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STEAM Learning Against Science Process Skills Viewed from the Scientific Attitude of Students in the Vocational Physics Study Course

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Abstract: 21st-century education requires students to have Science Process Skills (SPS) to be able to compete in the academic world and the industrial world 5.0. SPS itself is a skill needed to solve problems by following scientific stages. The application of the STEAM learning approach using the Project Based Learning (PjBL) learning model is expected to stimulate students to improve their skills. The research design used the One Group Pretest-Posttest Design. The instruments used were tests to observe SPS variables and non-tests to observe scientific attitudes. Hypothesis research analysis using one-way ANOVA analysis. The results of the study found that there was an effect of STEAM learning on student SPS and there were differences in student SPS that had high, medium, and low scientific attitudes.

Keywords: Attitude Scientific; Science Process Skills; STEAM

Introduction

The learning of independent learning campus independent curriculum *(MBKM)* emphasizes mastery of Science, Technology, and Arts both pragmatic and materialist to students (Junaidi, 2020). This curriculum policy itself provides the greatest opportunities and challenges for students to be able to compete nationally and internationally (Arifin & Muslim, 2020). The learning process in this curriculum uses a student-centered learning approach, which facilitates students in increasing their capacity, personality, creativity, and student need independently, both in formal and non-formal education (Vhalery et al., 2022; Boang et al., 2022). This curriculum is designed to produce superior human resources in the 21st century.

21st-century education prepares students to have skills appropriate to the industrial revolution 5.0 (Sakdiah & Jamilah, 2022). At this time science and technical matters will be replaced by technology, so soft skills and hard skills are of particular concern as outcomes of education (Muliani et al., 2022). Various skills must be possessed to survive in today's onslaught of technology. Science process skills (SPS) are one of them, where SPS is an ability or insight in exploring intellectual, social, and physical skills that originate from scientific fundamental abilities (Hasanah & Utami, 2017). SPS is a skill that is owned in solving problems so that it can form individuals who are competitive nationally and internationally (Turiman et al., 2012). SPS can also be defined as the ability to apply the scientific method to understand, develop scientific knowledge and find knowledge (Lestari & Diana, 2018).

The SPS indicators used in this study are: (1) Observing, namely the activity of using all the five senses and appropriate tools to find all information from objects, phenomena or situations; (2) Grouping, namely classifying objects based on the characteristics of the objects observed; (3) Making a hypothesis, namely making a provisional guess or tentative explanation based on experiences, phenomena, events, or the nature of an object; (4) Designing experiments, namely skills in determining tools and materials and designing them to investigate something scientifically; (5) Interpreting

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data, namely skills in reading, explaining, and providing temporary conclusions from data that has been described or placed in a table and is the result of an experiment; (6) Communicating, namely conveying observations, ideas, theoretical models, or conclusions by speaking, writing, drawing, making physical models, and so on; (7) Applying concepts, namely using concepts, theories or principles that have been understood in solving new problems; (8) Concluding, namely compiling the results of thoughts in the form of complete sentences that explain the data obtained simply.

As students in the Physics Education Study Program, students should have a scientific attitude. A scientific attitude is an attitude of being able to accept the opinions of other people properly and correctly, the ability to act to solve problems systematically following scientific steps that are not easily discouraged, and full of perseverance and openness (Ulfa, 2018). Maskoeri Jasin also stated that a scientific attitude is an attitude that scientists need to have including curiosity, unable to accept the truth without evidence, honesty, openness, tolerance, skepticism, optimism, brave, creativity, or self-help (Jasin, 2010). The scientific attitudes observed in this study are 1) Curiosity, 2) Critical thinking, 3) Open thinking and cooperation, 4) Respect for data, 5) Invention and creativity, 6) Perseverance and 7) Sensitivity to the surrounding environment.

Innovative learning is needed to guide students to learn independently, one of which is learning with the STEAM approach (Darmadi et al., 2008). STEAM is a development of the STEM (science, Technology, Engineering, and Mathematics) approach. STEM is an interesting topic to be explored collaboratively by researchers and educators around the world (Irwanto et al., 2022).

The STEAM approach is a multi-disciplinary approach that develops from the STEM approach by adding elements of art to learning (Mu'minah et al., 2019). The definition of 'A' from STEAM is creativity as a result of learning, where art is produced during the learning process. The addition of this art is intended to train students in expression, communication, creativity, imagination, observation, perception, and thoughts to improve their cognitive abilities (Taylor, 2016). The touch of art gives value to the project during learning.

STEAM learning is learning that directs students' independence in updating the scientific abilities of the younger generation, and, by adding artistic value and creativity as skills that must receive special attention in learning (Aguilera & Ortiz-Revilla, 2021). STEM learning is a learning process of solving a problem with systematic research (mathematics), by observing and testing (science), using the field of knowledge that is mastered (technique), and utilizing available facilities (technology).

The application of STEAM approach can be carried out by applying constructivist learning models such as Problem Based Learning, Inquiry, Cooperative Learning, and Project Based Learning (Baran et al., 2021). This study applies PjBL (Project-Based Learning) in implementing STEAM. The PjBL model involves project production and practice-oriented learning and because this activity fulfills the "engineering" skills in STEAM education the two approaches are compatible (Slough & Milam, 2013). PjBL learning directs students to be creative, skilled, and confident in designing, processing, and concluding completing projects (Sinta et al., 2022). The stages of the PjBL model used are: (1) determining basic questions; (2) creating a project design; (3) arranging the schedule; (4) monitoring project progress; (5) results from assessment; (6) evaluation of the experience.

Method

The research utilizes the Pre-Experimental Design method. The design used is the One Group Pretest-Postest Design, which is a study that compares the results before and after treatment without using a control class (Sugiyono, 2012). The instrument used was a test instrument in the form of 10 SPS questions and a non-test in the form of a questionnaire consisting of 40 questions assessing students' scientific attitudes.

Data analysis to see whether there is an effect of STEAM learning on student SPS using the t-test. Meanwhile, data analysis was performed using analysis of variance or ANOVA. This test was conducted to see whether there were differences in the creative thinking skills of students who had high, medium, and low scientific attitudes. The one-way ANOVA test design that will be carried out is shown in Table 1.

Table 1. One-Way ANOVA Design

Learning	Scientific Attitude	*Posttest* (SPS)
PjBL model STEAM approach	High	μ_1
	Middle	μ_2
	Low	μ_3

Information:
μ_1 : The average SPS of students with a high scientific attitude
μ_2 : The average SPS student with a moderate scientific attitude
μ_3 : The average SPS of students with a low scientific attitude

Result and Discussion

The average student SPS pretest score is 34.33 while the average student posttest score is 70.04. The difference in the average values can be seen in Figure 1.

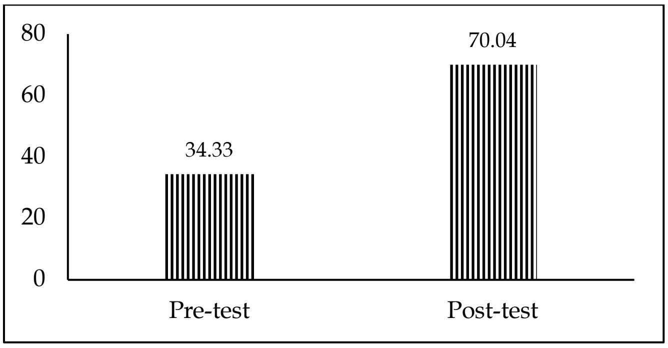

Figure 1. Graph of students' SPS pretest and posttest scores.

Figure 1 shows that the average SPS of students using STEAM learning has increased by 35.71 points. This increase shows that STEAM learning with the PjBL model can improve student SPS. The implementation of STEAM learning with the PjBL model can attract students to be actively involved in completing projects.

The results of the pretest-posttest are then carried out with a prerequisite test. The first test is the normality test, using the Shapiro-Wilk test because the number of samples is less than 50. The results of the pretest-posttest normality test can be seen in Table 2.

Table 2. Pretest-posttest Normality Test Results

Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Stat.	df	Sig.	Stat.	df	Sig.
Pretest	.152	24	.159	.930	24	.100
Posttest	.159	24	.120	.933	24	.111

a. Lilliefors Significance Correction

The significance of the Shapiro-Wilk column for the pretest row is 0.100 greater than 0.05 (0.100 > 0.05) so that the pretest data is normally distributed. Likewise, the posttest data obtained a significance of 0.111 greater than 0.05 (0.111> 0.05) so the posttest data is also normally distributed. Both data are concluded to be normally distributed, and the conditional test is then carried out by a homogeneity test.

The results of the pretest-posttest data homogeneity test can be seen in Table 3.

Table 3. Homogeneity Test Results

Levene Statistic	df1	df2	Sig.
.000	1	46	.993

The significance of the homogeneity test is 0.993 greater than 0.05 (sign 0.993> 0.05), so it can be seen that the data is homogeneous.

Whether or not the influence of STEAM learning on student SPS can be tested using a paired t-test. The hypothesis put forward is:

H_{01} = There is no effect of STEAM learning on student SPS.

H_{a1} = there is an effect of STEAM learning on student SPS.

The results of the t-test can be seen in Table 4.

Table 4. Data Results of the t-test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev	Std. Error Mean	95% Conf. Interval of the Difference				
				Lower	Upper			
Pair 1 SPS - Class	50.68	20.64	2.97	44.69	56.68	17.01	47	.000

Table 4 shows that a significant (2-tailed) value of 0.000 is smaller than a significant 0.05 (sig. 0.00 <0.05) meaning that Ha is accepted or there is an effect of STEAM learning on student SPS. Students' SPS has increased because students' STEAM learning stages are directed to solve their problems by applying science in the form of concepts - the law of conservation of momentum and Newton's third law. Applying technology in the form of the internet in finding references and utilizing various tools in completing projects. Applying engineering in completing the project design for making rocket projects. Applying Art in designing rocket projects. As well as applying Mathematics in designing and testing rocket projects. The results of the analysis applied in the research show that in the process of implementing STEAM project development, students brainstorm to solve problems, conduct research, and obtain the necessary materials.

These results are in line with research conducted by Fadilah which states that the purpose of STEAM learning is to improve students' skills in four fields of science, namely science skills, technology operating skills, technical problem-solving skills, and math skills which are very suitable to be applied to face the challenges of the 21st century (Fadhillah, 2022). This is in line with research conducted by Afrianti which stated that the development of STEM-based worksheets through Guided Inquiry is valid and feasible and can be used in the Physics learning process to improve Students' Science Process Skills (Afrianti et al., 2022). This is also in line with the research conducted by Fitriyah which concluded that the implementation of PjBL-based STEAM has a significant effect on students' creative and critical thinking skills (Fitriyah & Ramadani, 2021). These results were obtained because STEAM learning with the PjBL model provides a learning experience in completing a project with innovative ideas.

Whether or not there are differences in SPS students who have high, medium, and low scientific attitudes is done by testing the hypothesis:

H_{02} : There is no difference in SPS of students who have high, medium, and low scientific attitudes.

H_{a2} : There are differences in SPS students who have high, medium, and low scientific attitudes.

But before testing the hypothesis, the post-test scores were first classified based on the scientific attitude of students to test the next hypothesis to find out whether or not there were differences in the creative thinking skills of students who had high, medium, and low scientific attitudes by conducting a one-way ANOVA test. The description of the posttest value against the scientific attitude criteria can be seen in Table 5.

Table 5. SPS Posttest Data Description Based on Scientific Attitudes

Scientific Attitude	N	*Mean*	*Std. Dev*	*Std. Error*	*Min*	*Max*
High	7	78.00	8.66	3.27	63.00	88.00
Middle	12	68.25	11.28	3.25	50.00	88.00
Low	5	63.20	6.64	2.97	55.00	73.00
Total	24	70.04	10.92	2.22	50.00	88.00

The table above shows that seven samples have a scientific attitude in the high category with an average SPS of 78.00, twelve samples have a moderate scientific attitude with an average SPS of 68.25 and five samples have a scientific attitude in the low category with an average SPS of 63.20.

The post-test data based on this scientific attitude were then tested for homogeneity so that the hypothesis could be tested. The results of this data homogeneity test can be seen in Table 6.

Table 6. SPS Posttest Homogeneity Test Results on Scientific Attitudes

Levene Statistic	df1	df2	Sig.
1.73	2	21	.200

Table 6. shows a significance of 0.200, this value is greater than the significant level of 0.05, this means that the data is homogeneous so that a hypothesis test can be carried out with a parametric test. This study used one-way ANOVA.

Table 7. Results of the one-way Anova test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	715.90	2	357.95	3.70	.042
Within Groups	2027.05	21	96.52		
Total	2742.95	23			

The table above shows an F value of 3.70 with a significant value of 0.042, a significance value less than 0.05, indicating that H0 is rejected and Ha is accepted. This means that there are differences in SPS students who have high, medium, and low scientific attitudes.

To find out which group has the difference between the scientific attitude groups, the next test is carried out, namely the Tukey test. Tukey test results can be seen in Table 8.

Table 8. Tukey Test Results Dependent Variable: SPS Tukey HSD

(I) Scientific Attitude	(J) Scientific Attitude	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
High	Middle	9.75	4.67	.117	-2.02	21.52
	Low	14.80*	5.75	.045	.29	29.30
Middle	High	-9.75	4.67	.117	-21.52	2.02
	Low	5.05	5.22	.606	-8.13	18.23
Low	High	-14.80*	5.75	.045	-29.30	-.29
	Middle	-5.05	5.22	.606	-18.23	8.13

*. The mean difference is significant at the 0.05 level.

The Tukey table above shows that the average SPS scores of students who have a high scientific attitude are not significantly different from the average SPS scores of students who have a moderate scientific attitude but are significantly different from the average SPS scores of students who have a low scientific attitude and the average SPS scores of students who have moderate scientific attitudes do not have a significant difference to students who have high or low scientific attitudes.

These results indicate that only high and low scientific attitudes have a significant difference in the average student SPS score. A scientific attitude is an encouragement from within students to solve problems scientifically. This research is in line with research conducted by Fitriansyah which states that scientific attitudes affect scientific work, where when scientific attitudes are good, the scientific work carried out will also be good (Fitriansyah et al., 2021). The difference in SPS values is due to curiosity, critical thinking, open thinking, and cooperation, respect for data, invention, and creativity, perseverance, sensitivity to the surrounding environment better in groups with high scientific attitudes. The attitudes above are very helpful in carrying out student projects as well as in solving problems with the SPS indicator.

The scientific attitude itself is a scientific attitude. This scientific attitude is then expected to have a positive impact on learning outcomes in the cognitive domain, scientific literacy abilities, and attitudes toward science itself (Bruckermann et al., 2021). With a scientific attitude, students can hierarchically organize their thoughts so that they can solve the problems they face (Nurman et al., 2017).

The application of the STEAM learning approach using the PjBL learning model is proven to be able to improve students' science process skills. STEAM learning in its process needs the scientific attitude of students so that learning goes as well as possible.

Conclusion

The application of the STEAM learning approach using the PjBL learning model is proven to be able to improve students' science process skills. STEAM learning in its process needs the scientific attitude of students so that learning goes as well as possible. A high scientific attitude produces better SPS scores, this is evident from the difference in the average SPS scores of students who have high and low scientific attitudes.

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