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Exploration of Conceptual Understanding of Science Teachers and Students: Gap Conception of Current, Voltage in Indonesia

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Abstract

This study aimed to analyze the gap between the concepts of current and voltage between junior high school students and teachers in Indonesia. The number of samples was 720 students, class X, and 527 teachers who were selected by purposive sampling diagnostic test current, mains voltage, 30 question items valid and reliable. The results show that even with a simple circuit (one or two lamps and a battery), there are still gaps in the conception of current and voltage; if the circuit is more complicated, There will be many gaps in conception, namely: (1) consumption model, (2) local reasoning, (3) voltage source is seen as a constant current source rather than a fixed voltage source, (4) voltage difference, (5) series and parallel terms, (6) source electrons, (7) power consumption, (8) guess the answer choices, (9) the explanation does not match the correct choice.

Keywords: electrical current, voltage, local reasoning, consumption model, technical vocational education and training

INTRODUCTION

In the era of the industrial revolution 4.0 of the 21st century, understanding current and voltage is very important for students and teachers to master electrical energy sources that are developing very quickly. Shiva, teachers, and physicists interpret physics concepts in an idioasyncranic way. For example, the concept of atoms in a physicist's head differs only slightly from one another, but the image of an atom in a student's, teacher's head can be very different from one another. Atom is one of the physics concepts agreed upon by many physicists. The atomic concept is a person's interpretation of the atomic concept, how the person imagines the atom. So the concept is a general sense, while the concept can be different for each person. If a person's conception deviates a lot from what is meant by scientists, then a conception gap occurs (Turgut 2011; Kuczmann 2017; Nugraha et al. 2018).

In the learning process, the ideal conditions for understanding high school students regarding current and voltage should be understood correctly, but in fact, it was found that almost 90 percent of high school students gave wrong answers, for example asking class X students what is the difference between current and and voltage? Students answer: current flows from positive to negative pole, while voltage flows from negative to positive pole. This answer illustrates that there is a serious problem gap. This problem has been previously investigated which reported that applying the direct learning model can reduce the gap in understanding of high school students related to current and voltage, the difference with this research is to analyze how this problem occurs in junior high school, so that there is a gap in understanding current and voltage in Senior High School.

The novelties in this study include the contents of current and voltage tests accompanied by pictures of electrical circuits so that students in answering questions focus on the problems that must be solved, Give a written reason why you chose that answer. After you have answered each question and the reasons, you are also asked to put a Certainty of Response Index (CRI).

Every student, teacher and scientist of physics interprets physics concepts in their own way. Of course, the images of the concepts of current and voltage in the heads of physicists differ only slightly from one another, but the images of currents and voltages in the heads of students and teachers can differ greatly from one another. For example, electric voltage, according to physicists, is the potential difference between two points. Students think that current flows from negative to positive pole, while the teacher thinks that current is the source.

Several research results have found that often errors are not due to mathematical errors alone, but often there is a clear and consistent pattern of student error answers, hence the term "conception gap" (Yolanda 2017; Suprapto 2020; Popat 2021; Ahmad et al. 2021; Adhim et al. 2021; Ma'rufah et al. 2022). For example, Osborne (2006); Shipstone (2007), interviewed elementary school students in the United States who had never received a lesson in electricity. It turns out that they can have a conception gap regarding current, electric voltage. There are four models regarding current, voltage, i.e: current from only one pole that can light a lamp, calccing currents, consumption model, science model. Kapartzianis & Jeanne 2014; Hidayati et al. 2014; Arfiyanti et al. (2015); Sukarsa et al. 2015; McRorie & McKeown 2017; Villanueva et al. 2021, found that there was a gap in the conception of physics in high school students.

According to a report by Firmansyah & Wulandari 2016; Yolanda 2017; Afriyenni 2020; Fokides & Papoutsi 2020; Busyairi et al. 2021; Ahmad et al. 2021 states that one way to overcome the conception gap is to carry out remediation, in this regard many researchers suggest that students who experience conception gaps need to be remedied. According to Zulvita 2017; Suprapto 2020 that the conceptual gap regarding direct electric current is second only to that of mechanics

Conception of students and teachers is always different from the conception of physicists. Conceptions of physicists will generally be more sophisticated, more complex, more complicated, involving more relationships between concepts than the conceptions of students and teachers. If the conceptions of students and teachers are the same as the simplified conceptions of physicists, the conceptions of students and teachers cannot be said to be wrong. But if the conceptions of students and teachers conflict with the conceptions of physicists, we use the term "Conceptual Gap". Usually, the conception gap involves students' and teachers' mistakes in understanding the relationship between concepts. For example, errors in the relationship between current and voltage, between series and parallel circuits (Setyani et al. 2017; Widodo et al. 2018; Stolzenberger et al. 2022; Ramli et al. 2022).

Various sources of gap concption are derived from students' experiences in everyday life, common misunderstandings across different cultures and populations,instructional practices, textbooks and over-reliance on colloquial language should be considered as potential source of misunderstanding (Atasoy 2013; Urban 2017; Halim & Musdar 2020; Zainuddin, Mujakir, Ibrahim et al. 2020). Conception gap (Maison at al. 2020; Taqwa et al. 2020; Rico & Zonalia 2021; Rohmawatiningsih et al. 2021; Mengistu et al. 2022; Korganci et al. 2015; Rahmawati et al. 2018; Nugraha et al. 2018; Yolanda 2020; Luthfi et al. 2021).

METHODS

The Research Method

This research is a survey in nature with steps, i.e: 1) explaining the purpose of the survey to student respondents and natural science teachers at junior high schools in Indonesia, 2) conveying procedures for working on test questions, 3) distributing test questions to respondents, 4) collecting and check the test results and check.

Participants

The total sample size is 720 junior high school students and 527 natural science teachers in junior high schools in Indonesia. Each student consists of 175 from Bali, 150 from Java, 120 from Sulawesi, 170 from Sumatra, and 100 from Kalimantan. Furthermore, the teachers consisted of 157 from Bali, 100 from Java, 100 from Sumatra, 50 from Kalimantan. The indicators measured in this study consist of: consumption models, local reasoning, voltage sources seen as constant current sources, current not voltage reasoning, charge density reasoning, and series and parallel circuits.

The characteristics of the criteria for respondents have an average level of intelligence, age ranges from 15-16 years, class X , male and female gender, rural place of residence, and social heterogeneity and average economic status of employees.

Data Collection Tools

The data was collected using the current,voltage dianostic (CVD) test of 30 items a score 1 if it was true and 0 if it was wrong and Certainty of Response Index (CRI): 0 (If you answer the question by guessing 100%), 1 (If you answer the question by guessing between 75% - 99 %), 2 (If you answer the question by guessing between 50%-74%), 3 (If you answer the question by guessing between 25%-49%), 4 (If you answer the question by guessing between 1% - 24%) or 5 (If you answered the question without guessing at all (100% correct). Analysis of the coefficient of internal consistency of the test using Gregory analysis and student and teacher SPS data analysis using descriptive and inferential analysis with SPSS 21.

Validation and Reliability of Research Instruments

The CVD test was validated by 3 science education experts. Validation analysis using Gregory analysis (Arliniet al. 2017) as shown in TABLE 1. To calculate the value of the coefficient of internal consistency (internal validation) using equation (1), and to determine the category in Table The validation results show that the CVD test, internal validation value greater than 75 is included in the high category, this is eligible for use in research.

TABLE 1. Gregory's validation analysis tabulation

	Expert Assessment	
	(1 or 2) score	**(3 or 4) score**
weak relevance expert assessment (item is worth 1 or 2)	A	B
strong relevance expert assessment (item is worth 1 or 2)	C	D

$$\text{Internal Consistency Coefficient (Internal validation)} = \frac{D}{A + B + C + D} \quad (1)$$

Remarks:
A = Both experts give weak relevance
B = The first expert gives strong relevance
The second expert gives weak relevance
C = The first expert gives weak relevance
The second expert gives strong relevance
D = Both experts give strong relevance

TABLE 2. Content validation category (Arlini et al. 2017)

Interval	**Category**
> 0.8	high
0.4-0.8	medium
< 0.4	low

Analysis of the reliability of the CVD diagnostic test to calculate the level of percentages of agreements between the two raters stating "yes" or "no" used formula (2) (Grinnell, as citied in Fuadi et al. 2015). The results of the reliability analysis are 95 percent, which is greater than the lower limit of the reliability coefficient of .75, meaning that all research instruments are reliable.

$$\text{Percentage of Agrrement} = \frac{\text{Agreement}}{\text{Disagreement} - \text{Agreement}} \text{x}100\% \qquad (2)$$

Data Analysis

The research data was obtained through the provision of diagnostic tests to students and teachers at Junior high school who were members of the Subject Teacher Conference in every province in Indonesia. Research data were analyzed descriptively using SPSS 21.

RESULTS AND DISCUSSION

Results

The presentation of the data is sorted according to several types of conceptual gaps that are often found, namely: consumption models, local reasoning, voltage sources are seen as constant current sources, current rather than voltage reasoning, charge density reasoning as current carriers, and understanding of series and parallel circuits. According to the consumption or attenuation model, the electric current in the series circuit decreases in each resistor or lamp. So some of the current is absorbed in each component of the circuit so that according to students and teachers the current near the positive pole is greater than the near negative current from the power source. It turned out that with simple questions, students and teachers did not apply the consumption model. For example, in a series of 2 or 3 lamps in series they predict that the brightness of the lamp and the current through it are the same, but if the problem is made a little more complicated, the misconception of “consumption” still arises. The Distribution of Student (I) and Teacher (II) Answers is in TABLE 3.

Problems 1-3 (in appendix), conceptual gaps on the effect of resistance on current in electric circuits. All prisoners represented by the sign are of equal size. Each question consists of 3 series. In which circuit will the light shine brightest? If any of the components are changed in a series circuit, then the whole circuit is affected. When the resistance of a resistor is changed, the current in the entire circuit changes in magnitude. But students and teachers assume that the changed component only affects the flow in the following components and not the previous one. They seem to be analogizing a series to a river; the main effect of the embankment occurs in the downstream flow. In the theory of reasoning of students and teachers like this is called local reasoning, namely the effect of changing the series is only "local" or sequential reasoning, namely the components that are located before the change are not subject to change. In question 1, the CRI score: 2.70% of students; 60% of teachers; problem, 2, CRI: 3.95% of students; 85 % of teachers, and 3 questions, CRI scores: 1.90 % of students; 75% of teachers give guess answers, woud townon (Horowitz & Hill 2015; Crowell 2020).

Problems 4-8 (in appendix), the gap in the concept of local reasoning, many students and teachers apply the electric current consumption model: 213 (or 29.62%) students and 53 10 %) teachers assume that the current in L1 is greater than the current in the lamp L2. Problem 4, CRI scores: 1.85% of students; 75% of teachers give guess answers. Problem, 5 most students and teachers think that the current in lamp L1 is not affected by the change in resistor, but only the current through lamp L2. Question 5, CRI score: 2.80 % of students; 70% of teachers give guess answers. Problem, 7-8 are very consistent with questions 5-6, and the percentage of students and teachers who use local reasoning is high. The gap in the conception of students and teachers, i.e.: a voltage source produces a constant electric current rather than producing a constant potential difference (if the source is ideal).

TABLE 3. Distribution of Student (I) and Teacher (II) Answers in Percentage

Answer Option	**A**		**B**		**C**		**D**		**Proportion of correct answers (%)**		**Coorect option is**
Problem	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	
Consumption Model											
1	11.11	30	48.14	10	9.25	20	27.77	40	22.77	40	D
2	35.18	10	22.22	40	31.48	40	11.11	10	31.48	40	C
3	12.96	20	37.03	40	31.48	10	18.52	30	37.03	40	B
Local Reasoning											
4	29.62	10	7.40	20	61.11	70	0	0	61.11	70	C
5	37.03	10	33.33	60	32.48	30	0	0	33.33	60	B
6	29.62	0	50.00	70	22.22	30	0	0	50.00	70	B
7	37.03	70	31.48	10	31.48	20	0	0	37.03	70	A
8	29.62	50	38.88	10	29.62	40	0	0	29.62	50	A
The voltage source is seen as a constant current source											
9	42.59	80	33.33	0	22.22	20	0	0	22.22	20	C
10	42.59	80	33.33	0	24.07	20	0	0	24.07	20	C
11	38.88	60	33.33	10	27.77	30	0	0	27.77	30	C
12	27.77	50	37.03	20	33.33	30	0	0	37.03	20	B
13	25.92	10	57.40	70	5.55	10	11.11	10	25.92	10	A
14	24.07	50	57.40	30	7.40	20	11.11	0	24.07	50	A
15	29.62	40	37.03	30	22.22	0	11.11	30	29.62	40	A
16	31.48	60	12.69	0	16.66	10	38.88	30	31.48	60	A
17	37.03	80	40.74	20	11.11	0	11.11	0	37.03	80	A
Current rather than voltage reasoning											
18	53.70	40	11.11	10	37.25	50	0	0	37.25	50	C
19	75.92	30	9.25	0	1.85	0	12.96	70	12.96	70	D
20	11.11	10	27.77	0	31.37	40	31.48	50	31.48	50	D
21	50.00	20	18.51	50	31.48	30	0	0	50.00	20	A
22	29.62	30	37.03	50	9.25	10	22.22	10	22.22	10	D
23	44.44	20	18.51	10	16.66	20	20.37	50	18.51	10	B
24	11.11	0	31.48	0	25.92	40	31.48	60	31.48	0	B
Charge density reasoning as a current carrier											
25	51.85	80	18.51	0	24.07	10	3.70	10	18.51	0	B
26	12.96	10	16.66	60	14.81	10	55.55	20	16.66	60	B
Understanding of electric power											
27	33.33	20	37.03	30	13.72	50	14.81	0	33.33	20	A
28	12.96	30	25.92	20	14.81	0	44.44	50	12.96	30	A
Understanding series and parallel circuits											
29	40.74	0	16.66	10	22.22	30	18.51	60	18.51	60	D
30	31.48	30	27.77	10	16.66	30	24.07	30	31.48	30	A

Problem, 9-12 (in appendix), the gap in the conception of a voltage source is seen as a constant current source, more than 50% of the sample answered that the brightness of the lamp and the electric current will increase when source II is connected. Students and teachers argue that the current is approximately doubled rather than increased if the source is not ideal. There were 60% of students and 75% of teachers could not give reasons for the selected answers. Problem, 12 most students and teachers answered that the current through source I did not change, the answer reaffirmed that students and teachers view a voltage source as a current source. In addition to these problems, gaps also occur with the same circuit except for the location of the battery II and the lights are swapped. CRI score: 1.85 % of students; 80% of teachers give guess answers.

The gap in the conception of potential difference and at the same time shows errors that can occur if students and teachers only look at the current without a cause (potential difference). Problem, 13-15 (in appendix), only 28.60% of students; 36.67% of teachers who gave the correct answer, most of the samples answered that the brightness of the lamp and the electric current would increase when source II was connected. Students and teachers found the flow to be approximately doubled (rather than adding a little if the source was not ideal), and 70% of students and 55% of teachers were unable to give reasons for the chosen answers. In problem, 15 most students and teachers answered that the current through source I did not change, the answer reiterated that students and teachers viewed the voltage source as a current source. Conception gap also occurs with the same circuit except the location of the battery II and the lights are swapped. CRI scores: 1.40% of students; 30% of teachers with guessed answers.A four-tier diagnostic test can identify lesson (Negoro & Kartina 2019).

Problem, 14-17 (in appendix), only 29.13% of students and 30% of teachers gave correct answers, i.e: if I_2 is removed, the total resistance increases, the total current decreases, because of the potential difference, the current in the lamp L_1 increases. Most students and teachers answered that L_1 became brighter but with the wrong reason, namely the current that had passed through L_2 would pass through L_1. Students and teachers think that the potential difference between X and Y becomes zero after the lamp is removed. There were 75% of students and 65% of teachers, unable to give reasons for the selected answers. Problem, 19 most students and teachers answered that the current through source I did not change, the answer emphasized again that students and teachers viewed the voltage source as a current source. Conception gap also occurs with the same circuit except the location of the battery II and the lights are swapped. The results are very consistent with the results of problem 16-19. CRI scores: 1,65% students; 75% of teachers give guess answers.

Problem, 18-24 (in appendix), the gap in the concept of current-than-voltage reasoning, only 17.59% of students and 30% of teachers gave the correct answer, most of the samples answered that the electrons came from the lamp rather than from the battery. Students and teachers argue that when the switch is closed, current arises due to electrons moving from the positive pole to the negative pole. There were 80% of students and 70% of teachers could not give reasons for the selected answers. Problem, 18, most students and teachers answered that the current through source I did not change, the answer reaffirmed that students and teachers view a voltage source as a current source. In addition to these problems, the conceptual gap with the circuit is the same except for the location of the battery II and the lights are swapped. Problem 24, only 31.48% of students and 0% of teachers, problem, 25 (in appendix) only, 18.51 students; 0% of teachers, problem, 26 (in appendix), only 16.66% of students, 10% of teachers mostly in the sample answered that the electric current does not change when the switch is closed. Students and teachers think that the voltage on the lamps is different, 75% of students and 80% of teachers cannot give reasons for the chosen answers. The gap in the concept of current reasoning rather than voltage of students and teachers is consistent. CRI score: 2,65% students; teachers 75%. Students and teachers give guess answers. The results are very consistent with the results of problem 18-24. CRI scores: 1.65% students; 75% of teachers give guess answers. Electrical I = charge/t, when t (Horowitz & Hill 2015; Crowell 2020).

Problem, 25-26 (in appendix), gaps in the concept of charge density reasoning as current carriers, problem 25, 18.51% of students and 0% of teachers who gave the correct answer, and problem, 26; 66.66% of students; 60% of teachers, most of the samples answered that the voltage A is the same as the voltage B when the electric current flows. Students and teachers think that the voltage on the lamps is different, 85% of students and 80% of teachers cannot give reasons for the chosen answers. The conception gap also contains several other problems with the same circuit except the switch and lamp positions are swapped. The results are very consistent with the results of problem, 25-26. CRI scores: 1.75 % of students; 85% of teachers give guess answers. Colloqually two types of charge, i.e: positive, negative.

Problem, 27-28 (in appendix), the gap in the concept of understanding electric power that gives the correct answer, problem, 27; 33.33% of students and 20% of teachers who answered correctly and problem, 28; 12.96% of students; 30% teachers. Most of the samples answered that the electric power changed when the lamp was on. There were 75% of students and 80% of teachers could not give reasons for the selected answers. The gap in the concept of electrical reasoning of students and teachers is consistent. CRI score: 2.75% students; teacher 80%. Students and teachers give guess answers.

Problem, 29-30 (in appendix), the conceptual gap in understanding series and parallel circuits, give the correct answer, problem, 29, which is 10.51% of students and 60% of teachers, question 30, only 31.48% of students; 30% teachers. Most of the samples answered that the parallel circuit surrogate resistance is smaller. Students and teachers argue that the lamp voltages in parallel circuits are different. There are 75% of students and 80% of teachers cannot give reasons for the chosen answers. The gap in the concept of current reasoning rather than voltage of students and teachers is consistent. CRI score: 2.65% students; 75% teachers. Difference in students' understanding of simple DC circuits, in Indonesia (Marcelina & Hartanto 2021). Conception gap of current, voltage indicators, in FIGURE 1.

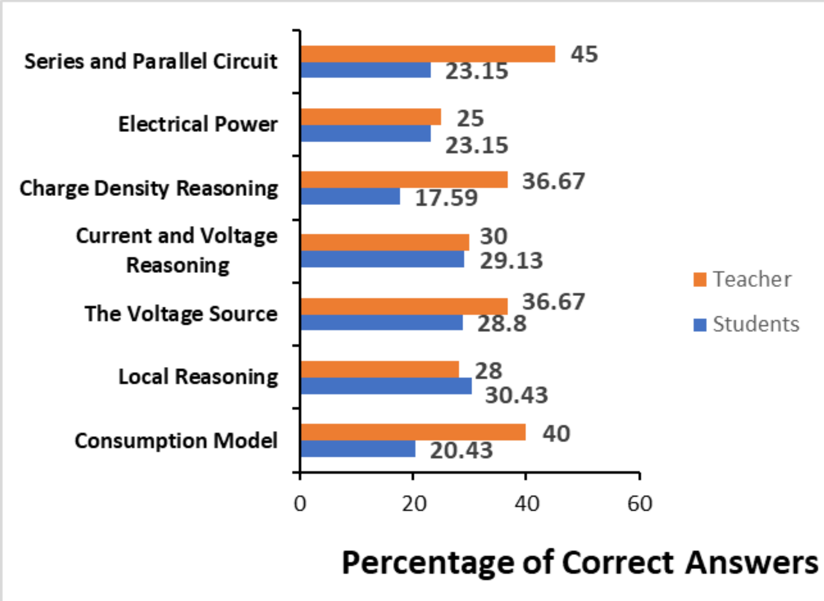

FIGURE 1. Percentage of Correct Answers

Gap consumption model, 20.43% of students, 40% of teachers, the difference in the gap is 19.67%, quite large; local reasoning, 30.43% students, 28% teachers, the difference is 2.43%, the gap is small, the voltage source, 28.8% students, 36.67%, the difference is 7.87%. Current and voltage reasoning, 29.13% students, 30% teachers, the difference is 0.87% very small gap; charge density reasoning, 17.59% students, 36.67% teachers, the difference is 19.08 quite large, electrical power, 23.15% students, 25% teachers, the difference is 1.85% small gap, series and parallel circuit, 23.15% students, 45% teachers, the difference is 21.85% big gap. It was found that several current and voltage indicators had a large conception gap, Junior High School students and teachers in Indonesia. This finding indicates that understanding the concepts of electric current and voltage really needs to be considered in the science learning process at Junior High School, so that students can overcome electrical problems. A tenthgrade high school student in Turkey, there is also a conceptual gap regarding the electric force between two objects independent of the relative permittivity of the medium between them' (Onder-Celikkanli & Tan 2022).

Discusion

The conception gap occurs when there is a problem with the effect of resistance on the current in electrical circuits. All prisoners are depicted with the same sign. Students and teachers argue that if one component is changed in a series circuit, then the whole circuit is affected. When the resistance of a resistor is changed, the current in the entire circuit changes in magnitude. Students and teachers assume that the changed component only affects the flow in the following components and not the previous one. They seem to be analogizing a series with the flow of a river. In the theory of reasoning of students and teachers like this is called local reasoning, namely the effect of changing the series is only "local" or sequential reasoning, namely the components that are located before the change are not subject to change. The average value of the Certainty of Response Index is 70%, the answer choices are guessing. There is a career skills gap in the electricity industry, conception of innovation of the electric, (Zhang & Huang 2012; Rodzalan et al. 2022).

The gap in the concept of local reasoning also still occurs, students and teachers apply the electric current consumption model. They still assume that the current in the first lamp is greater than the current in the second lamp in a circuit. Most students and teachers think that the current in the first lamp is not affected by the change in the resistor, but only the current through the second lamp. The percentage of students and teachers who use local reasoning is high. The gap in the conception of students and teachers, i.e.: a voltage source produces a constant electric current rather than producing a constant potential difference (if the source is ideal). High school students still experience a gap in the conception of simple electrical circuits from scientific conceptions (Wardiyah et al. 2019; Barniol & Zavala 2014).

The gap in the conception of a voltage source is seen as a constant current source, in general students, teachers answer that the brightness of the lamp and the electric current will increase when the voltage source is connected. Students and teachers argue that the current is about twice that of the non-ideal source. Most of the teachers did not give reasons for the selected answers. This indicates that the teacher is less able to reason. Likewise, it was found that most students and teachers answered that the current through the power source did not change, the answer emphasized again that students and teachers viewed the voltage source as a current source. Conception gaps also occur in the same circuit except where the batteries and lights are swapped.

The conceptual gap regarding potential difference and at the same time shows errors that can occur if students and teachers only look at currents without a cause (potential difference). According to students and teachers: the brightness of the lamp and the electric current will increase when the voltage source is connected. Students and teachers argue that the current is approximately doubled (rather than a little more if the source is not ideal). Students and teachers view voltage sources as current sources. Conception gap also occurs with the same circuit except the location of the battery and lights are swapped. The percentage of students who cannot give reasons for the selected answers is greater. The average value of the Certainty of Response Index is 50%, the answer is a guess. Handhika et al. 2016, found that there was a conceptual gap in Newton's law. This means that in other lessons there is also a conceptual gap.

The student who gave the correct answer is greater, i.e: if the current I2 is removed, then the total resistance increases, the total current decreases, because of the potential difference, the current in the lamp L1 increases. Most students and teachers answered that L1 became brighter but with the wrong reason, namely the current that had passed through L2 would pass through L1. Students and teachers think that the potential difference between X and Y becomes zero after the lamp is removed. Most students could not give reasons for the selected answers. Conception gap occurs in the problem of current through a voltage source I does not change, the answer confirms again that students and teachers view the voltage source as a current source. This also happens with the same circuit except the location of the battery II and the lights are swapped. This conceptual gap is very consistent. The average value of Certainty of Response Index is 65%, guess answers.

The gap in the conception of current rather than voltage reasoning, students and teachers answered that the electrons came from the lamp rather than from the battery. They argue that when the switch is closed, the current arises due to electrons moving from the positive pole to the negative pole. More percentage of students were unable to give reasons for the selected answers. They consider the current through the voltage source unchanged, the answer confirms again that they view the voltage source as a current source. Conception gaps also occur when the circuit is the same except for the location of the two batteries and the lights are swapped. They assumed that the electric current did not change when the switch was closed, and that the voltage across the lamps was different. The gap in the concept of current reasoning rather than voltage is consistent. A larger percentage of teachers could not give reasons for the selected answers. The average value of Certainty of Response Index is 55%, guess answers.

The gap in the concept of reasoning of charge density as a current carrier, only 18.51% of students, 0% of teachers who gave the correct answer, They assume that voltage A is the same as voltage B on electric current flowing, the voltage on the lamp is different. Conception gaps also occur with the same circuit except the switch and lamp locations are swapped. This conceptual gap is very consistent. A larger percentage of teachers could not give reasons for the selected answers. The average value of the Certainty of Response Index is 70%, the answer is a guess.

Gap in understanding the concept of electric power 33.33% of students, 20% of teachers. They assume the electric power changes when the light is on. The gap in the conception of electrical power reasoning is consistent. A larger percentage of teachers could not give reasons for the selected answers. Average value The average value Certainty of Response Index 70%, guess answers.

Gap in the conception of understanding series and parallel circuits, 10.51% of students and 60% of teachers. They consider the resistance of the parallel circuit to be smaller, the lamp voltage in the parallel circuit to be different. The gap in the concept of current reasoning rather than voltage is consistent. A larger percentage of teachers could not give reasons for the selected answers. The average value of Certainty of Response Index is 65%, guess answers. Students still have difficulty understanding electric lines of force and electric fields in a circuit (Garza & Zavala 2013; Leniz et al. 2017; Setyani 2017; Suciatmoko et al. 2018).

Conception gap of each indicator, i.e: (1) consumption model is quite large, namely 19.67%, (2) local reasoning, 2.43%, the gap is small, (3) the voltage source, around 7.87%, quite small , (4) current and voltage reasoning, 0.87% very small, (5) charge density reasoning, 19.08 quite large, (6) electrical power, 1.85% quite small, (7) series and parallel circuit, 21.85% is huge. Several current and voltage indicators show a large conception gap, Junior High School students and teachers in Indonesia. Understanding the concept of electric current and voltage really needs to be considered in the science learning process at Junior High School, so that students can overcome electrical problems.

The strength of this research is in the problems solved by students, and the limited number of samples still needs to be expanded to grades VIII, IX and X in various types of formal and non-formal schools.

CONCLUSION

Conception gaps found in other countries can also be found in Indonesia, among junior high school students and natural science teachers. If the conceptual gaps outside and inside the country are the same, then these conceptual gaps can be said to arise in the interaction between the human brain and nature, without (or almost without) cultural influences. This is an interesting conclusion that contradicts the opinions of many psychologists who, among other things, are looking for cultural causes of the lack of success of science education in Indonesia. This conclusion is also confirmed by physicists, for example there are many gaps in the conception of mechanics, heat, optics and geometry of physics, atoms, molecules that are common today. Several conceptual gaps were found in this study, namely: (1) consumption model, (2) local reasoning, the gap is small, (3) voltage source, around 7.87%, sufficient, (4) current and voltage reasoning, (5) charge density reasoning, (6) electric power, (7) series and parallel circuits. The implication of the findings of this study is that junior high school graduates in Indonesia will have difficulty understanding natural science subject matter, especially electric current and voltage in high schools, as a result their learning outcomes are low and it is difficult to solve problems in everyday life.

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Appendix

CURRENT AND VOLTAGE DIANOSTIC (CVD) TEST

Instruction:

a. The scope of the question is physics on the topic of electric current and voltage. These questions are intended to determine the extent of your understanding of these concepts, whether you already have an understanding of the concepts in accordance with the understanding of concepts by physicists.
b. Answer all the questions below directly on the question.
c. Choose one of the answers a, b, c, or d that you think is most correct by putting a cross (X) or red color on the available answers.
d. Give a written reason why you chose that answer.
e. After you have answered each question and the reasons, you are also asked to put a Certainty of Response Index (CRI) number: 0, 1, 2, 3, 4 or 5 in the CRI box provided with the following conditions:

CRI	Information
0	If you answer the question by guessing 100%
1	If you answer the question by guessing between 75% - 99%
2	If you answer the question by guessing between 50% - 74%
3	If you answer the question by guessing between 25% - 49%
4	If you answer the question by guessing between 1% - 24%
5	If you answer the question by not guessing at all (100% benar)

Example:

An atom is made up of particles. . .

a. hydrogen, deutron and triton
X b. protons, neutrons and electrons
c. protons, neutrinos and photons
d. alpha, beta and gamma

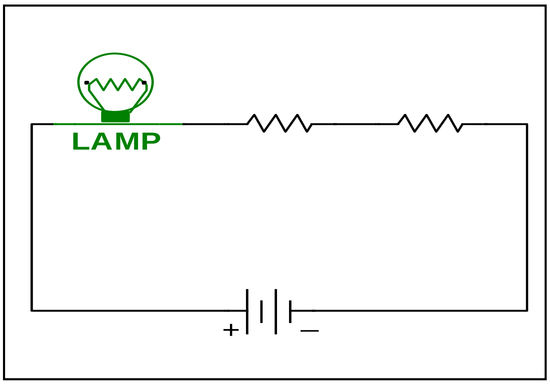
Reason: In atomic theory it is said that the basic particles that make up an atom are protons, neutrons, and electrons.

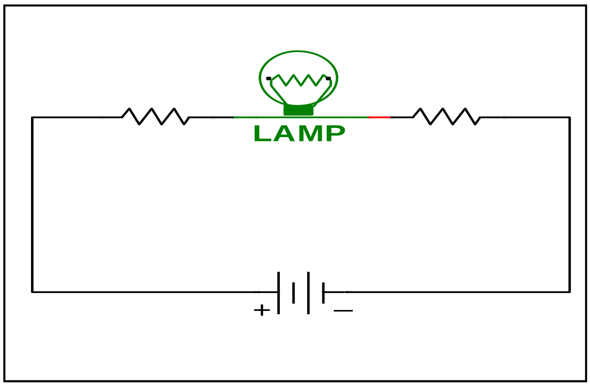
C R I: 5

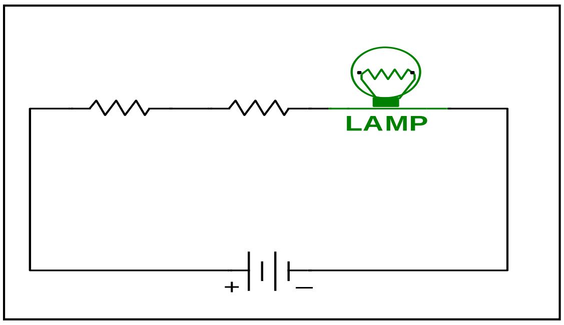
The following problem concerns the effect of resistance on current in the described electrical circuits. All prisoners represented by the sign are of equal size. Each question consists of 3 series. In which circuit will the light shine brightest?

Problem, 1-3

1.







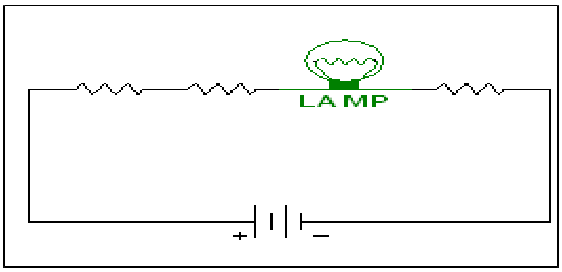
C

D. The lights will be equally bright in all circuits

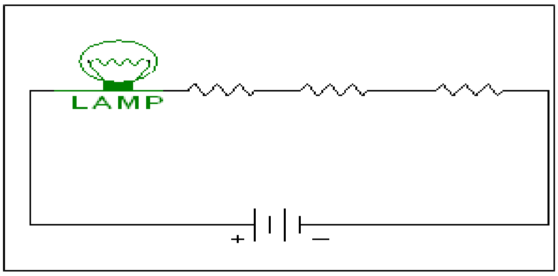
Reason:

CRI :

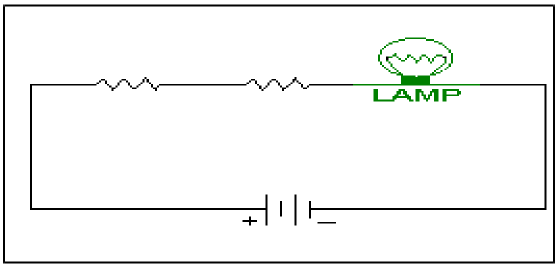
2.



A



B



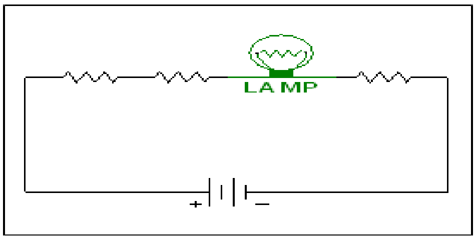
C

D. The lights will be equally bright in all circuits

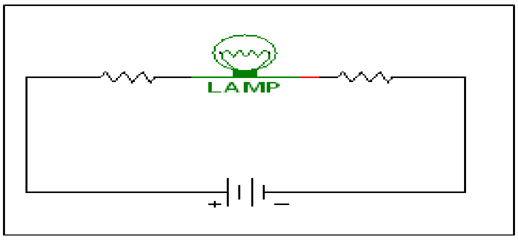
Reason:

CRI :

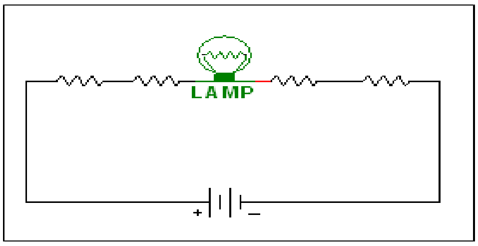
3.



A



B



C

D. The lights will be equally bright in all circuits

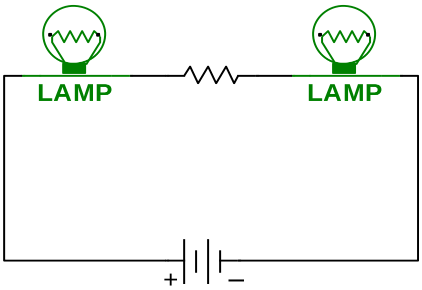
D

Reason:

CRI :

Problem, 4-8

In the following circuit there are 2 batteries, 2 lamps which are identical, and the resistance current of which magnitude can be changeable



. 4. Electric current leawt Lamp L_1

A. is greater than the current through the lamp L_2
B. is less than the current through the lamp L_2
C. is equal to the current through the lamp L_2

Reason: …

CRI:

5. If the resistance R decreases, then the current through the lamp L_1

A. decreases B. increases C. does not change

Reason: …… CRI:

6. If the resistance R decreases, then the current through the lamp L_2

A. decreases B. increases C. does not change

Reason: …… CRI:

7. If the resistance R increases, then the current through the lamp L_1

A. decreases B. increases C. does not change

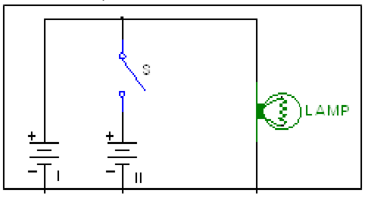
Reason: … CRI:

8. If the resistance R increases, then the current through the lamp L_2

A. decreases B. increases C. does not change

Reason: … CRI:

Problem, 9-12



The following question concerns addition voltage source (battery) in the circuit electricity. L lamp arranged with source voltage I, voltage source II arranged in parallel as shown in the figure below. Second source is the same and ideal, meaning that the voltage remains regardless of the electric current

9. Initially switch S is open as shown in the figure. If switch S is closed, then the brightness of L will be
   A. decreases B. increases C. does not change
   Reason: … CRI

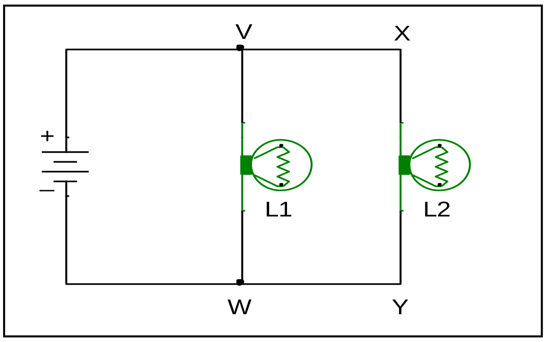
10. If switch S is closed, then the electric current in the lamp will be:
    A. decreases B. increases C. does not change
    Reason: …… CRI:

11. If switch S is closed, the potential difference between the lamps will be:
    A. decreases B. increases C. does not change
    Reason: …… CRI:

12. If switch S is closed, then the electric current flowing through the voltage source I will be:
    A. decreases B. increases C. does not change
    Reason: …… CRI:

Problem, 13-15

The following question concerns the effect of being revoked one of the two lamps arranged in parallel as shown below. The ideal voltage source (battery) is connected with the same two lamps L_1 and L_2. at first both lights are on. One of the lamps, namely L_2 taken from the place. What happened?



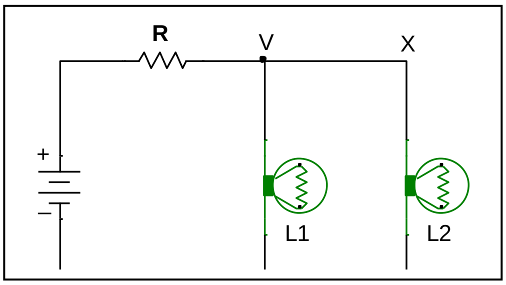
13. If lamp L_2 is removed, the electric current in lamp L_1 will be:
    A. decreases B. increases C. does not change
    Reason: …… CRI:

14. If the lamp L2 is removed then the potential difference between X and Y will be:
    A. becomes 0 B. decreases C. increases D. does not change
    Reason: …… CRI:

15. If the lamp L2 is removed then the potential difference between V and W will be:
    A. becomes 0 B. decreases C. increases D. does not change
    Reason: …… CRI

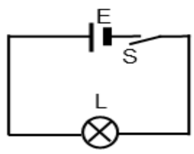
Problem, 16-19

The following question concerns the effect of issuingone of two lamps arranged in a rowparallel in a closed circuit which also containsresistance R and an ideal voltage source (voltageremains no matter how large the electric current). The two lights light up.
One of the lamps, namely L_2 , is then taken from the place. What happen?



16. If lamp L2 is removed from its place, the electric current through lamp L_1 will be:
    A. decreases B. increases C. does not change
    CRI: ☐
17. The reason for the answer I gave is…
    A. the current that passed through L_2 will now be added to the current that passed through L_1
    B. in a parallel circuit the presence or absence of current in the XY branch does not affect the current in the VW . branch
    C. the voltage difference between V and W decreases
    D. the total current decreases so the voltage difference VW increases
    CRI : ☐
18. If lamp L_2 is removed from its place, the potential difference XY will be:
    A. becomes 0 B. decreases C. increases D. does not change
    Reason: …… CRI: ☐
19. If lamp L2 is removed from its place, the potential difference VW will be:
    A. becomes 0 B. decreases C. increases D. does not change
    Reason: …… CRI: ☐

Problem, 20 – 21

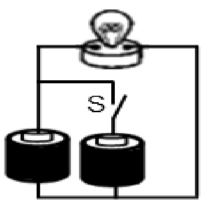


The circuit below consists of a battery E, lamp L, switch S and conductor wire

20. When switch S is connected, electrons will flow in the circuit. The electrons in the circuit come from...
    A. Battery C. conductor wire
    B. switch D. Lamp
    Reason: …… CRI: ☐

21. When the switch is connected but the lamp L is dim, the electrons in the circuit become. . .
    A. does not change C. increase
    B. reduced D. shrink
    Reason: …… CRI: ☐

Problem, 22 - 23

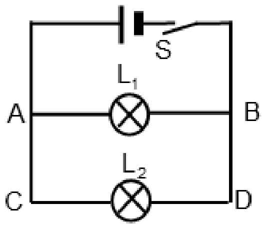


In the circuit below, the two batteries are identical and ideal (no internal resistance). The electric current in the circuit when switch S is disconnected is I

22. If switch S is connected, then the electric current flowing in the lamp becomes . . .
A. do not change
B. doubled from before
C. reduced by two times from the original
D. reduced by half from the original
Reason: …… CRI: ☐

23. If switch S is connected, then the clamping voltage of the lamp becomes. . .
A. do not change
B. doubled from before
C. reduced by two times from the original
D. reduced by half from the original
Reason: …… CRI: ☐

Problem, 24-26



In the circuit above, the battery is ideal (no internal resistance) and the lamp is identical. When switch S is connected, the electric current through the lamps L_1 and L_2 is the same

24. When switch S is connected and lamp L_1 is unplugged, the electric current through lamp L_2. . .
A. do not change
B. doubled from before
C. reduced by two times from the original
D. reduced by half from the original
Reason: …… CRI: ☐

25. When switch S is connected and lamp L_1 is unplugged, then . . .
A. point potential A is the same as point potential B
B. point potential A is less than point potential B
C. point potential A is greater than point potential B
D. there is no potential difference between point A and point B
Reason: …… CRI: ☐

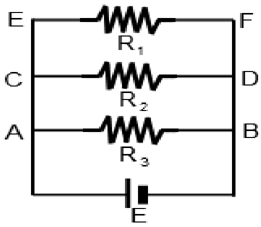
26. When switch S is connected and lamp L1 is removed, the potential difference between points C and D becomes. . .
A. do not change
B. doubled from before
C. reduced by two times from the original
D. reduced by half from the original
Reason: …… CRI: ☐

Problem, 27 - 28
27. If a lamp with a specification of 2.0W/6V is plugged into a 3V voltage source, then. . .
A. the power does not change
B. the power is half of the original
C. the power is a quarter of the original
D. twice the power from before
Reason: …… CRI: ☐

28. If the lamp is attached to a 12V voltage source for a long time, then. . .
    A. the power does not change
    B. twice the original power
    C. four times the power
    D. all wrong

    Reason: …… CRI: ☐

Problem, 29 - 30



The picture on the right shows a battery in parallel with three different resistances

29. The current and potential difference in a parallel resistance circuit are as follows:
    A. The electric current strength of the circuit is divided into resistance R_1, R_2 and R_3; and the potential difference of the voltage source is also divided into the clamping voltage V_{AB}, V_{CD} and V_{EF}
    B. Strong electric current circuit is not divided on resistance R_1, R_2 and R_3; and the potential difference of the voltage source is also not divided into clamping voltages V_{AB}, V_{CD} and V_{EF}
    C. Strong electric current circuit is not divided on resistance R_1, R_2 and R_3; and the potential difference of the voltage source is divided into the clamping voltage V_{AB}, V_{CD} and V_{EF}
    D. The electric current strength of the circuit is divided into resistances R_1, R_2 and R_3, and the potential difference of the voltage source is not divided into clamping voltages V_{AB}, V_{CD} and V_{EF}

    Reason: …… CRI: ☐

30. Parallel resistance can be replaced by a large resistance. . .
    A. smaller than the smallest obstacle
    B. bigger than the biggest obstacle
    C. equal to the biggest obstacle
    D. equal to the smallest resistance

    Reason: …… CRI: ☐