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Development of STEM Workers Based on STEM to Optimize Curriculum 2013 Implementation

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Abstract

The success achieved in the learning process is mostly determined by the ability of educators to develop teaching materials for basic automotive technology subjects with essential competencies evaluating battery work. This study aims to develop student worksheets based on Mathematical Science Technology Engaging (STEM), testing their feasibility, validity, and effectiveness. This study uses the Research and Development method and is carried out in the class X light automotive vehicle engineering at Vocational High School Harapan Mulya Kendal. The results of the study were obtained STEM-based student worksheets are appropriate to use so that they provide feedback to students to know the level of success of their learning and Completion in learning outcomes, the validity of STEM-based student worksheets Raising strong motivation and creativity for maximum learning because of guided education. Learning procedural, namely learning directed at the formation of character and work skills of participants, its effectiveness fosters collaboration between students and between students and teachers in the learning process. Based on the results of the development, it shows that the worksheet fulfills valid and practical criteria. It is recommended to be used as an alternative teaching material evaluating the work of the battery. The results of the study have new elements; namely, students know the relevance of concepts, practices, and content that directs thinking scientifically.

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INTRODUCTION

21st century was marked as a century of openness or the age of globalization, meaning that human life in the 21st century experienced fundamental changes that were different from the order of life in the previous century. In the face of global competition in the 21st century, which includes internationalization of education and the like, readiness from all parties is needed, Wijaya, Sudjimat, and Nyoto (2016). Vocational High School as one of the middle-level vocational education institutions that produce graduates to be ready to work in the business world and industry needs to prepare themselves as well as possible to be able to deliver competitive graduates. Vocational graduates are expected to work both in national companies, multinational and entrepreneurship to develop products and services to the international level. According to the Vocational High School Self Evaluation Team (2008)

Improving the quality of learning in vocational schools is a logical demand of the rapid development of science, technology, and art, and following the requirements of the business world and the industry, Yulianti (2018). The new demands demand various breakthroughs in thinking, drafting, and actions. In other words, a new paradigm is needed in the face of new challenges, said philosopher Khun. According to philosopher Khun, if new challenges are faced by using the old model, then all efforts will fail

The new challenge requires a *breakthrough thinking process* (*breakthrough thinking process*) if what is desired is *output* quality that can compete with the work in an open world. The 21st century has many differences with the 20th century in various ways, including employment, community life, and self-actualization. The 21st century is marked with the rapid development of information technology and the development of automation where many jobs of a routine and repetitive nature began to be replaced by machines, both production machines, and computers.

Developing and validating the results of education, *research and development* also aim to discover new knowledge through '*basic research*,' or to answer specific questions about practical issues through '*applied research*,' which is used to improve practice-education practice, Creswell (2016). Developing modules into STEM-based Student Worksheets provides an opportunity for educators to show students that the concepts, principles, and techniques of STEM are used in an integrated manner in developing products, processes, and systems in everyday life. The implementation of STEM-based participants' worksheets directly requires teachers and students to think critically, creatively, and innovatively. Teaching materials used by teachers greatly influence the learning process and student learning outcomes. In the learning process students are guided by the teacher to find their understanding related to learning material actively. Problem-solving activities become learning traits that develop creative thinking skills. Therefore we need a teaching material to support the learning process, one of which is the Student Worksheet (Abdurrahman, 2015).

Student Worksheets (LKPD) are sheets containing assignments done by students, providing instructions, steps to complete a task in the form of theory or practice. Morrison, 2006 revealed that STEM is one alternative to overcome this learning problem. STEM is a combination of knowledge that has been combined, such as science, technology, mathematics, and the selection of tools used is easily affordable. Akaygun, and Aslan-Tutak (2016) declares "science, technology, engineering, and mathematics (STEM) education have been an integral part of the education policies of many countries. In the last decade, a variety of practices have been carried out to create a valuable STEM area for the 21st century generation."

This issues can be started by building content mastery that can be done through the Skills process, which is based on attitude, character, and good habits. Keep in mind that the end of an educational process is instilling personality. Learning with STEM-based student

worksheets (LKPD) is one way of alternative learning approaches that are potentially used to build 21st century skills. Aldila, Abdurrahman, and Sesunan (2016) says: *That the LKPD with the STEM approach has been effective in training the creative thinking skills of students.*

Harapan Mulya Vocational School as a vocational school should prepare students to acquire 21st century skills, namely thinking skills through critical, creative thinking, being able to solve problems and make decisions and work together through collaboration and communication by integrating processes and concepts in the real-world context of STEM. California Department of Education (2015); Budiyono, Haryono, Utanto, and Subkhan (2017). Then the STEM approach was adopted to strengthen or optimize the implementation of Curriculum 2013 because the STEM approach is believed to be in line with the spirit of Curriculum 2013. To answer and equip students with competencies that are the demands of the 21st century, STEM is an alternative, a solution used in learning. Human resources who master STEM can be projected to occupy better positions in various jobs.

STEM education is an interdisciplinary approach, in which students are required to have knowledge and skills in the fields of science, technology, engineering and mathematics, Avery, and Reeve (2013). STEM is an approach in education where Science, Technology, Engineering, Mathematics is integrated with the education process focusing on the knowledge of problem-solving in real daily life as well as in professional life, Firman (2015). STEM shows students how to integrate concepts, principles, techniques in science, technology, engineering, and mathematics to develop products, processes, and systems that are useful for the lives of future students.

The current curriculum in Indonesia Curriculum 2013. In this curriculum, teachers are required to carry out the learning process oriented towards the development of the domain of attitudes, knowledge, and skills so that the quality of learning is needed to realize education that can produce students with better learning capacity (Haryono, Budisantoso, Subkhan, and Utanto, 2018). The curriculum is dynamic so that it will always experience changes and developments to be able to keep up with the times (Mulyasa, 2013). The scientific approach is believed to be the golden bridge of growth and development of attitudes, skills, and knowledge through experimental steps namely observing, asking, gathering information, associating or analyzing and communicating, thus, students will be accustomed to thinking scientifically in High Order Thinking (HOT), namely thinking rationally, empirically and systematically

The approach of Science Technology Engineering Mathematics (STEM) in Curriculum 2013 certainly must be adapted to the characteristics of STEM learning. Not all science topics in the curriculum can be learned using the STEM approach used in an integrated or connected way in developing products, processes, and systems used in everyday life. Identification is carried out on essential competencies (KD) in the realm of knowledge and skills related to design activities both in the form of processes, systems, and products by the field of science, technology, engineering, and mathematics.

Material evaluating the work of batteries is chosen because the content is very carefully related to everyday life. They understand the concept of caring for a battery that is quite broad in scope. Evaluating the work of cells studying the chemical reaction of electrolyte water batteries, the magnitude of the volt according to which is charged to the battery, the use of measuring instruments and checking correctly by the standard operating procedures. Problems made according to the real world make students analyze every event or problem faced.

Based on previous research on the Effectiveness of LKS *STEM* to Train Creative Thinking Skills Students conclude that LKS with the approach *STEM* has been effective in training students' creative thinking skills (Pertiwi, Abdurrahman, and Rosidin, 2017). Stemming LKPD development to foster students 'creative thinking skills, concluded that LKPD with approach *STEM* has been effective in training students' creative thinking skills (Aldila,

Abdurrahman, and Sesunan, 2016). Development of stemming (*science, technology, engineering, and mathematics*) in increasing motivation and learning activities Vocational High School 1 Beutong student in electromagnetic induction material. Concluding learning activities using STEM LKS can also improve student learning activities (Rahmiza, Adlim, and Mursal, 2015).

Based on the analysis of the results of previous studies that produce practical worksheets to train students' thinking skills, increase motivation and student learning activities, so it is very important to conduct research on STEM-based sheets to find out how much validity, effectiveness and the usefulness of the stem approach in the learning process, in contributing to optimizing the implementation of Curriculum 2013, therefore this study is entitled "development of STEM-based student worksheets to optimize the implementation of Curriculum 2013 in automotive light vehicle engineering"

Purpose of this study was to produce student-based worksheets STEM on essential competencies evaluates the work of a valid and effective battery in the automotive light vehicle engineering department of Vocational High School Harapan Mulya Kendal. So that it is useful for students as a learning resource to be able to learn independently. For teachers as a material to solve the problem of print-shaped teaching materials in the field of automotive light vehicle engineering and for other researchers, it can be used as a reference for further research.

METHODS

This study uses Research and Development, which produces STEM-based student worksheet products. Borg, and Gall (1989) states that research and development is *"a process used to develop and validate the educational product."* This research is also called '*research-based development*, which appears as a strategy and aims to improve education quality. According to Sugiyono (2016) the research and development steps are ten steps as follows: (1) potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) product testing, (7) product revisions, (8) usage trials, (9) product revisions**,** and (10) mass production. Sugiyono (2016). The researcher simplifies it into six steps, namely, data collection, product design, design validation, product testing, product revision, mass production.

The researcher conducted a pre-test to determine the condition of the student cognitively, continued to design a validated worksheet to assess its feasibility, the validity test was carried out, Reliability, normality and homogeneity test to find out whether the two variants of the groups are the same, the study population is regular and homogeneous, the researcher takes two classes, one class X TKRO 3 as the experimental class with the STEM learning model and class X TKRO 2 as the control class with learning conventional model. The process to determine the effectiveness of STEM-based student worksheets. The researcher conducted a product trial and post-test in the experimental type.

RESULTS AND DISCUSSION

This research was conducted in March to May 2019 in automotive light vehicle engineering, namely X Automotive Light Vehicle Engineering 2 and 3 Vocational High School Harapan Mulya Kendal. The feasibility test, effectiveness, and usefulness of STEM-based student worksheets were conducted on two classes, namely the experimental class (X TKRO3) and the control class (X TKRO2).

The results of this study are STEM-based student worksheets on essential competencies evaluating batteries for vocational high schools in the field of X technology and engineering that are tailored to the demands of the 21st century to produce a new learning process system. The following are some of the objectives in making STEM-based student worksheet products.

Validation and test results The reliability of worksheets in STEM-based students can be categorized as feasible to be used in the learning

process in the competence of Automotive Light Vehicle Engineering expertise at Vocational High School Harapan Mulya Kendal as support to optimize Curriculum 2013 implementation.

The results obtained in the feasibility test are as follows:

Design STEM-based student worksheets are validated with regard to the accuracy of the measuring instrument to the measured concept so that it actually measures what should be measured in the sheet based STEM, verified by experts, in this case, the material experts, vocational high school supervisors of the Central Java Provincial Education Office, Light Vehicle Engineering competency productive teachers by filling in the validation sheet.

Table 1. Test Validity

Validator	Position	Average value	Category
1	Material validator material	4.86	Good
2	Provincial education service supervisor	4.46	Good
3	Productive teachers	4.69	Good

Based on table 1 validation test filling validation sheet containing STEM-based forms and substances of the three validator categories.

Reliability Test

Based on table 2 which is derived from the output of SPSS 2019 data with criteria for measuring instruments (instruments) declared reliable if unreliable *alpha is Cronbach* > r_{table} and if *alpha is Cronbach* < r_{table} then proclaimed. So the basis for decision making: r positive results, namely 0.379 and more significant than r table (0.279), then the questions are reliable.

Table 2. Reliability of Statistic

Cronbach's alpha	N of Items
355	25

The design of new teaching materials made based on the conditions in the field during the learning process and assessment of the old learning system, so that weaknesses found in the order were found. Munandar (2001) revealed that conventional learning processes, in general, only train the process of convergent thinking, so that when faced with a problem, students will have difficulty solving problems creatively. The extended system time needed to discuss the theory longer and in its implementation in practice has not led to habits according to the real conditions in the field of work.

It is reviewing the latest references related to modern learning systems along with good work system indicators with good validation results, the concepts of student worksheets that fit the needs of the field so that the STEM-based student worksheets are recommended to be used for alternative teaching materials that can be used to the learning process.

The results of the normality, homogeneity, product trial test objectives showed a very significant increase in learning enthusiasm so that STEM-based student worksheets were effectively used as alternative teaching materials used in the learning process in the competencies of Automotive Light Vehicle Engineering expertise at Vocational High School Harapan Mulya Kendal as support for optimizing the implementation of Curriculum 2013.

Results obtained in the test The effectiveness of STEM-based student worksheets are as follows:

a. Normality test data in this study using the Kolmogorov-Smirnov technique. If this assumption is violated, the statistical test becomes invalid

Based on table 3, The Kolmogorov-Smirnov test results show that the Asymp. Sig value is 0.208. This value is much higher than 0.05, so it can be concluded that based on the test results, it is known that the model is not subject to normality problems. Homogeneity.

Table 3. One-Sample Normality Test
Kolmogorov-Smirnov Test

		Unstandardized predicted value
N		25
Normal parameters[a]	Mean	73.6000000
	Std. deviation	1.15138786
Most extreme differences	Absolute	.213
	Positive	151
	Negative	-.213
Kolmogorov-smirnov Z		1.063
Asymp. Sig. (2-tailed)		208

b. Test to find out whether the variants of the two groups are the same, or not? Data that fulfills the requirements is if the variance is the same or the subject comes from a homogeneous group

Tabel 4. Independent Samples Test

Levene statistic	df_1	df_2	Sig.
1.480[a]	4	17	252

[a] Groups with only one case are ignored in computing the test of homogeneity of variance for Nilai LPKD

Test of Homogeneity based on table 4 test of variant similarity (homogeneity). Data that meets the requirements is if the variant is the same or the subject comes from a homogeneous group, so P_{Value} = 0.252 is more significant than 0.05 (0.252 > 0.05), then H_0 is accepted, meaning that the two variants are the same.

Table 5. Summary of Normality Test and Homogeneity Test of Pre-test Value

Class	Average	Normality test			Homogeneity test		
		Ratio skewness	Ratio kurtosis	Category	P_{value}	α (0.05)	Category
X TKRO 3 Experiment	39.720	1.790	1.944	Normal	0.292	0.05	Homogene
X TKRO 2 Control	34.400	-0.875	-0.547	Normal	0.292	0.05	Homogene

c. Trial Test the Product

Trial Test the STEM-based student worksheet to find out whether there are differences between the control group with conventional learning methods, and the experimental group using STEM-based sheets. Data was taken from respondents, namely 25 students of class X TKRO 2 and 25 students of class X TKRO 3 in Vocational High School Harapan Mulya Kendal. The results of the data were obtained as follows:

Interpretation of Data Using Frequency

Table 6. Frequency

		Value of control groups with conventional learning methods	LKPD amount of experimental group STEM-based
N	Valid	25	25
	Missing	0	0
Mean		66.1600	73.6000
Median		68.0000	72.0000
Range		24.00	28.00
Minimum		52.00	60.00
Maximum		76.00	88.00
Percentiles	10	57.2000	64.0000
	25	60.0000	72.0000
	50	68.0000	72.0000
	75	72.0000	76.0000
	90	73.6000	84.0000

Interpretation of Data Based on Pie Charts

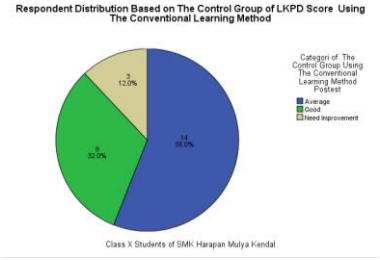

Figure 1. Pie Diagram of The Control Group

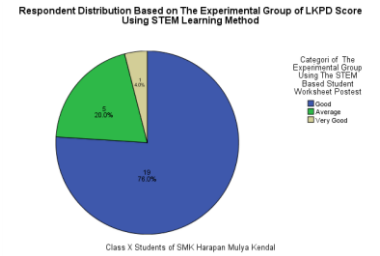

Figure 2. Pie Diagram of The Experimental Group

Analysis of t-test data

Based on the t-test the value of t_{value} = -4.516 while the t_{table} = 2.06390 or -4.516 < 2.06390, meaning H_a is accepted, meaning there are significant differences between the value of the control group using the conventional learning method and the amount of the experimental group using the STEM-based student worksheet. Based on the probability value of the probability value, or Sig (0.00) < 0.05. H_a is accepted, it means that there is a significant difference between the value of the control group using

conventional learning methods and the value of the experimental group using STEM-based student worksheets

t-test or test probability results are the same; namely, there is a significant difference between the value of the control group using conventional learning methods and the value of the experimental group using-based student worksheets. STEM Based on the t-test, it is known that from 25 respondents, the value of the control group uses the standard conventional learning method. Amounting to 66.1600 while the cost of 25 respondents or students. The experimental group using the based student worksheet STEM the average value increased to 73.6000.

Increased enthusiasm for learning in the experimental class, which is driven by the activities carried out by students is related to the theory proposed by Purwanto (2004) stated that motivation is something that encourages someone to do business (activity), and becomes an absolute requirement for learning because giving the right motivation will help students to work and study well.

Based on the above theory, printed teaching materials in the form of a decent and effective stem-based student worksheet will motivate students to learn this, as evidenced by the acquisition of data before using STEM-based students' sheets an average value of 39.72 while after treatment with using STEM student worksheets the average cost increased to 73.6 with the highest score of 88 and the lowest score of 60. The results of the above data, the STEM-based student worksheet was categorized as useful teaching material to be used in learning activities in the automotive light vehicle engineering Vocational High School Harapan Mulya Kendal

Reviewing by the results of normality and homogeneity, product trials in the sample showed a significant increase in enthusiasm for learning by STEM-based student worksheets could be recommended to be used for teaching materials in light automotive, automotive techniques.

Results of this research goal are the Enhanced spirit of learning and student activity significantly, and it indicates there is usefulness in competency skills Automotive Light Vehicle Engineering Vocational High School Harapan Mulya Kendal as support to optimize the implementation of Curriculum 2013.

Usefulness gained in the implementation of learner-based worksheets; STEM is as follows:

a. Increased student learning enthusiasm in the teaching and learning process by using STEM-based student worksheets, learning activities in the experimental class have a "good" category for each aspect assessed.
b. Activity during the teaching and learning process is one indicator of the desire or motivation of students to learn. Students are said to have a business when finding behavioral traits often ask the teacher or other students, want to do the assignments given by the teacher, can answer questions, enjoy being given jobs.

Seeing the changes in student behavior shows that the application of STEM-based student worksheets has benefits in learning success.

High enthusiasm for learning can improve learning outcomes, and this is following the research Andriani (2011) states there is a relationship between motivation to learn and student academic achievement. Undergraduate students of Nursing have loud and clear motivations, apparently influencing their learning outcomes.

An education expert, Trinandita (1984) states that "the most basic thing that is required in the teaching and learning process is student activity." The activeness of students in the teaching and learning process will lead to high interaction between the teacher and students or with the students themselves.

Assessing those related to changes in behavior such as enthusiasm for learning and activeness of students during the learning process shows the usefulness of the results of the application of STEM-based student worksheets.

Increased enthusiasm for learning and student activity is very significant, and this shows

that there is usefulness so that STEM-based student worksheets can be recommended to be used for teaching materials in automotive light vehicle engineering.

CONCLUSION

Based on the data from the research and discussion of the development of STEM-based student worksheets on basic automotive technology subjects in essential competencies evaluating the work of batteries in automotive light vehicle engineering, SMK Harapan Mulya Kendal can be summarized as follows: Based on the results of validation test results 4, 86 (right), 4.46 (good) SMK supervisor, teacher productive 4.69 (good) and reliability testing on the basis of decision making: r positive results, ie, 0.379 and more significant than r_{table} = 0.279, then the questions it is reliable. Worksheets of students with STEM language can be categorized as feasible to be used in the learning process in the competency of Automotive Light Vehicle Engineering expertise in Vocational High School Harapan Mulya Kendal as support for optimizing the implementation of Curriculum 2013.

As per the normality test results, Sig is 0.208. This value is far higher than 0.05, so it can be concluded that based on the test results it is known that the model is not subject to normality problems, homogeneity comes from homogeneous groups so that the P_{Value} = 0.252 is higher than 0.05 (0.252 > 0.05), then H_0 is accepted, meaning both variants is the same, product testing Based on t-test the value of t_{value} = -4.516 while the cost of t_{table} = 2.06390, or -4.516 < 2.06390, meaning that H_a is accepted, saying that there is a significant difference between the value of the control group using conventional learning methods on The sample shows a substantial increase in enthusiasm for learning so STEM-based student worksheets can be recommended for use in teaching materials in automotive light vehicle engineering.

Changes in student behavior indicate the application of STEM-based student worksheets that have benefits in learning success. So the profits obtained in the implementation of STEM-based student worksheets are an increase in students' enthusiasm for learning in the teaching and learning process. Learning activities in the experimental class have a "good" category for each aspect assessed. Activeness during the learning process students has the desire or motivation to learn by often asking the teacher or other students, want to do the assignments given by the teacher, able to answer questions, and enjoy being given tasks.

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