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Science Process Skills and Science Learning Motivation in Chemistry Learning with STEM Student Worksheets Through Floor Cleaning Formulations

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Abstract: This study aims to develop STEM student worksheets. The research method used is research and development (R&D) using the ADDIE model stages. Determination of the research sample using random sampling method with research subjects are students of class XI IPA 1 SMA Inshafuddin Banda Aceh. The results showed that students' science process skills increased significantly and were significantly different from the pretest based on the T-test. Students' science process skills increased in each indicator with an average N-gain score of 37 belonging to the medium category. Students' motivation to learn science is high with an average score of 87.38% belonging to the very good category.

Keyword: Science Learning Motivation; SPS; STEM; Student Worksheets

Introduction

Education is one of the efforts to increase the capacity of human resources to become a better human civilization (Sulistiyowati et al., 2018; Sujana, 2019). Scientific literacy is the ability to apply, identify, illustrate, explain, describe, and predict phenomena that occur and be able to relate them to everyday life. (Juhji & Mansur, 2020). Indonesia obtained an average scientific literacy score of 396 in the 2018 Program for International Student Assessment (PISA). The average score of PISA participants was 489. Indonesia was in 70th position out of 78 PISA participants. (Organisation for Economic Co-operation and Development, 2019). One effort to increase students' scientific literacy is to improve science process skills (SPS). Improving science process skills is one of the goals of learning in schools (Ariani et al., 2019).

Based on the national exam scores from 2015 to 2019, SMA Inshafuddin Banda Aceh has problems, especially in chemistry lessons. There are several factors that affect student learning outcomes. These factors are classified into internal and external factors (Ekowati, 2019). Less varied learning models can cause students to feel bored. Variations in learning models can increase learning motivation (Hasan et al., 2019). Improving student learning outcomes is inseparable from learning motivation (Ekowati, 2019). level of student motivation to learn can be indicated through their level of involvement in the learning process (Lukita & Sudibjo, 2021).

Science process skills are the basis of scientific inquiry and intellectual development for learning science concepts (Wahyuni et al., 2017), develop concept, developing facts (Siahaan et al., 2017), and develop a sense of responsibility (Elvanisi et al., 2018), therefore science process skills need to be owned by students. One of the efforts to improve science process skills is learning to use approaches science, technolonogy, engineering, and mathematics (STEM), because STEM activities can train students to design, experiment, develop engineering products, and reduce errors (Sari et al., 2020).

Teachers must be creative in developing teaching materials that can guide students to find their understanding related to learning materials actively. One of the characteristics of learning that can develop creative thinking skills is problem-solving activities.

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Learning with the STEM approach can solve student problems by combining science, technology, engineering, and mathematics (Astuti et al., 2021). To support the learning process, teaching materials are needed, one of which is student worksheets. One of the potential educational resources that can be created is a student workbook. This workbook includes pages designed to enhance cognitive skills and encompass various learning components. The student workbook serves as a document providing students with information or directions for engaging in learning activities, which involve practicing or applying acquired knowledge toward specific objectives. (Kuswidyanarko, Rohana & Jannah, 2021).

Student worksheets can be combined with a learning approach. One of them can be combined with the STEM approach. The STEM approach complies with the 2013 curriculum requirements (Ramli et al., 2020). The STEM approach can create fun learning for students because, with the STEM approach, students can understand concepts and relate them to everyday life. (Herak, 2019). STEM student worksheets can be used as an alternative to training students' scientific literacy. STEM student worksheets can affect learning outcomes (Sulistiyowati et al., 2018). Even though STEM student worksheets can improve learning outcomes, there has not been found a STEM student worksheet whose learning produces floor cleaning formula products as one of the innovative learning so that can increase students' motivation to learn science.

Method

This research uses the Research and Development (R&D) method, a type of research intended to develop, deepen, or expand existing (educational) knowledge (Arifin, 2011). The development carried out in this study is the STEM student worksheet with the STEM project to produce floor cleaning formulas.

The development stages in this research use the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). This study used a pre-experimental method. The research design used was the One Group Pretest-Posttest Design, which was to compare the results before and after the treatment (Sugiyono, 2012). The research instruments were needs analysis sheets, student worksheet assessment sheets, SPS test questions, and a science learning motivation questionnaire.

The subjects in this study were students of class XI IPA 1 at Inshafuddin Private High School Banda Aceh. Investigation of research subjects using a random sampling technique, namely by providing equal opportunities to each student to become a subject in this study. Student worksheet feasibility data and students' motivation to learn science were analyzed using a percentage formula based on the Yusrizal equation (2016).

$$P = \frac{\text{Score Obtained}}{\text{Max Score}} \times 100\% \quad (1)$$

The SPS test was analyzed using the t-test to see significant differences before and after learning using the STEM student worksheet. The n-gain test was also conducted to see the differences in student SPS before and after treatment on each SPS indicator. The N-gain test and t-test were carried out using the Statistical Package for the Social Science (SPSS) application.

Results and Discussion

Development of STEM student worksheets

STEM student worksheets were developed using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model stages. The ADDIE stages carried out in this study are as follows:

Analysis

The stages of analysis were carried out using a needs analysis questionnaire and teacher interviews. The results are that teachers rarely use worksheets in learning, STEM worksheets are never used, and teachers rarely do practicums because of a lack of supporting facilities. The teacher also said that he needed STEM student worksheets. Therefore, this study developed worksheets for STEM students to overcome teachers' problems hampered by the lack of material preparation for practicums.

Design

Table 1. STEM concepts in student worksheets

STEM Aspect	STEM Concepts
Science	Chemistry related to the concept of solution
Technology	Make a floor-cleaning formula
Engineering	Design procedures for making floor cleaning formulas and ways to prove the formula's success
Mathematics	Calculate the amount of material used to make floor cleaners, calculate costs, and calculate the selling price.

This stage designs STEM student worksheets and project ideas appropriate to STEM aspects. The products produced from STEM learning in this student worksheet are floor-cleaning kits. The STEM concept in student worksheets is shown in Table 1. floor-cleaning kits designed in STEM student worksheet consist of four different formulas. It is designed so that students are more active in learning.

Development

The development stage begins with the validation of student worksheets by expert validators. The validator conducts an assessment of the STEM student worksheets that have been prepared based on several evaluation aspects including material factors, learning components, presentation, language, physical appearance, illustrations/drawings, and the completeness of the details mentioned in the validation sheet brought by 2 validator experts. The validation results of STEM student worksheets obtained an average value of 83.75% with a very decent category according to Arikunto's eligibility score description (2013). Therefore, the developed STEM student worksheets can be used with revisions according to the expert validator's suggestions.

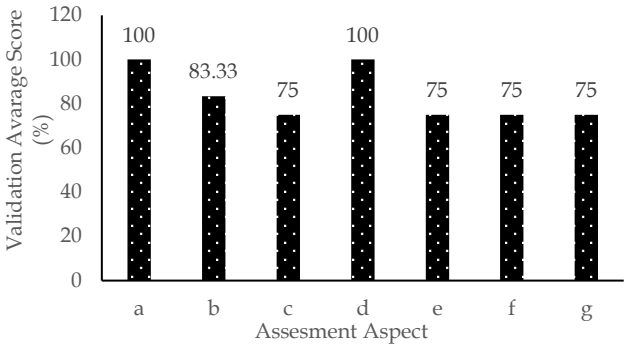

Figure 1. Student Worksheet Validator Results: (a) Material, (b) Learning Components, (c) Presentation, (d) Language, (e) Physical Appearance, (f) Illustrations/drawings, (g) Completeness of Components

Implementation

The implementation of the STEM student worksheet in this study was carried out in 2 meetings. In the first meeting, the students were divided into 4 groups according to the number of formulas designed in the student worksheet. Students discuss making floor cleaners such as choosing the type of formula, understanding the function of each ingredient used, and designing procedures for making floor cleaning kits. In the second meeting, students made floor cleaners according to previously designed procedures, proved the success of the floor cleaning kit on ceramics, and compared the level of cleanliness of ceramics cleaned with a floor cleaning kit and ceramics cleaned without a floor cleaning kit.

Table 2. Floor Cleaning Kit Formulas

Group	Formula
1	Dish soap, vinegar, soda, water
2	Dish soap, caustic soda, water
3	Dish soap, chlorine, water
4	Dish soap, salt, vinegar, water

The floor cleaning formula made by the students proved its success on hard-to-clean ceramics as shown in Figure 2.

(a) (b)

Figure 2. Comparison of ceramic samples: (a) dirty ceramics that are difficult to clean, (b) ceramics that have been cleaned with a floor-cleaning formula

Evaluation

Evaluation of the development of STEM student worksheets is carried out after the learning process uses the developed STEM student worksheets. Evaluation by analyzing the SPS test and questionnaire analysis of students' motivation to learn science.

Science Process Skills

The improvement of science process skills is seen based on the differences in pretest and posttest scores of science process skills. Data on SPS pretest and posttest values were collected using statistical test stages. The normality test is carried out to see that the data is normally distributed so that it can be tested with parametric statistics, namely the t-test. The normality test was carried out using the SPSS application. The normality test at the significant level $\alpha = 0.05$ as shown in Table 1 shows that the data is normally distributed, because the significance of the data is more significant than 0.05. Research data can be analyzed using parametric statistics, namely the t-test.

Table 3. Pretest and posttest Normality Value Test

Category	Normality test Kolmogorov-Sminrnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-Test	.137	20	.200	.959	20	.521
Post-Test	.192	20	.051	.953	20	.421

It can be seen that the posttest average value is 64.33> 43.00 which is greater than the pretest average value. T-test obtained is negative based on significant testing. Based on the parameters in the t-test, if the t-test is negative, the difference in value in this study is significantly different from t-test -8.894 which is smaller than t-table 2.093.

Table 4. Tests of Students' Science Process Skills

Activity	N	Average	Sd	t_{test}	df	t_{table}
Pre-Test	20	43.00	10.47	-8.894	19	2.093
Post-Test	20	64.33	11.90			

The average SPS score increased from 43 to 64.33. Based on the n-gain test, a value of 37 is obtained which

is in the moderate category. The acquisition of SPS student scores increased in each indicator. The findings of this study are supported by Mahjatia's research (2020), which found that overall learning using STEM student worksheets was very good and the SPS increased in each meeting.

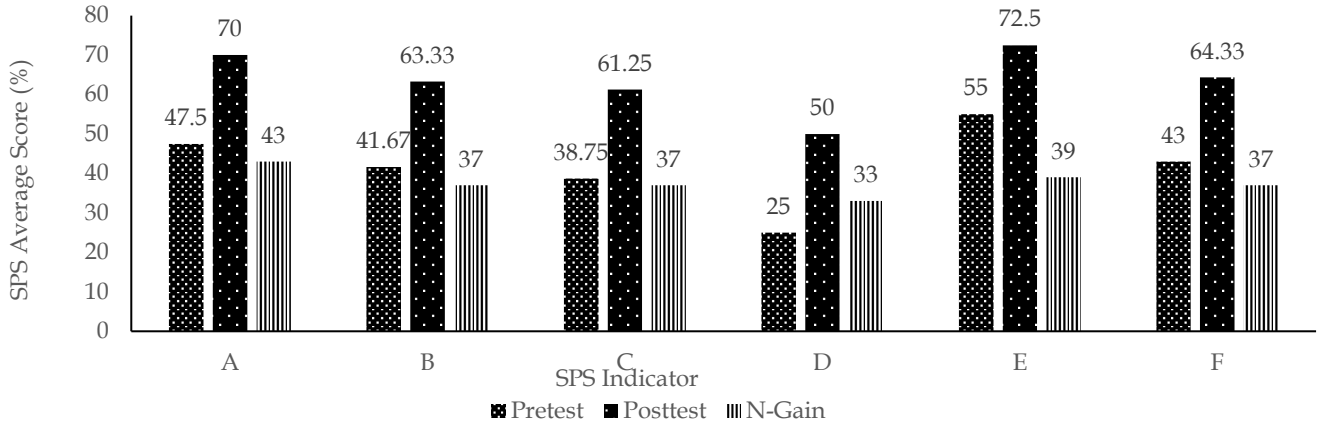

Figure 3. Percentage of Science Process Skills Tests (%); (A) Formulating Hypotheses, (B) Planning Experiments, (C) Conceptual Concepts, (D) Making Observations, (E) Interpreting Data, (F) Averages.

The acquisition of the SPS score in this study shows that the indicator for formulating a hypothesis has the highest increase compared to other indicators, with a value of 47.5 increasing to 70 with an N-gain value of 43 which is included in the medium category. This shows the beneficial impact of learning with STEM student worksheet on students' ability to develop hypotheses. STEM student worksheet allows students to conduct experiments, this can help students improve their ability to develop hypotheses (Salsiah, 2015).

Science Learning Motivation

The motivation to learn science was measured in this study consists of five indicators between the desire and desire to succeed, the urge and need to study, the hopes and aspirations for the future, the existence of exciting activities in learning, and the existence of a conducive environment.

Overall, students' motivation to learn science after learning with STEM student worksheets is very good with an average proportion of 87.38 in the very good category according to Purwanto's assessment description (2013). The existence of a desire to learn and a desire to succeed is an indicator of motivation to learn science which obtains the highest average percentage compared to other indicators. The indicator with the lowest percentage is a conducive learning environment. Based on statements from the chemistry teacher at Inshafuddin High School in Banda Aceh through interviews, school facilities related to chemistry learning are inadequate, especially in practicum activities. Practicum activities are rarely carried out in schools because of the lack of preparation of the materials needed.

Table 5. Assessment of Students' Science Learning Motivation

Motivation Indicator	Total Value	Percentage
There is a will and desire to succeed	1335	89
There is a drive and a need to learn	425	85
There are hopes and aspirations for the futures	173	86,5
There are exciting activities for learning	354	88.5
There is a conducive learning environment	247	82.33
Average		87.38

Motivation plays a crucial role in driving students to actively engage in STEM subjects and pursue careers in STEM fields (Bayanova et al., 2022). The implementation of STEM student worksheets in chemistry learning has a positive effect on students' motivation to learn science. STEM student worksheets with learning activities to produce floor cleaning tools are a variation of the learning method. Variations in learning methods are one of the causes of increased student motivation (Aziz & Shaleh, 2019). Learning motivation is an influential factor that can change students' thinking because learning motivation is crucial in learning activities (Arslan, 2017). The findings of Sugiyanto et al. (2020), study indicate that learning motivation has a significant impact on the results of learning.

Conclusion

STEM student worksheets developed to improve science process skills and students' motivation to learn science through making floor cleaning kits can be classified as very feasible with an average score of 83.75.

Overall, the SPS participants differed significantly based on the t-test. each SPS indicator measured has increased based on the n-gain test. Students' motivation to learn science is classified as very good based on the analysis of the angle of inspiration to learn science with an average proportion value of 87.38.

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Author Contribution
Ridha Maulana contributed Ridha as a researcher and article writer, M. Adlim contributed as a research idea and article writing supervisor, and Ibnu Khaldun contributed as a supervisor in processing research data.

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Conflicts of Interest
In writing this article, we solemnly declare that there are no conflicts of interest that might affect the impartiality and honesty of the results.

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