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FEASIBILITY OF STEM-APPROACHED WORKSHEET TO IMPROVE STUDENTS 'LEARNING OUTCOMES

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Abstract

This study aims to describe the feasibility of the STEM-approaced Worksheets to improve student learning outcomes on liquid pressure material. The feasibility of the worksheet is evaluated by the aspects of validity, practicality, and effectiveness. This worksheet was developed by using the ADDIE model. The subjects of this study were 30 students of class VIII-B of Junior High School 1 Wonosalam. The results of the validity aspects showed that the worksheet validation score was 4 with very valid criteria. The result of the practicality aspects shows the implementation of learning by using STEM-approached worksheets obtaining mode 4 with very good categories and very good student activities. The highest percentage of student activity is 26.77%, which is doing worksheets by conducting experimental activities and making STEM products in the form of Bottle Raft. The results of the effectiveness aspects based on an increase in student learning outcomes showed an average N-Gain score of 0.71 with a high category. Based on the posttest score, there was 83% of students completed and 17% of students did not complete. Students respond very well to STEM-approached worksheets. Based on the results of this study, it can be concluded that the STEM-approached Worksheets are feasible to improve student learning outcomes.

***Keywords**: student worksheets, STEM, learning outcomes.*

INTRODUCTION

Education has an important position in empowering human potential to develop and develop the culture and civilization of a nation's future (MONE, 2008). The objectives of the 2013 curriculum in Indonesia are to prepare students to have competencies including 1) having a religious and ethical attitude; 2) mastering science; 3) applying science and skills in scientific inquiry and present useful work (Rahayu, 2007). The demands of the 21st century are the demands of all parties (Trilling and Fadel, 2009). The Partnership for 21-century skill in the 21st century consists of 1) learning and innovation skills (creativity, innovation, critical thinking, problem-solving, communication, and collaboration); 2) information, media, and technology skills; 3) life and carrier skills.

STEM (Science, Technology, Engineering, Mathematics) is an important issue in education today. STEM education has many potential benefits for individuals and the nation as a whole (Beatty in Subekti, 2018). One of the characteristics of STEM education is integrating science, technology, engineering, and mathematics in solving real problems (Roberts and Cantu, 2012). The aim of STEM education is students can apply science so they can solve the problems in daily life related to the STEM science field (Bybee, 2013).

The occurrence of inequalities in the field of the global industry is a result of inadequate education in mathematics and science (Cooney and Bottoms, 2003). STEM education is important for developed countries because developed countries depend on workers in the STEM sector to survive in the world economy (Banning and Folkestad, 2012). The problem of the quality and quantity of Indonesian human resources cannot be solved if only applying the existing 2013 curriculum. Therefore, learning with the STEM approach is the key to solve this. The hope is to create the next generation that can compete globally.

Data from the PISA survey (International Student Assessment Program) shows that Indonesia ranks quite low in the subject of science and mathematics. Indonesia ranks 70th of 78 countries in the science subject and 72nd of 78 countries in mathematics subjects (OECD, 2019). Based on data from the Ministry of Education and Culture (2019), the average of Junior High School National Examination scores on science subjects in 2019 amounted to 48.79 with low categories. Because of these facts, learning by integrating STEM needs to be developed in Indonesia to improve student learning outcomes, especially in the subject of science and mathematics. Learning outcomes are defined as a process of changing student behavior after learning activities (Purwanto, 2014). The problems with completeness result student learning that low can be solved by applying the model of learning such as Learning Cycle 5E, STEM-approach, and other learning models that can increase student motivation and learning activities (Morrison, 2006).

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According to interviews result with the science teacher at Junior High School 1 Wonosalam showed that learning outcomes for students in science subject tends to be low, approximately 20 of 31 students are under the KKM. Especially in the sub science learning in physics, the application on daily life. The results of the pre-research questionnaire on students indicated that the teacher still applies the direct instruction model, so students get the information only from one, namely the teacher. Some factors influence learning are divided into internal and external factors. Internal factors are students' initial abilities and external factors are learning approaches. Learning approaches can be implemented using student worksheet (Sudibyo, 2018). A student worksheet is one component that supports the success of the teaching and learning process. Learning using student worksheets can increase student activity with very good criteria (Fauziah, 2017).

Research that has been conducted by Shahali, shows that learning that uses STEM design gives positive changes to students (Shahali, 2016). Other research was also conducted by Ulfa which showed that the application of STEM-based learning on pressure material had a significant influence on student motivation and learning outcomes. The average N-gain results of student learning outcomes are 0.7 in the high category (Ulfa, 2019).

The learning process must be systematically designed following the STEM integration forms so that the purpose of the STEM learning process can be fulfilled (Syarifah, 2015). STEM learning can be an alternative to learning. STEM delivered with an appropriate learning model with the help of student worksheet that it can improve student learning outcomes which so far tend is low. Especially in SMPN 1 Wonosalam, in the sub science learning in physics. The sub-physics material chosen is liquid pressure material. These ideas and supported by theory and some relevant research, the purpose of this study is to describe the feasibility of STEM-approach worksheets to improve student learning outcomes on liquid pressure material.

METHOD

This development research with the ADDIE model consists of Analyze, Design, Development, Implementation, and Evaluations (Mulyatiningsih, 2012). The trial design used One Group Pretest-Posttest Design (Sugiyono, 2012). The subjects of this trial were 30 students of class VIII-B of Junior High School 1 Wonosalam during two meetings in January 2020. The development phase will be reviewed based on validity aspects. In the validity aspect, the method used is a validation method with a validation sheet instrument. The worksheet is declared valid if obtaining score mode ≥ 3. The validation process is carried out by three validators, two lecturers from the Department of Natural Sciences, FMIPA, Unesa, and a science teacher at Junior High School 1 Wonosalam.

The implementation phase will be reviewed in the practical aspects and effectiveness of the worksheet. In the practical aspect, the method used is an observation with an instrument of learning implementation and student activity sheets. The worksheets are declared practical if the implementation of learning has a value mode ≥ 3. The observation process is carried out by three observers during the study. Meanwhile, the effectiveness aspect used the questionnaire method for student responses and the test method for learning outcomes. The technique of data analysis used is the N-Gain score test from the results of the pretest and posttest. The STEM-approached worksheet is declared effective if the N-Gain score obtained ≥0.30 is in the medium category. The N-Gain score criteria are presented in Table 1 below.

Table 1 N-Gain Category

N-Gain Score	Category
<g> <0,30	Low
0,30 ≤ <g> <0,70	Medium
0,70 ≤ <g> <1,00	High

(Hake, 1999)

RESULT AND DISCUSSION

The Based on research that has been done with the ADDIE model, the results obtained are described below.

Analysis Phase

At the analysis phase, pre-research questionnaires and interviews were conducted with the teacher to determine the problems and potential of the students. Based on the results of the pretest given to students of class VIII-B of Junior High School 1 Wonosalam, it was found that all students in one class got the score below the Minimum Mastery Criteria (KKM) on the liquid pressure material. This is supported by the results of interviews with a science teacher at Junior High School 1 Wonosalam stating that the majority of student learning outcomes on science materials were low, around 20 of 31 students still under the Minimum Mastery Criteria. Especially in the physics subject, most students still experience difficulties in understanding. The problems of student learning outcomes that are low can be solved by using various alternatives or learning models that can increase student learning activities (Morrison, 2006).

The results of the questionnaires to class VIII-B students at Junior High School 1 Wonosalam showed that teachers still use the direct instruction models, so students get the information only from one, namely the teacher. The results of the questionnaire also showed that students did not know much about STEM approach learning. After getting a little explanation, 84% of students are interested in STEM approach learning. Some factors influence learning are divided into internal and external factors. Internal factors are students' initial abilities and external factors are learning approaches. Learning approaches can be implemented using student worksheet (Sudibyo, 2018).

Design Phase

The design phase is the phase for designing products, learning tools, learning materials, and evaluation tools for learning outcomes based on the previous phase. Based on the analysis phase, the solution to improve student learning outcomes is through the development of STEM-

approached worksheets. At this phase the worksheet design approach is approached by STEM, supported by learning tools in the form of syllabus, Learning Implementation Plan (RPP), and pretest and posttest questions. The design phase begins with designing the syllabus, formulating indicators based on the selected Basic Competencies. Then the material is mapped to be integrated with STEM components and aspects in learning outcomes. Assessment in the 2013 Curriculum includes an assessment of processes both in aspects of attitudes, knowledge, and skills (Kemendikbud, 2013). There are three STEM learning approaches, namely the silo (separate) approach, the embedded (embedded) approach, and the integrated (integrated) approach (Winarni, 2016). The STEM-approached worksheet uses an embedded approach.

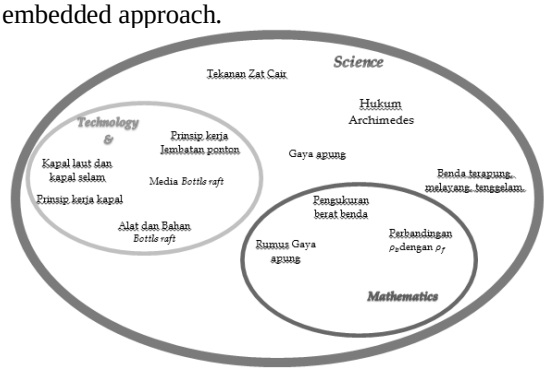

Figure 1 Chart the embedded STEM approach

The STEM-approached worksheet draft is a worksheet for two meetings on the subject of liquid pressure with sub-subject Archimedes Law. STEM-approached worksheets are equipped with Science, Technology, Engineering, and Mathematics features. In the worksheet, students will be invited to make examples of simple STEM products called "bottle raft" media (Challoner, 2019). This worksheet is equipped with pictures to support learning. The specifications of this worksheet sections include: (1) Cover page; (2) Table of contents; (3) Basic Competence; (4) learning indicators; (5) Instructions; (6) The contents are in the form of illustrations, material descriptions, simple experiments, questions, and summary; (7) Other features are STEM components, 5E learning stages, science info, and evaluation tests. In this worksheet, each activity is adjusted to the Engineering Design Process (EDP) and the Learning Cycle 5E model.

Development Phase

The development phase is the realization of product design and product feasibility testing. There are two worksheets. The first worksheet included a study of Archimedes' Law and a simple trial guide using a crusher. The second worksheet contains guidelines for making "bottle raft" media and experiments using the media. This worksheet also completed with STEM component features, 5E learning stages, STEM learning mapping, science info, and pictures that support learning. After realizing this worksheet, it will be tested for eligibility on the validity aspect. Based on the validation results obtained in the following Table 3.

Table 2 STEM Approach Worksheet Validation Recapitulation

No	Aspects	Rating Score			Mode	Criteria
		V1	V2	V3		
1	Didactic Requirements	4	3	4	4	Very Valid
2	Construction Requirements	3	4	4	4	Very Valid
3	Technical Requirements	4	4	4	4	Very Valid

Information:
V1: Validator 1
V2: Validator 2
V3: Validator 3

Based on Table 2, the STEM-approached worksheet is declared highly valid by three validators with a score mode 4. There are three eligibility requirements of a worksheet namely didactic requirements, construction requirements, and technical requirements (Widjajanti, 2008). The STEM-approached worksheet obtains a mode value of 4 in didactic requirements. The didactic requirements relate to the worksheet that can be used by universal (Widjajanti, 2008). It means that the STEM-approached worksheet can be used well for all the students because in this worksheet various features can help students in learning. This worksheet obtains a mode value of 4 in construction requirements. This requirement relates to the procedure for writing and for using language (Widjajanti, 2008). It means that this worksheet use language that is appropriate to the age and level of thinking of students. The technical requirement relates to writing, drawing, and display (Widjajanti, 2008). This worksheet obtains a mode value of 4 in technical requirements. It means that the selection of images and colors in worksheets can increase student motivation. Based on these results, the STEM-approached worksheets were declared feasible in the validity aspect.

Implementation Phase

This phase is the implementation of products in a real situation in the classroom. This phase is testing the feasibility of practical aspects and effectiveness aspects.

- Practical aspects

The practicality aspects of the STEM-approached worksheet is from the implementation of learning and student activities. The observation is carried out by three observers during two meetings in class. The implementation of learning results is presented in Figure 2 below.

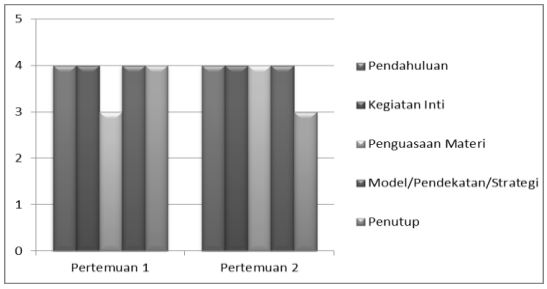

Figure 2 Learning Implementation Graph

Figure 2 shows the results of the implementation of learning using STEM-approached worksheets. This instrument refers to the PPG Performance Test (UKIN) instrument by the Ministry of Research, Technology, and Higher Education (2018). It obtains a mode of 4 in the introduction section. It shows that the activities for preparing students and providing apperception and motivation very well do. This section becomes the teacher's initial capital to find out the basic abilities possessed by students (Suciyanti, et al, 2017). Therefore in this section, the teacher's role is very much needed.

The core activities section consists of aspects of the material and the models/approaches/strategies used. The retention of material obtains mode 3 for the first meeting and 4 for the second meeting. It showed the difference in the material coverage between the first and the second meeting. The material covered at the first meeting is wider than the second meeting. The model/approach/ strategy aspect obtained mode 4. The learning model used is the Learning Cycle 5E model with the STEM approach. In research conducted by Kaniawati, the integration of STEM make every phase of learning in the 5E Learning cycle model to be more strength(Kaniawati, et al, 2015). It shows that the application of STEM on the Learning Cycle 5E model can increase student abilities.

The concluding section consists of summarizing learning material and reflection and follow-up. This section is also well done. Overall, learning using STEM-approached worksheets performed very well. The better the implementation of learning, the greater the expectations for high learning outcomes (Aminulloh, 2018).

The results of observing student activities during the two meetings are presented in the following figure.

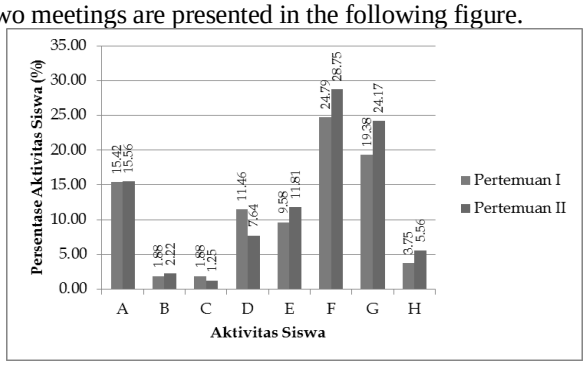

Figure 3 Student Activity Graph

Activity Description:

A: Listen to the teacher's explanation.
B: Asking questions.
C: Express opinions.
D: Take notes.
E: Studying LKS.
F: Doing worksheets.
M: Do group work.
H: Present the results of group work.

Figure 3 shows an increase in student activity during learning using STEM approached worksheets. Student activeness in learning is also one of the factors in achieving learning objectives (Rosidah, 2019). Based on the observation of student activities, it was found that the dominant activity at the time of learning activities was to do worksheets consist of conducting experimental activities in making STEM products with a percentage of 26.77%. The learning activity use worksheets can increase student activity with very good criteria (Fauziah, 2017). This is supported by research conducted by Rahmiza (2015) which shows that using STEM worksheets can improve student learning activities. It is also supported by Piaget's theory of learning which divides human cognitive levels into four levels. And the research object used is the eighth-grade junior high school students with a range of 14 years. This age included in the level of formal operations. At this level, the main ability possessed is abstract thinking and problem solving through experimentation. Overall the STEM-approached worksheets were declared feasible in the practical aspect.

- Effectiveness aspects

The results of the STEM-approached worksheet development have been declared feasible in the aspect of effectiveness based on student responses and learning outcomes. The 2013 curriculum emphasizes activity-based learning so that the assessment carried out includes an assessment of processes both in the aspects of attitude, knowledge, and skills (Kemendikbud, 2013).

Assessment of student learning outcomes on aspects of knowledge was obtained from the pretest and posttest question sheets which consisted of 10 multiple-choice questions. The mastery of student learning outcomes is determined based on the Minimum Mastery Criteria (KKM) that apply in Junior High School 1 Wonosalam. KKM that applies in Junior High School 1 Wonosalam is 73 for natural science subjects in eight grade.

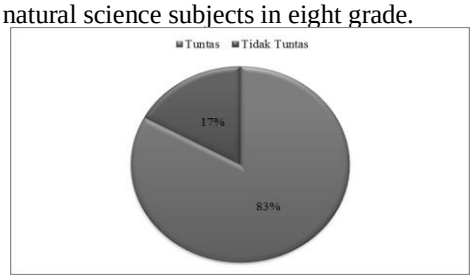

Figure 4 Completeness of students' Posttest Results

Figure 4 showed that after learning to use STEM-related worksheets, 83% of students are in a complete category and 17% of students are incomplete. The average score obtained by students at the posttest is 83. In BSNP (2006), the ideal criteria for completeness of learning for each indicator that has been applied in a basic competency are 75%.

Improved student learning outcomes were analyzed from the calculation of the N-Gain score based on the pretest and posttest scores. The results of the N-Gain score calculation are presented in Table 3 below.

Table 3 Improved Student Learning Outcomes with N-Gain score

Num.	*Pretest*	*Posttest*	*N-Gain Score*	Category
1	30	60	0,43	Medium
2	50	70	0,40	Medium
3	60	90	0,75	High
4	40	70	0,50	Medium

Num.	*Pretest*	*Posttest*	*N-Gain Score*	Category
5	30	80	0,71	High
6	40	90	0,83	High
7	60	90	0,75	High
8	40	80	0,67	Medium
9	30	80	0,71	High
10	30	80	0,71	High
11	30	80	0,71	High
12	40	90	0,83	High
13	40	90	0,83	High
14	40	80	0,67	Medium
15	30	90	0,86	High
16	40	80	0,67	Medium
17	40	90	0,83	High
18	50	90	0,80	High
19	40	90	0,83	High
20	30	70	0,57	Medium
21	40	90	0,83	High
22	40	90	0,83	High
23	40	90	0,83	High
24	50	90	0,80	High
25	50	80	0,60	Medium
26	50	90	0,80	High
27	40	90	0,83	High
28	30	60	0,43	Medium
29	40	90	0,83	High
30	30	80	0,71	High

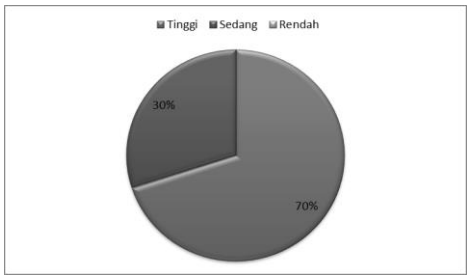

Figure 5 Interpretation Results N-Gain score Student Learning Outcomes

Table 3 shows that 21 students are included in the high category and 9 students in the medium category. It is supported by Figure 5 shows that 70% of students get a high N-Gain and 30% of students get a medium N-Gain. Improved student learning outcomes based on the analysis of N-Gain scores obtained an average of 0.71 with a high category. Increased student learning outcomes in the knowledge aspect shows that STEM-approached worksheets are effective for improving student learning outcomes. Improved student learning outcomes are also supported by learning activities that are following the Learning Implementation Plan (RPP) that has been designed and validated previously. The implementation of learning for two meetings obtains a mode value of 4 with very good criteria.

Assessment of learning outcomes is also carried out on skill aspects such as practical skills and product evaluation. The practice assessment was conducted at the first meeting by an Archimedes Law experiment. Meanwhile, the product evaluation was conducted at the second meeting by making a "bottle raft" product as an application of STEM simple media. The average results of the assessment of students' practical skills are 84.33 while, the average results of the assessment of products are 83.6. The overall assessment of student skills is presented in Figure 6 below.

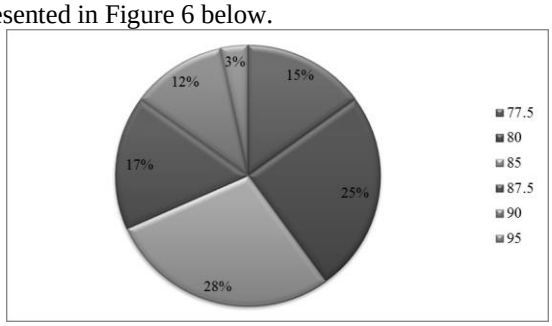

Figure 6 The Results of Assessment of Student Learning Outcomes on the Aspects of Skills

Figure 6 shows the average results of the assessment of the skills of students of class VIII-B of SMPN 1 Wonosalam amounted to 84. It shows that students have good skills. Good student skills are supported by student activity in learning. Assessment of learning outcomes on attitude aspects is done by self-assessment techniques. One of the characteristics of authentic assessment is self-assessment (Suciyanti, et al, 2017). The attitude aspects assessed include responsibility, perseverance, and cooperation. These attitudes support in learning to use STEM-approached worksheets developed. Students are given an assessment instrument that contains 14 statements related to learning using STEM-approached worksheets. The results of the assessment of student attitudes are presented in Figure 7 below.

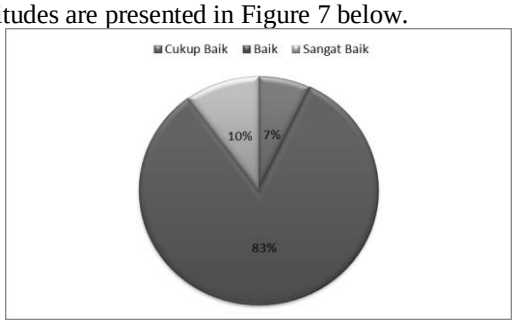

Figure 7 The Results of Assessment of Student Learning Outcomes on Attitude Aspects

Figure 7 shows the attitudes of VIII-B grade students of Junior High School 1 Wonosalam are in a good category. Students have an attitude of responsibility, perseverance, and good cooperation. It was shown during the learning activities using STEM-approached worksheets because the features and activities in the worksheets helped students to improve student attitudes. Attitude assessment with self-assessment techniques can

reduce the subjectivity of teachers in assessing student attitudes (Mulyana, et al, 2016).

Student responses were obtained based on a questionnaire response filled by 30 students. There were 10 questions given about the response after getting the lesson using STEM approached worksheets. The results of student responses are presented in Figure 8 below.

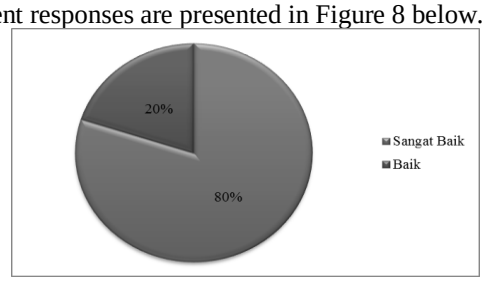

Figure 8 Student Response Results

Figure 8 shows that in 10 questions, students gave very good responses to 8 questions and good responses to 2 questions. Overall students gave a very good response to learning using STEM-approached worksheets. Students enjoy learning science using STEM-approached worksheets. It relates to the functions worksheet in Suyanto (2011), the functions of worksheets are as a guide for students in conducting experiments, observation sheets, discussions, training critical thinking and increasing students' interest in learning. Students also stated that in learning using these worksheets they could hone creativity, freely design ideas, and write relevant ideas. Based on these results the STEM-approached worksheet was declared feasible in the aspect of effectiveness.

Evaluation Phase

The evaluation phase is done after the learning ends. Evaluation results in the form of a description of increasing student competence and product development goals based on data obtained. In this research, STEM-approached worksheets stated to be very feasible to improve student learning outcomes. Highly valid STEM-approached worksheets supported by very well implemented learning practices and excellent student activity make high learning outcomes results. The validation results show that STEM-approached worksheets are declared feasible because they passed the eligibility requirements according to Widjajanti (2008) such as didactic, construction, and technical requirements. The result of the research shows that these worksheets validated by three validators get mode 4 with very valid criteria. It means that the worksheet can be used well for all the students because in this worksheet various features can help students in learning. The language used in the worksheet is following the age and level of thinking of students. And the selection of images and colors in this worksheet can increase student motivation.

The better the implementation of learning, the greater the expectations for high learning outcomes (Aminulloh, 2018). The STEM-approached worksheets very well implemented. It obtains a mode of 4 in the introduction section. It shows that the activities for preparing students and providing apperception and motivation very well do. This section becomes the teacher's initial capital to find out the basic abilities possessed by students (Suciyanti, et al, 2017). Therefore in this section, the teacher's role is very much needed. The core activities section consists of aspects of the material and the models/approaches/ strategies used. The retention of material obtains mode 3 for the first meeting and 4 for the second meeting. It shows that the application of STEM on the Learning Cycle 5E model can optimize student abilities. The concluding section consists of summarizing learning material and reflection and follow-up. This section is also well done. Overall, learning using STEM-approached worksheets performed very well.

Previous research conducted by Rahmiza (2015) shows that using STEM worksheets can increase student learning activities. It is also supported by Piaget's theory of learning which divides human cognitive levels into four levels. And the research object used is the eighth-grade junior high school students with a range of 14 years of age included in the level of formal operations. At this level, the main ability possessed is abstract thinking and problem solving through experimentation. It matches the results of this research whereby using a STEM-approached worksheet can increase student learning outcomes by obtaining an average of N-Gain of 0.71 with a high category and getting very good responses from students. Several relevant studies have been conducted by Shahali, showing that learning using the STEM design gives positive changes to students (Shahali, 2016). Another supportive research was also conducted by Ulfa which showed that the application of STEM-based learning on material pressure had a significant influence on student motivation and learning outcomes. The average N-gain result of student learning outcomes is 0.7 in the high category (Ulfa, 2019).

Evaluation results are used to provide feedback which is then used to improve the product. The students' responses after learning to use STEM-approached worksheets to another material. Because with STEM-approached worksheets students can understand better and enjoy learning science.

CONCLUSION AND SUGGESTION

Conclusion

STEM-approached worksheets are declared feasible to improve student learning outcomes supported by several aspects, such as validity, practicality, and effectiveness. STEM-approached worksheet stated very validly in the validity aspect with a value mode of 4. This worksheet declared very practical in aspects of practicality with very good results for the implementation of learning and student activities. STEM-approached worksheets were declared effective in increasing student learning outcomes with the completeness of 83% and an average N-Gain of 0.71 with a high category and getting very good responses from students.

Suggestion

Based on research that has been done, some suggestions from researchers:

- Selection of images adjusted to the characteristics of students and the level of thinking of students. For example, for students who have low learning motivation, many images can be used to increase student motivation in learning.
- Adding new features in the worksheet to increase student motivation and insight. As a glance the latest info in the STEM.
- The application of learning using the STEM approach worksheets on other material, so that it becomes a new alternative. The material chosen is material that can be reviewed from the aspects of Science, Technology, Engineering, and Mathematics. For sources of examples of learning, products can be seen in the book Challoner (2019).
- The use of other learning models to add variety in learning so students do not get bored easily. For example, the PjBL-STEM learning model.

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