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Effectiveness of E-module Based on Problem Research Based Learning (PRBL) on Students' Science Process Skills

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Abstract: The development of learning in the 21st century emphasizes the improvement of Science Process Skills (SPS). However, the implementation of SPS has not been able to be realized by teachers due to the limitations of the teaching materials used. The data obtained shows that the average value of SPS for students is still categorized as low, which is 43.3%. This study aims to test the effectiveness of the implementation of E-module based on Problem Research Based Learning (PRBL) on students' Science Process Skills (SPS). The research method used is Quasi Experimental research with research samples of class VIII A and VIII D in one of the Surakarta State Junior High Schools. The experimental class was given an e-module based on PRBL containing material on elements, compounds and mixtures while the control class used the BSE book with an interactive lecture method. The data collection technique used a written test instrument in the form of a SPS test with a reasoned multiple choice type. The effectiveness test used was the t-test, effect size and n-gain score. The results of the t-test showed a significance value of 0.00 which means there is a significant difference between the experimental class and the control class. These results prove that there is a difference in the results of students' SPS between the experimental class and the control class. Furthermore, the results of the effect size test with a moderate effect category of 0.63 and the n-gain score test with a high category of 0.702 for the experimental class. Based on the results of the three tests, it can be concluded that the implementation of PRBL-based e-modules is effective in increasing students' SPS.

Keywords: E-Module; Problem Research Based Learning (PRBL); Science Process Skills

Introduction

The 21st century brings major changes that demand the creation of quality human resources (Afsas, Sutikno & Fianti, 2023). Education in Indonesia must prepare a generation that has communication, collaboration skills (Pattipeilohy & Wijaya, 2020; Nungu, Mukama & Nsabayezu, 2023; Siew & Ahmad, 2023), critical thinking (Astalini et al., 2023), and creativity (Jufriadi et al., 2022; Wirayuda, Darmaji & Kurniawan, 2022; Avcı & Yildiz Durak, 2023). One way to develop these skills is by implementing Science Process Skills (SPS) (Ramdhayani et al., 2022), which can improve students' intellectual thinking (Putri, Sudarti & Prihandono, 2022). SPS plays a role in solving problems, understanding phenomena, building scientific concepts (Dilek et al., 2020; Rumalolas et al., 2021), developing scientific attitudes, and collaboration skills in experiments (Santiawati et al., 2022). Students who master SPS are expected to be able to critical thinking (Plotnikova & Strukov, 2019; Noris, Saputro, & Muzazzinah, 2021), creative and systematic in developing science (Wirayuda et al., 2022).

The implementation of SPS is an important strategy in facing the challenges of 21st century learning that requires students to observe, measure, interpret, classify, predict, and communicate (Inayah, Ristanto, Sigit, & Miarsyah, 2020). However, the implementation of SPS in schools is still rare due to the dominance of the

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Teacher Centered Learning (TCL) model, making students passive and less able to develop critical, creative, and innovative thinking (Afsas et al., 2023; Dariansyah et al., 2023; Saleh, Muhiddin & Rusli, 2020; Santiawati et al., 2022). The low SPS of Indonesian students is proven by the results of PISA in 2018 which placed Indonesia in 62nd place out of 71 countries with a score of 389 (Narut & Supriadi, 2019), as well as the results of TIMSS 2015 which showed Indonesia's score below the global average (Muhtadin et al., 2024; Wahyuningsih, Sumardjoko & Desstya, 2023). This is due to the tendency of students to memorize material without being able to analyze and apply concepts to solve problems (Hasasiyah, Hutomo, Subali, & Marwoto, 2020). The results of pre-research conducted at one of Surakarta's State Junior High Schools obtained an average SPS value of students of 43.3%, presented in Table 1.

Table 1. SPS Dimension Values

Dimensions	Percentage Value (%)
Observation	60.0
Measure	30.0
Interpretation	39.0
Classifying	45.0
Predicting	40.0
Communicating	46.0
Average	43.3

The low SPS of students is caused by the limitations of innovative learning (Sujudi, Idris, Suryanti, & Handayani, 2020) and minimal student involvement in finding concepts (Nurfitra, Mamin & Muhiddin, 2021). Interviews at SMP Negeri Surakarta showed that learning was still one-way and only relied on BSE textbooks, so e-modules were needed to improve SPS (Nazifah & Asrizal, 2022). Mobile phones, which are a primary need (Oktariani, Baruri & Saputri, 2024), support the accessibility of e-modules. The PRBL model has been proven effective in improving SPS (Zakiyah & Sudarmin, 2022; Suyatman, Saputro, Sunarno, & Sukarmin, 2021) by combining PBL for analytical thinking (Rahmi, Alberida & Astuti, 2019) and RBL for scientific discovery (Brew & Saunders, 2019) which encourages the formation of critical and creative thinking (Alrajeh, 2021). The PRBL e-module is applied to informative and abstract elements, compounds, and mixtures (Pramana, Jampel & Pudjawan, 2020; Widiyanti & Kurniawan, 2021) so that it can create interesting learning (Fauziah, Oktariani & Rahmawati, 2023; Yudha & Rahmi, 2023) and innovative through video, animation and audio (Rizaldi, Syahwin & Ramadani, 2022). The implementation of the PRBL e-module is expected to improve SPS and create a superior generation according to the needs of the 21st century.

Method

The type of research used is Quasi Experiment, with a research design in the form of Nonequivalent Control Group Design. The application of this design consists of two groups, namely the experimental class and the control class. Both classes are given a pre-test to measure the initial abilities of students. Then, the experimental class is given different treatment from the control class and ends with a post-test (Sugiyono, 2020). The research design plan can be seen in Table 2.

Table 2. Research Design Plan

Group	Pre-Test	Treatment	Post-Test
Experimental Class	O1	X1	O2
Control Class	O3	X2	O4

(Source: Sugiyono, 2020)

Information:
O1 : Experimental Class Pre-Test
O2 : Post Test Experimental Class
X1 : Learning Using E-modules Based on PRBL
X2 : Learning Using BSE Books School
O3 : Pre-Test Control Class
O4 : Post-Test Control Class

The effectiveness of the e-module was tested to determine the difference in the results of the Student SPS. The effectiveness test was carried out using the t-test or Independent Sample T-Test. Gozali (2021) explained that the t-test is a test used to determine the effect of independent variables on dependent variables. This test is the basis for determining the difference in the results of the student SPS between the experimental class and the control class, after being given different module treatments. In addition, as a basis for decision making that the application of the e-module is effectively used in learning so that it can improve the Student SPS.

The study was conducted in November 2024 at one of Surakarta's junior high schools. The data collection technique used evaluation questions, while the instrument used was a student evaluation sheet consisting of 15 multiple-choice questions. Before the effectiveness test was carried out, the questions had to meet the prerequisite tests in the form of normality and homogeneity tests to determine whether the data used was normally distributed and homogeneous. If all the prerequisite test data has been met, then the effectiveness test can be continued.

The sample used for the t-test was class VIII A as the experimental class and class VIII D as the control class. If the t-test calculation shows a result of less than 0.05, then the implementation of the PRBL-based e-module is effective in increasing students' SPS. In

addition to the t-test calculation, the effectiveness test is also equipped with an effect size test and n-gain score. All calculations use the SPSS 22 and Microsoft Excel applications.

The use of effect size in Quasi-Experimental research, according to Sullivan and Feinn (2023) can provide an overview of the impact or consequences of policy changes in the field of education, such as for example to measure the achievement of learning strategies against the results obtained. The effect size criteria are presented in Table 3.

Table 3. Effect Size Criteria

Score	Criteria
0 – 0.20	Weak Effect
0.21 – 0.50	Common Effects
0.51 – 0.80	Medium Effect
≥ 0.81	High Effect

Sullivan and Feinn, (2023)

Meanwhile, the n-gain score test is needed to measure changes in students' abilities after being given treatment with a particular learning model or method (Zulaichah, Hake & Taufik, 2021). This measurement is the main indicator to determine the increase in students' SPS scores which are measured through the acquisition of pre-test and post-test scores. The effectiveness of the PRBL-based e-module can be said to be effective if it obtains a score with high criteria. The following are the n-gain score criteria, presented in Table 4.

Table 4. N-Gain Score Criteria

Scale	Criteria
g ≥ 0.7	Tall
0.3 ≤ g < 0.7	Currently
g < 0.3	Low

Zulaichah et al., (2021)

Result and Discussion

Prerequisite Test

The prerequisite test aims to ensure that the data used is normal and homogeneous. The following are the results of the prerequisite test in tables 5 and 6.

Table 5. Normality Test Results

Class	Stats.	Df	Sig. (Shapiro-Wilk)	Conclusion
Experiment	0.942	31	0.095	Normal
Control	0.947	31	0.126	Normal

Table 6. Results of Homogeneity Test

Levene Statistics	df1	df2	Sig.	Conclusion
1.795	1	61	0.185	Homogeneous

Based on the data obtained from tables 5 and 6, it shows that the results of the data normality test are distributed normally and the homogeneity test is homogeneous because the significance value obtained is more than 0.05. The normality test for the experimental class produces a significance value of 0.095 and the control class is 0.126, while the homogeneity test is 0.185. Furthermore, further tests can be carried out to measure the effectiveness of the PRBL-based e-module.

Effectiveness Test

Table 7. Results of the t-test

F	Sig.	T	Df	Sig. (2-tailed)
1.927	0.170	6.737	61	0.000
		6.712	57.029	0.000

The t-test results from table 7 show a significance value of less than 0.05, which is 0.000, which means that there is a significant difference between the results of the experimental class SPS and the control class. This also states that the implementation of PRBL-based e-modules has proven to be effective in increasing students' SPS.

Effect Size

Table 8. Effect Size Results

	Pre-Test	Post-Test
Average	47.438	83.578
Standard Deviation	14.804	7.920
Cohen's d	= (8357812-4743750)/5697330,273132	
	= 0.634	

Based on the data in table 8, it shows the effect size result of 0.63 with a moderate effect category. The effect size calculation uses Cohen's calculation online so that the results are obtained. The purpose of the effect size calculation is to measure the increase in the application of PRBL-based e-modules to students' SPS through pre-test and post-test scores.

N-Gain Score Test

Table 9. N-Gain Score Test Results

Class	Statistics	Category
Experiment	70.278	Tall
Control	40.494	Currently

According to the data in Table 9, the results of the n-gain score test for the experimental class were 70.278% or 0.702, while for the control class it was 40.494% or 0.404. The implementation of PRBL-based e-modules can be declared effective if the n-gain score obtained is in the high category. Based on the n-gain score criteria, the experimental class showed an increase in the high category, while the control class showed an increase in the moderate category. This means that the implementation of PRBL-based e-modules is more

effective in increasing students' SPS compared to the implementation of teaching materials used from the school.

The results of the effectiveness test above show that the implementation of PRBL-based e-modules has proven to be effective in increasing students' SPS. This effectiveness is supported by 3 test results, namely the t-test, effect size and n-gain score. All three must meet certain standards and criteria so that the implementation of the e-module can be categorized as effective. One of the tests that determines the effectiveness of the module is the n-gain score test. Zulaichah et al. (2021) stated that the implementation of learning strategies is said to be effective if it meets a high N-Gain value. This statement is in accordance with the results obtained, there was a high increase in the post-test scores of class VIII A students as the experimental class after being given special treatment, namely the implementation of PRBL-based e-modules.

The implementation of e-modules in learning can encourage students to learn independently (Nazifah & Asrizal, 2022; Oktariani, et al., 2024; Yulando, et al., 2019) and interactively because it is equipped with interesting animations and audio to enrich their learning skills (Rizaldi, et al., 2022). E-modules have various types, one of which is an e-module that uses a scientific approach by integrating scientific methods in delivering learning materials. The scientific methods presented in the module are equipped with creative, critical, productive and innovative thinking skills. This aims to help improve students' SPS (Afriyanti, Suyatna & Viyanti, 2021; Efendi, Tobing & Susanti, 2022; Herlina, Ilmadi, Zetia & Maris, 2022; Sugihartini & Jayanta, 2017; Ulfa & Sucahyo, 2022; Herlina, et al., 2022).

Based on the opinions of several empirical studies, it is proven that e-modules have an important role in the teaching and learning process, especially technological advances in the 21st century encourage more flexible, efficient and affordable education (Oktariani, et al., 2024). The use of e-modules provides great opportunities for educators and students to achieve more effective and efficient learning. The need for flexibility in learning is very necessary to create quality human resources in accordance with the demands of the times. Therefore, the government focuses on adapting the curriculum to 21st century skills, such as character education, 4C skills (Critical Thinking, Creativity, Communication, Collaboration), literacy, and HOTS (higher order thinking skills) (Mukarramah, Gani & Winarni, 2021; Fitriani, Wati, Dewantara, & Lasiani 2024).

The skills needed in the 21st century are in accordance with the application of e-modules used to improve students' SPS. The SPS dimensions achieved through e-module learning are observation, measuring, interpreting, classifying, predicting and communicating (Inayah, et al., 2020). The six dimensions can train critical, analytical, systematic thinking, and improve understanding of deeper scientific concepts. This way of thinking can train students to be more competent and have superior competitiveness in the era of globalization (Nazifah & Asrizal, 2022).

The objectives of the student's SPS can be achieved optimally if equipped with a specific learning model that supports the achievement of educational programs in the 21st century. PRBL is one example of a learning model that can be used to optimize the usefulness of e-modules. The model is built based on the synthesis of PBL and RBL models. The PRBL model presented in the e-module can encourage students to obtain SPS (Zakiyah & Sudarmin, 2022). The aspects presented include matching, identifying, analyzing principles, organizing, and analyzing relationships (Suyatman, et al., 2021). All aspects can encourage students to think creatively and critically in solving problems (Rahmi, et al., 2019; Alrajeh, 2021).

Learning using e-modules based on Problem Research Based Learning (PRBL) has various benefits in the field of education, both for students, teachers, and the education system as a whole. PRBL encourages students to actively identify problems, formulate questions and find solutions (Alrajeh, 2021; Suyatman, et al., 2021). PRBL also has significant potential to empower students in various cognitive aspects (Suyatman, et al., 2021). Through the PRBL framework, students can understand problems in depth, formulate solutions and integrate new knowledge gained into relevant learning contexts. This process not only enriches the learning experience but also helps students develop holistic thinking skills (Brew & Saunders, 2019).

In this study, PRBL on the material of elements, compounds and mixtures focuses on research activities in the form of phet corolado and offline through several activities, namely: 1) activities to distinguish types of elements; 2) practicum by distinguishing colloids, solutions and suspensions; 3) practicum to distinguish acids, bases and salts in substances used in everyday life; and 4) practicum activities to separate mixtures. All of these activities are presented in the e-module through several stages of PRBL, namely: 1) orientation and formulating problems, 2) reviewing theoretical basis, 3) planning and carrying out investigations, 4) analyzing and evaluating data, 5) explaining research results, 6) presenting work results and presenting them (Suyatman, et al., 2021).

Based on the results of the literature, there is a relationship between PRBL syntax and the achievement of SPS dimensions, presented in table 10, as follows.

Table 10. Achievement of SPS Dimensions through PRBL Syntax

PRBL Syntax	Student Activities	Achievement of SPS Dimensions
Orientation and formulating problems	Encourage students to solve problems and improve critical, creative and innovative thinking processes.	Observation Measure Interpretation
Reviewing the theoretical basis	Encourage students to understand the theory that will be used for the investigation process.	Interpretation
Plan and carry out investigations	- Encourage students to develop the theories learned in experimental practice - Improve collaboration and discussion skills between groups of students	Observation Measuring Interpretation Classifying Predicting Communicating
Analyze and evaluate data	Analyze data from the results of previously conducted investigations	Interpretation Classifying Predicting Communicating
Explaining research results	Encourage students to interpret the results of data analysis	Interpretation Communicating
Presenting the results of the work and presenting it	Students can make presentations in front of the class regarding the work they have produced.	Communicating

Based on the description of the relationship in table 10, it can be seen that each stage of PRBL has a relationship with the SPS dimension. This shows that the use of the PRBL model in e-modules provides significant benefits and is effective in increasing students' SPS. Meanwhile, the results of the synthesis of several experts can be concluded that the implementation of PRBL-based e-modules provides a positive contribution to various parties, both for students, teachers and the progress of education in Indonesia. Students not only gain knowledge, but also develop 21st century skills, such as critical thinking, collaboration, creativity, and digital literacy. For teachers, the presence of e-modules will make it easier to deliver material so that the learning atmosphere becomes more innovative. The creation of interactive learning will produce optimal output so that learning objectives can be achieved. Furthermore, for the world of education in Indonesia, the use of PRBL-based e-modules contributes to the creation of more inclusive, adaptive learning, and oriented towards the development of global competencies. This approach encourages the progress of education by preparing a competent and competitive young generation at the national and international levels.

Conclusion

*E-module*PRBL-based learning model is effective in improving students' SPS in science subjects. The measurement of the effectiveness of the e-module was tested through the t-test, effect size and n-gain score. Based on the results of the t-test, it showed a significance value of 0.00, which means that there is a significant difference between the values of the experimental class and the control class. The effect size results showed a value of 0.63, which means that the achievement of the application of the e-module in learning on the results of students' SPS has a moderate effect. Meanwhile, the results of the n-gain score for the experimental class showed a value of 0.702 with a high category and the control class showed a value of 0.404 with a moderate category. Based on the results of the test conducted, the value obtained for the experimental class was much higher than the control class. This is due to the difference in teaching materials used. The experimental class uses a PRBL-based e-module, while the control class uses a BSE textbook from the school. Thus, the application of PRBL-based e-module has proven effective in improving students' SPS because it provides a more active and contextual learning experience compared to using BSE textbooks.

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