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Effectiveness of STEAM Differentiated Learning in Physics Learning of Measurement Concepts to Embody the Pancasila Student Profile Dimensions of Critical Reasoning

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Abstract. This study aims to evaluate the effectiveness of differentiated STEAM learning in physics learning that focuses on the measurement aspect. The application of this learning model is directed to realize the Pancasila profile of students in the critical reasoning dimension. The research method used was a quasi-experimental with a pretest-posttest control group design, namely the experimental class was given an intervention with a differentiated STEAM approach, while the control class was given conventional learning. Based on the results of the N-gain score test calculation, the average N-gain score of the experimental class (differentiated STEAM learning approach) is 63.51%, which is included in the fairly effective category. With a minimum N-Gain value of 22.22% and a maximum of 90%. While the average N-Gain score of the control class (conventional learning) of 55.77% is included in the less effective category, with a minimum N-gain score of -12.50% and a maximum of 100%. So it can be concluded that the use of the differentiated STEAM learning approach is quite effective in instilling the Pancasila student profile in the critical reasoning dimension.

Keywords: steam learning, differentiated learning, measurement, Pancasila student profile, critical reasoning.

1. Introduction

The Ministry of Education and Culture officially launched an independent curriculum to overcome the learning crisis. The independent curriculum is synonymous with differentiated learning and the Pancasila Student Profile[1]. Differentiated learning is a learning method that is based on meeting students' needs both in terms of learning readiness, interest, or learning profile and how teachers respond to these learning needs[2–4]. The students were born with various characteristics and unique circumstances [5,6]. As a teacher, in implementing Independent Learning, one must be able to become a student facilitator, so that student potential can develop optimally [7–9]. Through the application of differentiated learning, students not only maximize their potential, but also learn about various life values that will contribute to complete personal development[10–12] .

One of the movements that emerged was STEAM (Science, Technology, Engineering, Art and Mathematics) learning. This learning aims to equip students with various skills needed to face various unpredictable world changes [13]. In fact, learning activities in schools currently still focus on basic thinking skills. The low quality of education is reflected in student literacy which tends to be still not optimal, because scientific literacy is a real result that can be used as a guide to measure the quality of education in Indonesia [14]. There are two factors that influence students' scientific literacy, namely internal factors that come from within the student (psychological) and external factors that come from outside the student. One of the internal factors that can influence scientific literacy is student learning motivation [15]. There are various aspects that contribute to the low learning outcomes of Indonesian

students. First, the pedagogy and teaching effectiveness of Indonesian teachers still needs to be improved [16].

There are still many teachers who have not implemented learning following the Merdeka curriculum. One effort to overcome this problem is by implementing a learning process that can support high-level thinking skills, one of which is the ability to increase student creativity, namely with STEAM learning [17]. Learning with a STEAM approach is able to stimulate students' soft skills such as cooperation and collaboration in groups and criticizing surrounding phenomena [18]. STEAM can be a learning innovation that can give rise to creative and critical ideas and solutions, making it easier to solve problems [19]. STEAM approach can direct students to have skills in collaborating and communicating well so that there is an exchange of knowledge and information which has an impact on forming a cohesive relationship [20]. STEAM approach has a very good interaction effect on the creative thinking skills of high school students in terms of their ability to understand physics concepts [21].

In contrast to the 2013 Curriculum, the actualization of the Independent Curriculum is more basic with an emphasis on establishing a Pancasila student profile [22,23]. This means that graduates not only have scientific competence but also national personality-based character that must remain superior [24]. The Pancasila student profile consists of six dimensions, namely: faith, devotion to God Almighty, and noble morals; independence; mutual cooperation; global diversity; critical reasoning; and creativity [25]. It is important to look at the six dimensions of the Pancasila student profile as one unit so that each individual can become a lifelong learner who has competence, character and behavior in accordance with Pancasila values [26,27]. In order to facilitate a deeper understanding of the dimensions of the Pancasila student profile, it is necessary to explain the meaning of each dimension and sequence its development according to the stages of psychological and cognitive development of school-aged children and adolescents [28,29]. In addition, each dimension of the Pancasila student profile consists of several elements, and some elements are described in more detail into subelements [30,31]

To realize the Pancasila student profile, the application of character education must be integrated in all subjects, including physics subjects, especially the concept of measurement [32]. By implementing differentiated STEAM learning, it is hoped that it will be able to accommodate the dimensions of the Pancasila student profile in physics lessons, especially the dimensions of critical and creative reasoning [33].

Based on the results of teacher observations and interviews with teachers and students, the learning taking place at SMA N 1 Donorojo currently still uses the old pattern. Learning is still carried out classically with the assumption that the abilities of all students are relatively homogeneous. As a result, students' absorption of knowledge has not been maximized, for example in the aspect of learning measurement concepts, all content, processes and products in learning are the same for all students. Apart from that, students' actualization of the Pancasila profile is still minimal. Therefore, researchers believe that by applying differentiated STEAM learning to physics subjects, the concept of measurement can create a Pancasila student profile, especially the critical reasoning dimension. This research is important to study because it can provide insight into the extent to which differentiated STEAM learning methods can improve students' understanding and skills in understanding physics material on measurement concepts. This research aim to develop student to embody the profile of Pancasila students in the critical reasoning dimension in physics learning.

2. Method

The subjects in this research were class X students of SMA N 1 Donorojo. Sampling was carried out using the cluster random sampling technique which was carried out in class X.3 as the experimental group and class X.4 as the control group with a total of 40 students in each class. Students carry out differentiated learning on measurement material to test the effectiveness of differentiated STEAM learning on measurement material to instill Pancasila student profiles with critical reasoning dimensions. Implementation of STEAM in measurement concept material is by including STEAM elements in learning. Students are given a project to make various measuring instruments according to their respective designs. An assessment of how effective STEAM learning is differentiated from the concept of measurement in achieving the development of students' critical thinking with skills in accordance

with the Pancasila student profile is carried out by working on questions consisting of 20 multiple choice questions.
The flow diagram related to the stages carried out in this research is depicted in Figure 1.

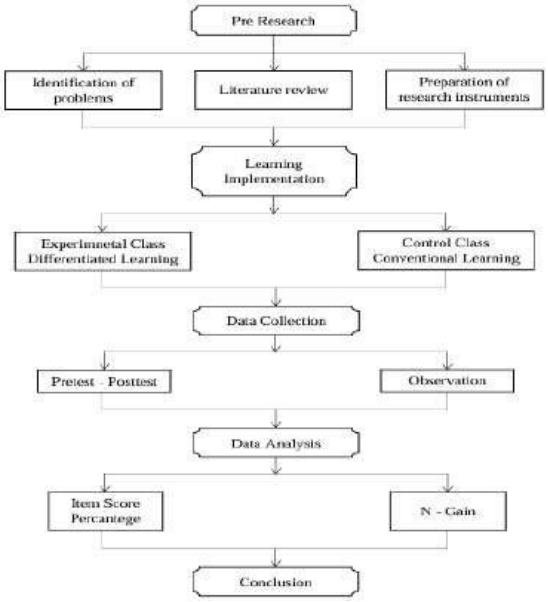

Figure 1. Research flow figure.

These questions are designed to measure critical thinking skills based on the criteria set by Ennis [34]. Which include (1) providing simple explanations, (2) building basic skills, (3) making conclusions, (4) making further explanation, and (5) determining strategy and tactics. Apart from tests, observation sheets were also created to determine the profile of Pancasila students in the critical reasoning dimension during learning. Data analysis using N-gain was used to determine whether or not there was an increase (Gain) in the profile of Pancasila students in the critical reasoning dimension of students whose learning was based on differentiated STEAM (experiment class) and students whose learning was not based on differentiated STEAM (control class). Data obtained from students' pre-test results and post-test with the following N-gain formula:

$$Gain\ (g) = \frac{\text{Post} - \text{test score} - \text{Pre} - \text{test score}}{\text{Maximum score} - \text{Pre} - \text{test score}} \quad (1)$$

The critical reasoning ability test instrument assessment criteria are in Table 1 and Table 2.

Table 1. Pancasila student profile score criteria.

Intervals (%)	Criteria
0 - 60	Not yet developed
61 – 70	Starting to develop
71 – 80	Developing as expected
81 - 100	Very developed

Table 2. N-gain effectiveness criteria.

Percentage (%)	Category
>76	Effective
56 - 76	Effective Enough
40 - 55	Less Effective
<40	Ine Effective

3. Result and Discussion

The first step in the research was to carry out an initial assessment, namely a cognitive assessment by giving 5 questions using Google Form to groups of students based on their readiness in the experimental class, namely class X.3 of SMA Negeri 1 Donorojo. Of the 36 students, 18 people were in the less prepared group, 7 people were in the quite ready group, and 11 people were in the ready group. From the results of this initial assessment, the researcher formed a heterogeneous group, where one group consisted of students who were less ready, quite ready and ready, so that students who were ready could become peer tutors for students who were less ready and quite ready. From the results of the initial assessment of students in one class, 6 groups can be formed, each group consisting of 6 people consisting of 3 students who are less ready, 1 student who is quite ready and 2 students who are ready. This is in accordance with the opinion [35], that each student has different abilities, learning styles and levels of readiness. Forming heterogeneous groups and providing differentiated STEAM-based learning can increase teaching effectiveness and information reception. Project-based learning in the experimental class takes place using process differentiation, where the product produced is a measuring instrument prototype.

The effectiveness of differentiated STEAM learning in physics lessons on measurement concepts in realizing the Pancasila student profile with critical reasoning dimensions, is carried out by providing multiple choice questions. The average percentage of pre-test and post-test scores on the critical reasoning dimension can be seen in Figure 2.

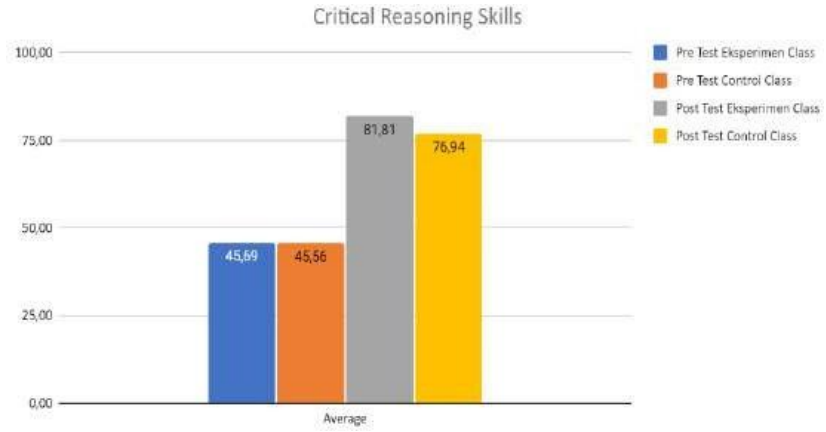

Figure 2. Average value of critical reasoning skills.

From the data presented in Figure 2, it can be seen that the average pre-test CBC score for the experimental group was 45.69 and the control group was 45.56. Meanwhile, the average post-test KBK score for the experimental group was 81.81 and the average KBK score for the control group was 76.81. The increase in post-test scores in the experimental class is in accordance with [35] the opinion that differentiated learning can increase student understanding and involvement. This approach allows students to learn at a level appropriate to their abilities, thereby creating a more positive learning experience.

Next, a t-test was carried out to compare the averages of two unrelated samples (control class and experimental class), to find out whether the two samples had any differences. An Independent sample t-test is shown in Table 2. From Table 2, the results of the t-test for post-test data show that the t-test value = 2.279 and the t-table = 2.030 with a significance of 0.026. It can be seen that the t-test value > the probability of the t-test table and the sig (2-tailed sig) is less than 0.05. So it can be said that there is a significant difference in the profile of Pancasila students in the critical reasoning dimension between students who use differentiated STEAM learning and those who do not use differentiated STEAM learning. This is in accordance with the opinion of Hattie who states that differentiation in teaching can have a significant impact on student learning outcomes [36].

Tabel 2. Independent sample t-test.

		Levene's Test for Equality of Variances		T-test for Equality og Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difrerence	95% Coafidence Interval of the Difference	
									Lower	Upper
KBK	Equal variances assumed	3.752	.057	2.279	70	.026	5.00000	2.19402	.62417	9.37583
	Equal Variances not Assumed			2.297	62.823	.026	5.00000	2.19402	.61536	9.38464

Next, an N-Gain analysis is carried out, this analysis is used to determine whether or not there is an increase (Gain) in the Pancasila student profile in the critical reasoning dimension of students in learning using the differentiated STEAM approach (experimental class) with students who do not use the non-STEAM differentiated learning approach (control class).

Table 3. N-Gain score test calculation results.

N-Gain Score		
	Experiment Class	Control Class
Mean	63.51	55.77
Minimum	22.22	-12.50
Maximum	90	100

Based on the N-gain results, it shows that the average N-gain score for the experimental class (differentiated STEAM learning) is 63.51% which is included in the quite effective category. With a minimum N-Gain value of 22.22% and a maximum of 90%. Meanwhile, the average N-Gain score for the control class (conventional learning) was 55.77%, which was included in the less effective category. With a minimum N-gain score of -12.50% and a maximum of 100%. So it can be concluded that the use of differentiated STEAM learning is quite effective in instilling the profile of Pancasila students in the dimension of critical reasoning in the Physics subject of measurement concepts in Class effective in increasing students' Pancasila profile in the critical reasoning dimension in the Physics subject of measurement concepts in Class students on the critical reasoning dimension than learning that does not use differentiated STEAM. The high N-gain value in the experimental group is consistent with Marzano's opinion regarding effective learning strategies, namely that effective education includes learning strategies that pay attention to the individual needs of students, namely the differentiated STEAM learning approach [37].

From Table 4, the results of observing the profile of Pancasila students in the critical reasoning dimension in the experimental class from 36 students obtained data on the elements of obtaining and processing information and information ideas, sub-elements of asking questions, sub-elements of questioning, and sub-elements of questioning. It was found that four students developed, 30 students developed according to expectations and two students developed significantly. In the element of obtaining and processing information and ideas, the sub-element of identifying, clarifying and processing information and ideas found that seven students developed, 27 students developed according to expectations, and two students developed very well. Sub elements state the reasons for decisions analyzing and evaluating reasons and procedures. Two students began to develop, five students developed, and 29 students developed as expected. In the reflective thinking element and the thinking

process sub-element of reflecting and evaluating one's thinking, it was found that four students were starting to develop, ten students were developing, 20 students were developing according to expectations, and two students were developing very well.

Table 4. Observation results of Pancasila student profiles on critical reasoning dimensions.

Element	Sub-Elements	Started of Develop	Is Developing	Developing According to Expectation	Very Developed
Obtain and process information and ideas	Asking question	-	4	30	2
Obtain and process information and ideas	Identify, clarify and process information and ideas	-	7	27	2
Analyze and aveluate reasoning and procedures	State the reasons for the coice of decision	2	5	29	-
Reflection of thought and thought processes	Reflect and evaluate one's thinking	4	10	20	2

Effective differentiated STEAM learning is able to realize the Pancasila student profile, where in this research the focus is on the critical reasoning dimension. This is in line with research on differentiated STEAM learning which accommodates students' learning needs, the learning becomes conducive and the learning objectives are achieved, namely realizing the Pancasila student profile [38].

4. Conclusion

The results of the research show that differentiated STEAM learning is quite effective in forming the Pancasila student profile of the critical reasoning dimension of high school students. Apart from that, the research results show that there is an increase in students' critical thinking abilities after receiving differentiated STEAM learning. From the observation results, it was also found that the majority of students in all elements of critical reasoning were able to reach the developing category as expected according to their phase, namely phase E. Differentiated STEAM-oriented physics learning allows students to learn actively, apply their knowledge in real situations, and develop reasoning skills. critical through measuring instrument projects. The interaction between students, teachers, and a learning environment that encourages understanding of scientific concepts has helped students develop their critical reasoning abilities. This learning process helps create an inclusive learning environment and supports student development. The implications of this research can provide guidance for educators to design learning strategies that do not only focus on understanding scientific concepts. Apart from that, the results of this research can make a positive contribution to the development of curriculum and learning methods that are oriented towards building student character in accordance with Pancasila values.

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