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The Comparison of Conceptual Understanding Between Secondary School Students and Pre-Service Physics Teacher in Direct Current Electric Circuit

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ABSTRACT

This study is aimed to compare the understanding of the concepts of secondary school students (junior and senior high school) and pre-service physics teachers in direct current electric circuits. This research was survey research using the quantitative descriptive method. The results showed that there were no significant difference among the junior high school, senior high school, and pre-service physics teacher students with the categories classified as sufficient for junior high school and pre-service physics teacher. However, senior high school students were still relatively weak. The difficulties were found in interpreting formulas and conceptual errors. This research provides practical benefits to the concept of electrical circuits, especially about the low mastery of student's concepts. The same mistakes at every level of education showed that there are misconceptions that are difficult to eliminate. It is needed to have more effort to master the concept deeply.

ABSTRAK

Tujuan penelitian ini adalah untuk membandingkan pemahaman konsep siswa sekolah menengah (SMP dan SMA) dan mahasiswa calon guru fisika pada materi rangkaian listrik arus searah.Penelitian ini merupakan penelitian survey dengan menggunakan metode deskriptif kuantitatif. Hasil penelitian menunjukkan tidak ada perbedaan yang signifikan antara pemahaman konsep siswa SMP, SMA, maupun mahasiswa calon guru fisika dengan kategori pemahaman konsep tergolong cukup untuk siswa SMP dan mahasiswa calon guru fisika. Namun, pemahaman konsep siswa SMA masih tergolong kurang. Ditemukan beberapa kesulitan yaitu kesulitan dalam memaknai rumus dan kesalahan konsep. Penelitian memberikan manfaat praktis pada konsep rangkaian listrik, khususnya tentang rendahnya penguasaan konsep siswa. Kesalahan yang sama pada tiap jenjang pendidikan menunjukkan adanya miskonsepsi yang sulit dihilangkan. Perlu upaya lebih agar siswa menguasai konsep secara mendalam.

Keywords: Conceptual Understanding; Direct Current Electric Circuit; Pre-Service Physics Teacher.

INTRODUCTION

Basic competencies in the 2013 Curriculum are agreed to be completed, analyzed, and conceptually applied. The concept of mental construction, which is incompatible with time, is universal and can be transferred across time or understanding (Wathall, 2016). Understanding the concept becomes very crucial. Therefore, understanding student's concepts is one of the earliest and most extensive studies in physics education (Docktor & Mestre, 2014).

Research on understanding concepts in electrical material is mostly needed. Electricity is the main topic in the primary level physics curriculum with abstract concepts that pose challenges in learning (Preston, 2017). Student's knowledge of procedural concepts regarding electricity material is still lacking (Yusrizal, Halim, & Junike, 2017). The students who have a good understanding of the concept of electricity will also have good thinking in solving a physics problem (Ding, Wei, & Liu, 2016). Also, the level of scientific reasoning of students is influenced by an understanding of a physics concept

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(Hidayah, Wiyanto, & Sopyan, 2017).

Several studies have been conducted in the last two decades. Engelhardt & Beichner (2004) conducted a research study with a comparison between high school and college students, then found that they had complicated identifying series and parallel relationships in diagrams. The results of Papanikolaou, Tombras, Van De Bogart, & Stetzer's (2015) research stated that students felt difficulties in understanding single-loop sub material and resistive circuit. Another finding comes from (Smith & van Kampen, 2011). They stated that students think that batteries are sources of the constant current so that they are incompatible with the concept of conservation of direct current electric circuits.

From the results of these studies, further research needs to be done on students' misconceptions. One way is to compare the ability of students at different levels of education. This comparative study is critical because it is based on Piaget's Theory. The theory stated that cognitive development depends on four factors, namely biological maturity, experience with the physical environment, experience with the social environment, and balance (Schunk, 2012). These four factors should be more mature, along with the increase in education levels. Therefore, it is expected that there are differences in the mastery of concepts among students of different levels of education.

The benefit gained when comparing physics concept understanding in junior high school (JHS), senior high school (SHS), and pre-service physics teacher (PSPT) students is that researchers can know the extent of mastery of the concepts of each education level and identify misconceptions that are still embedded in secondary school students and physics teacher candidate students from data obtained. Ideally, pre-service physics teacher students have more ability because they are more biologically mature, have longer social experiences and physical environments. Also, researchers can also find out the mindset of secondary school students (junior and senior high school) and physics teacher candidate students when solving problems in direct current electricity of circuit material. Researchers want to prove that misconceptions about material that is not fixed from the beginning will take root and interfere with the next solution.

This study aims to compare the understanding of the concept of direct current electric circuit material students at the secondary school level (junior and senior high school) and PSPT candidate students. The research also aims to describe the difficulties experienced by students and pre-service physics teacher candidates. This becomes important to be examined in order to measure the achievement of the mastery of the concept of each education level. Also, it is expected that the results of this study can be a reference for teachers and lecturers in designing better learning to improve understanding of the concept of electrical circuits for students. Also, it is also expected to be a study for researchers in the development of research on understanding the concept of electrical circuits in learning physics.

METHOD

This study was included in the survey research design with quantitative descriptive methods. The data collection of research results used purposive sampling techniques. This technique was chosen based on the research objectives. The selection of samples is following the objectives of the study and facilitates the conduct of research. The sample selection criteria are students who have studied the material in the electrical circuit according to the indicator questions to be given. The research subjects consist of 26 students of IX grade JHS in Malang, 29 students of XII IPA SHS in Tulungagung, and 25 PSPT students in one of Malang State Universities. All three samples have the same physical, social, and balanced environment, which are in the environment of educational institutions in East Java Province, which has the same curriculum. The question points are the most basic concepts and are taught from junior high school level to the university level.

The instrument of this research, including ten choice questions with ten items, was adapted from the Determining and Interpreting Resistive Electric Circuit Concepts Test (DIRECT). The item indicators are presented in Table 1.

Table 1. Item indicator

Indicator Number	Indicator Description	Question Number
1	Apply the concepts of power and energy conservation (electricity) to a direct current electrical circuit (C3)	1, 5,8

2	Interpret physical aspects of direct current electrical circuits (C3)	2, 4,7
3	Apply the concept of potential difference to direct current electric circuits (C3)	3, 9,10
4	Apply current conservation to direct current electric circuits (C3)	6

C3 is a classification of students' level of thinking ability with applying skills. The C3 category was chosen because the necessary competencies at the junior level reached the stage of applying the concept. Therefore, this C3 category should have been mastered by high school and college students.

Data analysis was performed using Kruskal-Wallis non-parametric descriptive and inferential statistics. The rating range is 0-100, so for correct answers, each question is given a weighting of 100 and 0 for incorrect answers. The categorization of students' understanding of concepts is based on the criteria of (Arikunto, 2009), as shown in Table 2.

Table 2. Category Understanding Student Concepts

Concept Mastery Score	Category
0 - 20	Very less
21 - 40	Less
41 - 60	Enough
61 - 80	Good
81 - 100	Very Good

RESULTS AND DISCUSSION

Descriptive statistics on the conceptual understanding of junior high school (JHS) students, senior high school (SHS) students and pre-service physics teacher (PSPT) students are presented in Table 3.

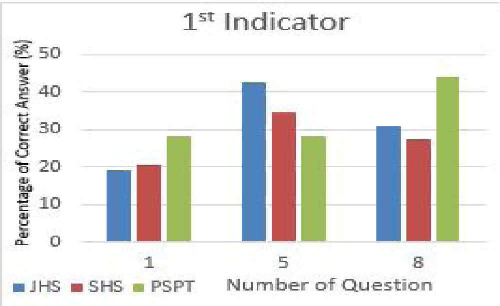
Table 3. Descriptive statistics

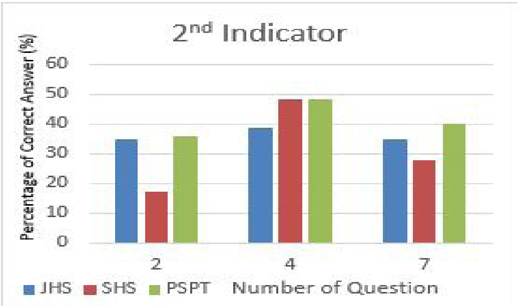
Variable	Score		
	JHS	SHS	PSPT
Total students	26	29	25
Standard Deviation	2.43	1.91	3.15
Minimum Score	0	0	0
Maximum Score	70	50	80
Mean	40.83	37.93	43.14
	Value		
Chi-Square	0.697		
Df	2		
Significance	0.706		

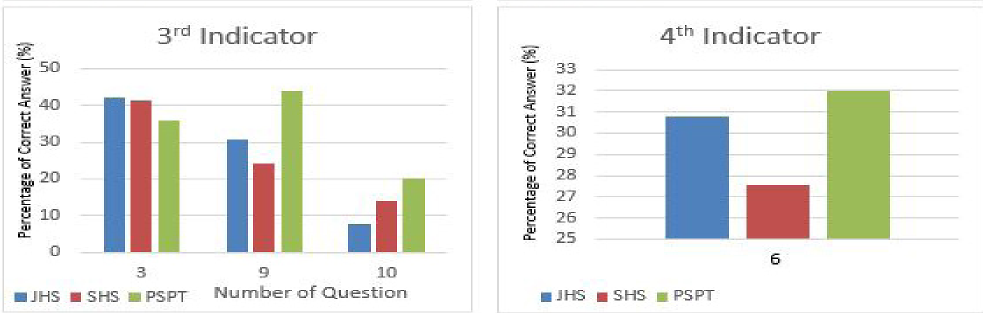
Descriptively, the average score of students at each grade of junior high school, senior high school, and college students, there is a slight difference. The highest grade pointers are on college students. Inferential statistics that are used to analyze the score of understanding the concept of direct current electric circuit students of junior high school, senior high school students, and pre-service physics teacher students are non-parametric Kruskal-Wallis. Kruskal-Wallis nonparametric statistics are used because the data analyzed are healthy and not homogeneous.

Table 3 shows the significant value of 0.706> 0.05, so it can be said that there is no significant difference from the three samples, so there is no need for further tests. It was found that understanding the concept of a direct current electric circuit did not differ among secondary schools, whether in junior high, senior high school, and pre-service physics teacher students.

From the information in Table 3, it can be categorized that the understanding of the concept of junior high school students and pre-service physics teacher-students is sufficient, with the average scores of 40.83 and 43.14, respectively. However, senior high school students are still classified in low categories because the average score only reaches 37.93.







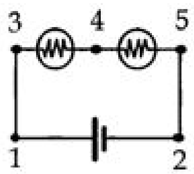
*Information :
JHS is for Junior High School
SHS is for Senior High School
PSPT is for Pre-Service Physics Teacher

Figure 1. Percentage of correct answers per indicator

In Figure 1, the correct answers of students and college students are displayed on each indicator item as follows.

The four graphs above show the percentage of correct answers for junior high school, senior high school, and pre-service physics teacher students based on the item indicators. In question numbers 1 and 10, there was an increase in correct answers at each level from junior high school, senior high school, and to the physics teacher candidate students. Also, it found a decrease in incorrect answers at each level from junior high school to senior high school and physics teacher candidates in questions number 3 and 5. There was also a decrease in incorrect answers from junior high school to senior high school, then increased from high school to physics teacher candidate students, namely on questions number 2, 6, 7, 8, and 9. In question number 4, there was an increase in incorrect answers from junior high school to high school but slightly decreased from high school to physics teacher pre-service students. The decline occurred because both high school students and college students are still often fooled on the matter of the electrical circuit. They only glance at the question without exploring questions based on the concept.

Question no. 3:
A battery is assembled with two lights which have certain internal obstacles as shown below



The sequence of potential differences from the largest to the smallest between points 1 and 2, 3 and 4, and 4 and 5 in the above circuit is .....1 dan 2; 3 dan 4; 4 dan 5
a. 1 and 2; 4 and 5; 3 and 4
b. 3 and 4; 4 and 5; 1 and 2
c. 3 and 4 = 4 and 5; 1 and 2
d. 1 and 2; 3 and 4 = 4 and 5
Reasoning :

Correct Answer: E

The above problem is item number 3 with an indicator that is applying the concept of potential differences to the electrical circuit. Students are expected to be able to apply their knowledge of the concept of potential difference to a direct current electrical circuit. Of course, to be able to apply the concept to a problem, students must understand correctly about the concept of the 1st Kirchoff Law which reads, "The total current entering through a branching in an electrical circuit is equal to the total current strength coming out of the branching point.". The Ohm's Law concept which states a simple relationship between potential difference and strong currents. The smaller the obstacle, the greater the current (Knight, 2017). The distribution of student's answers in answering correctly on item number 3 for JHS was 42.3%, SHS was 41.37%, and PSPT was 16%, as presented in Table 4.

Based on these data, it can be seen that the junior high school and pre-service physics teacher students pick D answer with the higher levels percentage than the correct answer choice E. The percentage of choice D at the junior high school level is 53.85% higher than the correct answer choice E by 42.3%. Pre-service physics teacher level who answers choice D as much as 40% higher than E choice with a percentage of 36% and the high school level the percentage of answer choices A are higher than the choice of key answers E. The percentage of choices A at the high school level is 44.83% higher than the percentage of key answer choices E that is 41.37%.

This happens because junior high school students assume that the potential difference only exists around a series of obstacles (see Figure 2). They believe that the higher the value of the obstacles, the greater the potential difference. Some college students even think that the most significant potential difference is in a circuit that is closest to the battery (see Figure 4). Inversely, high school students, they can already know that the most significant potential difference exists in a circuit with a battery. However, they still do not understand that the voltage in a circuit with resistance either closest to the battery or not has the same value (see Figure 3).

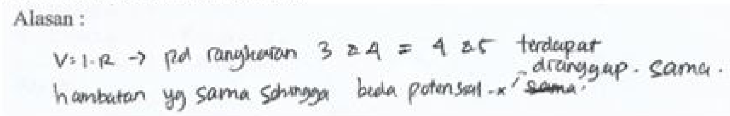
Table 4. The Distribution of Student's Answer for Item Test Number 3

Distribution of Student's Answer			
Choice	Overall Students		
	JHS	SHS	PSPT
	Percentage (%)	Percentage (%)	Percentage (%)
A	0	44.83	0
B	3.85	0	8
C	0	3.45	0
D	53.85	3.45	40
E*	42.3	41.37	36
Empty	0	6.90	16
Total	100	100	100

Note: the sign (*) is the correct answer choice

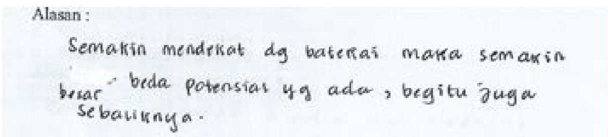
"The greater the resistance, the greater the voltage too."

Figure 2. Junior High School Student's Answer



"V=IR -> at point 3 and 4 = 4 and 5. There is the same resistance, so the potential difference is the same too."

Figure 3. High School Student's Answer

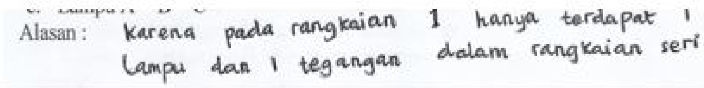


"The closer of point with the battery, the greater potential difference too."

Figure 4. Pre-Service Physics Teacher's Answer

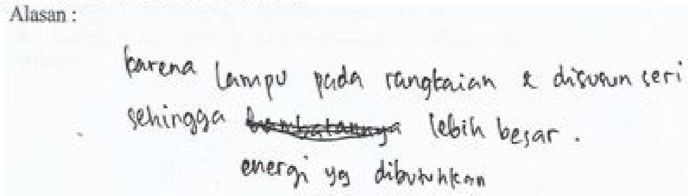
"Because the resistance is small."

Figure 5. Junior High School Student's Answer.



Because at circuit 1, only have one bulb and one voltage in a series circuit."

Figure 6. Senior High School Student's Answer.



"Because the bulb at the circuit 2 arranged series, so the energy is greater than the other."

Figure 7. Pre-Service Physics Teachers' Answer.

Figures 5, 6, 7 show the reason for the answer to question number 8 of junior high school, senior high school students, and pre-service physics teacher candidates with answer choices A. The reasons are written by using different diction but have the same meaning. They assume that energy is directly proportional to resistance. This assumption is contrary to the actual concept. If the same current passes through several obstacles arranged in series, then the formula that applies is

$$P_R = I^2R = \frac{V_R{}^2}{R}.$$

This means that more significant barriers will eliminate more power (Knight, 2017).

Based on the results of data analysis, it was found that there was no significant difference between conceptual understanding between the junior high school, senior high school, and physics teacher pre-service students. Understanding the concept of direct current electricity circuits does not differ between high schools, whether in junior high, senior high school, and tertiary institutions due to indications of misconception by students when they were still in high school and carried up to college. Based on the research by Engelhardt & Beichner (2004)revealed that female students experienced more misconceptions about direct current electric circuits. This is shown from the analysis test and percentage graph. Moreover, (Engelhardt & Beichner, 2004), there is also no significant difference between the level of secondary school and tertiary institutions. Learning that focuses on physics formulas cause student's understanding to lack depth.

From the reasons for students' answers, several difficulties are found regarding the concept of a direct current electric circuit. First, the difficulty of applying the concept of potential difference to direct current electric circuits. This can be seen from the wrong reasons in interpreting the formula

$$V = IR.$$

In this case, the students fail to understand the relationship between V and R. In addition; they also have difficulty applying the concepts of power and energy conservation (electricity) in a direct current electric circuit with the formula

$$P_R = VI = I^2R = \frac{V^2}{R}.$$

Students tend to understand formulas textually or not conceptually. Research by (Afra, Osta, & Zoubeir, 2009)also found students' failure to apply these two concepts. The next finding is that students assume that the potency will continue to decrease if it is away from the battery. It appears that students assume wrong because they failed to apply the principle of the voltage value in the series circuit. According to Preston's research (2017), it is found that the differences in student's understanding of electrical circuits influenced by prior knowledge, meta conceptual awareness, and diagram conventions, including the style diagram features used.

CONCLUSION

This study concludes that the understanding of the concept of direct current electric circuits in secondary school students (junior and senior high school) and pre-service physics teacher students do not differ significantly. Lack of understanding of students who only focus on physics formulas is one of the causes. The results of the study also found some difficulties experienced by students on the concept of direct current electric circuits, namely: first, the difficulty in interpreting the formula, in this case students fail to understand the relationship between V and R. Junior high school students and physics teacher candidates students assume that V is proportional to R. The second mistake is in understanding the concept of flow. High school students assume that the amount of current (I) is proportional to the position of the battery (V), so the further the position of the battery from the lamp, the higher the current generated. The third difficulty is in applying the concepts of power and energy conservation (electricity) in a direct current electrical circuit. Junior high school, senior high school students, and pre-service physics teacher students think that energy is proportional to obstacles. These difficulties are found that not only experienced by high school students (junior and senior high schools), but also by pre-service physics teacher students who have previously taken secondary education (junior and senior high school). If it is allowed to someday, it can potentially cause misconceptions about direct current electric material, such as misconceptions about the relationship of obstacles and electric current as well as about power in the electrical circuit.

Based on the results of research and discussion, researchers suggest that teachers and lecturers of physics design learning that invites students and pre-service physics teacher students to interpret the concept of direct current electric circuits as a whole and in-depth. Researchers recommend to teachers and lecturers to be able to map students' mistakes on direct current electric circuit material. This becomes very important because it will help students to find out their mistakes. It is also expected that the teacher can improve physics learning and not make an assessment at the end of the course in order to prevent student difficulties. Researchers are expected to examine further why there are no significant differences between different levels of education.

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