive style, namely independent field (FI) and the dependent field (FD). So there are 4 groups, namely the experimental group with independent field cognitive style, the control group with independent field cognitive style, the experimental group with field-dependent cognitive style, and the control group with field-dependent cognitive style.

The instruments in this research consisted of tests and non-tests. The test in this research uses a pre-test and post-test mathematical representation ability and Group Embedded Figures Test (GEFT). Referring to the research method and design, the tests were conducted twice, namely pre-test and post-test. Research material relating to integral calculus courses. The test used in this research is a test in the form of a description. Based on the results of the face validation and the content of the mathematical representation ability test, the test instrument has been valid and reliable so it is suitable to be used as a research instrument. Quantitative data analysis used is the normality test, Mann Whitney test, and the percentage of achievement indicators.

3. Result and Discussion

3.1 Achievement of students' mathematical representation ability

Post-test data analysis was conducted to determine which was better between achieving the mathematical representation ability of the experimental group students and the control group students after each given a different treatment. Based on the results of the normality test using SPSS 24 software, the average value of the post-test of the experimental group was 18.09, while the average value of the post-test of the control group was 13.65. The results of the normality test using the Kolmogorov-Smirnov test obtained sig values. The experimental group by 0.008 < 0.05 and the value of sig. the control group by 0.010 < 0.05, the post-test data of the experimental group and the control group were not normally distributed. Then the nonparametric test is performed with the Mann Whitney test.

Student's mathematical representation ability is measured by Mann Whitney test, as has been done in other studies where the sample is from an non-normal distribution [34]. In this study Mann Whitney test calculations using SPSS 24 software. While the calculation results can be seen in table 1.
Table 1. Mann Whitney test results post-test test data

|              | Post-test |
|--------------|-----------|
| Mann-Whitney U | 521.000   |
| Wilcoxon W    | 327.000   |
| Z             | -4.613    |
| Asymp. Sig. (2-tailed) | 0.000    |

Based on Table 1, because of asymp. sig. (2-tailed) = 0.000 < 0.05, $H_0$ is rejected. It can be concluded that the achievement of mathematical representation ability of students who get GeoGebra-assisted project-based learning models is better than students who obtain project-based learning models. This is because the GeoGebra-assisted project-based learning model makes it easy for students to illustrate in the form of images [35]. In the process, the combination of project-based learning and GeoGebra models provide opportunities for students to collaborate with their respective groups. After the lecturer gives direction and material in face-to-face lectures, students are given time to work on their projects with the help of GeoGebra.

Table 1 shows that the students have begun to adapt to the learning model. Students who use GeoGebra-assisted project-based learning models find it helpful to combine the learning model and the GeoGebra application used. The role of GeoGebra in this learning model as a tool for students when the learning process takes place. GeoGebra will assist students in presenting visually in the work process starting from the stages of project planning, testing results, and evaluating experiences[9,21]. In line with some previous research, that learning mathematics using GeoGebra can influence the ability of mathematical representation and can be improved mathematical representation ability [14,36–38].

Table 2. Categories of achieving mathematical representation ability

| Category of Mathematical Representation Ability | Group | Experiments | Control |
|------------------------------------------------|-------|-------------|---------|
| High                                           | 68%   | 23%         |         |
| Medium                                         | 32%   | 41%         |         |
| Low                                            | 0%    | 41%         |         |

Based on Table 2, it was found that the achievement category of the mathematical representation ability of the experimental group was high by 68% and medium by 32%. While the achievement of the mathematical representation ability of the high control group is 23%, medium 41%, and a low 41%. In the experimental group, the achievement of mathematical representation ability was mostly dominated by the high category, while the control group was mostly in the high category.

Table 2 shows that the effect of the learning model is very dominantly felt, even though both are using the project-based learning model. Only different in the media assistance provided, namely in the control group using GeoGebra as a helpful tool. This means that the media greatly influences the achievement of students' mathematical representation abilities [39,40]. In line with several studies that have been conducted, that the ability of student representation depends on the learning model provided and the combination of learning models with GeoGebra has a positive impact on students in the process of working on their projects [41].

In Figure 1 it can be seen that 80% of the experimental group with the field-independent cognitive style are in the high category, 58% of the experimental group with the field-dependent cognitive style are in the high category, the other groups are in the 50% and below are in the high, medium, and low categories.
The individual cognitive style has an influence, but seen from Figure 1 the effect is not too large on the achievement of students’ mathematical representation ability. Dominance is still influenced by the treatment given and the media given. The difference in the learning model used still provides a large enough dominance of the effect. Students from the control group with field-independent cognitive styles have a high category of 50% or part of the group and have a medium category of 25% or a quarter of the group. The project-based learning model for the control group can improve the initial conditions or pre-test. However, in Figure 1 the results are not optimal because they do not use the GeoGebra application tool.

Figure 1 shows that the important role of GeoGebra is seen so that students are encouraged to work on their projects from the material on integral calculus given. The experimental group and the control group students used the same learning model. However, it is the role of GeoGebra that distinguishes it because students if it is difficult to draw can be assisted by GeoGebra, as well as checking manually and automatically so that it synchronizes [35,42]. This student with the help of GeoGebra makes it easy to work on the projects that are given.

The achievement of mathematical representation ability is directly influenced by the application of the project-based learning model assisted by GeoGebra [20]. Experimental group students dominate the ability to represent from visual form to everyday problems. While the minimal achievement of students is in representing the form of daily problems to the form of mathematical expression. This achievement is due to the effectiveness of the learning model used. GeoGebra is a tool that helps students visually visualize from everyday problems well. In several research conducted, GeoGebra has succeeded in assisting students in working on problems of mathematical representation ability. The Project-Based Learning Model assisted by Geogebra is a learning model that provides an opportunity for lecturers to manage in the classroom by involving project work assisted by GeoGebra software. Project work contains complex tasks based on problems as the first step in gathering and integrating new knowledge based on experience in real activities and demanding students to design, solve problems, make decisions, conduct investigations, and provide students with opportunities, to work independently or in groups. The final result of the project work is a product in the form of project results in the form of GeoGebra. Several research has shown that GeoGebra can drive the process of student discovery and experimentation in the class [21,43]. Its visualization features can effectively assist students in proposing various mathematical conjectures [44].

### 3.2 Improvement of students’ mathematical representation ability

Gain index data analysis is performed to determine which is better between increasing the mathematical representation ability of the experimental group students and the control group students after each given a different treatment. Based on the results of the normality test using SPSS 24 software, the average value of the experimental group gain index is 0.53, while the average value of the control group gain index is 0.30. The normality test results using the Kolmogorov-Smirnov test obtained sig values.
experimental group was $0.010 < 0.05$ and the value of sig. the control group at $0.010 < 0.05$, the gain index data of the experimental group and the control group were not normally distributed. Furthermore, the nonparametric test was carried out with the Mann Whitney test.

Improvement of students' mathematical representation ability is measured by performing the Mann Whitney test, as has been done in other studies where the sample is from an non-normal distribution [34]. In this study Mann Whitney test calculations using SPSS 24 software. While the calculation results can be seen in table 3.

| Table 3. Mann Whitney Test Results Gain Index Data |
|-----------------------------------------------|
| Gain Index                                    |
| Mann-Whitney U                                | 67.000 |
| Wilcoxon W                                    | 343.000 |
| Z                                             | -4.227 |
| Asymp. Sig. (2-tailed)                        | 0.000  |

Based on Table 3, because of asymp. sig. (2-tailed) $= 0.000 < 0.05$, $H_0$ is rejected. It can be concluded that increasing the mathematical representation ability of students who obtain GeoGebra-assisted project-based learning models is better than students who obtain project-based learning models.

Table 3 shows that the Project-Based Learning model assisted by GeoGebra is a learning model that provides an opportunity for lecturers to manage to learn in the classroom by involving project work assisted by GeoGebra software. Project work contains complex tasks based on problems as the first step in gathering and integrating new knowledge based on experience in real activities and requiring students to design, solve problems, make decisions, conduct investigations, and provide students with opportunities to work independently or in groups. The final result of the project work is a product in the form of project results in the form of GeoGebra.

Table 3 shows that the success of student projects is influenced by lecturers' didactic competencies, for example, preparation of meaningful assignments and student involvement. This proves that the involvement of motivated students in project assignments leads to higher levels of responsibility and produces the best results possible. Jolanta Lasauskiene and Asta Rauduvaite in their research results concluded that when implementing Project-Based Learning there was a development of student competencies, the collaboration between lecturers and students, lecturer professional development [19]. The role of GeoGebra in this learning model as a tool for students when the learning process takes place [39]. GeoGebra will assist students in presenting visually in the work process starting from the stages of project planning, testing results, and evaluating experiences. In line with previous research, that learning model that helps multimedia will improve the ability of mathematical representation [9,35,45].

3.3 Achievement of student mathematical representation ability indicators
In Figure 2, the average achievement indicator of students' mathematical representation ability has different values, namely for the experimental group by 75.38%, and for the control group by 56.88%. Achievement indicator of mathematical representation ability in the experimental group which is achieved by most students is to represent from the visual form to the daily problems of 90.91%, represent the visual form to the form of mathematical expression of 89.77%, and represent the form of a mathematical expression to the visual form of 77.27%. The achievement indicator of mathematical representation ability in the control group which is achieved by most students is to represent from the visual form to the form of mathematical expression of 77.10%. The achievement of indicators of students’ mathematical representation ability for the good experimental group category and the control group categorized as sufficient.
In Figure 2, achievement in the experimental group is good. Indicators of mathematical representation ability from visual forms to everyday problems are achieved by students very well. Students can translate from the form of graphic images given to the forms of everyday problems they know [3]. The ability of mathematical representation of experimental group students is also seen from the ability to represent from visual form to mathematical expression. This is because students feel helped by GeoGebra. GeoGebra makes it easy for students to visualize from algebraic mathematical models to images as well as from images to algebraic mathematical expressions [7]. The learning process with the project-based learning model also has a good impact on students [19]. Project-based learning aided by computer-based applications makes students more independent but still focused [46].

3.4 Achievement of student’s mathematical representation ability indicator judging from the cognitive style

Table 4 shows that the average achievement indicator of mathematical representation ability of experimental group students with field-independent cognitive style was 77.08%, the experimental group with field-dependent cognitive style was 73.96%. The difference is not too significant. While the control group with the field-independent cognitive style was 63.02% and the control group with the field-dependent cognitive style was 53.61%.

Table 4. Achievement indicators of students’ mathematical representation ability in terms of cognitive style

| Indicator                                      | Experiments Group | Control Group |
|------------------------------------------------|-------------------|---------------|
|                                               | FI                | FD            | FI              | FD              |
| Visual to mathematical expression             | 90.00 %           | 89.58 %       | 81.25 %         | 75.00 %         |
| Mathematical expression to visual             | 80.00 %           | 75.00 %       | 56.25 %         | 60.00 %         |
| Daily problems to mathematical expressions    | 70.00 %           | 52.08 %       | 50.00 %         | 48.33 %         |
| Mathematical expression to daily problems    | 65.00 %           | 62.50 %       | 50.00 %         | 53.33 %         |
| Daily problems to the visual                  | 70.00 %           | 70.83 %       | 68.75 %         | 43.33 %         |
| Visual to the Daily Problems                  | 87.50 %           | 93.75 %       | 71.88 %         | 41.67 %         |
| Average Achievement                           | 77.08 %           | 73.96 %       | 63.02 %         | 53.61 %         |

Note: FI: Field Independentcery style, the experimental group with field-dependent cognitive style, the control group with field-independent cognitive style can already represent from the visual form to the form of mathematical expression and can represent from the visual form to the form of everyday problems very well. the achievement of indicators of mathematical representation ability of students in the experimental group with independent and field-dependent cognitive styles is categorized as good, the control group with independent and field-
dependent cognitive styles. Cognitive style affects the human ability to think further [23]. Actions taken are in the human habit of doing things [32]. This is also shown in terms of students' mathematical representation ability, where the field-independent cognitive style factor becomes students becoming more independent and not dependent on others [47]. Also, in terms of work assignments, students always try to be responsible and find information well. Whereas students with field-dependent cognitive styles, make students more dependent on others, is waiting, and feeling less responsible [31]. Thus affecting the learning outcomes.

4. Conclusion

Based on the results and discussion that have been explained clearly, it can be concluded that the achievement and improvement of the mathematical representation ability of students who get a project-based learning model assisted by Geogebra are better than students who obtain a project-based learning model, the achievement of indicators of students' mathematical representation ability for the good experimental group category and the control group categorized as sufficient, and the achievement of indicators of mathematical representation ability of students in the experimental group with independent and field-dependent cognitive styles is categorized as good, the control group with independent and field-dependent cognitive styles.

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