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FEASIBILITY OF STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATEMATHICS)-BASED STUDENT WORKSHEET IN ENERGY SUB-MATERIAL TO IMPROVE CRITICAL THINKING SKILLS

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Abstract

This study aims to describe the validity, practicality, and effectiveness of STEM-based student worksheets to improve critical thinking. The research method using the ADDIE development model include Analyze, Design, Development, Implement, and Evaluation stages. Research design uses One Group Pretest-Postest. Research subjects were 33 students of VII-L class at Junior High School 21 Surabaya. Pretest and posttest analyzed using N-gain scores. The results obtained are validity of student worksheets get score 5 with very valid criteria. Practicality Student worksheets in implementation of PjBL-STEM learning overall get score 5 with very well criteria, and the highest percentage of 24.30% in designing, making, and simple project experiments Wind -Up Car. The effectiveness of student worksheets in pretest results get average of 41.09 and the posttest results get average of 73.51 with average N-gain score of 0.56 (medium category). The percentage of N-gain with high category was 24.24% and the medium category was 75.76%. Students' critical thinking skills have increased in each indicator, the highest increase in Advanced clarification is 50.76%, Elementary clarification is 22.28%, Basic support is 1.36%, Inference is 45.15%, and Strategies and tactics is 40.15%. The average results of responses to student worksheets obtained 88.49% with a very well category. The conclusion of the study is STEM-based student worksheets are declared feasible to improve critical thinking skills. STEM student worksheets that implemented with the suitable learning model become one of the learning alternatives to support the activeness of students and improve critical thinking skills.

Keywords: *STEM, Critical thinking, and Student worksheets*

INTRODUCTION

Rapid progress in the 21st century in development of technology and science has become a demand in all aspects of life, which is the field of education. The 21st century education was expected to create human resources having complete competence known as 21st century skills in order to compete in era of globalization. Greenstein (2012) in Ramdani (2019) said the skills that need to be owned in dealing with the 21st century include critical thinking, problem solving, creative thinking skills, metacognition, communication, collaboration, and various literacy.

The development of technology and knowledge causes technology, science, and techniques to break through all aspects of life as a key in facing current and future challenges (Rosnia, 2018). Next Generation Science Standards (2013) responds these demands by creating a new standard that integrates aspects of science, science, and technology through Engineering Design in science learning so that students are able to solve social and environmental challenges in the next few decades.

Science learning in curriculum 2013 in Indonesia was expected to be appropriate with the Ministry of Education and Culture Regulation Number 22 of 2016 that learning is held in an inspirational, interactive, challenging, enjoy, motivating students to participate actively. System of curriculum 2013 that is centered on students will automatically encourage students as active learners. As active learners, critical thinking skills will be needed especially in science learning.

Critical thinking becomes part of the HOTS (Higher Order Thinking Skills) that needed to face the 21st century. Facione (2011) in Nuryanti (2018) explains critical thinking as self-regulation in deciding something to produce interpretation, inference, analysis, and evaluation, or contextual considerations as the basis for decisions. To define, describe, measure, and evaluate critical thinking processes, it is important to understand indicators of critical thinking abilities (Duran and Sendag, 2012).

Critical thinking skills can be improved using learning with the right methods and approaches. One of them is using *STEM* learning (*Science, Technology, Engineering, and Matemathics*). *STEM* is an approach by integrating aspects of science, technology, engineering, and mathematics in a learning (Satriani, 2017). Roberts and Cantu (2012) divide the approach in *STEM* into Silo Approach, Embedded Approach, and Integrated Approach. *STEM* is one alternative solution for 21st century learning (Bashooir, 2018).

The National Research Council (2014) defines component *STEM* approach, (1) Science is the body of knowledge that accumulates scientific inquiry to produce new knowledge, (2) Technology is the whole system of processes, knowledge, and devices in creating and operating objects, (3) Engineering is knowledge in the

design and creation of objects and problem-solving processes using mathematical concepts, science, and technology, (4) Mathematics is knowledge of patterns and relationships between numbers, amounts, and spaces utilized in science, technology, and technique. In integrating STEM components, the stages of designing a project called the Engineering Design Process (EDP). Jolly, A. (2017) stated Engineering Design Process in implementing STEM learning is (1) Define the problem, (2) Research, (3) Imagine, (4) Plan, (5) Create, (6) Test and evaluate, (7) Redesign, and (8) Communicate.

STEM education is a way to bridge a gap between education and job that needed for 21st century skills (Mutakinati, 2018). STEM education aims to develop 21st century skills, critical thinking skills, problem solving, creative, innovative, and provide experience in applying skills and knowledge to life situations that meaningful and socially relevant (Bybee, 2013).

The Student Assessment International Program (PISA) in 2018 survey on Trends Performance in Science, Reading and Mathematics, Indonesia was ranked 79th with an average score of 379 in the "Mathematics" aspect and score of 396 in the "Science" aspect with lower category than the OECD average. PISA assessment requires students to apply knowledge in a variety of situations, and evaluate problem solving strategies that require higher-order thinking skills such as critical thinking (OECD, 2018). This shows that the critical thinking ability of students in Indonesia is low, so it needs to be improved. Previous research by Khoiriyah (2018) shows that STEM learning can improve students' critical thinking skills with an N-gain score of 0.63 in the medium category. Based on interviews with science teachers at SMPN 21 Surabaya, STEM-based learning has never been applied in learning activities. Science learning that was applied doesn't support students' critical thinking skills, laboratory activities and simple projects are rarely carried out because of limited tools.

Based on pre-research result in VII-L class at Junior High School 21 Surabaya, it is known that 90% of students have difficulty in understanding science material that contains calculations and formulas so that the ability to integrate science with the concept of mathematics is still low. Laboratory activities and making simple projects are rarely done, causing the ability of engineering and technology is also less trained.

On the other side, the achievement of learning objectives is inseparable from the role of the teacher, learning media, and resources such as student books, handouts, and Student Worksheet. Student Worksheet is a source for student learning that used as guide to investigation or problem solving activities (Sudibyo, 2018). The interview results show that the student worksheet that used today was less attractive and not effective in practicing critical thinking skills. The STEM approach applied in the learning model, teaching materials, and student worksheet can have a good impact (Lestari, 2018). One of them is increase ability to think critically and understand concept (Pangesti, 2017).

In Basic Competence 3.5 (analyzing the concept of energy, various sources of energy, and changes in the form of energy in daily life) there are sub-materials for analyzing changes in the form of energy such as kinetic energy. The ability to analyze is included in the cognitive of C4 in Bloom's Taxonomy which demands higher order thinking skills such as critical thinking that students must have in order to achieve these basic competencies. Higher order thinking skills include logic and reasoning, analysis, evaluation, creation, problem solving, and judgment (Brookhart, 2010). As part of higher order thinking skills, critical thinking needs to be taught for students because it is very necessary in life (Sulardi, 2015).

Based on the description above, it is necessary to develop learning resources in form of STEM-based student worksheet on energy sub-materials which is completed with simple projects to improve critical thinking skills. The purpose of this research is to describe the feasibility of STEM-based student worksheet based on validity, practicality, and effectiveness aspect to improve students' critical thinking skills at Junior High School 21 Surabaya.

RESEARCH METHOD

The study used *ADDIE* development model which includes stages of *Analyze*, *Design*, *Development*, *Implement*, and *Evaluation*. Trial subject on this study are 33 students of Junior High School 21 Surabaya in VII-L class. The product developed is *STEM*-based Student Worksheet on energy sub-materials to improve critical thinking skills. Student Worksheet contains topics on *STEM* approach include (1) *Science*, (2) *Technology*, (3) *Engineering*, and (4) *Mathematic*, which is completed by simple Wind-Up Car project.

This study used *One Group Pretest-Postest Design*. The experimental group was given a pretest to find out score early of the group, then gived a treatment and posttest.

$$O_1 \quad X \quad O_2$$

Figure 1. One Group Pretest-Postest Design (Sugiyono, 2016)

Information :
O_1 = *Pretest* score
O_2 = *Posttest* score
X = Variable of student worksheet learning treatment.

Research instrument used a review and validation sheet as assessment of validity aspect, an observation sheet of learning implementation and student activities as assessment of practical aspect, a responses questionnaire and test (*pretest* and *posttest*) as assessment of effectiveness aspect. Data collection techniques used review and validation technique to assess the feasibility of student worksheet based on validity aspect, observation (student activities and learning performance) to assess practical aspect, test and questionnaires to assess effectiveness aspects.

Data analysis of validation and learning performance seen from mode data or score that most often appear and categorized according to specified criteria. Result observations of students' activity were analyzed with the percentage of activities observed during learning activities. Students' responses were analyzed with the

Guttman scale then a percentage was calculated and categorized according to the specified criteria. Pretest and posttest score was analyzed with *N-gain score* to find out increase of critical thinking skills using the formula according to Hake (1999):

$$< g > = \frac{< S_f > - < S_i >}{S_{max.} - < S_i >}$$

Information :
g = Normalized gain score
S_f = Posttest score
S_i = Pretest score
$S_{max.}$ = Maximum score

Table 1. *N-Gain* Range Categories

***N-Gain* Category**	**Range**
g ≥ 0,7	High
0,3 ≤ g < 0,7	Medium
g < 0,3	Low

(Hake,1999)

RESULT AND DISCUSSION

Based on research using the stages of *ADDIE* development model, the result can be described as follows.

Analyze

The distribution of pre-research questionnaires and interviews with teachers was done in *Analyze* stage. The results showed that 90% of students had difficulty in science material that contained calculations and formulas because they didn't understand the concept of mathematic properly. In science learning activities, practicums (laboratory activities) and simple project are rarely. This fact shows that ability of students to integrate knowledge (science) with the concept of calculation (mathematics) is still lack so that it has difficulty to understand whole concept. In addition, the ability in engineering and technology is also less trained because the learning rarely involves practicum and making simple project.

Interview with science teachers at Junior High School 21 Surabaya showed that science learning contain concept Of mathematics still using lecture method. Student work-

increasing critical thinking skills. Science learning that applied also not completely support critical thinking skills. This is caused by several factors, include learning that is still teacher-centered, laboratory activities and making simple projects are rarely carried out due to limited facilities.

This is not in line with learning curriculum 2013 which is centered on students and Ministry of Education and Culture Regulation Number 22 of 2016 that learning is held in an inspirational, interactive, fun, motivating learners to participate actively. In addition, teachers must create learning that invites students to be active in learning such as actively working with groups to look for various information (Fauziah, 2017).

The interview also stated that *STEM* approach never applied in science learning before. *STEM* education can become a reference frame for the education process in Indonesia to produce the next generation that is able to compete at global level (Sartika, 2019). Based on research by Lestari (2018), the use of *STEM* in form of learning resources such as student worksheet can improve students' ability to think critically.

Questionnaire distribution showed that most of students were not familiar with *STEM* learning and would interested with *STEM* learning by making simple project. Therefore, it needs a learning resources in form of STEM-based student worksheet with a simple project that can involve students to be active in learning activities and encourage critical thinking skills.

Design

Based on the analysis, design of product can be made as a solution to improve critical thinking skill through STEM-based student worksheet. Design begins with outlining Basic Competency 3.5 into a few indicators and learning objectives as a reference for developing student worksheet. Then the material mapping made to integrate STEM component with critical thinking indicators.

Ennis (2011) classifies five indicators of critical thinking, include 1) Elementary clarification (providing a simple explanation), 2) Bassic support (building basic skills), 3) Inference (drawing or making conclusions), 4) Advanced clarification (providing further explanation) , and 5) Strategies and tactics (determining strategies and tactics). Mapping material by integrating STEM components and indicators of critical thinking can be seen in the following table.

Table 2. Mapping of STEM Integrated Materials and Critical Thinking Indicators

***STEM* Component**	**Critical Thinking Indicators**
Science	
a. Identify problems from a phenomenon that showed, and make alternative solutions about eco-friendly car.	*Elementary clarification* (Focusing questions, asking and answering questions)
b. Explain concept of energy and kinetic energy.	*Elementary clarification* (Asking and answering questions)
c. Explain concept of kinetic energy in Wind-Up Car, whe... energy stored in the mainsprings is converted into n... energy so that the Wind-Up Car can move forward.	
Science	
d. Experiment Wind-Up Car to analyze the relationship between mass of the load (m) to velocity of the object (v) and amount of kinetic energy (E_K).	*Ba*... co... co...
Technology	
a. Collect and search for information through digital literacy to find eco-friendly car.	*Ba*... co...
b. Make solutions and alternative cars without using gasoline fuel, that is Electric Car.	*St*... *Ac*... co...
Engineering	

The STEM approach applied in developing student worksheet is an Integrated Appoach, which is an approach by emphasized the integration of component STEM and make it one subject (Roberts and Cantu, 2012).

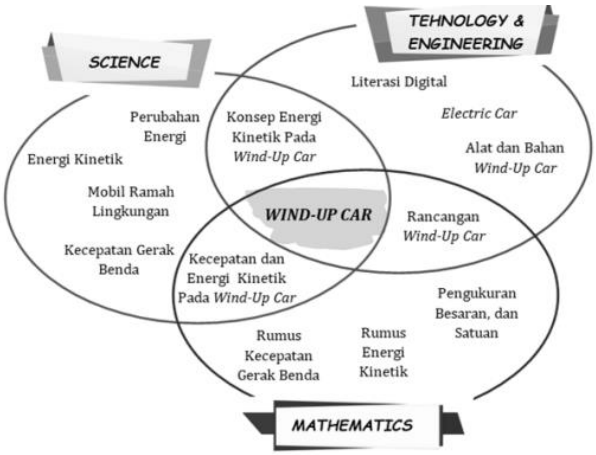


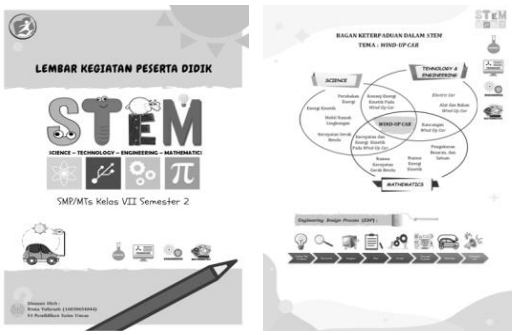
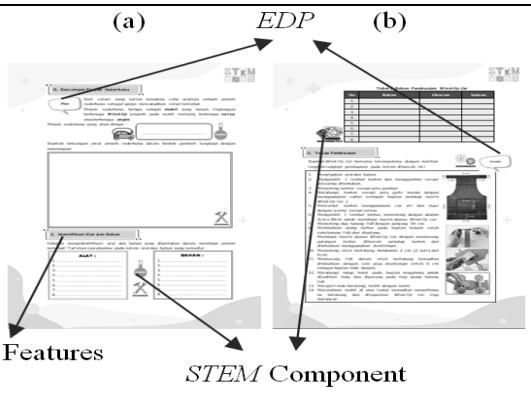
Figure 3. Chart of STEM Integrated Approach

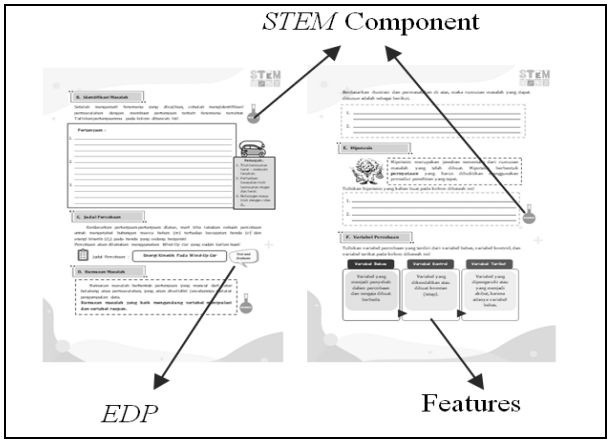
Student worksheet consists of 3 Worksheets, there are Worksheet 1 (Designing a simple Wind-Up Car project), Worksheet 2 (Creating a simple Wind-Up Car project), and Worksheet 3 (Conducting an experiment using a Wind-Up Car). Student worksheet is equipped with a main cover page, a STEM approach chart, and a bibliography. Every activity in worksheet is customized to STEM component, Engineering Design Process (EDP), and STEM Project-Based Learning (PjBL-STEM) model.

Development

Development stage produces the final design of student worksheet. The results can be seen in the following table.

Table 3. STEM-based Student Worksheet Design

Cover and STEM Chart

(a) Worksheet 1, (b) Worksheet 2

Worksheet 3



Worksheet 1 consists of a cover, illustration, identification problems, solutions or ideas, the initial design of the Wind-Up Car, and the material for making project. Worksheet 2 consists of covers, steps of making Wind-Up Cars, and technology inspired by Wind-Up Cars. Worksheet 3 consists of covers, illustrations and problem identification, problem formulation, hypotheses, experimental variables, experiment tools and materials using Wind-Up Car, table of experimental results, discussion questions and conclusions, and identification advantages and disadvantages of Wind-Up Car .

Then validation is performed to test the feasibility of STEM-based student worksheet on validity aspect. The validity aspect based from the results of review and validation. The results of review and validation can be described as follows.

a. Review

The first suggestion is to add hint for problem identification feature, and formulate a solution to make it easier for students to make questions according to desired criteria. The second suggestion is to add an additional explanation of the problem formulation, hypothesis, and experimental variables. It aims to make students know in advance about the formulation of problems, hypotheses, and variables so that it makes easier for investigations using STEM-based student worksheet. Beside from being a source of learning, student worksheet is need as a guide in solving problems or investigative activities (Sudibyo, 2018).

b. Validation

Validity aspects based on the assessment of three validators. STEM-based student worksheet can be said valid if the mode value obtained ≥3 with very valid criteria. The following are the results of student worksheet validations presented in table form.

Table 4. Student Worksheet Validation Results

Component	Score			Mode	Criteria
	V1	V2	V3		
The suitability of content	5	5	4	5	Very valid
The suitability of Presentation	4	5	5	5	Very valid
The suitability of language	4	5	4	4	Valid
The suitability of EDP	5	5	4	5	Very valid
The suitability of critical thinking indicators	5	4	4	4	Valid

Information : **V1=** Validator 1, **V2** : Validator 2, **V3** = Validator 3

The validity of student worksheet was assessed based on the suitability of content, presentation, language, suitability of Engineering Design Process, and suitability of critical thinking indicators. Content suitability consists of conformity of learning objectives and material in worksheet, writing titles, bibliography, and facilitating to improve critical thinking skills. The validation results of the suitability of content get a score of 5 with very valid criteria.

The suitability of presentations include the appearance (pictures and colors), suitability of the illustrations, use of sentences, and systematically of the worksheet function as a learning resource to facilitate students in understanding the material provided (Prastowo, 2011). A good display of images at worksheet will convey the contents or messages of image effectively and overall (Umbaryati, 2016). The results of the validation on the presentation get a score of 5 with very valid criteria. The language component includes the use of grammar in worksheet, according to its function in clarifying the delivery of material so can increase motivation and activeness of students (Resita, 2016). The result of validation on the language component obtained a score of 4 with valid criteria.

The suitability of Engineering Design Process involves stage of designing a simple project by combining STEM components in student worksheet. Engineering Design Process consists of Define the problem, Research, Imagine, Plan, Create, Test and evaluate, Redesign, and Communicate (Jolly, 2017). Validation on the suitability of EDP get a score of 5 with very valid criteria. The suitability of critical thinking indicators includes activities in LKPD that are adjusted to the indicators of critical thinking ability according to Ennis (2011), there are elementary clarification, bassic support, inference, advanced clarification, and strategies and tactics. Validation on the suitability of the critical thinking indicator get a score of 4 with valid criteria.

Student worksheet validation results overall obtained a mode score of 5 in very valid criteria, so that STEM-based student worlsheet was declared feasible based on validity aspect.

Implement

In the implementation stage, trials are carried out on the product to test the feasibility based on aspects of practicality and effectiveness.

a. Practicality of STEM-based Student Worksheet

Practicality aspect based on the implementation of learning using STEM Project-Based Learning model combined with Engineering Process Design. The Reflection Stage is carried out by displaying a phenomenon or illustration and giving students the

opportunity to identify the problem. At the Research stage students look for and find solutions to problems through various sources. At the Discovery stage the students draw a simple project design in the form of a Wind-Up Car in an effort to realize a solution. At the Application stage students make a Wind-Up Car to conduct kinetic energy experiments. At the Communication stage students can present their Wind-Up Car designs and projects.

The implementation of learning at the 1st meeting (designing Wind-Up Car) get a score mode of 5 with very well implemented criteria. The 2nd meeting (making a simple Wind-Up Car project) get a score mode of 4 with the criteria well implemented. The 3rd meeting (kinetic energy experiment using Wind-Up Car) obtained a score mode of 5 with very well implemented criteria. The learning performance score mode uses PjBL-STEM model overall is 5 with very good criteria. The use of STEM-based PjBL learning models can improve critical thinking skills more effectively (Dywan, 2020).

Practicality was also assessed from activities of students using STEM-based student worksheet during learning. Student activities are observed in each group with an interval of 5 minutes, consisting of: A) Listening and paying attention to the teacher's explanation, B) Giving opinions, C) Asking questions, D) Answer student worksheet in groups, E) Reading and gathering information from various sources (Student Handout), F) Designing, making, and conducting experiments using Wind-Up Car, G) Presenting the results of the discussion, H) Responding to the results of other group discussions, I) Making conclusions from the learning material, J) Other activities (irrelevant behavior with learning).

The following is average percentage of student activity in each meeting:

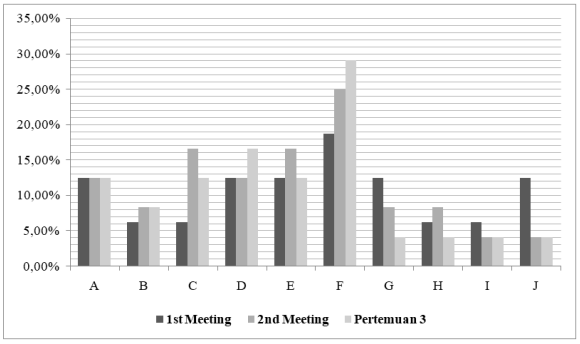


Figure 4. Percentage of Student Activity in Each Learning

The percentage of activities at each meeting is used to determine the average percentage of activities as a whole:

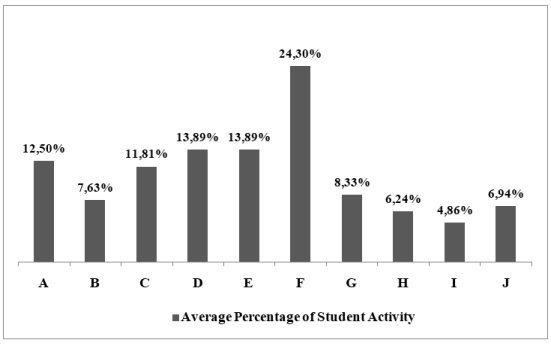


Figure 5. Average Percentage of Student Activity

The highest percentage of student activity is obtained when designing, making, and conducting experiments using a Wind-Up Car (Code F) and has increased at each meeting. The first meeting obtained a percentage of 18.75%, the second meeting of 25%, the third meeting of 29.16%. The highest percentage was obtained at the third meeting, namely conducting kinetic energy experiments using Wind-Up Car of 29.16%. The highest percentage of activity has an average of 24.30%. This is because most of the students are very active involved in simple project activities of STEM student worksheet, which is designing and making Wind-Up Cars, and doing kinetic energy experiments using Wind-Up Cars. In line with the role of student worksheet is a source of learning for students as guidelines in investigation activities (Sudibyo, 2018). Student worksheet which integrates STEM includes the activities of students in the form of trying, observing, interpreting, analyzing, and concluding to support the development of critical thinking (Pangesti, 2017). Critical thinking skills can be improved by actively involving students in learning (Yogantari, 2014).

Based on the implementation of learning using the PjBL-STEM model and the percentage of student activity, the STEM-based student worksheet can be declared feasible in the practicality aspect.

b. Effectiveness of STEM-based Student Worksheet

The feasibility of effectiveness aspect is evaluated from the increase of pretest and posttest score using N-gain and students response to worksheet. Pretest and posttest in essay questions were adjusted to indicators of critical thinking skill by Ennis (2011). STEM-based student worksheet can be said effective if an increase in test results is obtained> 0.3 with medium criteria and get a percentage of responses ≥61% with a very well category.

Based on the result of prestesr and posttest, can be calculated the averaage score to determine the average of gain score overall.

Table 5. Average of Gain Score

Average of *Pretest*	Average of *Posttest*	Gain Score	Category
41,09	73,51	0,56	Sedang

Pretest scores get an average of 41.09 and an average posttest of 73.51. Increasing of critical

thinking skill by 32.42 after learning using STEM-based worksheet, where as 25 students have a medium category in N-gain and 8 students have a high increase in N-gain category. The following is a graph of the percentage categories of N-gain scores obtained:

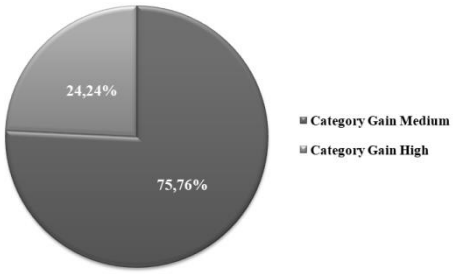


Figure 6. Percentage of N-gain Score Categories

Increasing in each critical thinking indicator is calculated through the recapitulation of the increase in pretest and posttest scores. Questions are adjusted to the indicators of critical thinking skills so that it makes it easier to know the improvement of each indicator. The following is a graph of increasing indicators of critical thinking:

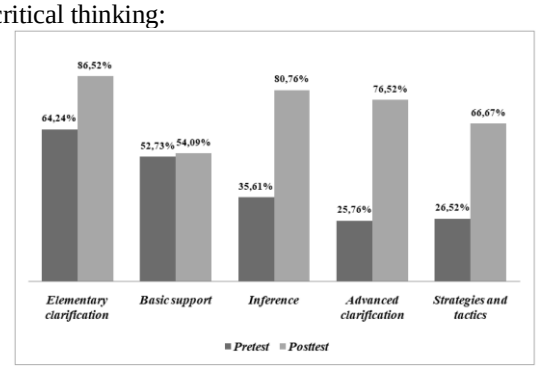


Figure 7. Increasing of Critical Thinking Indicators

Based on the graph shows an increase in each indicator of critical thinking. As for the increase in *Elementary clarification* (providing simple explanations) by 22.28%, *Basic support* (building basic skills) increase is only 1.36%, *Inference* (making conclusions) increased by 45.15%, *Advanced clarification* (providing further explanation) increased by 50.76%, and for *Strategies and tactics* (managing strategy and tactics) increased by 40.15%. The highest increase is *Advanced clarification* indicator by 50.76%.

In Elementary clarification indicator, students identify problems and alternative answers or solutions through phenomena in illustrations in the form of pictures and readings (Science). In Basic support indicator, students determine the experimental steps in solving a problem (Science, Engineering, and Mathematics). In Inference indicator, students determine the problem formulation and hypothesis from the experimental illustrations presented (Science). According to Rahayuni (2016), critical thinking skills grow when students can identify and decide on the steps of an investigation. STEM helps students utilize technology and compile investigations to prove the concepts of science in learning physics (Selisne, 2019).

In Advanced clarification indicator, students analyze energy changes in the example of the development of environmentally friendly technologies (Science and Technology). In Strategies and Tactics indicators, students make a engineering design as a form of environmentally friendly technology (Technology and Engineering). Critical thinking is a process of constructivist analysis to examine what is happening in the environment to define problems, take action, make decisions and conduct evaluations (Duran and Sendag, 2012).

The response to student worksheet obtained an average of 88.49% in the very well category. Through learning using STEM-based worksheet, students are very enthusiastic and active in designing and making simple Wind-Up Car projects. Active learning takes place if students as a center of learning through STEM learning can find their own answers, so students play an active role in learning activities (Khoiriyah, 2018).

Based on the improvement of critical thinking skills through test score and students' responses, the STEM-based student worksheet was declared feasible in the effectiveness aspect.

Evaluation

Evaluation is done after learning activities using STEM-based student worksheet are finish. The result of evaluation is improvement of each indicator of students' critical thinking skills. Result of the study stated that STEM-based worksheet was appropriate to improve critical thinking skills. The feasibility of student worksheet in aspect of validity, which is supported by the implementation of learning using PjBL-STEM very well and activities of students while participating in STEM learning. Increased of critical thinking skills obtain an average N-gain of 0.56 with the category of medium category and get a positive response of 88.49%.

Previous research by Khoiriyah (2018) showed that STEM learning on sound wave material could significantly improve critical thinking skills and obtain an N-gain score of 0.63 with a medium level category. Research by Lestari (2018) showed that STEM Student Worksheet can improve critical thinking skill by increasing N-gain scores by 0.5 on medium category.

The results of the study can be used as an evaluation to provide suggestions for improving quality product. The STEM approach can be applied in teaching materials, handouts, books, and others. With STEM applied in learning activity or learning resources, it can maximize the quality and improve high order thinking ability like critical thinking. STEM is positioned to bring new perspectives and opportunities to school education (Li et al., 2019). STEM learning is able to train students' critical thinking skills and solve problems in order to face global challenges (Selisne, 2019).

CONCLUSIONS

From result of the study, it was concluded that STEM-based student worksheet was declared feasible in validity aspect in terms of the validation result getting a score

mode of 5 with very valid criteria. STEM-based student worksheet is declared feasible on the practical aspects based on the implementation of learning and student activities. The implementation of learning obtains a score mode of 5 with very well implemented criteria. The highest percentage of student activity with an average of 24.30% when designing, making, and conducting experiments using Wind-Up Car. STEM-based LKPD is declared feasible in the effectiveness aspect based on the results of increasing critical thinking skills. N-gain scores obtained an average of 0.56 in the medium criteria, where 24.24% of students were in the high N-gain category and 75.76% of students were in the medium N-gain category. Each indicator of critical thinking ability has increased, with the highest percentage in the Advanced clarification indicator that is 50.76%. The results of responses to LKPD showed that 88.49% of students gave positive responses in the very well category.

Suggestions given from this research are 1) STEM approach can be applied to other Basic Competencies with C4 cognitive level (Analyzing) that supports critical thinking skills, 2) Allocation of time while implementing STEM learning and involving project making activities need to be considered properly, and 3) There is a need for supporting teaching materials in form of STEM-based handouts to support the success of STEM learning.

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