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Analysis of Science Process Skills and Scientific Attitudes of Students in STEM Integrated Project-Based Learning

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ABSTRACT
In order to adapt to the rapid development of technology and information in the 21st century, various abilities and skills are required.As an instrument of social change and scientific attitudes, education has a responsibility to facilitate every learning process so that it is oriented to the needs of the times.This study uses a quantitative descriptive method that aims to analyze the results of Science Process Skills and Scientific Attitudes of students through the application of STEM (Science, Technology, Engineering and Math) integrated Project-Based Learning.The subjects in this study were 70 students who took Basic Physics lectures using a sampling technique, namely total sampling.The content validity of the instrument through analysis of the Vaiken index obtained an average index of 0.84 in the High category for the Science Process Skills instrument and an average index of 0.83 in the High category for the Scientific Attitude instrument, indicating that the instrument was declared valid and feasible.used.The results of the Science Process Skills assessment of students obtained the highest average in the Conducting Experiment aspect with a score of 89.29 and in the Very High criteria, while for the average of all aspects of Science Process Skills a score of 83.72 was obtained in the High criteria.For the results of the Scientific Attitude assessment, students obtained the highest average in the Curious Attitude aspect with a score of 94.29 and in the Very High criteria, while for the average of all aspects of Scientific Attitude, a score of 89.71 was obtained in the Very High criteria.Based on these results it can be stated that the implementation of PjBL – STEM has a positive impact and contribution to Science Process Skills and Scientific Attitudes of Students.

Keywords:*Science Process Skills, Scientific Attitudes, Project-Based Learning, STEM.*

1. INTRODUCTION

Science and technology are two fields of knowledge that synergize with each other in the development of human civilization, especially in the last century and entering the current 21st century[1]. Science and engineering take on the role of being the foundation and creator of every influential invention in the development of human civilization, while technology produces innovations for every discovery made by science and provides efficiency for human life[2].So much effectiveness and efficiency that is felt from the development of technology and information today must be in line with the adaptation that everyone has in this era, not only adapting in terms of ability to apply or apply technology in everyday life, but also must pay attention to the values in responding to technological developments without ignoring environmental sustainability[3], [4].It has become a necessity, in order to be able to adapt to an era, everyone must have a series of abilities, skills, and qualified attitudes needed in this era.[5].Efforts that can be made in preparing and providing provision so that they can adapt to the development of an era are through education, both formal and non-formal, through proper learning it is hoped that it will be able to equip students as future generations with the abilities and skills that are in accordance with the needs of the 20th century. 21 currently[6].

Literacy ability is one of the various skills needed in the 21st century, but based on the results of the PISA survey in the last few editions, Indonesian students occupy a very low position with an average score far below the international average[7], [8]. Based on the results of observations that the author carried out through interviews with several high school teachers in Lhokseumawe and North Aceh, it was found that the average student literacy ability was still in the poor category, and the problems that often arise were students' difficulties in applying the scientific method, in understanding, developing, and discover science. Science process skills are skills that mobilize all students' abilities to acquire knowledge, which includes observing, counting, grouping, asking questions, making hypotheses, making plans, and conducting experiments, skills in science process skills

are expected to influence learning outcomes which are a form of change experienced by students after learning[9]. The scientific attitude is the most important human quality that allows for rational thinking that leads to planned and logical systematic actions[10].The scientific attitude is important for critical thinking and reasoning, the importance of developing a scientific attitude among students because it can develop objectivity, develop curiosity, critical thinking, and decision making[11].

The role of educators as guardians of the learning process in the classroom, must be able to properly consider the learning process in accordance with the expected competencies [12]. Through STEM integrated Project-based Learning (PjBL), it enables students to creatively apply scientific knowledge, skills, and attitudes related to mathematics, natural sciences and other disciplines for scientific and technological activities to solve simple real-life problems, and offers opportunitiesfor students to verify their theoretical knowledge and achieve unity of learning and practice[13].Interdisciplinary STEM-integrated PjBL aims to emphasize the importance of developing 21st century skills such as adaptation skills, social skills, communication skills, problem solving skills, and self-development[14].

Project-based learning (PjBL) is designed primarily to help students develop their thinking, problem-solving and intellectual skills; learning adult roles by experiencing them through real or simulated situations; and become independent and self-directed learners[15].The PjBL model is excellent for integrating multiple process skills into one meaningful unit of experience, with instructional effects Project Based Learning is a scientific process, a strategy for creative discovery, a spirit of creativity, independent learning, tolerance of ambiguity, a scientific attitude, and the tentative nature of knowledge[16].Literature review of relevant research shows that the implementation of STEM-integrated PjBL has a significant effect on students' science process skills and scientific attitudes[3], [17]–[21].

2. METHOD

This study uses a quantitative descriptive method that aims to analyze the science process skills and scientific attitudes of students[22]. The research was carried out in October 2022 with research subjects involving 70 students. The procedure in this study was started by compiling an observational assessment instrument for science process skills and scientific attitude, which then carried out content validity through three validators as expert judgments. The data results from the validation were then analyzed through the V-aiken index[23]. The results of the Vaiken index analysis are then adjusted based on the categories in Table 1.

Table 1. Instrument Validity Level Category [24]

V-Aiken Index	Validity Level
$V < 0,4$	Low
$0,4 \leq V < 0,8$	Medium
$V \geq 0,8$	High

After the assessment instrument is declared valid and feasible, the instrument is then applied to assess students' science process skills and scientific attitudes during STEM-integrated PjBL learning. To observe the assessment of science process skills and scientific attitudes of students, each follows the indicators and assessment rubrics in Table 2 and Table 3[24].

Table 2. Science Process Skills Assessment Rubric and Indicators

Aspect	Indicator	Behavior Item	Score
Observing	Using the appropriate senses to describe and collect information or facts that are relevant to the results of observations based on criteria: a. Using all the senses to observe objects or events that occur during research activities b. Examine every work procedure	A total of 2 criteria have been carried out properly	4
		A total of 2 criteria have been carried out, but 1 criterion has not been carried out completely	3
		As many as 1 criterion has not been carried out properly	2
		Both criteria are not visible	1
Predicting	The ability to be able to predict what will happen based on trends from data obtained	A total of 2 criteria have been carried out properly	4

	based on criteria: a. Identify the accuracy of the data obtained based on relevant reference sources b. Identify the inaccuracy of the power obtained based on the relevant reference sources	A total of 2 criteria have been carried out, but 1 criterion has not been carried out completely	3
		As many as 1 criterion has not been carried out properly	2
		Both criteria are not visible	1
Proposing a hypothesis	The ability to formulate tentative conjectures about possible relationships found in an experiment with criteria: a. formulate research alternative hypotheses and research null hypotheses appropriately b. Formulate hypotheses that can be tested for truth	A total of 2 criteria have been carried out properly	4
		A total of 2 criteria have been carried out, but 1 criterion has not been carried out completely	3
		As many as 1 criterion has not been carried out properly	2
		Both criteria are not visible	1
Experimenting	Ability to carry out experimental procedures appropriately to prove research hypotheses with criteria: a. Choose an appropriate design to test the hypothesis b. Carry out all experimental procedures in a coherent and systematic manner	A total of 2 criteria have been carried out properly	4
		A total of 2 criteria have been carried out, but 1 criterion has not been carried out completely	3
		As many as 1 criterion has not been carried out properly	2
		Both criteria are not visible	1
Interpreting	Ability to interpret data to answer problems or prove research hypotheses with criteria: a. Interpret experimental data based on research hypotheses in tabular form carefully and thoroughly b. Formulate final conclusions to answer problems or prove research hypotheses correctly	A total of 2 criteria have been carried out properly	4
		A total of 2 criteria have been carried out, but 1 criterion has not been carried out completely	3
		As many as 1 criterion has not been carried out properly	2
		Both criteria are not visible	1
Make a conclusion	The ability to link observations with relevant theoretical studies as a basis for drawing conclusions based on criteria: a. Arranging data that leads to the possibility of solving problems or proving research hypotheses b. Formulate initial conclusions through organizing the data that has been collected	A total of 2 criteria have been carried out properly	4
		A total of 2 criteria have been carried out, but 1 criterion has not been carried out completely	3
		As many as 1 criterion has not been carried out properly	2
		Both criteria are not visible	1
Communicating	The ability to present the results of observations obtained from experiments with criteria: a. Presenting accurately based on experimental results in practicum b. Ask rational, logical questions and respond to the opinions of others	A total of 2 criteria have been carried out properly	4
		A total of 2 criteria have been carried out, but 1 criterion has not been carried out completely	3
		As many as 1 criterion has not been carried out properly	2
		Both criteria are not visible	1

Table 3. Rubric and Indicators for Assessment of Scientific Attitudes

Aspect	Indicator	Criteria	Score
Curious Attitude	Enthusiasm in learning activities	If 4 indicators appear	4
	Pay close attention to every object observed	If 3 indicators appear	3
	Ask about things you don't know	If 2 indicators	2

		appear	
	Excited to find answers to questions	If 1 indicators appear	1
Respect for Facts	Students carry out practical activities well	If 4 indicators appear	4
	Fill in the data objectively	If 3 indicators appear	3
	No data manipulation	If 2 indicators appear	2
	Make decisions based on facts	If 1 indicators appear	1
Open Minded Attitude	Appreciate any criticism, suggestions and opinions of others	If 4 indicators appear	4
	Not self-righteous	If 3 indicators appear	3
	Active in group activities	If 2 indicators appear	2
	Give your opinion during the discussion	If 1 indicators appear	1
Perseverance	Try repeating the experiment to get accuracy data	If 4 indicators appear	4
	Complete the task to completion	If 3 indicators appear	3
	Totality in carrying out practicum	If 2 indicators appear	2
	Complete all stages in the practicum	If 1 indicators appear	1
Sensitive Attitude Toward The Environment	Always pay attention to events around	If 4 indicators appear	4
	Maintain the cleanliness of practicum tools and classroom environment	If 3 indicators appear	3
	Use practical tools properly and carefully	If 2 indicators appear	2
	Clean and tidy up practicum tools after use	If 1 indicators appear	1

After analyzing the data on the results of science process skills and students' scientific attitudes, they are then categorized according to the criteria based on Table 4[24].

Table 4. Categories of Assessment of Science Process Skills and Scientific Attitudes

Score	Criteria
≥ 85	Very High
70 – 84	High
55 – 69	Medium
41 – 54	Low
≥ 40	Very Low

3. RESULTS AND DISCUSSION

This study aims to analyze Science Process Skills and Scientific Attitudes of students in the application of STEM-integrated Project-Based Learning (PjBL – STEM).The data collection technique for Science Process Skills and Scientific Attitudes uses an observational assessment instrument, before the instrument is suitable for use, a validity test is first carried out on three experts, then the results are analyzed through the V-aiken index.The validation results through experts for the Science Process Skills assessment instrument can be seen in Table 5.

Table 5. Results of the Validation of the Science Process Skills Assessment Instrument

Aspects of Validity Assessment	V	Category
Instructions for filling in the observation sheet are clearly	0.78	Medium

formulated		
The assessment format is easy to understand	0.89	High
The assessment criteria are clear and easy to understand	0.89	High
The assessment aspect is in accordance with the objectives of measuring students' science process skills	0.78	Medium
Assessment aspects can be assessed through observation	0.89	High
The assessment aspect can show the attitude of students in actual or real situations	0.78	Medium
Use language that is in accordance with good and correct Indonesian rules	0.89	High
Use communicative language	0.78	Medium
The language used is clear, so it doesn't lead to multiple interpretations	0.89	High
Mean	**0.84**	**High**

From the results of the validation of the Science Process Skills assessment instrument, an average score of 0.84 was obtained in the High category which stated that the assessment instrument was declared valid and suitable for carrying out an assessment of students' Science Process Skills. Furthermore, the results of the validation of the Scientific Attitude assessment instrument can be seen in Table 6.

Table 6. Results of the Validation of the Scientific Attitude Assessment Instrument

Aspects of Validity Assessment	V	Category
The indicators used are in accordance with the scientific attitude aspect	0.78	Medium
The boundaries of the statement are clear so that they are not ambiguous	0.89	High
The formulation of the main questions is clear and straightforward	0.78	Medium
Filling instructions are clear	0.78	Medium
The formulation of the declarative sentence is clear	0.89	High
Use of grammar in standard statements	0.78	Medium
Use of words/terms generally accepted	0.89	High
Formulation of communicative statement sentences	0.89	High
Mean	**0.83**	**High**

From the results of the validation of the Scientific Attitude assessment instrument, an average value of 0.83 was obtained in the High category which stated that the assessment instrument was declared valid and suitable for carrying out an assessment of student Scientific Attitudes.

After the assessment instrument is declared valid and feasible, then an assessment of students' Science Process Skills and Scientific Attitudes is carried out during the implementation of PjBL - STEM. The results of the Science Process Skills assessment of 70 students can be seen in Table 7.

Table 7. Results of Assessment of Student Science Process Skills

Assessment Aspects of Science Process Skills	Mean of Each Aspect	Category
Observe	88.21	Very high
Predict	87.50	Very high
Make a Hypothesis	86.43	Very high
Doing Experiments	89.29	Very high
Interpreting Data	65.00	Medium
Conclude	88.93	Very high
Communicate	80.71	High
Mean	**83.72**	**High**

From the observation results for the assessment of Student Science Process Skills (KPS) in the six aspects, in the Conducting Experiments aspect the highest average result was 89.29 and in the Very High criteria. During the PjBL - STEM learning activities, each group of students was very active and enthusiastic in presenting the results of their project, and explained very well to their classmates how their project worked and also involved STEM elements in the project.

The aspect of interpreting data has the lowest average score of all other KPS aspects with a value of 65.00, even though the results of this aspect are still in the sufficient category. The main factor that causes the Interpreting Data aspect to not be as good as the assessment results on other aspects is that most of the projects produced by student groups are still limited to explaining phenomena and concepts, have not shown data or produced a measurement of magnitude. This is quite reasonable, because the projects assigned to student groups are limited to the theme of Environmental Sustainability and Management of Environmental Pollution Impacts, which require minimal data interpretation. Even so, in general, students' KPS assessments on the implementation of PjBL - STEM in this study obtained an average score of 83.72 with High criteria, this shows that the implementation of PjBL - STEM makes a positive contribution to students' Science Process Skills.

Several relevant assessments also found that there was a significant influence and also an increase in Science Process Skills through PjBL - STEM Learning, and could encourage students to be more active during the learning process[21], [25], [26].Furthermore, the results of the Scientific Attitude assessment of 70 students can be seen in Table 8.

Table 8. Results of Student Scientific Attitude Assessment

Aspects of Scientific Attitude	Mean of Each Aspect	Category
Curious Attitude	94.29	Very high
Respect for Facts	92.86	Very high
Open Minded Attitude	83.93	Very high
Perseverance	88.21	Very high
Sensitive Attitude Toward The Environment	89.29	Very high
Rata-rata	**89.71**	**Very high**

From the results in Table 8 for the Scientific Attitude assessment, it shows that of the five aspects of the assessment, an average of 89.71 is obtained in the Very High criteria, as well as the average criteria for each aspect. During the implementation of PjBL – STEM learning, each group of students was observed to show behavior that was very much in line with the Scientific Attitude indicator, especially when discussing and exchanging arguments between groups showing an attitude of persistence and curiosity to prove hypotheses about scientific phenomena through projects and discussions between student groups. Based on Table 8 it also shows that the implementation of PjBL - STEM provides a positive role and contribution to the Scientific Attitude of Students, in accordance with several relevant studies which found that the implementation of PjBL - STEM shows a positive influence on the Scientific Attitude of students[14], [27], [28].

4. CONCLUSION

The application of STEM-integrated Project-Based Learning (PjBL – STEM) has a very good impact on students' Science Process Skills and Scientific Attitudes. Based on the results of the analysis of the average value of the perspective for Science Process Skills, the highest rating was obtained on the Conducting Experiment aspect with a score of 89.29 on the Very High criterion and the lowest rating on the Interpreting Data aspect with a value of 65.00 on the sufficient criterion, while the results of the average assessment for all aspects of students' Science Process Skills, a score of 83.72 was obtained on the High criteria. For the assessment of students' Scientific Attitudes from the five assessment aspects, an average of 89.71 was obtained in the Very High criteria, as well as the average criteria for each aspect being in the Very High criteria.

AUTHORS' CONTRIBUTIONS

1. Fajrul Wahdi Ginting as the lead researcher and facilitator in PjBL - STEM learning
2. IsnaRezkiaLukman as observer and research data analyst
3. Mellyzar as the author of the research instrument
4. RismaAndriani and SapinaTiarani as research assistants

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