JPPIPA 10(11) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Effectiveness of Using Project-Based Learning Static Fluid Modules in Improving Student SEPs Skills

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Received: May 10, 2024
Revised: September 02, 2024
Accepted: November 25, 2024
Published: November 30, 2024

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DOI: 10.29303/jppipa.v10i11.9323

Abstract: Education in the era of the Industrial Revolution 4.0 has become one of the hot topics discussed, one of which is in the field of science. This high-quality generation is supported by skills, including collaboration, communication, professionalism, problem-solving, innovation, creativity, critical thinking, flexibility, business and management, digital literacy, agility, initiative, productivity, accountability, leadership, practical responsibility. intelligence, high ethical standards, dynamics, and resilience. NGSS provides students with continuous opportunities from primary to secondary school to develop and engage a deeper understanding of the three dimensions of science. This study is intended to determine the effectiveness of using project-based learning modules seen from the skills of students' SEPs. This study used a one-group pretest-posttest design involving 40 class XI students of Engineering Specialization, consisting of 20 female students and 20 male students from SMAIT Ulil Albab Batam. Data were collected using test techniques with Two-Tier Multiple Choice. (TTMC) instrument. The developed modules are effectively applied in physics learning to improve the skills of SEPs. This is indicated by the percentage value on each aspect of the SEPs. The results of the Science and Engineering Practices skill data analysis of students obtained test of normality pretest results of 42.4363 and posttest of 70.5765 (results using modules > without modules). In the homogeneity test used, namely *Shapiro-Wilk*, a significance value (p) *pretest* = 0.973 and *posttest* = 0.938 (p > 0.05), so it can be concluded that the SEPs skill data are normally distributed. Based on the results of calculations obtained from wide-scale trials, it shows that the value of N-Gain from the skills of SEPs in the aspects of SEPs 1 of 0.4875, SEPs 2 of 0.5067, SEPs 3 of 0.4062, SEPs 4 of 0.5146, SEPs 6 of 0.4887 and SEPs 8 of 0.5517, so that the average value of N-Gain of 0.49255 is obtained. So it can be concluded that the effectiveness of the module is in the medium category.

Keywords: Industrial Revolution 4.0, NGSS, SEPs

Introduction

Education in the era of the Industrial Revolution 4.0 has become one of the hot topics discussed, one of which is in the field of science. This is because science in the era of the Industrial Revolution 4.0 is very important; However, what is more important is how to implement it. The important agenda of this century is to create a quality generation to face the Industrial Revolution 4.0 (Rusdin, 2018). This high-quality generation is supported by skills, including collaboration, communication, professionalism, problem-solving, innovation, creativity, critical thinking, flexibility, business and management, digital literacy, agility, initiative, productivity, accountability, leadership, practical responsibility. intelligence, high ethical standards, dynamics, and resilience (Iturbe et al., 2009) Another focus is on Indonesian education which is

How to Cite:
Chasani, A., Azizahwati, & Yennita. (2024). The Effectiveness of Using Project-Based Learning Static Fluid Modules in Improving Student SEPs Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8875–8881. https://doi.org/10.29303/jppipa.v10i11.9323

oriented toward human resource development (Zubaidah et al., 2017). This is the purpose of Indonesian education, which is to create creative, innovative, productive, and competent human resources to develop skills, attitudes, and knowledge (Permendikbud, 2016).

A quality generation can be created by innovating in learning. One of them has been developed in physics education (Lazzaro, 2015) to make the latest physics learning objectives called next-generation science standards often referred to as NGSS. This NGSS is expected to improve students' abilities in learning science, technology, engineering, and mathematics (STEM) (Barakos et al., 2012; States, 2013). This NGSS not only represents a set of up-to-date science standards but is also repackaged (Atwood-Blaine, 2017). NGSS provides students with continuous opportunities from primary to secondary school to develop and engage a deeper understanding of the three dimensions of science. This NGSS has three dimensions to be developed: Scientific content (core ideas of subjects), scientific applications (scientific techniques and practices), and ideas that connect scientific subjects (concepts) (States, 2013).

In science learning, especially physics, to development of students' skills is needed to foster science process skills. Science and Engineering Practices (SEPs) are repetitions of the term science process skills (Karadan & Hameed, 2016) or scientific inquiry skills on previous versions of science standards (Brand, 2020). There is a gap between the knowledge and skills of students who studied in school with what is needed in everyday life (Gura & Percy, 2005)). As the NGSS points out which uses the terms "practice" as well as "skill", conducting scientific inquiry involves not only procedural skills but also conceptual understanding, which is specific to each discipline (Hynes-Berry & Berry, 2021). Skill SEPs consist of eight aspects (States, 2013). Asking questions and defining problems, in activities carried out by asking and refining questions that lead to descriptions and explanations of how the natural and designed world works and can be tested empirically. Developing and using models, in activities carried out with the practice of science and engineering using and building models as useful tools to represent ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Planning and carrying out investigations, in activities students plan and conduct investigations in the field or laboratory, and work collaboratively or individually. Learners' investigations are mathematical and require clarification of what counts as data and identifying variables or parameters.

Analyzing and interpreting data, in the activities of students investigating scientifically to produce data that must be analyzed to obtain meaning. Because data patterns and trends are not always clear, scientists use a variety of tools including tabulations, graphical interpretation, visualization, and statistical analysis to identify important features and patterns in data. The scientist identifies the source of error in the investigation and calculates the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing a secondary source for analysis.

Using mathematics and computational thinking in both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for various tasks such as building simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships. Constructing explanations and designing solutions [SEP-6]. Building explanations and designing solutions, science products are explanations and engineering products are solutions. Engaging in argument from evidence [SEP-7]. Involved in argument for evidence, argumentation is the process by which explanations and solutions are reached. Obtaining, Evaluating, and Communicating Information [SEP-8]. To acquire, evaluate, and communicate information, scientists and engineers must be able to communicate the ideas and methods they generate clearly and persuasively. Criticizing and communicating ideas individually and in groups is a critical professional activity.

The vision of the NGSS framework is that students utilize SEP as a method to demonstrate that they can apply their knowledge to a more significant learning experience (Stephenson et al., 2020). This study used six aspects of SEP: SEP-1; SEP-2; SEP-3; SEP-4; SEP-6; and SEP-8 about static fluids. Static fluid material is material that students learn from elementary school to junior high school. Physics classes on the concept of static fluid in high school have a wide range and are widely used in everyday life (Lindsey et al., 2012). Therefore, students need to study the material more deeply.

One of the learning methods that can be applied to improve students' skills is project-based learning. Project-based learning used in research has been packaged in learning modules so that students can more easily learn it. The use of modules also provides a direct learning experience to students so that their skills can be well accommodated. One of the learning methods that can be applied to improve students' skills is project-based learning. Project-based learning used in research has been packaged in learning modules so that students can more easily learn it. The use of modules also provides students with hands-on learning experiences so that their skills can be properly accommodated.

This study is different from previous studies because in previous studies researchers used project-based learning to improve the skills of SEPs (which are limited to one or two aspects) through learning tools such as RPP and LKS (Hapsari & Rosana, 2019; Kusumaningrum & Djukri, 2016; Maryani et al., 2017; Nursaida et al., 2020; Santoso, 2019) So researchers conducted research with novelty in the form of making project-based learning modules to improve six aspects of science and engineering practice.

Method

This study is intended to determine the effectiveness of using project-based learning modules seen from the skills of students' SEPs. This study used a one-group pretest-posttest design involving 40 class XI students of Engineering Specialization, consisting of 20 female students and 20 male students from SMAIT Ulil Albab Batam. Data were collected using test techniques with Two-Tier Multiple Choice. (TTMC) instrument. TTMC was first developed by Treagust (1988) of Curtin University in Australia.

This test instrument consists of two levels. The first level is the main question which is often referred to as the first level. The second level is the reason why the answer to the main question is chosen and is often referred to as the Second Level (Treagust, 1988). Two-tier multiple choice is the same as multiple choice questions in general, what distinguishes it is that this TTMC question requires high-level thinking coaching and reasoning skills (Adodo, 2013). This study only used six aspects of SEPS skills, the indicators of six aspects of SEP are presented in Table 1.

Table 1. SEPs Aspect Indicator

SEPs	Aspects of SEPs	Sub Indicators
I	Asking questions and defining problems	ask questions that arise from careful observation of phenomena. Ask questions to determine the relationship, including quantitative relationships, between independent and dependent variables.
II	Developing and using models	Compare models to identify a variable Using information to make predictions
III	Planning and carrying out investigations	Identify variables used Identify tools and materials to be used in experiments Build experiment work steps
IV	Analyzing and interpreting data	Organizing (creating tables, and graphs) the results of the experiments obtained Analyze charts
V	Constructing explanations and designing solutions	Create models to build knowledge
VI	Obtaining, evaluating, and communicating information	Analyzing hypotheses Brainstorm

TTMC assessment instruments use the Graded Responses Model (GRM) method. GRM developed in polysome item assessment (Ayala, 2017). This method can help teachers find out and correct student mistakes. answers, then detect and demonstrate students' skills (Wardani et al., 2015). The scoring rules of TTMC instruments are presented in Table 3.

Table 2. SEPs Skill Assessment Rules According to GRM Method

Assessment Aspect		Score
First Tier	Second Tier	
Did not answer or was wrong	Not choosing a reason or wrong	0
Wrong	True	1
True	Wrong	2
True	True	3

Assessment of students' SEPS skills using the GRM method makes it easier for teachers to provide grades. In addition, teachers can also find out students' understanding from the selection of answers to the first and second-layer questions. Therefore, this instrument can help teachers see the initial skills of students (Ratnasari et al., 2017) and detect students' skills (Wardani et al., 2015).

Result and Discussion

Based on the results of the research that has been carried out, the results of student test comparisons were obtained when using and not project-based static fluid modules. The test is carried out before (pretest) and after (posttest) during the learning process. Comparison data of module usage tests can be seen in Figure 1.

From Figure 1, it can be analyzed that there is an increase between the pretest and posttest with an average increase of 27.80%. Details of the percentage increase in SEPs 1 of 23.75%, SEPs 2 of 29.17%, SEPs 3 of 32.22%, SEPs 4 of 28.75%, SEPs 6 of 25.42%, and SEPs 8 of 27.50%.

The next stage is the application of physics modules for the learning process. After all learning activities are carried out by students; followed by giving post-test to them. SEP skill data consisting of six aspects were measured using pretest and posttest. The skill test result data can be seen in Table 3.

Table 3 presents data on students' SEP skill test results before and after the experimental class and the control class is given a physics module based on project-based learning developed by the researcher. Based on the table, it can be seen that students' SEP skill scores after using the module are higher than before using the module.

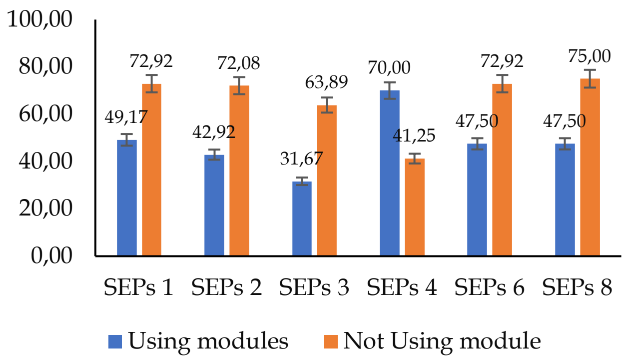

Figure 1. Comparison results of pretest and posttest use of project-based learning-based static fluid modules

Table 3. Description of SEPs Skill Test Results Data

Descriptives Science and Engineering Practices			Pre Test	Post Test
Test of Normality	Mean		42.4363	70.5765
	Variance		129.122	202.600
	95% Confidence Interval for Mean	Lower Bound	38.8021	66.0243
		Upper Bound	46.0704	75.1287
	Std. Deviation		11.36317	14.23375
	Minimum		17.95	41.03
	Maximum		66.67	97.44
	Std. Error		1.79667	2.25055

Pretest and posttest values are used to determine the effectiveness of modules developed by researchers in improving the skills of SEPs. Based on the analysis, the skills of Science and Engineering Practices of pretest and posttest students using the physics module presented calculations obtained by the test of normality results with pretest results of 42.4363 and posttest of 70.5765 (results of using modules > without modules). Standard deviation in the Science and Engineering Practices obtained results with details of experimental classes with pretest values of 11.36317 and posttest 14.23375 (posttest > pretest). Based on the analysis, the skills of Science and Engineering Practices of pretest and posttest students using the physics module presented calculations obtained by the test of homogeneity results with pretest results which can be seen in Table 4.

The next prerequisite test is performed with a homogeneity test. The homogeneity test used, namely Shapiro-Wilk, obtained a significance value (p) pretest = 0.973 and posttest = 0.938 ($p > 0.05$), so it can be concluded that the SEPs skill data are normally distributed.

Table 4. Science and Engineering Practices Homogeneity Test Results

Parameters		Pre Test	Post Test
Kolmogorov-Smirnova	Statistics	0.165	0.197
	Df	40	40
	Sig.	0.007	<0.001
Shapiro-Wilk	Statistics	0.973	0.938
	Df	40	40
	Sig.	0.437	0.030

The effectiveness of the module is calculated using the normalized N-Gain test, which can be seen in Table 5.

Table 5. Results of N-Gain Test Science and Engineering Practices

SEPs	Aspects of SEPs	N-Gain	Std. Error
1	Asking questions and defining problems	0.4875	0.06284
2	Developing and using models	0.5067	0.05764
3	Planning and carrying out investigations	0.4061	0.03749
4	Analyzing and interpreting data	0.5146	0.04327
6	Constructing explanations and designing solutions	0.4887	0.06770
8	Obtaining, evaluating, and communicating information	0.5517	0.04559
	Average	0.49255	0.05

Table 5 presents the results of the thermalized N-Gain with an average value of 0.49255 and a standard deviation of 0.05. Based on the criteria put forward (Hake, 1998), it was concluded that project-based learning is effective in improving SEP skills (Maryani et al., 2017). Improved SEPs skill test results of medium category students.

This is supported by several studies conducted by previous researchers. Research conducted by Council (1996), Santoso (2019), and Windriyana et al. (2019) explains that the application of project-based learning can improve students' science and engineering practices in aspects of planning and implementing investigations as well as constructing explanations and designing solutions. Project-based learning can hone students' skills especially those related to students' psychomotor, which is making hypotheses, using tools to conduct experiments. Low skills of SEPs in aspects of planning and implementing investigations because students are learning about SEPs for the first time.

Research conducted by Rosyidah et al. (2019) explained that real learning and practice can improve students' SEP skills in aspects of model development and use. It also increases the concentration of students' practical skills. Based on this description, it can be concluded that project-based learning modules can improve students' thinking skills.

Discussion

Based on the analysis, learners' SEP skills after the use of the physics module increased compared to before the use of the module. The skill improvement of SEPs is presented in the calculation results obtained from wide-scale trials in Table 5. Description of data on Science and Engineering Practices skill test results with a pretest value of 42.4363 and a posttest of 70.5765 (posttest> pretest). Before being used to calculate the effectiveness of a module, it is necessary to test the prerequisites first. The prerequisite tests used are normality, homogeneity, and paired samples T-Test.

The first prerequisite test is the homogeneity test. The homogeneity test used, namely Shapiro-Wilk, obtained significance values (p) pretest = 0.973 and posttest = 0.938 ($p > 0.05$). So it can be concluded that the skill data of SEPs is normally distributed. The second prerequisite test is homogeneity. This test uses Levene's Test, with significance (p) obtained at 0.407 ($p > 0.05$) which indicates homogeneous data. After that, a paired sample T-Test was carried out to see if there was a significant difference between the skills of SEPs before and after the use of the module. The paired sample T-Test gets a significance value (p) of 0.000 ($p < 0.05$). These test results show that there is a significant difference in SEP skill scores during the pretest and posttest.

After the prerequisite test is carried out, the test is carried out with Gain normalized. Based on the results of calculations obtained from wide-scale trials, it shows that the value of N-Gain from the skills of SEPs in the aspects of SEPs 1 of 0.4875, SEPs 2 of 0.5067, SEPs 3 of 0.4062, SEPs 4 of 0.5146, SEPs 6 of 0.4887 and SEPs 8 of 0.5517, so that the average value of N-Gain of 0.49255 is obtained. Based on the criteria expressed by Hake (1998) It can be concluded that the increase in SEP skill test results of learners is categorized as moderate.

Upskilling SEPs using module-based Project Based Learning This is also supported by research (Citradevi et al., 2017; Jumroh, 2016; Yalçin et al., 2009). The research they conducted states that learning using models Project Based Learning can improve learners' practice skills. Febu et al. (2017) mention the advantages of implementing Project Based Learning Among other things, it can improve science practice skills and skills to communicate learning outcomes. Student activities in project-based learning can improve the skills of SEP students, including making and predicting hypotheses, identifying variables, identifying relationships between variables, designing experiments, determining experimental steps and projects to be created (Darmaji et al., 2019; Lunetta et al., 2013; Rezba et al., 2003).

Improvement also occurred in each aspect of SEP skills, with the highest increase in aspects of SEPs with an average NGain of 0.52. The SEP skills of learners who are still in the low category are: Planning and carrying out investigations (Windriyana et al., 2019). This is because students still do not use practicum or project learning in learning (Astuti & Aziz, 2019). So that students have not been able to optimize these skills.

Based on the results of the N-Gain value, the improvement of SEP skills is because the modules used for learning students have been designed using stages associated with aspects of SEPs. So it can be concluded that the use of project-based learning physics-based modules can effectively improve the skills of SEP students, with an increase in the moderate category.

Conclusion

The developed modules are effectively applied in physics learning to improve the skills of SEPs. This is indicated by the percentage value on each aspect of the SEPs. The percentage of improvement in Science and Engineering Practices (SEPs) in aspect 1 was 67,428%, aspect 2 was 59.537%, aspect 3 was 49.565%, aspect 4 was 58,928%, aspect 6 was 65,143%, and aspect 8 was 63,334%. The homogeneity test used, namely Shapiro-Wilk, obtained a significance value (p) pretest = 0.685 and posttest = 0.260 ($p > 0.05$). So it can be concluded that the skill data of SEPs is normally distributed. Based on the results of calculations obtained from wide-scale trials, it shows that the value of N-Gain from the skills of SEPs in the aspects of SEPs 1 of 0.4875, SEPs 2 of 0.5067, SEPs 3 of 0.4062, SEPs 4 of 0.5146, SEPs 6 of 0.4887 and SEPs 8 of 0.5517, so that the average value of N-Gain of 0.49255 is obtained. So it can be concluded that the effectiveness of the module is in the medium category.

Acknowledgments

Thanks to Dr. Azizahwati, M.Si, and Dr. Yennita, M.Si for guiding me in this research. Hopefully, this article can be useful for the readers.

Author Contributions

The authors listed in this article contributed to the development of the article, and have read, approved the published manuscript.

Funding
This research received no external funding

Conflicts of Interest
The authors declare no conflict of interest

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