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# The Use of Concept Cartoons in Overcoming The Misconception in Electricity Concepts

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Electricity is a very important concept in learning Physics. Mastering this concept can make learning Physics meaningful and relatable to real life problems. However, literature indicates that students have poor conceptual understanding of concepts about electricity. The current research aims to improve Form 5 (aged 17 years) students' understanding of direct current circuits by using Concept Cartoons Worksheets. Concept Cartoons are A single-group pre-test/post-test investigation was carried out using seven Concept Cartoons Worksheets designed to address common conceptual misconceptions about direct current circuits with a total of 30 physics student participants. The seven Concept Cartoons were modified based on the Concept Inventory Test "Determining and Interpreting Resistive Electric Circuit Concepts Test (DIRECT). Concept Cartoons Worksheets were used to correct students' misconceptions about direct current circuits and to increase their level of conceptual understanding. The data collected were analysed quantitatively to obtain percentages, means, and t-test values. The descriptive statistics showed an increase in the level of student's conceptual understanding after the use of Concept Cartoons. The t-test analysis reported that the difference was significant. The results show that Malaysian students do have

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misconceptions about electricity concepts. However, Concept Cartoons Worksheets are effective to overcome students' misconceptions about electrical concepts, specifically toward current circuits. Concept Cartoons are not only effective in overcoming misconceptions among students, they are also refreshing and unique because of the cartoons presented while relating to Physics concepts that are abstract.

## Introduction

Literature related to misconceptions in electricity can be traced back as early as the 1970s (Driver & Easly, 1978). Numerous researchers have contributed in identifying learners' common misconceptions. Although they used different terms to explain the misconceptions, all these studies found that learners held similar misconceptions about electricity concepts to the point of saturation (Cohen *et al*., 1983; Dupin & Joshua, 1987; Fredette & Lochhead, 1980; Fredette & Clement, 1981; McDermott & Shaffer, 1992; Picciarelly *et al*., 1991a, 1991b; Shipstone, 1984). Recent studies are focused on how to eliminate learners' misconceptions about electricity concepts (Hesti *et al*., 2017; Mahmudiah *et al*., 2019; Mataka & Taibu, 2020; Ramnarain & Moosa, 2017; Samsudin *et al*., 2019; Suma *et al*., 2019).

Literature reports that students face difficulties in learning the concept of Electricity (Azzarkasyi *et al*., 2019; Engelhardt & Beichner, 2004; Fallon, 2019; Halim & Mustafa, 2019; Marhadi *et al*., 2019; Suma & Pujani, 2019), indeed misconceptions about electricity concepts are found at almost all academic levels, including elementary (Fallon, 2019; Marhadi *et al*., 2019), high school (Halim & Mustafa, 2019; Suma & Pujani, 2019), university (Azzarkasyi *et al*., 2019; Engelhardt & Beichner, 2004) and at PhD level (Li & Singh, 2016). Hence, it is not surprising that Malaysian students have similar misconceptions (Beh & Tong, 2004; Osman, 2017).

Studies show that misconceptions are strong and difficult to overcome through conventional methodologies (Tippett, 2010). However, it is important to eliminate misconceptions as they negatively affect students' academic achievement to a great extent (Gürefe *et al.*, 2014). Various approaches have been developed by science educators to deal with students' misunderstandings in electricity. These including approaches such as Multi Step Inquiry (Mataka & Taibu, 2020), multiple-choice conception diagnostic tests from tiers one to four (Marhadi *et al*., 2019; Hermita *et al.*, 2017; Ramnarain & Mossa, 2017; Suma *et al.*, 2019), virtual labs (Samsudin *et al.*, 2019) and computer simulation (Bakri & Muliyati, 2019; Fallon, 2019; Ramnarain & Mossa, 2017). However, the results showed that no single method can accommodate all concepts. One method may only be effective on certain concepts but not others (Halim *et al.*, 2019).

This work aims to contribute to the research into ways of reducing students' misconceptions in electricity. Concept Cartoons, first created in the year 1991 by Brenda Keogh and Stuart Naylor, are a teaching tool that can be used to deal with the issues discussed. They suggested the use of cartoon drawings to enhance scientific argumentation through daily life situations. In the cartoons, several characters argue about different opinions regarding the science concepts related to daily life situations. All the opinions are designed based on common misconceptions of the related topic. Students are asked to discuss and argue the alternative views probed by the cartoon characters (Keogh & Naylor, 1996; Keogh *et al*., 1998). Since all the opinions are arguable, as the argumentation process continues, learners are led to a cognitive conflict. Once the cognitive equilibrium state is reached, the misconceptions can be overcome and changed to scientific concepts. Thereby helping the students to overcome the misconception (Naylor & Keogh, 2013; Pekel, 2019).

Many studies concluded that Concept Cartoons are an effective tool in resolving misconceptions (Ekici *et al*., 2007; Kabapinar, 2009; Keogh & Naylor, 1996; Keogh & Naylor, 1999; Naylor & Keogh, 2013; Pekel, 2019; Samková, 2017; Serttaş & Türkoğlu, 2020). Through this approach, the teacher can identify students' misconceptions and discover the reasons behind them (Kabapinar, 2009). Through this, a teacher can easily help the students to overcome misconceptions and to fully grasp the scientific knowledge and concepts (Ekici *et al*., 2007; Şengül & Üner, 2010; Pekel, 2019; Samková, 2017; Serttaş & Türkoğlu, 2020; Stephenson & Warwick, 2002).

Therefore, this study uses Concept Cartoons as a treatment to overcome students' misconceptions about electricity concepts. This is seen when students' level of conceptual understanding of an electricity concept increases throughout the research. A series of Concept Cartoons in electricity concepts was developed, with seven Concept Cartoon Worksheet designs (CCWs) based on a high validity and reliability instrument: "Determining and Interpreting Resistive Electric Circuit Concepts Test (DIRECT), version 1.2". The DIRECT test created by Engelhardt and Beichner (2004) is a common Concept Inventory (CI) test for identifying misconceptions about direct current circuits.

Students' level of understanding of electricity concepts was assessed using the CCWs. Hence, the objective of the study is to determine the effectiveness of CCWs in overcoming these misconceptions.

The research question for this study is:

How effective are concept cartoon worksheets in overcoming the misconceptions about electricity concepts and hence increasing the level of conceptual understanding among students?

## Methodology

The current research is a single group pre/post-test investigation. According to Creswell (2014), this research design begins with a pre-test, followed by a treatment and a post-test for a single group of samples.

### *Instrument*

In the current research, seven CCWs were modified based on the CCW model in which a cartoon poster is embedded in a worksheet (Kabapinar, 2005; Kabapinar, 2009; Taşlıdere, 2013). In each CCW, some cartoon characters are arguing on a problem in electricity. Most of the cartoon characters are probing alternative concepts, and there is only one correct answer for each CCW. The alternative concepts being probed by the cartoon characters must have equal status and be based on research into students' common misconceptions (Keogh & Naylor, 2013; Keogh *et al*., 1998), the questions and distractors used in designing the CCW were selected from DIRECT, which is an inventory test created by Engelhardt and Beichner (2004) focusing on learners' conceptual understanding of direct current (DC) circuits and was reported to have high validity and reliability for identifying learners' misconceptions about electricity (Engelhardt & Beichner, 2004). This research uses DIRECT version 1.2. The test consisted of 29 items assessing four constructs in electricity: 1. Physical aspects of DC circuits, 2. Energy, 3. Current, and 4. Potential Difference, using 11 objectives (refer to Table 1). However, not all constructs were modified to CCWs. Among the 29 items in the test, only 16 were selected for the Cartoon Worksheet materials with 13 items being removed. The removed items involved concepts that were not integral to the current physics syllabus (MOE, 2002). They include - items 3, 7, 12, 16 (items involving circuits with two or more batteries), items 10, 19, 27 (items involving short-circuits), items 2 & 12 (power in series and parallel circuits), items 9 & 18 (items involving elements that have two possible points at which to make connections), and item 21 (Kirchhoff's loop rule). Moreover, although some constructs had multiple items, only one item was chosen to design the corresponding CCW. Table 1 shows the design of CCW items based on the DIRECT constructs that created by Engelhardt & Beichner (2004).

Table 1: The design of CCWs items based on the DIRECT constructs

| **Objective** | | **Question number** | **Items chosen as material** | **Concept Cartoon Worksheet (CCW)** |
|---|---|---|---|---|
| Physical Aspects of DC electric circuits (objectives 1–5) | 1) "Identify and explain a short circuit (more current follows the path of lesser resistance)" | 10, 19, 27 | Not evaluated | |
| | 2) "Understand the functional two-endedness of circuit elements (elements have two possible points at which to make connections)." | 9, 18 | Not evaluated | |
| | 3) "Identify a complete circuit and understand the necessity of a complete circuit for current to flow in the steady state (some charges are in motion but their velocities at any location are not changing and there is no accumulation of excess charge anywhere in the circuit)." | | | - |
| | Objectives 1–3 combined | 27 | Not evaluated | |
| | 4) "Apply the concept of resistance (the hindrance to the flow of charges in a circuit) including that resistance is a property of the object (geometry of the object and the type of material of which it is composed) and that in-series the resistance increases as more elements are added and in-parallel the resistance decreases as more elements are added." | 5, 14, 23 | 5 | CCW1 |
| | 5) "Interpret pictures and diagrams of a variety of circuits including series, parallel, and combinations of the two." | 4, 13, 22 | 4 | CCW2 |
| Energy (Objectives 6–7) | 6) "Apply the concept of power (work done per unit time) to a variety of circuits." | 2, 12 | Not evaluated | - |
| | 7) "Apply a conceptual understanding of conservation of energy (including Kirchhoff's loop rule $(\sum V = 0)$ around a closed loop) and the battery as a source of energy." | 3, 21 | Not evaluated | - |
| Current (Objectives 8–9) | 8) "Understand and apply conservation of current (conservation of charge in the steady state) to a variety of circuits." | 8, 17 | 8 | CCW3 |
| | 9) "Explain the microscopic aspects of current flow in a circuit using electrostatic terms such as electric field, potential difference, and the interaction of forces on charged particles." | 1, 11, 20 | 20 | CCW4 |
| Potential difference (voltage) (objectives 10–11) | 10) "Apply the knowledge that the amount of current is influenced by the potential difference maintained by the battery and the resistance in the circuit." | 7, 16, 25 | 25 | CCW5 |
| | 11) "Apply the concept of potential difference to a variety of circuits including the knowledge that the potential difference in a series circuit sums while in a parallel circuit it remains the same." | 6, 15, 24, 28, 29 | 29 | CCW6 |
| | Current and voltage (objectives 8 and 11) | 26 | 26 | CCW7 |

Next, the question, correct answer, and distractors of DIRECT test items were embedded in the cartoon poster as the different opinions of cartoon characters, as shown in Figure 1. Boxes are for learners to select which cartoon character(s) they agreed with, while a space is left for writing the justification. After that, the CCWs were sent to three experts to check the content validity and construct validity based on three foci: 1) is the content of the Concept Cartoons Worksheets modified correctly from the DIRECT test and suitable to correct students' misconceptions of Electricity Concepts? 2) is the construct of the Concept Cartoons Worksheets in line with the construct of the DIRECT test? According to Mehrans and Lehmann (1991), a table of specifications is needed to identify the content validity and construct validity. Thus, the table of specifications of the DIRECT test was requested from its creator - Dr. Paula Engelhardt from Tennessee Technological University - and sent to the experts **carrying out the validation both of whom have a** post-doctoral qualification and a teaching background in physics education. Modifications to the CCWs were made based on their comments, and the final CCW versions are shown in Appendix A.

After that, a preliminary study of the CCWs was carried out with four students who have the same academic background as the research sample. The purpose of the preliminary study was to identify the effectiveness of the instructional materials in the Concept Cartoons Lesson (CCL). In the study, a full CCL was carried out. Participants joined a group discussion section with the aid of a Concept Cartoons Worksheet. The details on how to run a Concept Cartoons Lesson are discussed in the *Data collection* section.

After the lesson, participants were asked to go through all 10 CCWs **in order to** identify whether they could understand the questions asked and the terms used in the CCWs. Overall, all the participants could understand all the questions asked and all the terms used in the CCWs. One suggestion was adopted, **namely stating before using the CCWs that the resistance of all wires involved could be neglected.**

***CCW example***

Figure 1 describes the examples of materials within CCWs, and the details of how they were designed (see Appendix A for the other CCWs). This figure was labeled 'Concept Cartoons Worksheet 3' (CCW3). This cartoon worksheet was designed based on the misconceptions under the construct "Current" in understanding and applying the process of conservation of current. The cartoon poster showed that five cartoon characters A, B, C, D, and E were arguing about the amount of current between point 1 and point 2. In this cartoon, only C gave the correct explanation where the amount of current is the same through any component in a series circuit. Both A and B probed the "current consumed" misconception that the total amount of current decreases when it moves along the circuit elements. Once the current returned to the battery, there is no more current left. D was wrong as the DC circuit has only one direction of flow. E was labeled with "?" to give students the opportunity to provide opinions that were different from those stated.

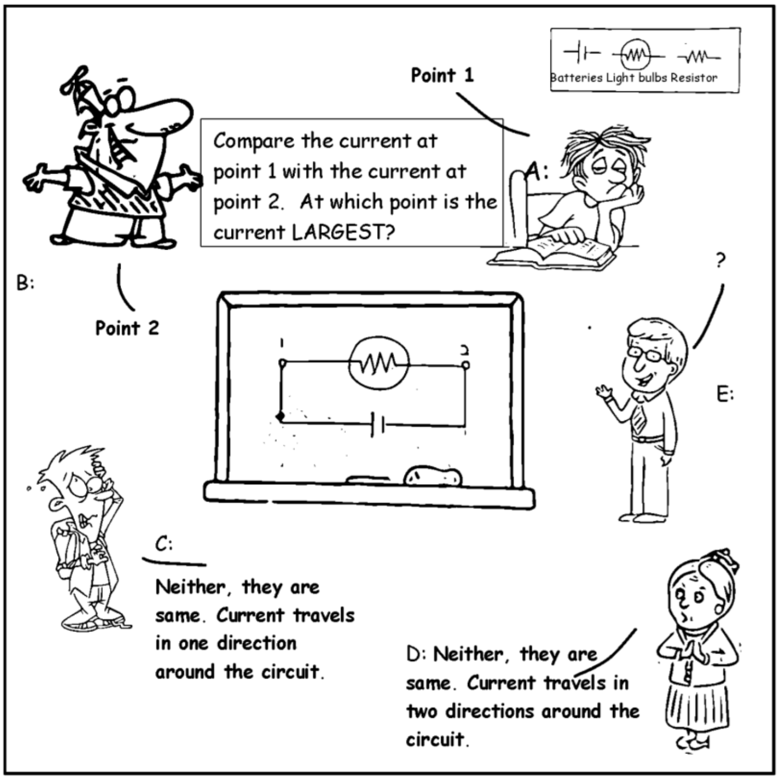


Figure 1: Concept Cartoon Worksheet 3 (CCW3)

***Sample***

This research was implemented based on the convenience sampling method. A total of 30 students (female=8, male=22) from a secondary school in Johor, Malaysia were selected as the sample. The group discussion for all the selected students was conducted by the researcher. All the samples selected were science stream (taking physics, chemistry, and biology subjects) students aged 17 who studied the Electricity topic.

***Data collection***

Before the research began, the students had learned and completed the Electricity topic in the syllabus (MOE, 2002) through conventional classroom learning. After that, the research began with seven 40-min Concept Cartoons Lessons. In these lessons, students were divided into six groups, with five members per group. When the lesson started, each of the students received one CCW. Students were given 5 minutes to study the worksheet. Later, they were asked to select the cartoon character(s) with the acceptable view and write out the reason(s) for their choice in the space provided in the cartoon worksheet. Next, students were invited to join in the discussion over the cartoon characters and decide which of the cartoon characters' opinions were most acceptable. The teacher, as a facilitator, motivated the students in the discussion and also challenged students' justifications with follow-up questions. The teacher also tried to identify the misconceptions held by students and the reasons behind those misconceptions. As the alternative views provided in CCWs represent common misconceptions about electricity, teachers can easily identify students' misconceptions from their answer and justification. The teacher can choose to rectify them immediately or lead the students to discuss or discover more depending on the group's situation. The discussion section lasted 20 minutes. The worksheet was then answered again by the students. Before the end of each Concept Cartoons lesson, a sharing session conducted by the teacher shared the correct answer with the students. In adition, the teacher discussed the misconceptions that been identified during the group discussion and rectified them.

### *Data analysis*

To answer the research questions, the data on the answers provided by students in the CCWs were analysed. They were asked to tick in the box of the character that they agreed with and write down their justifications for doing so before they continued with the discussion session (Pre-test). Then, students discussed the Concept Cartoon in their respective groups. They were asked to select again the character that they agreed with and provide the reason for their choice after the discussion (Post-test). To avoid guessing, a scoring method suggested by Ingec (2008) was used. The worksheet was scored as:

0 — Chose the wrong character(s). Left the answer space blank.
1 — Chose the right character(s) but unable to give the precise justification.
2 — Chose the right character(s) and gave the justification using the correct concept.

Thus, the maximum scoring of each CCW is 2 if the student can choose the right cartoon character and give the correct justification.

The data were analysed using descriptive statistics. The scoring of the pre- and post-tests was recorded. The level of understanding was assigned to three categories (Low, Medium and High). Finally, the analysis was followed by a paired sample t-test with a 95% confidence interval (p = 0.05).

## Findings

### *The level of understanding of electricity concepts among students before and after the use of CCWs*

This section shows the outcome of the research question. To answer the research question, descriptive statistics based on the students' score from the seven CCWs, according to the scoring suggested by Ingec (2008) were used. The level of understanding is defined based on those scoring persentage: **33%** and below (Low), in between **33% to 66%** (Average), above **66%** (high). The data from both before (pre) and after (post) the discussion sessions for the corresponding CCWs were analyzed. Students' scoring was converted to percentages. Table 2 shows the results of this analysis.

Table 2: Analysis results for the research question

| Concept Worksheet | Cartoons | Score | Before (%) | Level | After (%) | Level |
|---|---|---|---|---|---|---|
| | | 0 | 46.67 | | 10.00 | |
| CCW1 | | 1 | 3.33 | Average | 6.67 | High |
| | | 2 | 50.00 | | 83.33 | |
| | | 0 | 80.00 | | 23.33 | |
| CCW2 | | 1 | 0.00 | Low | 10.00 | High |
| | | 2 | 20.00 | | 66.67 | |
| | | 0 | 90.00 | | 50.00 | |
| CCW3 | | 1 | 0.00 | Low | 23.33 | Low |
| | | 2 | 10.00 | | 26.67 | |
| | | 0 | 90.00 | | 76.67 | |
| CCW4 | | 1 | 3.33 | Low | 0.00 | Low |
| | | 2 | 6.67 | | 23.33 | |

| | | | | | |
|---|---|---|---|---|---|
| | 0 | 76.67 | | 56.67 | |
| CCW5 | 1 | 16.67 | Low | 13.33 | Low |
| | 2 | 6.67 | | 30.00 | |
| | 0 | 63.33 | | 23.33 | |
| CCW6 | 1 | 6.67 | Low | 10.00 | High |
| | 2 | 30.00 | | 66.67 | |
| | 0 | 26.67 | | 33.33 | |
| CCW7 | 1 | 36.67 | Average | 30.00 | Average |
| | 2 | 36.67 | | 36.67 | |
| | 0 | 67.62 | | 39.05 | |
| Mean Score | 1 | 9.52 | Low | 13.33 | Average |
| | 2 | 22.86 | | 47.62 | |

These data indicate a lower level of understanding of electricity concepts before the use of CCWs. This can be demonstrated by the high percentage of students that obtained a zero score (mean score 0 = 67.62%). Only 22.86% of students scored two before the use of CCWs. However, the data showed changes after the use of CCWs (0 = 39.05%, 2 = 47.62%), where the students who scored zero decreased by 28.57%, while the students scoring two increased by 24.76%. Even though the data indicated an increase in students' level of understanding of electricity concepts, the level is still considered to be below average.

***Significant differences in the level of understanding of electricity concepts***

To answer the research question further, a paired sample t-test was conducted based on the scores before and after the discussion. A two-tailed test was conducted with 95% confidence interval ($p<.05$). Table 3 shows the descriptive statistics of students' scores before and after the discussion for each CCW and the total scoring for the seven CCWs.

Table 3: Descriptive statistics of students' scores before and after the discussion

| | | **Mean Score** | **Gain / Loss** | **N** | **Std. Deviation** | **Standard error mean** |
|---|---|---|---|---|---|---|
| CCW1 | Before | 1.03 | + 0.70 | 30 | 1.00 | 0.18 |
| | After | 1.73 | | 30 | 0.64 | 0.12 |
| CCW2 | Before | 0.40 | + 1.03 | 30 | 0.81 | 0.15 |
| | After | 1.43 | | 30 | 0.86 | 0.16 |
| CCW3 | Before | 0.20 | + 0.57 | 30 | 0.61 | 0.11 |
| | After | 0.77 | | 30 | 0.86 | 0.16 |
| CCW4 | Before | 0.17 | + 0.30 | 30 | 0.53 | 0.10 |
| | After | 0.47 | | 30 | 0.86 | 0.16 |
| CCW5 | Before | 0.30 | + 0.43 | 30 | 0.60 | 0.11 |
| | After | 0.73 | | 30 | 0.91 | 0.17 |
| CCW6 | Before | 0.67 | + 0.77 | 30 | 0.92 | 0.17 |
| | After | 1.43 | | 30 | 0.86 | 0.16 |
| CCW7 | Before | 1.10 | − 0.07 | 30 | 0.80 | 0.15 |
| | After | 1.03 | | 30 | 0.85 | 0.16 |
| Total | Before | 3.87 | + 3.73 | 30 | 2.61 | 0.48 |
| | After | 7.60 | | 30 | 3.16 | 0.58 |

Table 4 outlines the t-test results of this research. On average, the data on students' total score shows that they performed worse before ($M = 3.87$, $SD = 2.61$) than after using Concept Cartoons ($M = 7.60$, $SD = 3.16$). This improvement, 3.73, was significant, ($t(29) = -7.426$, $p<.001$). This result suggests students' level of understanding in electricity increases after the use of Concept Cartoons.

Table 4: Paired sample t-test results

| | Paired differences | | *t* | Sig. (2-tailed) |
|---|---|---|---|---|
| | Mean | Std. Deviation | | |
| CCW1 | − 0.70 | 0.99 | − 3.88 | 0.001* |
| CCW2 | − 1.03 | 0.96 | − 5.87 | 0.000* |
| CCW3 | − 0.57 | 0.77 | − 4.01 | 0.000* |
| CCW4 | − 0.30 | 0.95 | − 1.73 | 0.095 |
| CCW5 | − 0.43 | 0.94 | − 2.54 | 0.017* |
| CCW6 | − 0.77 | 1.01 | − 4.17 | 0.000* |
| CCW7 | 0.07 | 1.05 | 0.35 | 0.730 |
| Total | − 3.73 | 2.75 | − 7.426 | 0.000* |

For the particular CCW, t-test results show a significant difference in the level of understanding of electricity concepts in CCW1, CCW2, CCW3, CCW5 and CCW6. However, the results failed to show a significant difference in CCW4 and CCW7. Thus, the result suggests that CCW1, CCW2, CCW3, CCW5, and CCW6 had successfully increased students' level of understanding of electricity (according to the corresponding constructs listed in Table 1). However, for both CCW4 and CCW7 this failed to occur.

## Discussion

Based on the analysis, the results support the findings that Malaysian students are still having misconceptions about electricity (Hussain *et al*., 2012; Osman, 2017), and that these misconceptions are difficult to remove through the conventional class **teaching** (Tippett, 2010). This can be proven by the low mean score **before the use of CCWs.** However, the results increased after the use of CCWs. The paired sample t-test results also indicated that there is a significant effect in the level of understanding of electricity concepts by students before and after the use of CCWs. The results are in line with the literature (Ekici *et al*., 2007; Kabapinar, 2009; Keogh & Naylor, 1996; Naylor & Keogh, 2013; Pekel, 2019; Serttaş & Türkoğlu, 2020), where the Concept Cartoons approach is deemed effective in resolving students' misconceptions.

Furthermore, the written answers in the CCWs show that a teacher can easily identify students' misconceptions and discover the reasons behind them through the implementation of this concept (Kabapinar, 2009). For example, a student answering A in CCW3 (refer to Figure 1), with a justification "*because current passes through point A first*" or "*the bulb has used up some of the electricity*" clearly shows that he/she has the "current consumed" misconception where current/electrons are consumed by the electrical devices thus causing the amount of current returning to the negative terminal to be reduced . This understanding of the reasons behind the wrong view points enables teachers to easily rectify students' misconceptions during the discussion or sharing sessions before the end of the lesson.

However, the results also indicated that CCW4 and CCW7 failed to show any significant difference in increasing the learners' understanding of the intended concept. In CCW4 (refer to CCW4 in Appendix A), students were unable to relate the concept of electric field to electric charge. This is because in the current physics syllabus, students are only taught explicitly the definition of the electric field and exposed to some experiments to prove that an electric field exists (MOE, 2002). Thus, most of the students probed the misconception that an electric field is created by the flow of current (Engelhardt & Beichner, 2004). This is proven by the justification written by students "*Electric Charge is zero because there is current flowing*", "*The circuit is complete, current is flowing, so zero*". Although they have participated in the discussion, they still failed to state the correct concept that electric field is caused by electric charges. For CCW7, most of the students retained the sequencing misconception even after the CCWs experience. This misconception is stated in the literature that any changes occurring before an element won't affect an element after it (Dupin & Joshua, 1987; Picciarelly *et al*., 1999a). Thus, students believed that when the resistance C increases, only bulb B will be affected (see CCW7 in Appendix A). Through the observation during the discussion, this misconception is due to confusion in understanding the concept that "*current in a series circuit is always constant*". Students thought that the current that passed through bulb A will be the same even when the resistance C increased since the current passed through bulb A first. Only bulb B is affected as it is behind resistance C. This is proven by the justification written by the students: "*Current passes through bulb A first then only blocked by resistor C*.", "*Resistor C is after bulb A so only will affect bulb B*." Hence, more exposure to this concept would be required so that learners will have a better understanding of these concepts.

Besides that, through the observation in the class, students involve themselves actively in the group discussion. They responded that the humor of the cartoons motivated them to try the worksheet. Besides that, since nobody knows the correct answer, this encourages them to join the discussion without fear of making mistakes. The students' responses are in line with the literature that Concept Cartoons motivate learners toward physics lessons (Greenwald & Nestler, 2004; Keogh *et al*., 1998; Naylor & Keogh, 2013; Pekel, 2019; Serttaş & Türkoğlu, 2020). This is because teaching using Concept Cartoons liberates students from the usual boring traditional approach to teaching and helps teachers to improve their instruction and adopt the constructivist learning theory, making the lessons more interesting and entertaining plus allowing students to become more actively involved in their learning (Birisci *et al*., 2010; Aydin, 2015).

## Conclusion

The study confirmed that Malaysian students do have misconceptions about electricity concepts even when they have been explicitly taught them. Moreover, these misconceptions seem difficult to remove. This is proven by the low conceptual understanding recorded in the pre-test. Fortunately, this research also shows Concept Cartoons to be an effective tool for overcoming students' misconceptions (Ekici *et al*., 2007; Kabapinar, 2009; Keogh & Naylor, 1996; Keogh & Naylor, 1999; Naylor & Keogh, 2013; Pekel, 2019; Samková, 2017; Serttaş & Türkoğlu, 2020). This research shows that misconcptions can be detected and corrected by the use of Concept Cartoons. This can be see from the improvement in students' level of understanding in the post-test. Thus, it is concluded that Concept Cartoons provide a potential platform for teachers in overcoming students' misconceptions in the physics classroom.

## Limitations and Recommendations

As this research was conducted with a small group of students (30 science stream students), the findings could not therefore be generalized so that the same result may not apply to a bigger population and wider group of students. In addition, since this research **relies on statistical analysis**, more detailed qualitative research is suggested to explore the process whereby students involve themselves in using Concept Cartoons when correcting their conceptual misconceptions.

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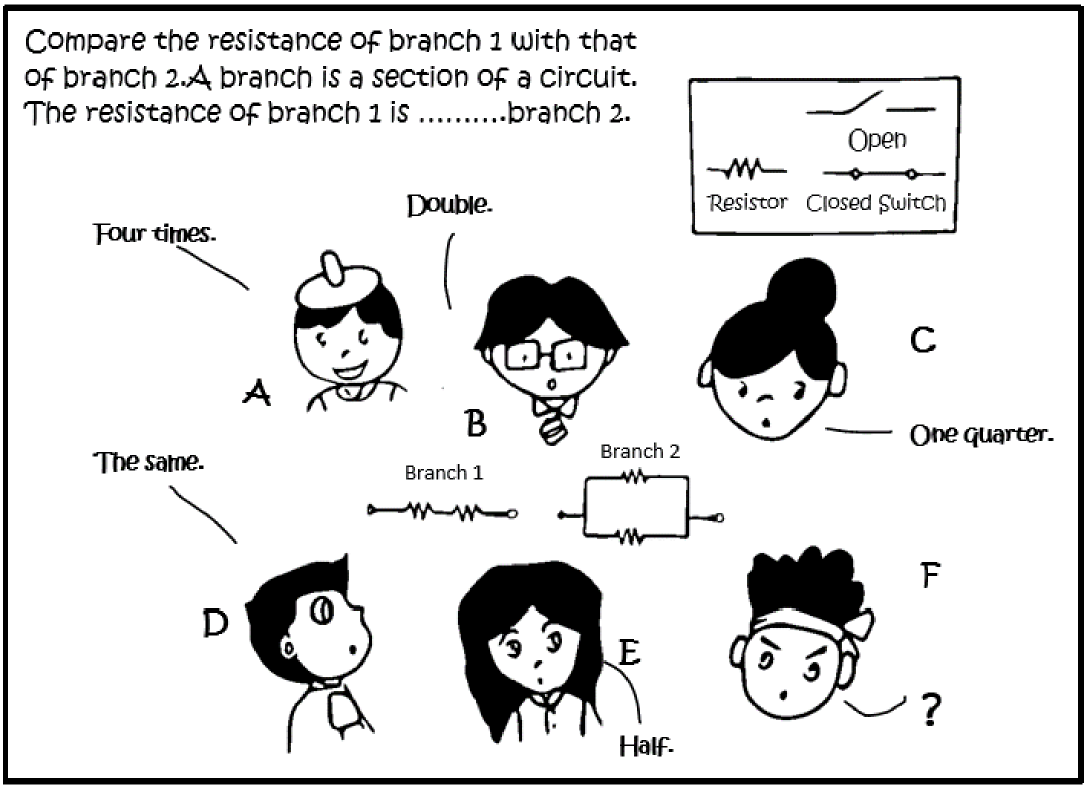
## Appendix A

CCW1

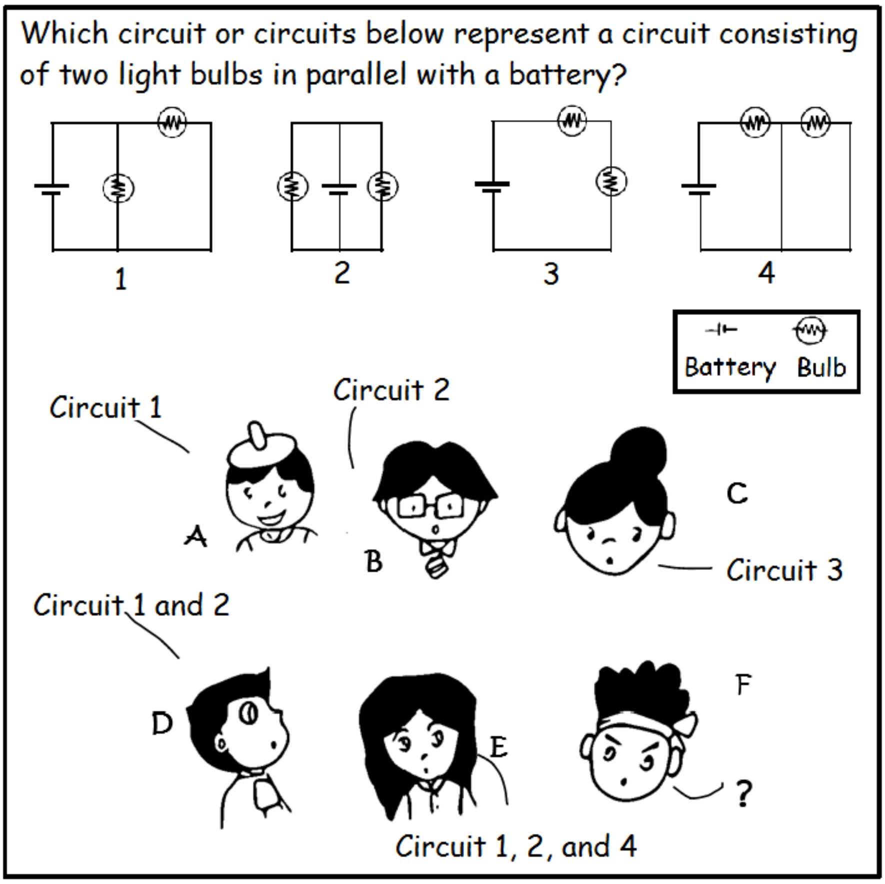



Which opinion do you agree with?

A B C D E F

Write reason(s) for your answer.

CCW2

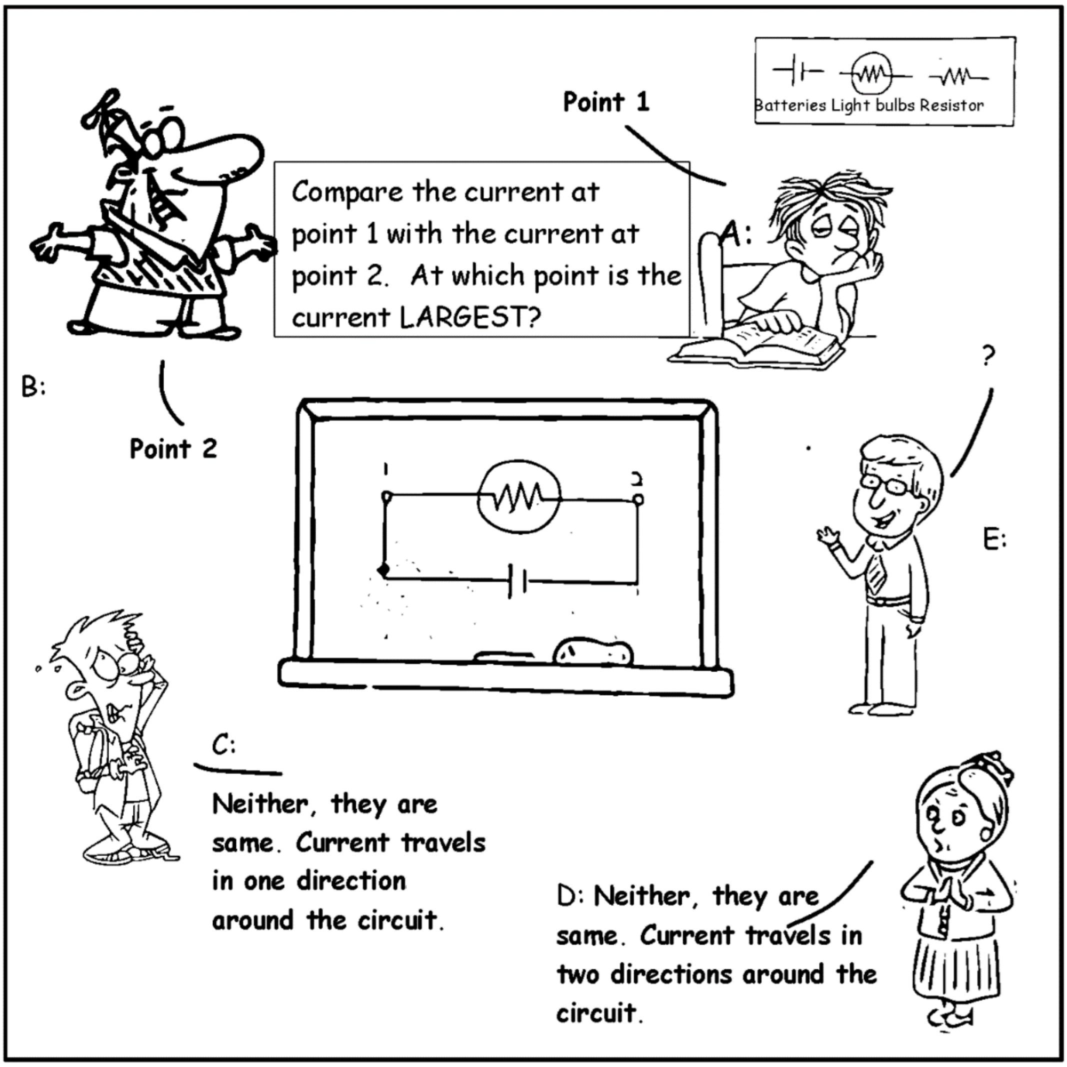



Which opinion(s) do you agree with?

A B C D E F

Write reason(s) to support your answer.

CCW3

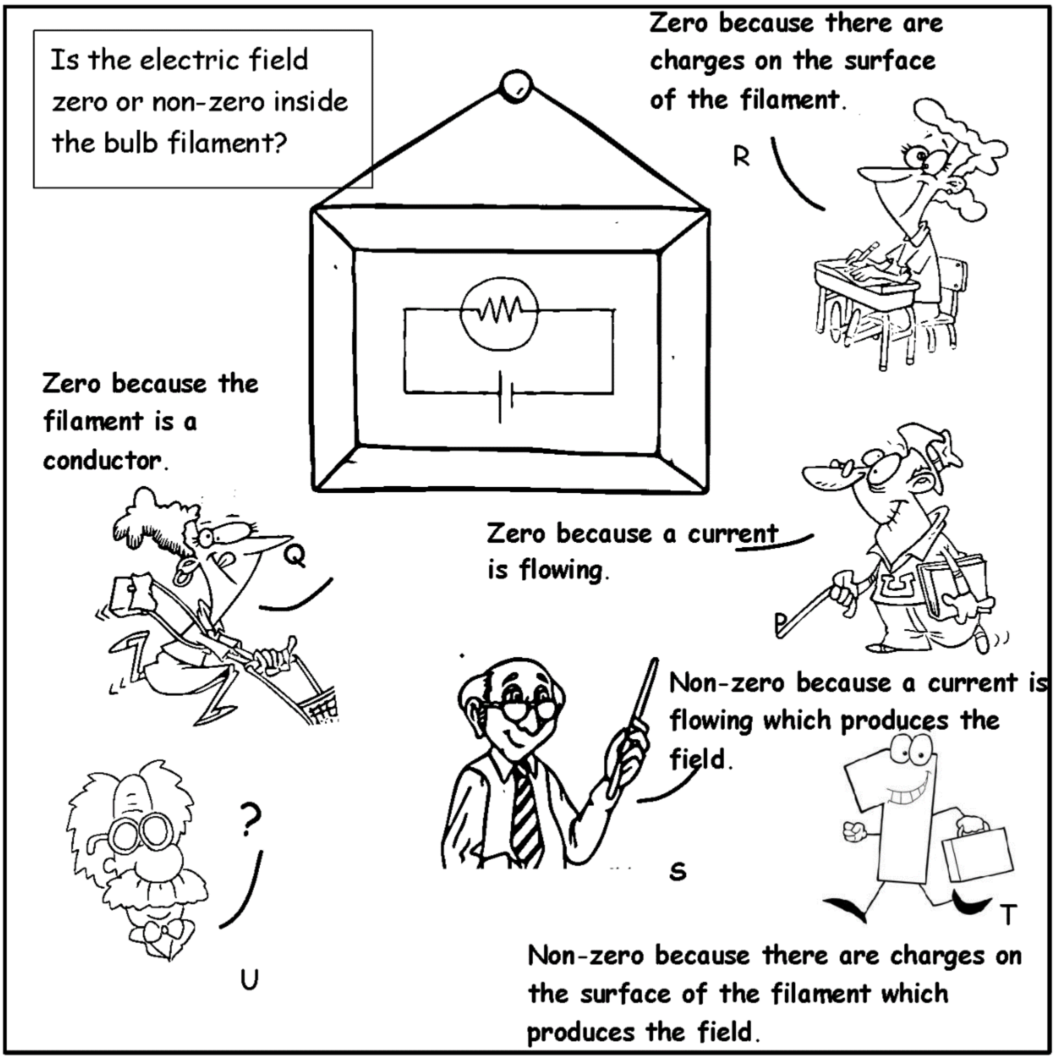



Which opinion do you agree with?

| A | B | C | D | E |
|---|---|---|---|---|
| | | | | |

Write reason(s) for your answer.

CCW4

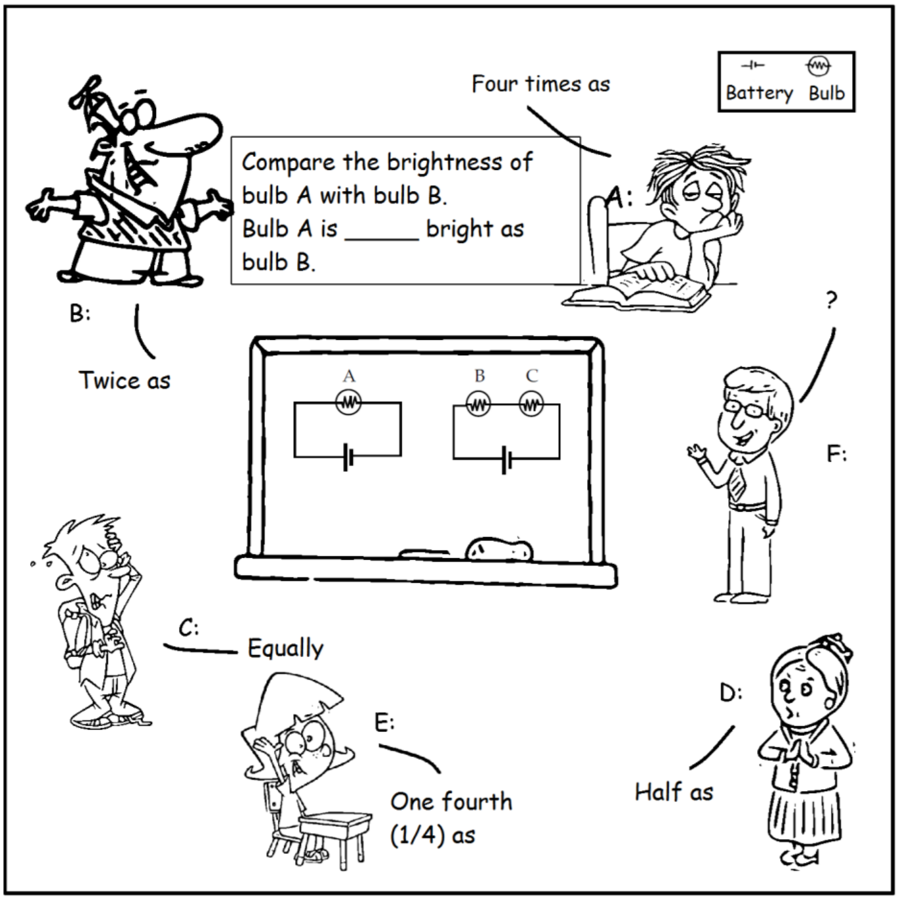



Which opinion do you agree with?

| P | Q | R | S | T | U |
|---|---|---|---|---|---|
| | | | | | |

Write reason(s) for your answer.

CCW5

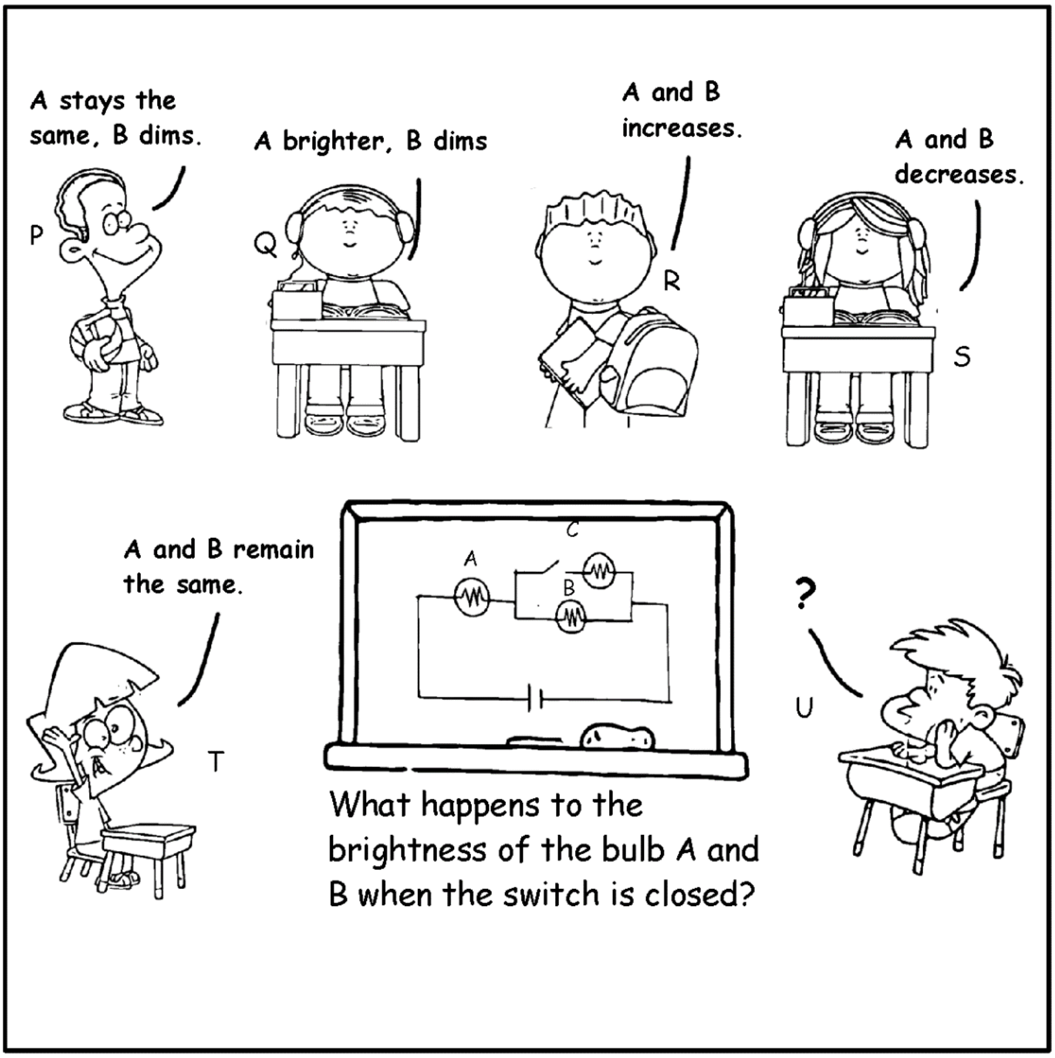



Which opinion(s) do you agree with?

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| ☐☐ | ☐☐ | ☐☐ | ☐☐ | ☐☐ | ☐☐ |

Write reason(s) to support your answer.

CCW6

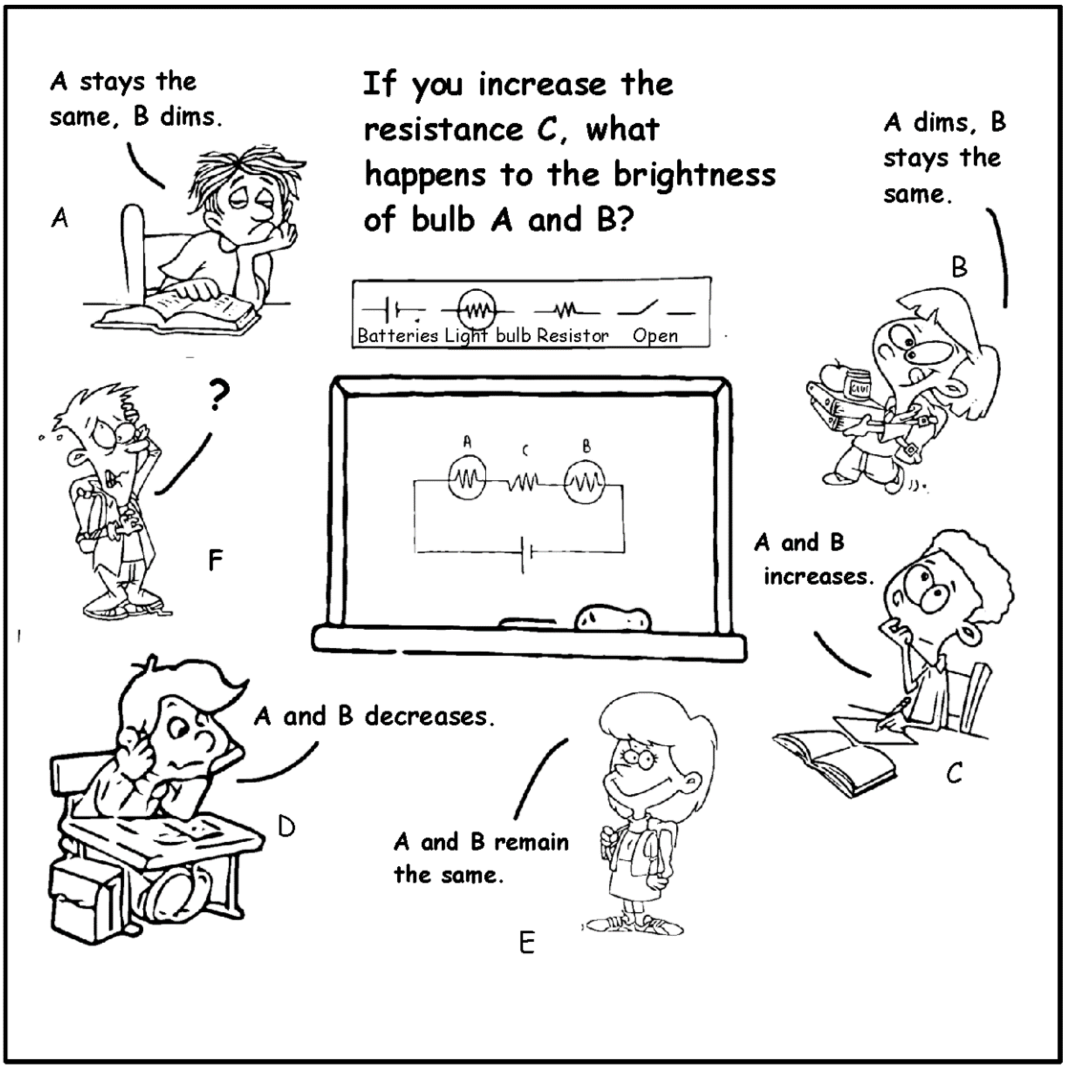



Which opinion do you agree with?

| P | Q | R | S | T | U |
|---|---|---|---|---|---|
| | | | | | |

Write reason(s) for your answer.

CCW7




Which opinion do you agree with?

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| | | | | | |

Write reason(s) for your answer.