The effectiveness of project-based learning assisted by digital module toward mathematical connection ability

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Abstract. The aim of the study is to analyze the effectiveness of Project-Based Learning assisted by digital module in increasing students' mathematical connection ability. The study was conducted using quantitative method with quasi experimental design. The study population was the mathematical connection ability of grade XI students of SMK Negeri 1 Kandeman with the mathematical connection ability of students of grade XI TAV 1 and XI TITL as the sample. The result showed that Project-Based Learning assisted by digital module was effective in increasing students' mathematical connection ability. Learning is carried out through virtual meeting. The digital module contains the design of student activities in the implementation of Project-Based Learning according to indicators of the mathematical connection ability. The learning activity was recorded and a link to access the recording was shared to students so that it could be used as learning material.

1. Introduction

This study was motivated by the results of the initial observation of the mathematical connection ability at SMK Negeri 1 Kandeman. Initial observation was made on 35 students of SMK Negeri 1 Kandeman. Initial observation data shows the average of 57.94 with the proportion of students who attain the minimum learning completeness of 60 is 42.86%. Based on this condition, the students' mathematical connection ability in the category is sufficient. This condition needs to be improved again.

Mathematical connection ability is the ability to understand and associate relationships between mathematics topics or mathematical topics with other topics outside mathematics, and to use these relationships \[1-3\]. Mathematical connections are schematic components that are connected in structured mental networks as links between mathematical ideas, just like spider webs \[4-5\]. Low mathematical connection ability will affect the quality of learning which can lead to low mathematics learning achievement \[6\].

There are five mathematical connection indicators, namely (1) inter-topic connection in one mathematical material being studied; (2) the connection between the topic in the material being studied and other material in mathematics that has been studied; (3) connection between mathematics topics and other subjects other than mathematics; (4) connection between math topics and everyday life; (5) the connection between the topic of mathematics and technology \[7\].

Mathematical connection supports students to understand material substantially, help improve understanding, and describe the relationships between concepts, data and situations, and can expand
students' thinking skills in mathematics [7-8]. It should be noted that teachers' low mathematical connection skills affect students' opportunities to make meaningful mathematical connection [9].

The digital module can be used in learning. The digital module is a form of presenting independent learning materials that are systematically arranged into specific learning units, which are presented in an electronic format. The use of digital module in learning independently can develop learning steps, needs, and abilities that affect student learning outcomes [10-11]. The advantages of using digital module in learning are that they are attractive, easy to understand, easy to use, and can contain various features such as videos, can be used anywhere and anytime, and student learning outcomes can be adjusted according to student abilities [12-14]. This digital module is opened with a smartphone. The use of smartphone can facilitate students in active learning without direct instruction from the teacher, learning without restrictions on time and place [15].

Project-Based Learning assisted by digital module can be used as an alternative to increase students' mathematical connection ability. Project-Based Learning is a learning model that involves knowledge exploration when students work on projects over a certain period of time [16]. Project-Based Learning is in line with the implementation of the 2013 curriculum at SMK Negeri 1 Kandeman. The steps for project-based learning are (1) starting with essential questions, (2) designing project planning, (3) compiling a schedule, (4) monitoring project progress, (5) testing the learning process and outcomes, and (6) experience evaluation [17].

It is necessary to conduct study on Project-Based Learning assisted by digital module. The study objective was to analyze the effectiveness of Project-Based Learning with digital modules in increasing mathematical connection ability.

2. Method
The study was conducted using a quasi-experimental method with a nonequivalent control group design. The study was conducted at SMK Negeri 1 Kandeman Batang Central Java in the 2019/2020 academic year. The population of the study conducted was the mathematical connection ability of grade XI students of SMK Negeri 1 Kandeman in the 2019/2020 academic year. The sample of this study was the mathematical connection ability of students of grade XI TAV 1 as an experimental class by implementing Project-Based Learning assisted by digital module and grade XI TITL as a control class by implementing Project-Based Learning which was determined by random sampling.

The research instrument was the mathematical connection ability test (MCAT) questions and the learning implementation observation sheet. The research data were tested using the normality test, homogeneity test, average completeness test, proportional completeness test, two-mean difference test, and gain test.

3. Results and Discussion
The effectiveness of Project-Based Learning assisted by digital module in this study includes three stages, namely (1) planning and preparation, (2) learning implementation, and (3) learning evaluation. Project-Based Learning assisted by digital module is said to be effective in increasing students' mathematical connection ability if at the stage (1) planning and preparation, the results of the validation of learning instruments are said to be valid; (2) the learning implementation, the observation result of the learning implementation with the minimum categorized as good; and (3) learning evaluation, Project-Based Learning assisted by digital module is said to be effective with the criteria (a) the average mathematical connection ability of students in Project-Based Learning assisted by digital module attains minimum learning completeness 60, (b) proportion students who achieved minimum learning completeness in Project-Based Learning assisted by digital module were more than 75%, and (c) the average mathematical connection ability of students in Project-Based Learning assisted with digital modules was better than the average mathematical connection ability of students in Project-Based Learning.

Since March 16, 2020, learning has been held through learning from home due to the Covid-19 pandemic. The learning can be carried out online or offline. Online learning can be implemented through
virtual meeting or a learning management system, while offline learning can be carried out by visiting teachers to students' homes or using television and radio. Learning during a pandemic needs to be done in an interesting way, for example using learning software or videos [18].

At the planning and preparation stages, validation of learning instruments and research instruments was carried out. Learning instruments and research instruments are said to be valid if the average score is in the good or very good category. The validation result of the learning instruments and research instruments are presented in table 1 below.

| Instrument                                      | Score | Category  |
|-------------------------------------------------|-------|-----------|
| Syllabus                                         | 4.37  | Very good |
| Lesson plan                                      | 4.25  | Very good |
| Student worksheet                                | 4.17  | Good      |
| Digital module                                   | 4.17  | Good      |
| Initial MCAT question                            | 4.17  | Good      |
| Final MCAT question                              | 4.17  | Good      |
| Learning implementation observation sheet         | 4.00  | Good      |

According to the validation result in table 1, it was found out that the learning instruments and research instruments in Project-Based Learning assisted by digital module to the mathematical connection ability of vocational students were in very good and good categories. Based on these results, it can be concluded that the learning instruments and research instruments in Project-Based Learning assisted by digital module can be used in research in effort to explore students' mathematical connection ability.

To support the implementation of virtual learning, the researcher prepared the tools needed for virtual learning, namely (1) compiling a virtual learning plan, (2) creating a WhatsApp social media group as a medium for communication and learning information, (3) creating an online attendance list using Google Forms, (4) preparing the Google Meet application as a virtual learning tool, (5) making a guide to using the Google Meet application for virtual learning, and (6) filling in a virtual learning schedule on the Google Calendar so that researcher can get a virtual meeting link on Google Meet to be shared with students via WhatsApp.

At the learning implementation stage, observations of learning activities are carried out during the Project-Based Learning assisted by digital module. Observation of learning activities is carried out by using the learning implementation observation sheet. Furthermore, the results of these observations are analyzed to determine the quality of the implementation of learning. The implementation of learning is assessed based on the suitability of the implementation of Project-Based Learning assisted by digital with the learning plan contained in the lesson plan. The observation result of the learning implementation is presented in table 2 below.

| Meeting | Score | Category |
|---------|-------|----------|
| I       | 4.32  | Very good|
| II      | 4.39  | Very good|
| III     | 4.45  | Very good|
| IV      | 4.43  | Very good|
| V       | 4.49  | Very good|
| VI      | 4.55  | Very good|
According to the observation result of the learning implementation in table 2, it is found that the average score of learning implementation at each meeting is very good. Based on these results it can be concluded that the implementation of Project-Based Learning assisted by digital module can explore students’ mathematical connection ability.

Learning is carried out according to the steps in implementation guidelines of learning from home, namely (1) checking attendance and making sure students are ready to take part in learning, (2) inviting students to pray before and after learning, (3) implementing learning according to scenarios of Project-Based Learning assisted by digital module, and (4) giving students the opportunity to ask questions and reflect. Activities during this virtual learning are recorded, then the results of the recorded learning are shared to students to be studied again or as learning material for students who do not participate in virtual learning. Researcher uses Google services in the form of Google Meet for virtual meetings which contains recording facilities, as well as Google Drive and Youtube which are integrated with Google to share recordings. This Google services can be used because it is the facilities that is integrated with the Google Suite for Education account owned by researcher as a student of Universitas Negeri Semarang.

The result of the mathematical connection ability test is presented in table 3 below.

| Indicator                   | Score  |   |
|-----------------------------|--------|---|
| The highest score           | 84.00  | 88.00 |
| The lowest score            | 44.00  | 36.00 |
| Average                     | 66.33  | 59.03 |
| Proportion of completeness  | 77.78% | 57.58% |

Before the effectiveness test is carried out, the data is tested first with a normality test and a homogeneity test. Based on the test results, it was found that the data were normally distributed and homogeneous. Furthermore, testing the effectiveness of Project-Based Learning assisted by digital module in the form of the average completeness test, the proportion completeness test, the two-mean difference test, and the gain test.

The calculation of the average completeness test results in \( t_{\text{count}} = 3.331 \) and \( t_{\text{table}} = 1.688 \) with the test criteria, namely accept \( H_0 \) if \( t_{\text{count}} \leq t_{\text{table}} \) with a significance level of 5% and \( df = n - 1 \). Based on these results, because \( t_{\text{count}} > t_{\text{table}} \) then \( H_0 \) is rejected, it means that the average is more than 60. It can be concluded that the average mathematical connection ability of students who receive Project-Based Learning assisted by digital module is more than 60.

The calculation of the proportional completeness test results in \( z_{\text{count}} = 0.3849 \) and \( z_{\text{table}} = 0.1736 \) with the test criteria, namely reject \( H_0 \) if \( z \geq z_{1-\alpha} \) with a probability \( \left( \frac{1}{2} - \alpha \right) \) and a significance level of 5%. Based on these results, because \( z_{\text{count}} > z_{\text{table}} \), \( H_0 \) is rejected, it means that the proportion of students who achieve minimum learning completeness is more than 75%. It can be concluded that the proportion of students who achieve minimum learning completeness in Project-Based Learning assisted by digital module is more than 75%.

The calculation of the difference between the two average results obtained \( t_{\text{count}} = 2.828 \) and \( t_{\text{table}} = 1.671 \) with the test criteria, namely accept \( H_0 \) if \( t < t_{1-\alpha} \) with \( df = (n_1 + n_2 - 2) \), probability \((1 - \alpha)\), and significance level of 5%. Based on these results, because \( t_{\text{count}} > t_{\text{table}} \), \( H_0 \) is rejected, it means that the average of the experimental class is more than the average of the control class. It can be concluded that the average mathematical connection ability of students who receive Project-Based Learning assisted by digital module is more than the average mathematical connection ability of students who receive Project-Based Learning.

Calculation of the normalized gain test obtained an experimental class gain score of 0.3486 with the medium category and the control class gain score of 0.2257 with the low category. After testing the
normality and homogeneity of the gain scores with the results of the gain scores being normally distributed and homogeneous, then the significance test is carried out. Based on the calculations obtained $t_{\text{count}} = 2.462$ and $t_{\text{table}} = 1.671$ with a significance level of 5%. According to this result, because $t_{\text{count}} > t_{\text{table}}$, $H_0$ is rejected, it means that there is a difference between the two averages. It can be concluded that there is a significant difference in effectiveness between Project-Based Learning assisted by digital module and Project-Based Learning. Thus, Project-Based Learning assisted by digital module is significantly effective in increasing students' mathematical connection ability.

4. Conclusion

Project-Based Learning assisted by digital module is effective to increasing students' mathematical connection ability with medium category. This can be seen in the average mathematical connection ability of students to achieve minimum learning completeness, the proportion of students who achieve minimum learning completeness more than 75%, and the average of students' mathematical connection ability in Project-Based Learning assisted by digital module is more than the average of students' mathematical connection ability in Project-Based Learning. It can be concluded that Project-Based Learning assisted by digital module can explore and increase students' mathematical connection ability.

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