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The Effect of Using Wave E-modules on Science Process Skills of Public High School 10 Padang Students

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Abstract— This study aims to investigate the effect of e-modules on students' science process skills of public high school 10 Padang. The type of research used was quasi- experimental, with the posttest-only control group method. The sample in this study consisted of 36 experimental group students and 36 control group students. Data on science process skills were collected using quantitative methods where the research instruments were in the form of observation formats and posttest instruments that had been tested for quality in the form of validity tests and reliability tests. The test instrument was carried out before data collection which had been tested valid and reliable. The results of data analysis show that there is a difference between the experimental group and the control group with a value of 0.001 at a significance value of 5%. Based on these results, it can be concluded that there is a positive effect of using the wave e-module on the science process skills of Public High School 10 Padang students.

Keywords—E-modules; Science Process Skills (SPS)

I. INTRODUCTION

21st century skills need to be provided to students in facing challenges in the field of science and technology. 21st century skills include various abilities such as critical thinking, creativity, communication, collaboration, and information and technology literacy. It aims to enable students to compete well in the 21st century era [1]. The implementation of learning that students must achieve by educational units must be able to improve and develop 21st century competencies [2]. The development of 21st century skills can be done through the discipline of physics. Physics is the objective and quantitative study of scientific conclusions that engages in the process of observe, measure, and model the connection between of the relevant variables in reflection of the laws of nature and attract conclusions that are integrated into applied and proven theory [3].

Physics learning as one of the science learning that can combine various aspects of skills and has the potential to train 21st century skills that students must achieve. One of the most talked about skills in science education is science process skills [4]. Science process skills allow students to engage with scientific concepts actively, improving their understanding and ability to apply knowledge in

experimental and theoretical contexts. These skills are essential not only for the development of scientific knowledge but also for encouraging critical thinking and constructive learning in students [5].

Science process skills offer a comprehensive learning approach that allows students to engage with science as both a process and a product. This approach encourages students to be more creative, proactive, and independent in acquiring knowledge, skills, and values, all of which are needed to apply the scientific approach to real-life situations [6]. Effective learning through science process skills requires an emphasis on hands-on experience, which allows students to observe, experiment, and reflect, thus developing a deeper understanding of physics concepts.

In fact, at the senior high school level in Indonesia, science process skills do not match the expected reality. The PISA 2022 results show that Indonesian students' achievement in science is still below the average of OECD countries in the assessment aspects of Explain scientific phenomena; Evaluate and design scientific investigations; and Interpret scientific data and evidence [7]. The assessment aspects measured by PISA include critical thinking, problem solving, and use of the scientific method, all of which are important indicators of science process skills. The average science score of Indonesian students is 383 points, far below the OECD average of 485 points [7]. A contributing factor to students' below-average science skills in Indonesia is the limited availability and quality of educational facilities. This shows that the science process skills of Indonesian students still require significant attention and improvement. Science process skills are very valuable because they include basic abilities in scientific thinking, such as identifying problems, formulating hypotheses, designing experiments, and interpreting data, all of which are the core of science education.

The same fact also occurred at High School 10 Padang. Initial research conducted in the 2023/2024 academic year by 72 students aimed to measure the initial ability of students' science process skills. Initial research was conducted with an observation format for the use of teaching materials and students' science process skills measured during learning in the classroom with ten main indicators namely: observing, classifying, interpreting, predicting, questioning, formulating hypotheses, planning experiments, using tools/ materials, applying concepts, and communicating. The average score of students' science process skills is 36.04 which is in the “poor” category. The low score indicates that the existing teaching materials are inadequate in contributing to the development of science process skills, which indicates the need for improvement.

Considering the problems that happen, there is an effort to increase science process skills so that students can compete well in the era of the 21st century. The first alternative is through the use of e-modules that are proven to increase students' science process skills as done by Sarah, et al., with SETS-based e-modules [8] then those done by Asrizal [9] with STEM-based e-modules and followed by Hamidi, et al., [10] with PBL-based e-modules. The second alternative is through contextual teaching materials assisted by an android-based virtual laboratory conducted by Karanggulimu, et al [11] which is proven to improve students' science process skills. The third alternative is through the implementation of a guided inquiry learning model conducted by Serevina, et al, [12] that proves that the guided inquiry learning model can help to increase students' science process skills.

Success in implementing physics learning that develops science process skills, appropriate learning support that is aligned with the content being taught is very important. Researchers are interested in conducting research that focuses on the application of e-modules to find out whether the e-modules have an influence on students' science process skills. This study uses e-modules made by the Physics Department Research Team, Universitas Negeri Padang, under the guidance of Prof. Asrizal, M.Si. and Naurah Nazifah, M.Pd. This e-module has gone through validation tests and practicality tests that prove its feasibility as teaching material for physics lessons. For the purpose of maximizing the research, the guided inquiry learning model is used to enhance students to explore and discover concepts by themselves.

II. Research Methods

This study used a quasi-experimental type of research, using the posttest-only control group design method. This research was conducted in the academic year 2023/2024 in the even semester at public high school 10 Padang. The sample consisted of 36 experimental group students and 36 control group students. Quantitative data used in this study is intended to measure how the effect of e-module treatment on students' science process skills.

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TABLE 1. Post-test Only Control Design

Group	Treatment	Post-test
Experiment	X_1	O_2
Control	X_2	O_4

Description:

X_1 = The Treatment given to the experimental group is to use the wave e-module

X_2 = The treatment given to the control group is using physics teaching materials provided by public high school 10 Padang

O_2 = The final test of the experimental group after treatment

O_4 = The final test of the control group that was not treated

The data analysis technique in this study is to analyze students' science process skills by finding the percentage for each indicator which includes ten indicators, namely: observing, classifying, interpreting, predicting, questioning, hypothesizing, planning experiments, using tools/materials, applying concepts, and communicating. After analyzing students' science process skills, they then conducted normality, homogeneity, and hypothesis tests. The data analysis technique has two conditions. The first condition is before being treated by not using e-modules to identify the initial ability of the sample class. The second condition is after being treated using e-modules to prove the accuracy of the hypothesis. Science process skills data were analyzed by determining the percentage for each indicator using the percentage formula as follows [13].

$$Percentage\ Score = \frac{Gained\ score}{maximum\ score} x100\% \quad (1)$$

Each SPS indicator can be calculated using the following average formula [14]

$$\bar{X} = \frac{\sum x_i}{n} = \frac{\sum total\ score}{number\ of\ students} \quad (2)$$

The results of the analysis were then categorized using the following student science process skills criteria.

TABLE 2. Science Process Skills Score Criteria

Score	Category
81 ≤ SPS ≤ 100	Very Good
61 ≤ SPS ≤ 80	Good
41 ≤ SPS ≤ 60	Enough
21 ≤ SPS ≤ 40	Poor
0 ≤ SPS ≤ 20	Very Poor

Source : Nismalasari, et al. [15]

The instruments in this study were in the form of an observation format and a posttest instrument that had been tested for quality in the form of validity and reliability tests. The observation format instrument contains an assessment of student learning activities based on indicators of student science process skills with a score of 1 to 4 points. Based on the instrument test using SPSS, the results obtained that the observation format for assessing the initial ability of students' science process skills containing ten instrument items proved to be valid at the sig level. 0.05 and a reliability value of 0.64 at the sig level. Cronbach's Alpha 0.6 so it is said to be reliable. The results of the analysis of the test instrument in the form of a posttest resulted in 25 items that proved valid from 30 items tested in different schools. The reliability results on 25 items show the results of relible with a very high reliability value, namely r_{11} = 0.876 at the sig level. Cronbach's Alpha 0.6.

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III. Result and Discussion

The data from this research was collected in the value of students' science process skills. The data has two groups of data, namely the first is the observation format which is measured when learning takes place during class and the second is the final test which is the posttest. Data on the value of science process skills through the observation format has the aim of knowing the initial ability of science process skills possessed by students presented in the following figure.

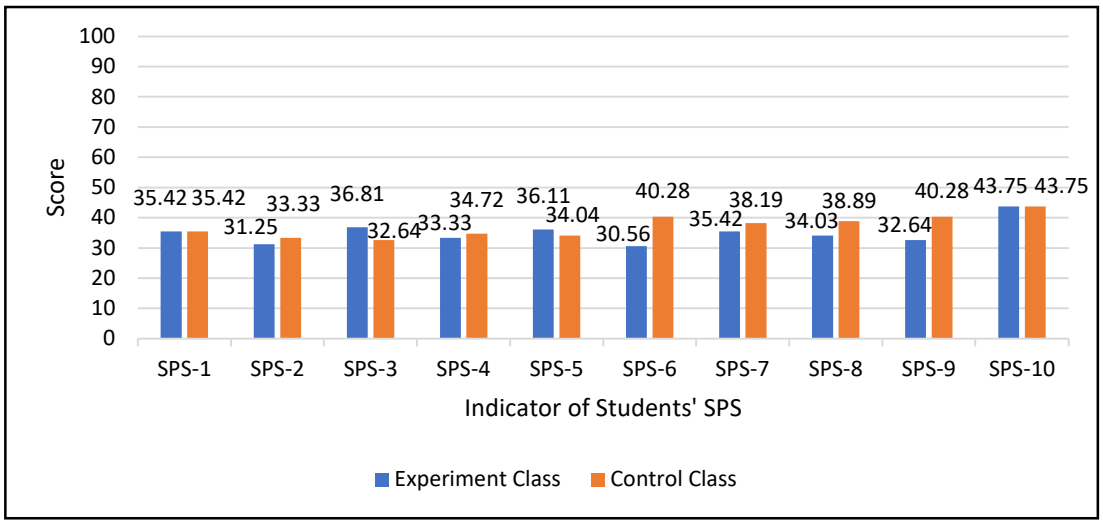

Fig. 1. Observation Score of Students' Science Process Skills

Description:

SPS-1 = Observing
SPS-2 = Classifying
SPS-3 = Interpreting
SPS-4 = Predicting
SPS-5 = Formulating Hypothesis
SPS-6 = Questioning
SPS-7 = Planning an Experiment
SPS-8 = Using Tools/Materials
SPS-9 = Applying the Concept
SPS-10 = Communicating

Based on the results of data analysis in Figure 1, the experimental group obtained the value of science process skills in each indicator is 35.42; 31.25; 36.81; 33.33; 36.11; 30.56; 35.42; 34.03; 32.64; and 43.75. The data showed that nine out of ten indicators were in the "poor" category with an index of $21 \leq SPS \leq 40$ and one other indicator was in the "enough" category with an index of $41 \leq SPS \leq 60$. The average value of science process skills in the experimental group was 34.93 in the "poor" category.

In the control group, the results of the data analysis of the value of science process skills in each indicator is 35.42; 33.33; 32.64; 34.72; 34.03; 40.28; 38.29; 38.89; 40.28; and 43.75. The data showed that seven of the ten indicators were in the "poor" category with an index of $21 \leq SPS \leq 40$ and the other three indicators were in the "enough" category with an index of $41 \leq SPS \leq 60$. The average value of science process skills in the control group was 37.15 in the "poor" category.

In this data, if averaged in total, the total average result of the two sample groups is 36.04 which is included in the "poor" category in the index $21 \leq SPS \leq 40$. This problem happened because when the teacher presented a problem, only a few students were able to respond to the teacher in solving the problem and the teaching materials used in learning had not facilitated students' science process skills. This problem has also been found by other researchers. Research conducted by Indri, et al. [16], found that high school science process skills were in the low category because students were not accustomed to solving a problem or statement scientifically and even experienced misconceptions. The results of the research by Indri, et al. were strengthened by Darmaji, et al. [17], which states that science process skills are low because in the learning process the skills in analyzing scientific owned by students are still not optimal. The second research by Juliana, et al. [18], found that the teaching materials used were only teaching materials provided by

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the school library and were not maximized to increase students' science process skills. The results of research by Juliana, et al, were strengthened by Ghaida, et al. [19] which states that physics teaching materials provided at school do not contain science process skills and emphasize the substance of physics concepts and principles.

The normality test on the preliminary ability observation data of students' science process skills was carried out using the Kolmogorov-Smirnov test at sig. $\alpha = 0.05$ to determine if data is normally distributed. The results of the normality test analysis of students' initial skills can be seen in Table 3.

TABLE 3. Preliminary Data Normality Test Results Sample Groups

Group	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Experiment	0.141	36	0.067
Control	0.143	36	0.059

Based on Table 3, it is found that in the experiment group the statistical value obtained is 0.141 with a degree of freedom (df) of 36 and the sig. value is 0.067. Because the sig. value in the experiment group is greater than sig. $\alpha = 0.05$, it can be concluded that the data in the experimental group is "normally" distributed. While in the control group, the statistical value obtained is 0.143 with a degree of freedom (df) of 36 and the sig. value is 0.059. Just like the experimental group, the sig. value in the control group is greater than 0.05, so that the control group can also be said to be "normally" distributed.

The homogeneity test on the observation data of the preliminary ability of students' science process skills aims to see whether the two sample groups come from a population that has a homogeneous variance, so a homogeneity test is carried out using Levene's test, with a significance level of $\alpha = 0.05$. The results of the analysis of this test can be seen in Table 4.

TABLE 4. Homogeneity Test Results on Preliminary Data of Sample Groups

Leven Statistic	df_1	df_2	Sig.
0.193	1	70	0.662

Based on Table 4, the Levene's statistical value is 0.193 with the first degree of freedom (df_1) of 1 and the second degree of freedom (df_2) of 70. The sig. value of Levene's test is 0.662. Because the sig value. 0.662 is greater than the sig value. $\alpha = 0.05$, it can be concluded that the variance between groups is homogeneous. This means that there is no significant difference in variance between groups, so the assumption of homogeneity of variance is achieved.

After conducting the normality test and homogeneity test, the next step is hypothesis testing. To test the hypothesis, an independent sample t-test was used to see the initial ability by comparing the average between two groups. This test was conducted with a significance level set at $\alpha = 0.05$. The results of this hypothesis testing analysis can be seen in Table 5.

TABLE 5. Hypothesis Test Results on Preliminary Data of Sample Groups

SPS	t-test for Equality of Means		
	t	df	Sig. (2 tailed)
Equal variances assumed	2.411	70	0.019
Equal variances not assumed	2.411	69.490	0.019

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Based on Table 5, the t value obtained is 2.411 with a degree of freedom (df) of 70. The Sig. 2-tailed is 0.019. Because the sig value. 0.019 is smaller than 0.05, it can be concluded that there is a significant average difference between the two groups. This means that the two sample groups have the same initial skills before treatment.

The second science process skills data is the final test in the form of a posttest. Data on the value of science process skills by posttest was collected after the treatment was given to the sample group. The experimental class used e-modules while the control class used ordinary teaching materials used at school. Each indicator of science process skills is assessed individually. The results of this study are illustrated in figure 2 below.

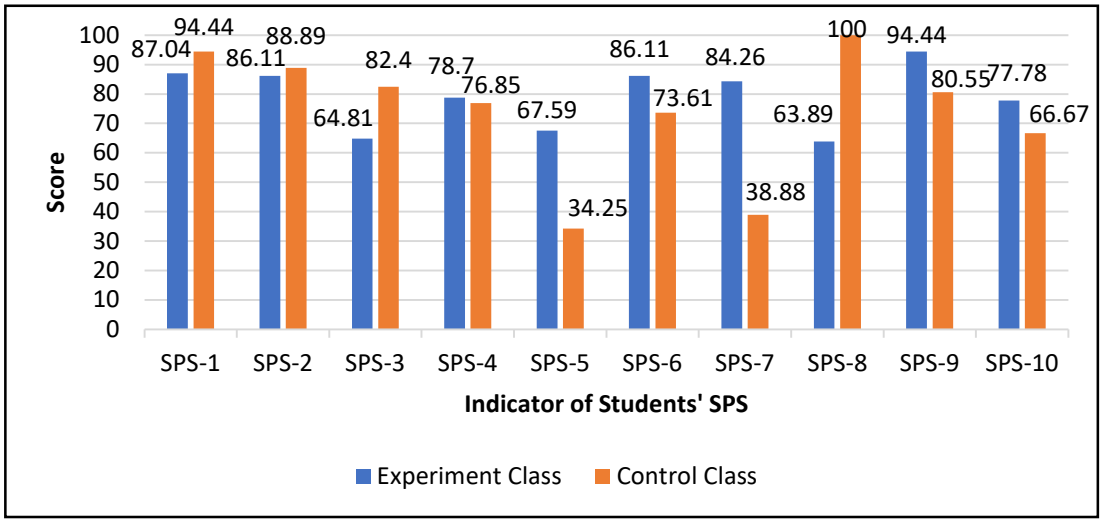

Fig. 2. Posttest Score of Students' Science Process Skills

Description:

SPS-1 = Observing
SPS-2 = Classifying
SPS-3 = Interpreting
SPS-4 = Predicting
SPS-5 = Formulating Hypothesis
SPS-6 = Questioning
SPS-7 = Planning an Experiment
SPS-8 = Using Tools/Materials
SPS-9 = Applying the Concept
SPS-10 = Communicating

Based on the results of data analysis in Figure 2, the experimental group obtained the value of science process skills in each indicator is 87.04; 86.11; 64.81; 78.70; 67.59; 86.11; 84.26; 63.89; 94.44; and 77.78. The data showed that the results of the ten indicators were in the "good" category with an index of $61 \leq SPS \leq 80$. The average value of science process skills in the experimental group was 79.07 in the "good" category.

In the control group, the results of the data analysis of the value of science process skills in each indicator is 94.44; 88.89; 82.41; 76.85; 34.26; 73.61; 38.89; 100; 80.56; and 66.67. The data showed that nine out of ten indicators were in the "good" category with an index of $61 \leq SPS \leq 80$ and one other indicator was in the "poor" category with an index of $21 \leq SPS \leq 40$. The average value of science process skills in the control group was 73.66 in the "good" category.

In the data of the two sample classes, if averaged in total, the total average result of the two sample groups is 76.37 which is in the "good" category in the index $61 \leq SPS \leq 80$. According to the results of the analysis of the two sample group data, it can be concluded that there was an increase in the average science process skills of students before being treated and after being treated then students who used e-modules in the experimental group had higher science process skills scores than students in the control group. This happens because the e-modules used include materials, videos, animations, and audio features, thus facilitating science process skills that contribute to this increase. This statement can be supported by some previous research.

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The first research conducted by Serevina, et al. [20], e-modules are able to improve students' science process skills because e-modules contain animations, images, videos and audio so that they can help students learn independently. The research conducted by Serevina, et al, was strengthened by Mayanty, et al. [21], that e-modules are able to improve students' science process skills because the e-modules developed contain animations, videos, images and so on that can require students to be able to solve problems related to physics concepts. The second research conducted by Sumiati, et al. [22], showed that e-modules with the presentation of material that indirectly has aspects of students' science process skills can make students able to find their own facts, concepts, or procedures in knowing physics knowledge itself which makes an increase in science process skills possessed by these students.

The normality test on the posttest data of students' science process skills was carried out using the Kolmogorov-Smirnov test at sig. $\alpha = 0.05$ to determine if data is normally distributed. The results of the normality test analysis can be seen in the Table 6.

TABLE 6. Normality Test Results on Posttest Data of Sample Groups

Group	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Experiment	0.143	36	0.060
Control	0.118	36	0.200

Based on Table 6, it is found that in the experiment group using e-modules, the statistical value obtained is 0.143 with a degree of freedom (df) of 36 and the sig. value is 0.060. Because the sig. value in the experiment group is greater than sig. $\alpha = 0.05$, it can be concluded that the data in the experimental group is "normally" distributed. While in the control group that used teaching materials provided by the school, the statistical value obtained was 0.118 with a degree of freedom (df) of 36 and the sig. value was 0.2. Just like the experimental group, the sig. value in the control group is greater than 0.05, so that the control group can also be said to be "normally" distributed.

The homogeneity test on the data of the posttest results of students' science process skills aims to see whether the two sample groups come from a population that has a homogeneous variance, so a homogeneity test is carried out using Levene's test, with a significance level of $\alpha = 0.05$. The analytical results of this test can be seen in Table 7.

TABLE 7. Homogeneity Test Results on Posttest Data of Sample Class

Leven Statistic	df_1	df_2	Sig.
3.741	1	70	0.057

Based on Table 7, the Levene's statistical value is 3.741 with the first degree of freedom (df_1) of 1 and the second degree of freedom (df_2) of 70. The sig. value of Levene's test is 0.057. Because the sig. 0.057 is greater than the sig value. $\alpha = 0.05$, it can be concluded that the variance between groups is homogeneous. This means that there is no significant difference in variance between groups, so the assumption of homogeneity of variance is achieved.

After conducting the normality test and homogeneity test, the next step is hypothesis testing. To test the hypothesis, an independent sample t-test was used to see the initial ability by comparing the average between two groups. This test was conducted with a significance level set at $\alpha = 0.05$. The results of this hypothesis testing analysis can be seen in Table 8.

TABLE 8. Hypothesis Test Results on Posttest Data of Sample Groups

SPS	t-test for Equality of Means		
	t	df	Sig. (2 tailed)
Equal variances assumed	3.463	70	0.001
Equal variances not assumed	3.463	48.115	0.001

Based on Table 8, the t value obtained is 3.463 with a degree of freedom (df) of 70. The Sig. 2-tailed is 0.001. Because the value of sig. 0.001 is smaller than 0.05. This indicates that the null hypothesis (H_o) is rejected and the alternative hypothesis (H_a) is accepted. This study shows that there is a significant difference between the experimental group using e-modules and the control group using teaching materials usually given by physics teachers. This significant difference supports the conclusion that e-modules on wave material have a positive and effective influence on the science process skills of Public High School 10 Padang students.

IV. Conclusion

Data analysis on the effect of E-Modules on Science Process Skills of Public High School 10 Padang students showed that there was a positive effect of e-modules on students' science process skills.

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