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Research Article

The effect of STEM-EDP in professional learning on automotive engineering competence in vocational high school

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Abstract

The quality of teacher learning practices currently continues to be improved through various training programs, mentoring, and evaluations from Indonesian government support. The 21st-century teacher's ability to develop learning technology is a cooperative learning approach and multidisciplinary integration of science to solve surrounding problems. This study describes the effectiveness and benefits of Science, Technology, Engineering, and Mathematics (STEM) in the Automotive Engineering Competency with the Engineering Design Process (EDP) approach in the "motorcycle burglary case studies." This research is a type of pre-experimental design in the form of a pretest-posttest group design. The purposive sampling technique was carried out to find out the sample of students in one of the vocational schools Yogyakarta, Indonesia in 2019. The results showed that (1) the assessment of lesson plan in the form of review and supervision was declared complete; (2) aspects of the STEM-EDP assessment consist of formative tests, the 1st Student Worksheet, the 2nd Student Worksheet, and Products which stated in the seven stages of EDP; (3) Wilcoxon test, Z = -4.86 with significance (p) = 0.00 <0.05, illustrates that STEM-EDP is effective than summative learning, and can improve learning.

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Introduction

The key to vocational education is declared successful, professional and sustainable, determined on three aspects, namely curriculum, learning, and teachers, in responding to the challenges of the 21st century. Currently, vocational education in Indonesia is undergoing a curriculum transition that was originally in the Competency based curriculum and the education unit level curriculum developed into the 2013 curriculum even the most recent was the 2013 curriculum revised (Nurtanto et al. 2018). As a result, vocational teacher understanding must adjust and this is not easy, especially the teacher's initial habits in classrooms, and workshops (teaching behavior in learning). The process of curriculum change is a new and relevant study to discuss. Researchers analyzed the conditions in vocational schools that there were three phenomena, including (1) teachers working in the Competency based curriculum was experiencing delays in following the latest curriculum developments; (2) teachers working in the education unit level curriculum at middle age can still be triggered to follow events; and (3) new teachers or teacher graduates in the last

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decade have been able to keep up with changes and developments. Of course, changes are carried out in full and comprehensively with the current conditions.

Furthermore, curriculum changes are adjusted to the needs of the workforce and even refer to results. This is experienced by some developed countries, that changes in the new curriculum have an impact on the implementation of learning that is not stable. Meanwhile, the challenges in dealing with changes in industrial technology 4.0, the need for competence in sociology, education 5.0 and 21st century have not well understood by vocational teachers.

The development of the revised 2013 curriculum was due to teaching skills and curriculum development in the past that did not have the impact of improving the quality (Cannon & Widodo, 1994), while the quality of graduates must answer the competency needs of the workforce. Authentic evidence based on the Program for International Student Assessment (PISA) initiated by the OECD shows that the results of competency tests in the form of Mathematics, Reading, and Science in children aged 15 years, Reading, and Science in children aged 15 years, contested every 3 years Indonesia is ranked 12th (60) out of 72 countries, and in 2015. Even in 2018, the problem is circulating, Indonesia has decreased again. After evaluating through a survey by (Stacey, 2011), contributing factors are the problem of overall achievement, equality, and even classroom environment. This skill is strengthened by (Argina et al., 2017). The main factors are the quality of teachers, the education system, education funds, and the decentralization of education. The researcher assumes that the problems that arise have an impact on the low national teacher exam scores at the standard limits (Kurniawati et al. 2018). Following are the achievements of the PISA index for 2009-2015 (OECD, 2018).

Table 1.
PISA Index Achievement Results from 2009–2015

Year	Competency test	Indonesian average score	International average score	Indonesia's ranking	Country of participation
2009	Read	402	500	57	
	Mathematics	371	500	61	65
	Science	383	500	60	
2012	Read	396	500	62	
	Mathematics	375	500	64	65
	Science	382	500	64	
2015	Read	397	500	61	
	Mathematics	386	500	63	69
	Science	403	500	62	

Source: (OECD, 2018)

Researchers believe that many other factors have not discussed yet. However, the focus on the existing problem is the improvement of professional human resources, as a critical factor by describing the strong objectives of the revised 2013 curriculum in entering the global market in 2013. Following is the relationship of change analysis with the revised 2013 curriculum.

Table 2.
Analysis of the 2013 Curriculum Change, the Impact of PISA

Component	Curriculum of 2013	Analysis of changes
Achievement Targets	Students master the core competencies of processing, reasoning and serving in the realm of concrete related to the development of what they learn in school independently and can use methods according to scientific principles	The aspects of reading competence categorized into three types which include: a) The ability to disclose retrieving information, b) Developing an interpretation, c) Reflect and evaluate the text. High-level thinking dominated the entire PISA reading problem from 2000 to 2009
Emphasis on Subject Subjects	Emphasized in science and technology, especially science and mathematics subjects	PISA only consists of math, reading, and science tests. The means that the emphasis on science and technology and mathematics is in line with what PISA experts in the human resources needed in the 21st century for mastering science and mathematics
Subjects tested	Emphasis on three subjects in Mathematics, Indonesian, English	PISA consists of math, reading, and science tests.

Component	Curriculum of 2013	Analysis of changes
Types of Questions on National Examination, evaluation	Questions are curriculum evaluations added with HOTS (high order thinking skills)	HOTS character is the same character in PISA competence. That is exercising higher-order thinking skills, including the ability to develop interpretations, the ability to reflect, and the ability to evaluate texts.
Learning process	Emphasis on practice and seeking learning information independently	One of the goals in PISA is to measure students 'understanding of learning that can answer students' problems in daily life. Emphasis on practice and search for information independently makes students seek knowledge through the surrounding environment so that it is expected to be able to answer problems in the life to come.
The role of the teacher in the classroom	The teacher is a facilitator	Before joining PISA, the teacher figure was a central figure. After joining PISA, the teacher is only a student facilitator in gaining his knowledge.

The curriculum that is compiled and developed must be able to anticipate changes in the future, which means it has a function of sustainable development. The 2013 curriculum revised according to market needs, namely the 2030 labor market and the 2045 market, with the challenges of technical characteristics such as IoT, block chain, artificial intelligence, three-dimensional printing, robots, and even automation. It is predicted (Bughin et al. 2017) that by 2030, in Indonesia, there will be 23 million jobs that will be replaced by machines. At the same time, around 27 - 46 million new jobs created. In this case, the researcher concludes that the modern era is described as a condition of volatility, uncertainty, complexity, and even ambiguity. To be able to adapt to change requires collaboration from various fields of scientific discipline. Problem-solving, producing new products, critical thinking, creative, systematic, communicative, and reflective is the culture in every vocational education learning. Several scientific method approaches have offered to transform conventional concept learning into active learning. The methods in question include problem-based learning, project-based learning, inquiry learning, discovery learning, and several other methods that are considered successful in developed countries. However, the collaborative value and the combination of multidisciplinary science not integrated yet. Finally, the STEM concept can adopt as a training program for several professional teachers in vocational education to provide tangible reinforcement in learning.

Vocational education in Indonesia in the next three years, starting in 2019, is completing a major project, namely the application of the STEM model that is integrated into learning. The STEM concept is new and has not widely applied in various vocational schools in Indonesia. Several researchers have started even some studies, but the stages in integrating STEM are not detailed. As a result, it has not been done by several other researchers for adoption and also seems to confuse the concept under construction. Through the ongoing program, the researchers explain the STEM concept in detail, from decreasing essential competencies (C-13) to the processes and products to be exposed. Learning with STEM is seen as strengthening TVET is learning to prepare for the 21st-century job market (Voogt & Roblin, 2012), new technology-based skills (Lwakabamba & Lujara, 2003; Williams, 2011), competitiveness (Zakaria & Iksan, 2007), will soon emerge new employment (Lwakabamba & Lujara, 2003). The economic potential will be built up (Sohoni, 2012), and Increased entrepreneurship (Tikly et al. 2018).

The STEM concept is considered capable of improving the quality of vocational education learning (Nadelson & Seifert, 2017). Teachers as learning actors as well as crucial factors in the success of education reform (Milner-Bolotin, 2018). Some researchers recommend STEM to be integrated into quality curriculum development (Margot & Kettler, 2019), increasing student motivation and behavior (Vennix et al. 2018). It is even believed to be the most effective method, and students are actively involved (Zakaria & Iksan, 2007). However, the success of previous researchers is inseparable from the teacher's professional competence (Ring et al. 2017).

The scientific disciplines involved in the STEM concept consist of Science-Technology-Engineering-Mathematics. In the future, STEM will experience expansion in Art and Design by changing the idea into STEAM. This study in developing countries. Vocational education teachers need to realize that STEM is a disciplined approach or a temporary framework in implementing STEM learning that can integrate with scientific methods such as Problem Based Learning (La Force et al. 2017; Nurtanto, Nurhaji, Baser, et al. 2018; Nurtanto, Nurhaji, Widjanarko, et al. 2018), Project-Based Learning, STEM, 5E, and EDP (Zheng et al. 2020). One of the characteristics of STEM is being able to solve problems (Widowati et al. 2017; Hu & Adey, 2002; Laius et al. 2011) in current and long-term needs. In the field of Engineering and Technology together with engineering design or so-called Engineering Design Process (EDP) (Schnittka, 2009). Many researchers reveal that EDP improves student achievement, especially in the mastery of science (Apedoe et al. 2008; Mehalik et al. 2008; Riskowski et al. 2009; Schnittka, 2009) students' interests and attitudes in science (Apedoe et al. 2008; Rogers & Portsmore, 2004), and improving technical skills (engineering and technology) (Schnittka, 2009; Syukri et al. 2017). With the EDP-based STEM concept, teachers creatively and collaboratively find innovations (Turner et al. 2016) to manage the process and learning objectives.

The characteristics of vocational education in the implementation of the STEM model, which integrated with the EDP, illustrate the stages of STEM implementation and determine its effect after the experiment. What needs to be understood by vocational teachers is that STEM is not only product-oriented, but process strengthening is an essential focus on discovery. Furthermore, researchers call STEM-EDP. The seven stages are explained and broken down on fundamental technological themes in automotive expertise. STEM implementation completed by looking at the potential of each BC (Basic Competency) to be directed to the product/design/procedure. Vocational teachers must be able to identify BC, then coordinate with other learning, teachers to be involved in the same project, including in terms of Science (physics and chemistry teachers), Technology, Engineering (productive teachers), and Mathematics (mathematics teachers). Next, confirm the role between disciplinary vocational teachers by the chosen BC. The following table topics and BC in the field of Automotive Technology in Vocational Schools.

Table 3.
Understanding Topics and Basic Competencies

The topics: Identifying electronic components	
Basic Competencies	**Indicators of Competency Achievement**
3.12. Understanding the basics of simple electronics	3.12.1. Identifying the types of electronic components 3.12.2. Explaining the working principle of electronic components 3.12.3. Interpreting simple electronic circuit wiring diagrams
4.12. Make a simple electronic circuit	4.12.1. Making a simple electric circuit 4.12.2. Measuring resistance, current, and voltage in a simple electrical circuit

Operational verbs in BC.3 and BC.4 have the potential to use STEM. The main and primary reason is in BC.4 (skill aspect) it is stated for "making", which means it produces a product/design/procedure and others. Of course, with the achievement of BC.4 (aspects of skills), BC.3 (aspects of knowledge) can be achieved. From each BC, the stages of competency achievement are explained. A total of 4 ICAs from BC.3 (aspects of knowledge) serve as benchmarks for achievement with operational levels, while 2 ICAs in BC.4 (aspects of skills) are a measure of skills. Teachers in the STEM discipline collaborate to determine problems and the roles or support during learning. Finally, the STEM pattern approach from various scientific disciplines is explained as follows.

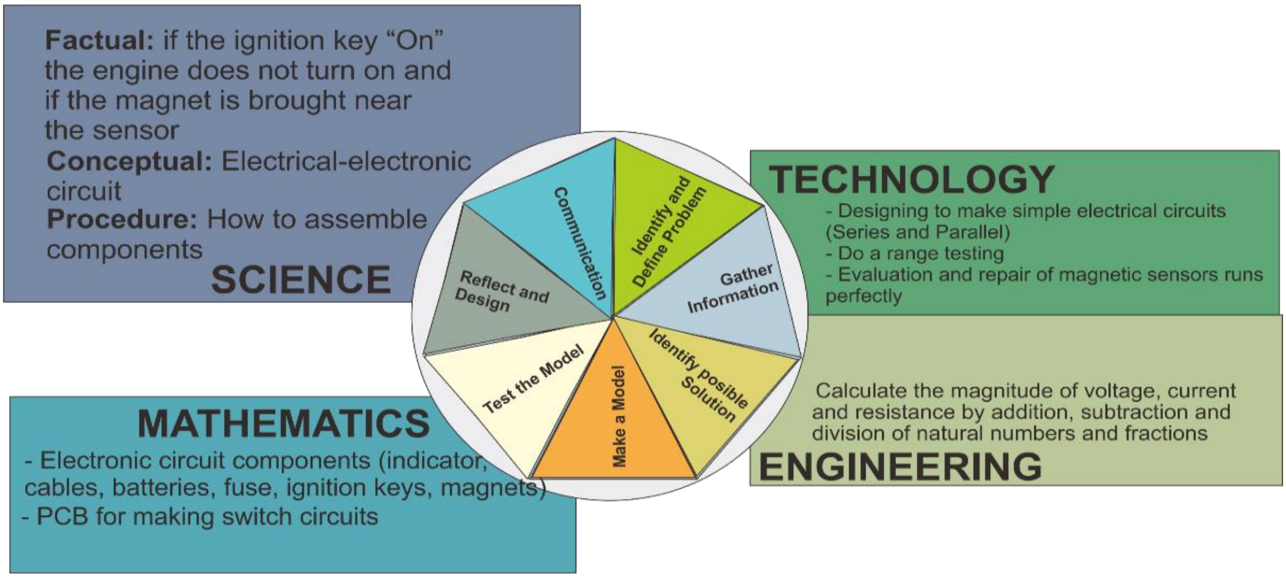


Figure 1.
Concept of STEM-EDP Approach "Identifying Electronic Components"

Based on the picture above, the integration of scientific disciplines with STEM is responsible for competency approval. The problem that must be solved is a motorcycle theft case, which is done by breaking into a lock area with the help of a key T. STEM education connects the scientific process with EDP (Engineering-Design-Process), which consists of seven stages, namely defining the problem, the background of the research, planning solutions, building models, testing models, reflecting and redesigning, and communicating. EDP is the key for engineers in making models and systems.

Stage 1: Identify and Define the Problem

Vocational education teachers divided students into six groups, each consisting of 5-6 students randomly. The pretest results with the six highest scores represent leaders in the group to appoint sequentially their members. The teacher distributes the student worksheets and provides a stimulus in the form of problems regarding "motorcycle burglary cases that are rife." Next, the teacher brings students to formulate the problem and provide inspiration to identify the problem accordingly. Students observe, criticize the problem and formulate possible solutions to be applied and choose the right solution. In this stage, the character of students in the form of curiosity and carefully formed by itself. The results of the 1st student worksheet shown in the following table.

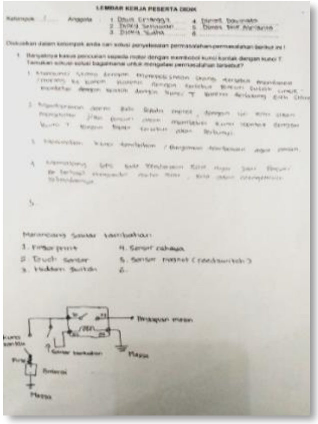
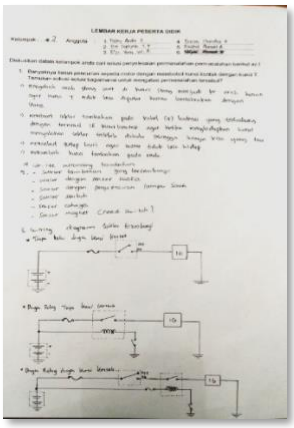
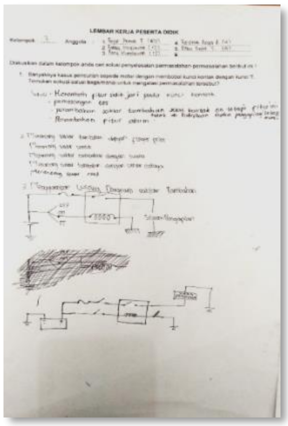
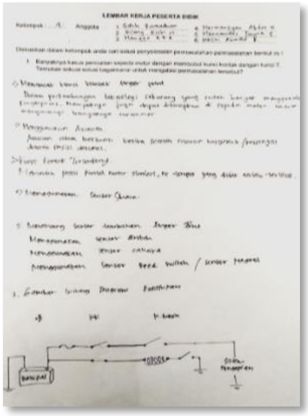
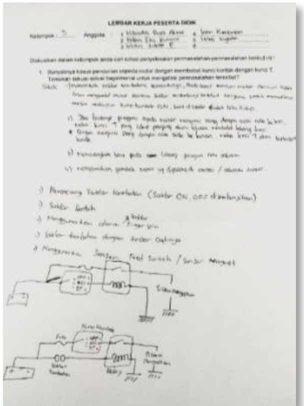
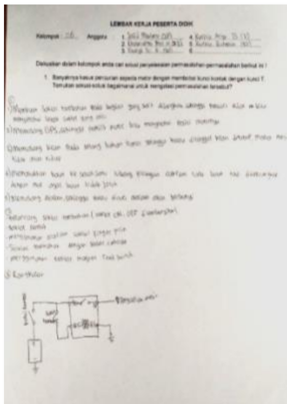
		
The 1st student worksheet in Group 1	The 1st student worksheet in Group 2	The 1st student worksheet in Group 3
		
The 1st student worksheet in Group 4	The 1st student worksheet in Group 5	The 1st student worksheet in Group 6

Figure 2.

Results of the 1st Student Worksheet

The results of the identification of problems offered to students grouped:

Table 4.

Problem Identification in Motorcycle Theft Cases

No	Problem identification	G1	G2	G3	G4	G5	G6
1	Lock the handlebar by positioning the handlebar to turn right, so that it is difficult if broken using a T key	I	I	-	-	I	-

No	Problem identification	G1	G2	G3	G4	G5	G6
2	Make an alarm on the motorcycle, so that when a theft occurs the alarm sounds	I	-	I	I	-	I
3	Add additional keys in the form of a padlock on the disc or padlock on the wheel.	I	I	-	-	I	I
4	Install GPS on a motorcycle, so that the vehicle's position when parking monitored	I	-	I	-	-	I
5	Make an additional switch on the battery positive cable connected to the ignition key's "IG" terminal, so that when turned on you must first switch on the other switch	-	I	I	-	-	-
6	Pull out the spark plug cap so that the motor does not start	-	I	-	-	-	-
7	Add a fingerprint feature to the ignition	-	-	I	-	-	-
8	Move the default ignition key to an invisible place	-	-	-	I	I	-
9	Use additional switches with sound/magnet/light/touch sensors.	-	-	I	I	I	I

Stage 2: Gather information

The teacher invites students to think critically and hypothesize in choosing and determining the right solution and assuming making a safety device with electronic technology. Students in literacy collect fundamental theories and information about the concept of safety switches, ignition keys, "IG" motorcycle ignition systems, electronic components. The character of students in the form of critical and creative is thinking formed in group learning situations.

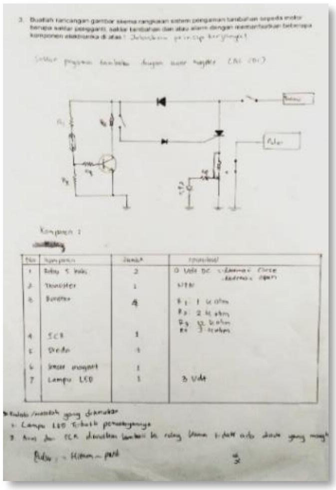
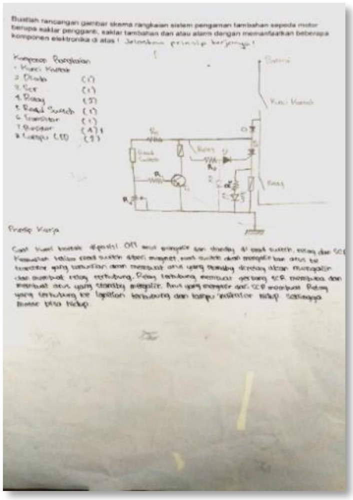
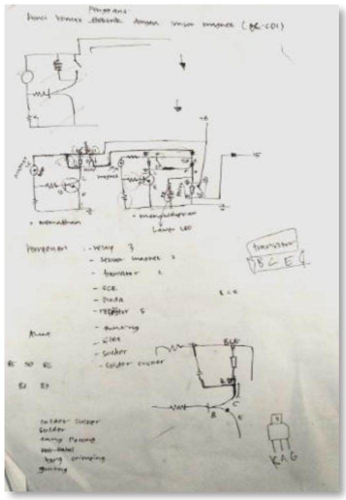
Stage 3: Identify Possible Solution

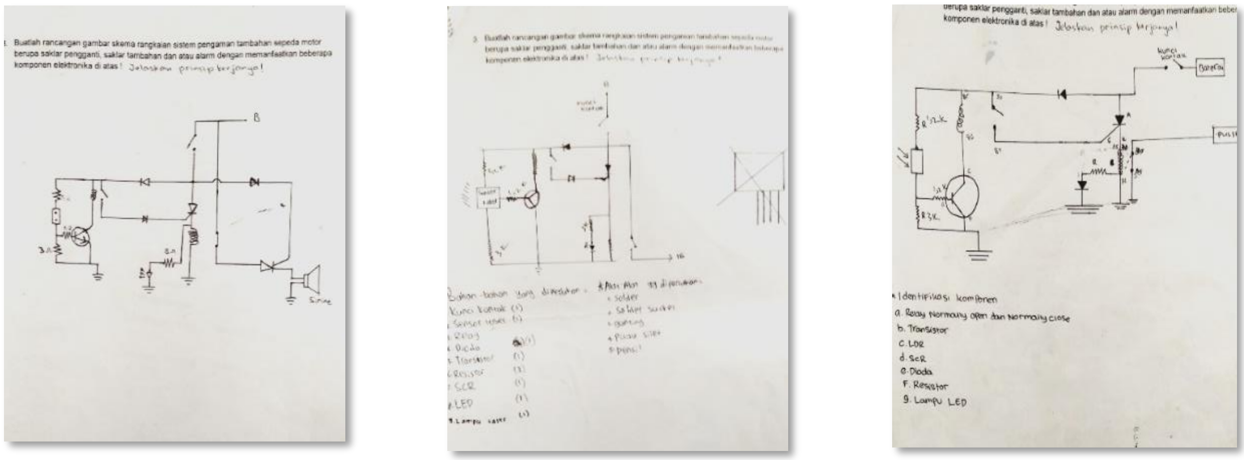
Together with the group, the discussion continues to determine the product design concept from a simple electronic circuit that serves as an additional safety or alarm with available materials and is guided by the ideas and working principles of electronic components in previous learning. Creative, innovative, and responsible characters are inherent at this stage. The titles of students' product designs are as follows:

Table 5.

Results of Discussion Focus on Title to Designed

Group	Title to be designed
1	Additional safety switch with a magnetic sensor (DC ignition)
2	Additional safety switch with a laser beam (AC ignition)
3	Electric ignition with a magnetic sensor
4	Additional safety switch with a magnetic sensor (AC ignition)
5	Motorcycle burglar alarm with a magnetic sensor
6	Additional safety switch with a laser beam (DC ignition)

		
The 2nd student worksheet in Group 1	The 2nd student worksheet in Group 2	The 2nd student worksheet in Group 3



The 2nd student worksheet in Group 4	The 2nd student worksheet in Group 5	The 2nd student worksheet in Group 6

Figure 3.
Results of 2nd Student Worksheets

Stage 4: Create a Prototype or Make a Model
The simple electronic circuit concept scheme is making according to the product ideas of each group. Students create a prototype by applying a simple electric circuit scheme that has been prepared by assembling electronic components of the planned project by connecting cables between components. The character of self-confidence, cooperation, and accuracy forms.

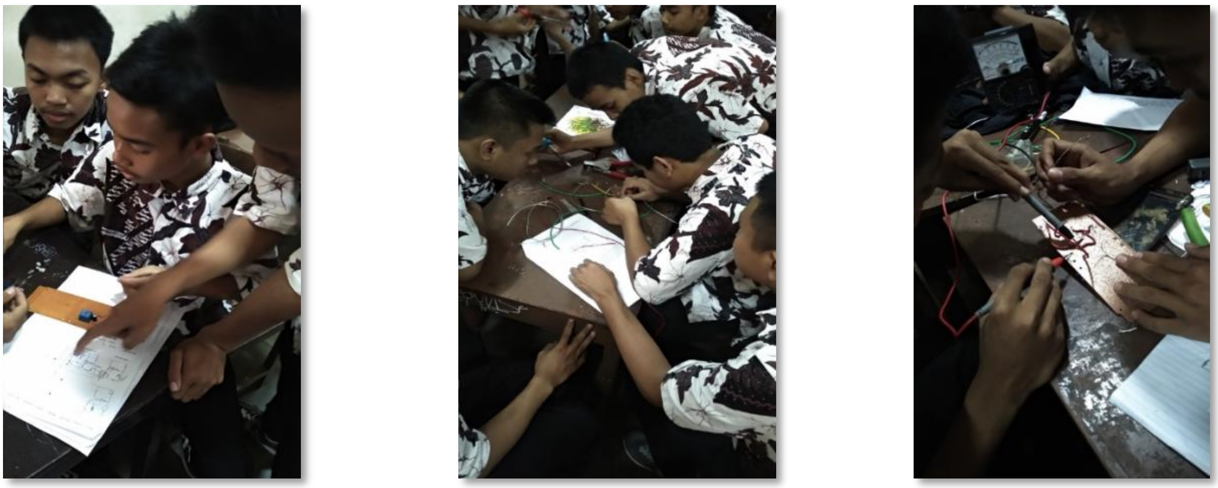


Figure 4.
Creating a Prototype in a Group

Stage 5: Test the Model
Products that have designed in the form of safety or alarm switches must undergo preliminary testing of the product's function and performance before been installed on the vehicle. Next, students record the findings and phenomena that occur in the results of paired tests. The character of cooperation, overall, and forms of responsibility.

Figure 5.
Test the Simple Electronic Circuit Model that has Made

Stage 6: Reflect and Redesign

Concluding and identified the weaknesses of the product tests as an evaluation material to redesign the next product. Products that are declared successful can then install on motorized vehicles-products that have not successfully grouped for review, evaluation, and redesign. The evaluation process is done by looking at and reviewing the designs and cables made. During the STEM EDP learning process, the teacher does not justify mistakes and does not blame the results of the product failure. Thus the product of learning outcomes during STEM EDP is classified into two, namely the finished product and product error. Both have essential and complementary levels of learning.

Figure 6.
Reflecting the Results of Design and Performing a Redesign by Analyzing the Design

Stage 7: Communication

The final results are presented or communicated to other groups to get feedback. Furthermore, the teacher, as a source of information, provides reinforcement and involves students in concluding the resulting project.

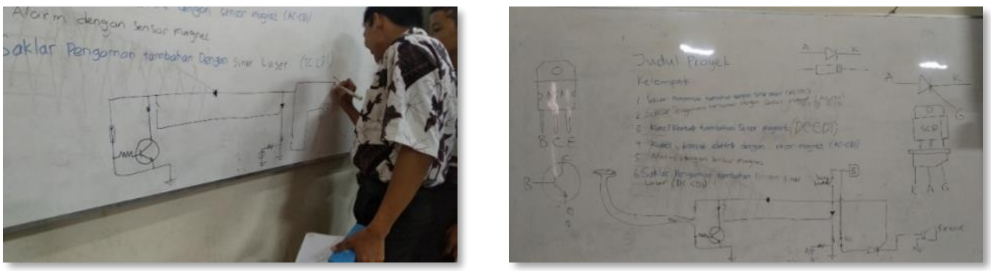


Figure 7.
Presenting Product Results to other Friends in Teacher Supervision

Problem of Study

Learning Conditions Before Using the STEM Method

The ability of teachers in the learning process determines the achievement of learning objectives. The revised 2013 curriculum establishes the principles of active or student-centered learning. This condition is not comfortable for the characteristics of Vocational Education students. Less than optimal level of class mastery and the number of students in a class that is more than ideal becomes difficult, even in public schools. Problem-based learning (PBL) and product-based learning (PjBL) approaches have been applied. However, the concept of individual teachers in achieving learning objectives is still on going. On the other hand, the condition of students in producing something in learning and solving problems related to daily life has not been applied. Thus, learning must be changed to a better way of thinking.

Learning Conditions in Applying the STEM Method

The experience of the new teacher after gaining an understanding of the STEM program and applying it to the vocational classroom provides a better chance. The teacher gives a theme or topic about "motorcycle theft". Their initiative and creativity provided a solution to the incident that emerged. Coordination in teamwork as a group designs the proposed settlement, the division of work and reading skills in teacher observation. STEM-EDP provides changes to teachers that involve disciplines through other subjects and other learning teachers to help strengthen concepts. On the one hand, students in the STEM-EDP learning group brings out collaborative, creative, communication and critical characteristics and problem-solving.

Learning outcomes find two important concepts, namely the product that was completed and succeeded in testing and the product that was finished and failed during testing. Good learning is not limited to, testing success, but identifying the causes of failure. Thus, the critical level of students in the same context can solve problems. It is the researchers 'recommendation that STEM provides life skills for students' future and learning that are important for vocational teachers.

Method

Research Model

This study uses a pre-experimental design method. The research design used is a one-group pretest-posttest (Allen, 2017). Students are given tests before and after treatment is given.

Figure 8.
One-group Pretest-posttest Design

The one-group pretest-posttest design with O_1 details is the learning outcomes of the Formative STEM-EDP, while O_2 is the learning outcomes of the Summative STEM-EDP.

Participants

This research conducted by purposive sampling and the sample size is 31 respondents in one group of student vocational schools in Yogyakarta, Indonesia, in 2019. One group consisted of 31 respondents.

Data Collection Tools

Research data collection using formative assessment sheets, summative assessments, student worksheet assessments, and product assessments. Formative and summative test assessments use multiple choice question items with a "True and False" dichotomy (scale of 1-0). This instrument was developed by teachers, VEDC BOE Malang, and Widyaiswara as expert judgment. A total of 20 question items with the results of the Cronbach alpha test (KR-20) amounted to 0.78 with a reliability of 0.82. Whereas the 1st student worksheet instrument test, the 2nd student worksheet used a polytomy data of four questions obtained by alpha Cronbach, 0.80 with reliability 0.90, and for testing the product instrument using a scale of 1-4 polytomy test data (strongly disagree - strongly agree), a total of 10 items were obtained and alpha Cronbach 0.83 was obtained with a reliability of 0.91. All aspects of the assessment were obtained by Cronbach alpha in both good and very good categories above 0.6 and item reliability more than 0.8, which is good.

Data Analysis

Learning outcomes carried out by the Normality test, t-test. Wilcoxon (non-parametric) performed if the data tested using SPSS 25 not normally distributed.

Results

Application of STEM-EDP

STEM-EDP at vocational education consists of four assessments from seven stages of EDP, including formative tests, 1st Student Worksheet Evaluation, 2nd Student Assessment Worksheet, and STEM-EDP products. The application of STEM carried out through the preparation stage of the STEM-EDP learning document with the lesson plan review instrument and the Supplement to the STEM-EDP lesson plan Supervision Instrument. Lesson plan learning indicators includes subject identity, formulation of indicators, formulation of learning objectives, selection of teaching materials, selection of learning resources, selection of learning media, learning methods, learning scenarios, and authentic assessment. While the STEM-EDP lesson plan supervisory instrument indicator consists of

- Range of Teaching Materials: (a) the suitability of science with the topic; (b) compatibility of Technology with the theme; (c) Engineering suitability with the topic; and (d) Mathematics compatibility with the topic;
- Learning Scenarios: (a) identify the problem; (b) examine the problem; (c) identifying potential solutions; (d) work on the product/model; (e) carry out product tests; (f) design improvement process; and (g) presenting solutions that produce products: and
- Authentic Assessment Design: (a) conformity between forms, techniques, and attitude assessment instruments; (b) compatibility between forms, techniques, and instruments of knowledge assessment; (c) compatibility between forms, techniques, and an instrument for assessing skills.

The assessment scores include the value two on the document declared complete, value one of the documents in an incomplete space (some not yet met in full), and zero means that there are no documents available. The results of the assessment of lesson plan studies and lesson plan supervision showing in the following diagram.

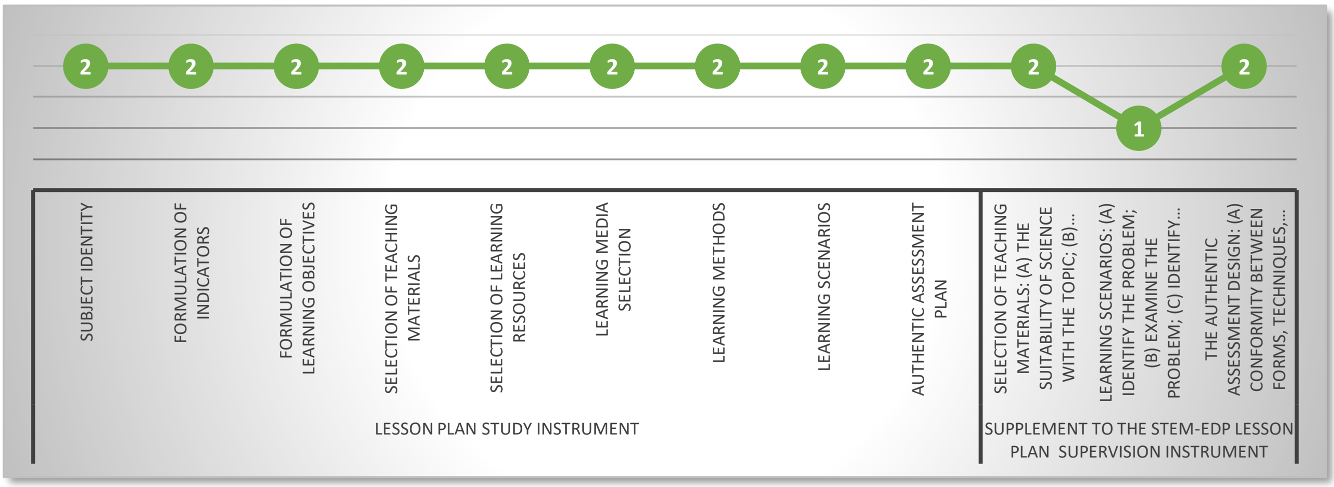


Figure 9.
The Results of the Assessment of the Lesson Plan Document Review and Lesson Plan STEM-EDP Supervision

The above results indicate that the learning scenario on the supervision instrument needs minor improvements. The overall assessment has fulfilled with a score of 2. It is clear that the lesson plan readiness plan (Roberts & Cantu, 2012), contributes to student learning.

STEM-EDP learning stage

STEM-EDP in terms of several aspects, Formative Assessment, the 1st student worksheet, the 2nd student worksheet, and Products. Further details displayed in the following table:

Table 6.
Description of Aspects and Results of the STEM-EDP Stage Assessment

Aspect	STEM-EDP stage	Score	
		(1)	(0)
Formative Test	Identify and Define Problem	31	0
The 1st student worksheet	Gather Information	31	0
The 2nd student worksheet	Identify Possible Solution	31	0
Product	Create a Prototype or Make a Model	31	0
	Test the Model	31	0
	Reflect and Redesign	31	0
	Communication	31	0

The table above is a score of all aspects of learning and STEM-EDP approach interpreted in a graph.

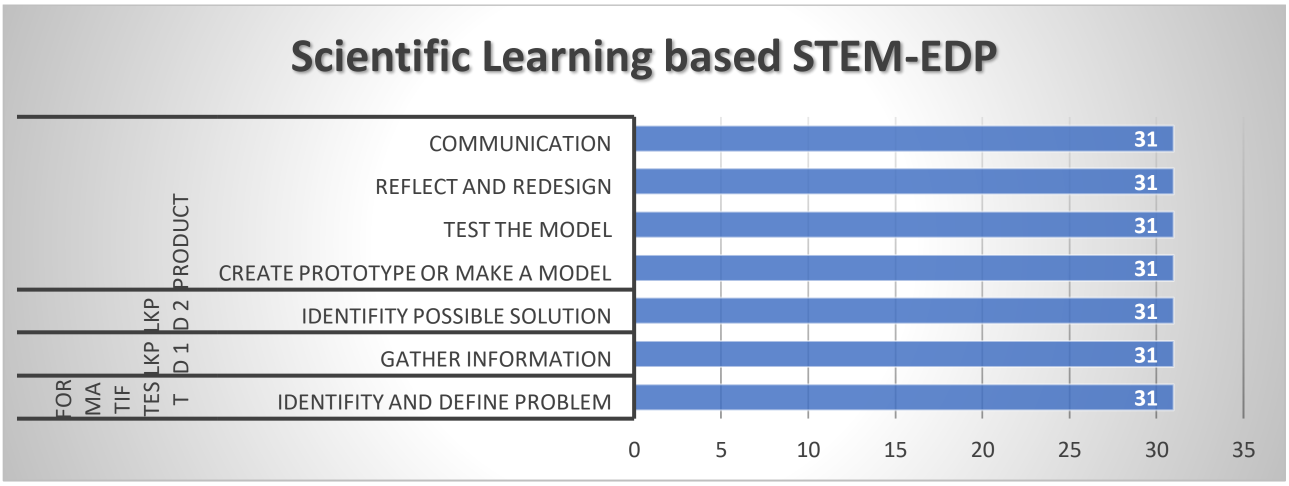


Figure 10.
STEM-EDP interpretation

STEM-EDP carried out in several stages of observation and assignment, Formative Assessment, the 1st student worksheet, the 2nd student worksheet, and products that are divided into learning processes and learning outcomes. In the formative test aspect, it appears that students conduct the identification stage of the problem studied, namely "the rise of motorcycle theft cases by breaking into using the" T key. Along with formative tests, the 1st student worksheet test conducted, and gather information, namely students offer solutions to cases of problems. The next aspect of the 2nd student worksheet is the identification of determining Solutions and Making Prototypes or Making Models, namely directing the concept of magnetic sensors and students making the title of planning and designing electrical circuits. , failure analysis, and product data delivery STEM-EDP is not limited to seeing the product succeed or not, because STEM-EDP is more meaningful if redesigned, the stage is carried out by several groups, as a manifestation of deep learning.

Description of STEM-EDP

The successful implementation of EDP in the competence of creating electronic components in the automotive field explained in four tests during the process, formative assessment, the 1st student worksheet, the 2nd student worksheet, and the final project in product form.

Table 7.
Description of BTA C2 Competency based on STEM-EDP

		Formative Test	The 1st Student Worksheet	The 2nd Student Worksheet	Product
N	Valid	31	31	31	31
	Missing	0	0	0	0
Mean		89.55	87.58	90.42	92.97
Median		86.00	90.00	89.00	93.00
Mode		95.00	90.00	95.00	90.00
Std. Deviation		7.070	4.808	6.903	2.501
Minimum		80.00	80.00	80.00	90.00

	Formative Test	The 1st Student Worksheet	The 2nd Student Worksheet	Product
Maximum	100.00	95.00	100.00	97.00
Sum	2776	2715	2803	2882

During the STEM-EDP learning process, taking individual scores in study groups is done by looking at simple electronic circuit learning activities. Formative test results obtained a score of 89.55, the 1st student worksheet with the acquisition of 87.58, the 2nd student worksheet with the addition of 90.42, while the product with the addition of 92.97. Acquisition scores for each aspect have increased. It appears that every aspect of STEM-EDP well implemented.

Effectiveness of STEM-EDP

The effectiveness of learning STEM-EDP by comparing the results of summative learning. The results of summative learning at STEM-EDP are as follows:

Table 8.
Description of STEM-EDP and summative learning outcomes

		STEM-EDP Learning Outcomes	Summative Learning Outcomes
N	Valid	31	31
	Missing	0	0
Mean		90.23	78.71
Median		88.75	78.00
Mode		96.75	78.00
Std. Deviation		4.588	2.425
Minimum		84	75
Maximum		97	84
Sum		2794	2437

Description of STEM-EDP learning outcomes obtained a result of $\bar{X}$= 90.23; with a median of $\bar{X}$= 88.75 and a mode of $\bar{X}$= 88.75 while summative learning outcomes obtained a result of $\bar{X}$= 78.71; a median of $\bar{X}$= 78.00; and mode at $\bar{X}$= 78.00. These results are interpreted that STEM-EDP learning outcomes have a higher average than summative learning outcomes. The difference in the results shown in the following graph.

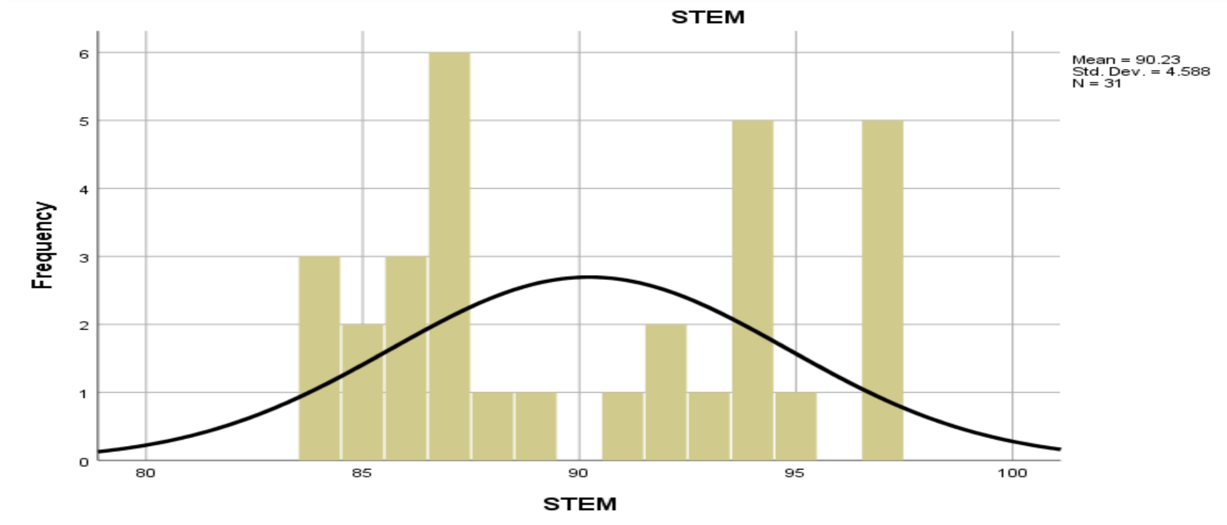


Figure 11.
The STEM-EDP Learning Outcomes Histogram

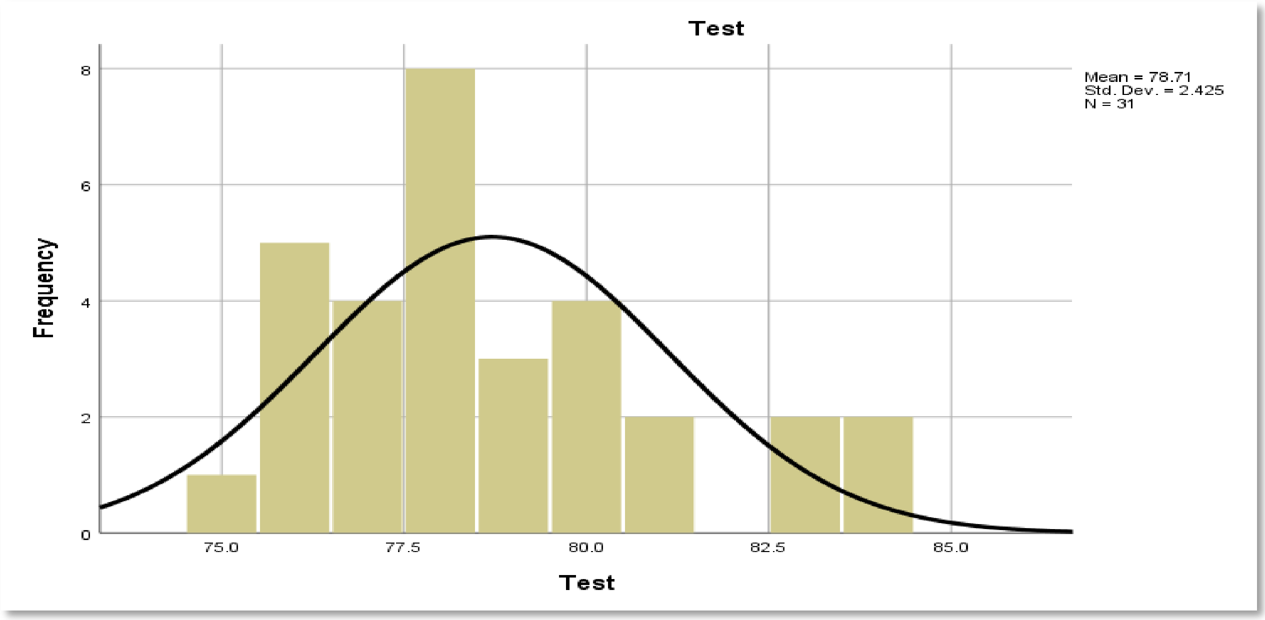


Figure 12.
Histogram Summative Learning Outcomes

Figure 13.
STEM-EDP Leaf Plot and Summative Leaf Plot Test

The description of learning outcomes with the STEM-EDP method is more effective than summative learning outcomes. STEM-EDP provides a stronger impact mode value. It means that learning using STEM is more meaningful, and students can enjoy it during learning. Learning during STEM-EDP is active. The success of STEM influenced by the beliefs and perceptions of teachers in increasing student talent (Margot & Kettler, 2019).

Data normality test performed to describe the effectiveness of STEM-EDP hypothesis testing on STEM summative learning outcomes. The results of the normality test are explained in the following table.

Table 9.
Data on the normality of STEM-EDP learning test results and summative tests

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
STEM-EDP	.211	31	.001	.888	31	.004
Test Summative	.196	31	.004	.917	31	.020

a. Lilliefors Significance Correction

The normality test results above use significance (p) <0.05. So, it concluded that the data not normally distributed explain in the Kolmogorov-Smirnov and Shapiro-Wilk test results. Sig values below (p) <0.05, so it is necessary to do a hypothesis test using a non-parametric difference test, namely the Wilcoxon test.

Table 10.
Wilcoxon Test Results

Test Statistics[a]	
Test Summative Results – STEM-EDP	
Z	-4.867[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.

Wilcoxon test results, Z = -4,867 with a significance (p) = 0,000 <0.05, it can be concluded that an alternative hypothesis is accepted which means that STEM-EDP is effective in summative learning outcomes on BTA material. The STEM-EDP learning concept can improve learning outcomes and activities. In line with research (Saptarani et al. 2019; Stohlmann et al., 2012), that STEM makes a positive contribution during learning. Even students and teachers think that STEM is essential in future career development. During STEM-EDP learning in the given problems (Havice et al. 2018), students work in groups to develop their skills and creativity (Havice et al. 2018; Meyrick, 2011), the learning teacher plays a role in the achievement of learning objectives. STEM-EDP provides a useful learning environment (Avery & Reeve, 2013), in developing students' reasoning skills, critical thinking skills, creativity, and innovation. STEM-based learning needs to integrate multidisciplinary teachers in providing skills development to problems in the learning environment (Tortop & Akyildiz, 2018).

Discussion

The STEM-EDP method illustrates better results ($\bar{X}$=90.23) compared to the $\bar{X}$=78.71 formative test. The assessment results explained that learning using the STEM-EDP method in vocational classes provides an impact and quality of effective learning. However, to get effective learning outcomes using the STEM-EDP method is controlled through the stages of the 1st student worksheet, the 2nd student worksheet and products. All steps of EDP were successfully implemented. Good learning is demonstrated through control activities, and changes in learning outcomes can be observed. Vocational teachers immediately take action outside of planning if the assessment results show a decrease (ineffective).

The histogram graph shows that the increase in acquisition value of 84 as a minimum score differs from the summative diagram of 75 Likewise. The maximum score obtained at STEM-EDP is 97 while the summative is 84 Different results when using various methods, classes, vocational teachers, and instruments. However, it must be used as a reference that the STEM method with EDP characteristics provides positive changes in assessment and learning behavior. Professional vocational teachers are able to observe activities in learning and control the achievement of learning objectives. STEM-EDP is one of the effective methods of vocational learning and is not the only method. Vocational teachers have greater potential in learning.

Learning activities using the STEM-EDP method increase the effectiveness of a simple circuit electric and learning outcomes (Rosidin, 2019). Problem-based learning can complete in a group learning approach that is assisted by the teacher by directing learning objectives (Nurtanto et al. 2019). Finally, an additional safety switch with a magnetic sensor can function according to function and can apply for a motorcycle for double safety. This is a natural ability born from the learner's personality. Thus, STEM can predict and prepare for future career development (Saptarani et al. 2019), and students will better prepare for it. STEM with EDP approach has an effective role in vocational education, learning, and related evidence in STEM learning conducted at vocational schools Yogyakarta, Indonesia, in 2019. STEM-EDP learning outcomes are more meaningful when compared with summative tests. Furthermore, the Wilcoxon test results obtained Z = -4,867, with a significance level (p) = 0,000 <0.05. STEM-EDP will be more meaningful if multidisciplinary science teachers contribute to their role and have the same problem to solve. Besides, STEM needs to be developed with other methods and other types such as Silos, embedded, and Integration (Margot & Kettler, 2019).

Conclusion and Recommendations

The STEM method is adapted to the learning outcomes of the field of expertise. It is explored in the 2013 revised curriculum to be packaged into essential and core competencies (as learning objectives). Teachers' understanding of EDP-based learning, problems and projects, needs to be considered, other disciplines, application of learning levels, and support from the education parties involved. The success of the STEM method is influenced by the factors of vocational teachers in measuring the carrying capacity of learning.

The application of the STEM-EDP Method is adjusted to the needs of work skills, life independence, and work organization. Vocational teachers must be able to encourage student development independently and in groups. A common cause of mistakes is neglected in learning and not achieving effective learning targets.

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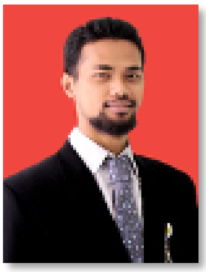

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