Development of an Assessment of Science Process Skills of Basic Electrical Engineering in the Vocational High School

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Abstract: ***Basic Electrical Engineering (BEE) is one of the subjects that are very important for the student mastered the expertise Electrification program in Vocational High School (VHS). Mastery of the concept of BEE so that the students are able to apply in analyzing electric circuits and advanced subjects such as electrical installation, electrical machinery and so on. BEE subjects is part of physics that categorized as science. The aims of this research is to develop the assessment of science process skills (SPS) in learning BEE vocational students. Subjects were vocational schools in the province of North Sulawesi, Indonesia. The method used is research and development (R & D) model of ADDIE (Analyze, Design, Develop, Implement, and Evaluate). The research finding showed that the assessment of SPS who developed in BEE's learning is practical, suitable, and effective to assess the SPS.***

Index Terms**: *Assessment; Science Process Skills; Basic Electrical Engineering***

I. INTRODUCTION

Learning consists of three domains, that is cognitive, affective, and psychomotor. Cognitive domain involves thinking about something that is processed through the brain of individuals, the affective domain concerns the feeling that someone wants to learn, and psychomotor skills regarding [1] [2]. Three domains which mentioned are integrated with each other. Affective domain for an active person to think and do things that they have certain skills [3, 4]. The learning process is a complex activity. Often the subject matter presented poorly absorbed by the student's teacher. This is due to students' thinking skills. Based on the data, students' thinking skills Indonesia is still low, ranks 64 of 65 countries surveyed [5]. Many factors affect the issue, such subjects as complex as a lesson about electricity which is part of science. Because teachers are not able to form students' thinking skills, so they are not able to absorb the learning material. Students who have good thinking skills will have the SPS. While these skills are essential for students [6]. A person who cannot use the SPS will have difficulty when facing problems in daily life [7]. In general, individuals can develop these skills through formal and informal education process by interacting in learning activities at school [8]. A person or student using SPS has a positive attitude in learning science [9]. SPS is useful for students in learning activities, students who do not acquire these skills cannot understand the world and are not able to build the necessary connectivity [10]. Learning activities using a scientific approach will strengthen the students' learning process becomes active than tell students to find out [11]. According to Bilgin, this skill is an understanding of the methods and procedures in the conduct of scientific investigation [12]. Because SPS plays a key role in the learning of science [13]. According Susilowati, these skills contribute to shaping the students conscientious, sensitive identifying, science phenomena and developing thinking skills [14]. Often in learning activities, students are less conscientious and sensitive to the phenomenon of science.

This study aims to measure SPS of vocational students in learning activities of BEE. The results of these measurements will be used as a reference for teachers to find effective forms of teaching to develop and improve students' SPS in order to facilitate their understanding of subjects BEE.

II. LITERATUREREVIEW

Electricity is part of a physics lesson or often called science. Thus, to study electrical, students must have a SPS in order to understand a lesson about electricity. SPS is defined as a process to identify, to formulate hypotheses concerning the issue, predicting, designing experiments, collecting data, analysis of data, and present the findings rational [15]. The literature states SPS consists of two categories: basic SPS and integrated SPS [16-19]. Basic SPS will form integrated SPS [17] [20]. Basic SPS includes the skills of observing, classifying, communicating, making measurements, linking, using quantitative data, and predict. While the integrated skills include the skills of identifying the problem, determine which variables, to formulate hypotheses, interpret data, define, create graphs, perform experiments [19], [21-23]. These factors should be observed teachers in conducting teaching in the classroom and can be seen through the tasks given to the students.

Electricity is an abstract scientific-concepts and elusive [24] Learning science is more complex than other subjects [25]. Thus, students' SPS need to know to look for alternative solutions in order to find appropriate teaching with BEE lessons and to improve these skills. Teacher as a teacher is able to develop students' SPS for one teacher's job is to know the characteristics of the students.

VHS is expected to produce graduates who have specialized

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skills in areas of expertise that practiced and required by the industry. One of the skill programs in VHS, namely Electrical Engineering. The subject matter to be mastered students in the first semester are BEE. BEE material discussed about electricity. Electrical phenomena including in the field of scientific knowledge. So as to master the material BEE, students must have science skills. The lessons learned include the amount of the charge, the amount of current, voltage, and electrical resistance. In theory to determine the quantities of electricity in a circuit must use the concept of Coulomb's Law (CL), Ohm's Law (OL), Kirchhoff's Current Low (KCL) and Kirchhoff's Voltage Law (KVL) [26, 27].

These concepts students should be able to apply the course material covering BEE analysis techniques for series resistor circuits, analysis techniques for parallel resistor circuits, analysis techniques for series-parallel combination circuits, and analysis of electric current loops. This material is relatively complex so that students must have a SPS be able to analyze the electrical phenomena.

SPS owned by the vocational students is important to note that teachers would know students' barriers in learning BEE so teachers can evaluate the way of teaching to increase students' SPS, so that it can be seen SPS owned by the students. Thus, the necessary instruments to measure the ability of SPS owned vocational students in learning activities BEE. Teachers monitor student progress obligated at any time in the learning process through instruments that can measure in accordance with the expected goals. In general, researchers measured SPS students using a test instrument to determine the level of truth answers based on questions given to students [28-30].

In this study, SPS owned by the students are assessed on the activities in the process of resolving the problems BBE given to them. It is important to know the behavior of students. SPS indicators include observing, counting, measuring, classifying, communicating, predicting, making hypothesis, experimenting, variable control, connecting, interpreting the data, applying, and conclusion [31-35].

Table 1. Description of SPS

No.	SPS aspect	Description
1	Observing	Electrical phenomena observed
2	Counting	Analyzing and calculates the electrical quantities in accordance with the procedure
3	Measuring	Take measurements of electrical quantities (current, voltage, resistance)
4	Classifying	Classifying and using the concept, the argument of Ohm's law, Kirchhoff 1, and Kirchhoff 2 in analyzing electrical circuits
5	Communicating	Explaining the data on the magnitude of electric current and voltage in the form of a vector diagram, curves and graphs
6	Predicting	Predicting the phenomenon / electrical phenomenon that will occur
7	Making hypothesis	Make assumptions that are considered right about the consequences that occur due to the effect of electricity on a component or load (load)
8	Experiment	Carry out electrical experimental procedures with determining and using the tool, an ingredient in making experiments and determine which variables, measure, observe, and record the measurement data
9	Control variables	To control and treatment of a variable electrical quantities of the components or specific electrical load
10	Connecting	Linking the concept of Ohm's law, Kirchhoff 1 and Kirchhoff 2 in analyzing the electrical circuit in accordance with the procedure
11	Interpreting	Estimating / interpreting data on electricity magnitudes presented in the form of tables, vector diagrams, curves, and graphs.
12	Applying	Applying concepts, propositions, and formulas about electricity.
13	Conclusion	Concluding up facts, concepts, laws, and arguments about electricity

The frame in Table 1 is a reference for the development of SPS assessment instruments. Every aspect of SPS is made a statement to assess the SPS owned by students. This measurement uses a Likert scale.

Based on the survey conducted, Vocational Schools in North Sulawesi, they did not yet have the instruments to assess SPS capabilities.

III. METHODOLOGY

This study uses research and development (R & D) use models ADDIE (Analyze, Design, Develop, Implement and Evaluate). The research phase is as follows:

A. Analyze Phase

The first stage is doing literature studies, analysis of curriculum, syllabus and student characteristics. It aims to produce an instrument that is practical to use and effective in the measurement and assessment as well as having essentially value.

B. Stage Design

At this stage do still conceptual product design as a reference in order to further the instrument development process. The design of the instrument is based on the theories as a reference for the development. This stage is also preparing product specifications and determine the scale of the instrument.

C. Development Phase

This stage is to do

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development or realization of products based on the concept that has been designed. The instrument is developed based on the theory. The results of product development will be tested the validity and reliability. Validity testing involves experts from the scientific field of electrical engineering education and practitioners who are teachers. This stage will be revised based on input from the validator.

D. Implementation Phase

Stage four is a concrete step for the application of the product. To implement a product, carried out on a limited sample, which involves teachers who teach in vocational BEE. The implementation for testing the practicality and the effectiveness of the product instruments.

E. Evaluation Phase

This stage is carried out on a broad sample, which involves expert or lecturer in the field of Electrical Engineering and teacher BEE. You mean the implementation of this stage is to do an evaluation of the essence or the urgency of the assessment instruments developed products. This test aims to determine the level of essentially of the instruments developed and useful for assessing SPS owned by the students. According to Merriam-Webster, essence are attributes with a sense of quality that is important and that can be placed appropriately in the classroom [36]. Meanwhile, according to Macmillan Dictionary, essence is the most important part of something, or the argument [37].

In this study involving experts in the field of electrical engineering education and teachers who teach subjects BEE Electrical Engineering study program at the vocational school in North Sulawesi, Indonesia. The reason involves the teachers because they are the users of the assessment instrument to measure SPS owned by students in teaching activities in the classroom and in the laboratory practical work.

IV. RESULTSANDFINDINGS

Total grain items are validated as many as 13 items. Content instruments modified according to their subject matter and silbus BEE based curriculum. The validity of the instrument is validated by a validator 7 consisting of four experts who work Electrical engineering education lecturers and 3 practitioners who work teachers have experience teaching subjects BEE more than 20 years. Instruments used to determine the validity of the concept of Aiken's V formula [38], the formula is:

$$V = \frac{\Sigma S}{[n(C-1)]} \qquad (1)$$

Where: V = coefisien validity; $S = r - lo$; Lo = lowest (1); C = the highest score (5); and r = scores given by the assessors (validators). Benchmark testing criteria using the table Aiken's V. Because the instrument amount to 13 items and 7 validators then at the table with a chance of $p < 0.05$ was obtained index $V = 0.67$. This means that grain items can be declared valid if the index $V \geq 0.67$

Magnitude of assessment data provided by 7 validator r and the score S explained in Table 4.

Table 4. Data validator assessment and the value of r

Validator	Items																									
	1		2		3		4		5		6		7		8		9		10		11		12		13	
	r	S	r	S	r	S	r	S	r	S	r	S	r	S	r	S	r	S	r	S	r	S	r	S	r	S
A	4	3	3	2	5	4	4	3	4	3	4	3	4	3	5	4	5	4	4	3	3	2	5	4	4	3
B	4	3	4	3	4	3	4	3	5	4	3	2	4	3	4	3	5	4	5	4	4	3	4	3	5	4
C	5	4	4	3	5	4	4	3	5	4	4	3	3	2	5	4	5	4	4	3	4	3	4	3	3	2
D	4	3	3	2	5	4	5	4	4	3	5	4	5	4	5	4	5	4	4	3	4	3	5	4	4	3
E	5	4	4	3	5	4	4	3	5	4	4	3	4	3	4	3	4	3	5	4	5	4	5	4	4	3
F	3	2	5	4	4	3	3	2	4	3	5	4	3	2	4	3	5	4	3	2	3	2	3	2	5	4
G	4	3	3	2	5	4	4	3	4	3	4	3	4	3	5	4	5	4	4	3	4	3	4	3	3	2
ΣS	22		19		26		21		24		22		20		25		27		23		20		24		21	
V	0.79		0.68		0.93		0.75		0.86		0.79		0.71		0.89		0.96		0.83		0.71		0.86		0.75	

Description: r = the value of the validator; S = r - 1.

The benchmark index is the validity coefficient $V \geq 0.67$. The results of the data analysis are presented in Table 3 indicates greater than the value benchmark. This shows that the quantities of analytical results is a valid value [39, 40]. Thus the assessment of the SPS was developed to meet the requirements of validity.

A. Reliability

To test reliability using the Spearman-Brown equation, the formula is:

$$r_{11} = \frac{2\, x\, r_{½}}{(1 + r_{½})} \qquad (2)$$

Where: = reliability of the instrument; = Index of correlation between the two parts of the instrument. Is said to be reliable if $r_{11} > r_{table}$.

Based on the analysis of correlation between odd and even parts of the data in Table 4 using product moment correlation technique, the value of the correlation coefficient $r = 0.84$. After this value is substituted into the equation Spearman Brown, the obtained $r_{11} = 0.84$. From Table r product moment correlation to the level of 95% ($\alpha = 0.05$), obtained $r_{table} = 0.75$. These test results show that $r_{11} = 0.84 > r_{table} = 0.75$. This indicates the instrument is consistent and high level of reliability [39, 40].

B. Practicality Instruments

For testing practicality of instrument developed is to determine the practicality of an instrument to assess SPS in BEE learning. This measurement uses Linear scale. The formula used to test the practicality of the concept Rinduan modified from [41], the formula is:

$$P = \frac{\Sigma AP}{n} \qquad (3)$$

Wherein: the level of practicality, P = total value of practicality, and many teacher's

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assessors. Practicality testing criteria can be seen in Table 2.

Table 2. Criteria for testing the practicality

Range	Information
P > 4:50	very practical
3:50 < P ≤ 4.50	Practical
3:00 < P ≤ 3:50	Quite practical
2:50 < P ≤ 3:00	Less practical
P ≤ 2:50	Not practical

The test result is obtained the instrument practicality total value of practicality given by 8 teachers of BEE is ΣAP = 38 and the index practicality P = 4.75. The value is included in the category P= *4.75* > 4.5. This indicates that the instrument developed very practical.

C. Effectiveness Instruments

Testing the effectiveness of the instrument aims to find out the effectiveness of SPS in learning BEE instrument. To test the effectiveness of the concept Rinduan modified [41], the formula is:

$$E = \frac{\Sigma AE}{n} \qquad (4)$$

Wherein: the level of effectiveness E = total value of effectiveness, and many teacher's assessors. Testing criteria set out in Table 3.

Table 3. Criteria testing effectivity

Range	Information
E > 4:50	Very effective
3:50 < E ≤ 4.50	effective
3:00 < E ≤ 3:50	Effective enough
2:50 < E ≤ 3:00	Less effective
2:50 E ≤	Ineffective

The test the effectiveness of the instruments developed SPS obtained the data ΣAE = 33 and P = 4.12 the practicality index. Values are among the results of the analysis 3:50 < E ≤ 4.50. These results indicate that the instruments developed effective to use.

D. Essential Instruments

Essential testing modified assessment instrument products from Lawshe concept [42]. The formula is:

$$L = \frac{(n_e - N/2)}{(N/2)} \qquad (4)$$

Where L = the index Lawshe; N = the number of panelists; and ne = number of panelists who expressed the essence.

The trial is to measure the essence or importance of the instrument for measuring the BEE SPS students learn. Assessor acts as a jury or judge to assess the instruments developed content. Lawshe concept approach is a method to measure the agreement of several appraisers or subject matter experts as judges to give answers to questions of each item that consists of three possible answers: (1) Essential (Essentially); (2) Essential (Essentially), but not necessary; and (3) do not need. Lawshe index ranges from +1 to -1. If the number of panelists more than half the states "essence", the instruments developed essential categorized. A benchmark to test the essence of the product that indices L > 0.50 [42]. Participants involved in testing these instruments amounted to 28 people consisting of 14 subject matter experts works as a lecturer and have a background in the field of science Electrical engineering education and 14 teachers who teach subjects BEE. The participants have to understand the concept of SPS.

After assessed by panelists who acted as jurors obtained the following data: the 25 panelists expressed the essence; 2 panelists expressed the essence, but not necessary; and one panelist said it was not necessary. The results of data analysis:

$$L = \frac{25 - 28/2}{28/2} = 0.79$$

The analysis showed an index L = 0.79> 0:50. Based on the results of data analysis can be stated that this instrument is "very essence" or important and useful for assessing student learning SPS BEE. So that this instrument can be used as a reference by teachers of BEE to assess SPS owned by the students.

V. CONCLUSION

Based on the results of data analysis can be concluded that:

1. The product this instrument is practical for used to assessment SPS of students in learning BEE;
2. This instrument effective for assessment SPS of student in learning BEE;
3. This instrument has a very high essential values that can be said is very important for used of teachers in activity learning BEE;
4. Using this assessment instrument, the teacher can find out the student's abilities and teacher's weaknesses while carrying out BEE teaching activities. So that the teacher can think of the right teaching method to present BEE lesson material at class room.

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