

7th Graders' understanding of a fire caused by an electrical short circuit

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Abstract. The aims of this study were 1) to develop a fire caused by an electrical short circuit learning activity and 2) to survey 62, 7th graders' understanding of a fire caused by an electrical short circuit. This cause consists of three parts of understanding, which are 1) an electrical short circuit causes the overload current, 2) this amount of current causes high heat, and 3) this high heat increase the temperature of the surrounding materials until the temperature reach to the Ignition Temperature. The Problem Based Learning (PBL) approach was used to design the learning activity. Students were challenged to design their own group experiment to make a combustion with the provided materials: rubber band, paper clip, AA battery, cotton rope, chewing gum with wrapping aluminium paper, and cotton pad. The open-ended question as "How does the electrical short circuit cause a fire?" was used to survey the students' understanding of electrical fire causes in the case of short circuit. The result revealed that only one student was able to give all three parts of the explanation, two students could give only second and third part of the explanation. While 2, 4, and 18 students could get only the first, second, and third part of the explanation, respectively. Moreover, some misconceptions of current, similar to the previous research, were found such as 13 students described that current was stored at a part of a conductor to generate heat and 10 students thought that current came from both terminals of a battery and clash at the burning point.

1. Introduction

The Green wood dictionary of education [1] defines Active Learning as 1) the process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas 2) requiring students to regularly assess their own degree of understanding and skill at handling concepts or problems in a particular discipline 3) the attainment of knowledge by participating or contributing 4) the process of keeping students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving.

Problem based learning is an active learning which enables the student to become aware of and determine his/her problem-solving ability and learning needs, to learn to learn, to be able to make knowledge operative and to perform group works "in the face of real life problems" [2].

Students are familiar with electricity in their daily life as it is used to make our life more convenient. On the other hand, electric can cause a fire by physical damage (to wires, fixtures, junction boxes, motors, and equipment), carbonization of insulation, overvoltage, poor connection, gross overloads, external heating, short circuit, etc. [3-4] However, students often get the information that the cause of many house fires is electrical short circuit. In addition, many research [5-9] found that students had many misconceptions about the electricity including of circuit elements, current, potential difference and resistance.

As researchers would like to know students' understanding of fire by electrical short circuit, the activity with the PBL approach was developed to give students a chance to think, design, share, explore, discuss about the fire by electrical short circuit.

2. Fire by electrical short circuit

Short circuit is an abnormal connection (including arc) of relative low impedance, whether made accidentally or intentionally, between two points of different potentials [10].

Young and Freedman [11] states that a short circuit can be caused by faulty insulation or by any variety of mechanical malfunctions, provided a very low-resistance current path, permitting a very large current that would quickly melt the wire and ignite their insulation if the current were not interrupted by a fuse or circuit breaker. This statement can be used to describe the electrical fire causes in the case of short circuit. To analyze students' understanding, the researchers divided a fire caused by an electrical short circuit into three parts. First, an electrical short circuit causes the overload current. Second, this amount of current causes high heat. Last, this high heat increases the temperature of surrounding materials until the temperature reach to the Ignition temperature, the combustion will occur. Ignition temperature is the lowest temperature at which a combustible substance when heated (as in a bath of molten metal) takes fire in air and continues to burn [12].

3. Methods

3.1. Purpose

The purpose of this study were to develop a fire caused by an electrical short circuit learning activity and to survey 62, 7th graders' understanding of electrical fire causes in the case of short circuit. The research question is "How do students understand about a fire caused by an electrical short circuit after learning through the developed learning activity?".

3.2. Subjects and setting

There were 62 7th graders, 2 classes from a school in Bangkok, Thailand participated in this study. Class A had 29 students and 33 students in class B. Each class attended the activity which lasted 100 minutes at a time. Students freely grouped of 5 to 6 people. All students do not have the prior knowledge of short circuit, ignition temperature, and heat. They only have the basic knowledge of simple electronic circuit in primary level according to Thailand Basic Education Core Curriculum B.E. 2551 [13].

There were three sections of the activity as the first section; students were asked to design their own experiment. The second section allow students to conduct the experiment as they design. The last section was the section that the hint was provided.

3.3. Activity treatment

This activity was developed by researchers to demonstrate the electrical fire causes in the case of short circuit via the PBL approach. Students were challenged to make a combustion with the limited materials: rubber band, paper clip, AA battery, cotton rope, chewing gum with wrapping aluminium paper, and cotton pad. To help students link the activity to the real-life situation, the comparison between an aluminium paper and an electric wire was introduced to the students after they had finished the activity.

First, to engage students, the scenario was provided as all students were the explorer that lost in the jungle. When they wanted to set the fire, they found out that there were a bunch of materials that they

carried; rubber band, paper clip, AA battery, cotton rope, chewing gum with wrapping aluminium paper, and cotton pad. From this point, students had to design the way to set the fire using these materials under the question “How can you ignite the fire with limited materials?”. An A3 paper was given to each group for designing and presenting their idea with the reasons in front of the class.

Next, materials were given to students and let them do the experiment as they designed. This method took a plenty of time for students to figure out their troubles and try to do the experiment again and again to light the fire up. Researchers then provided a clues to students that they could use only aluminium paper and battery to light the fire. Students did the experiment until they got the result.

Researchers asked students to compare between the aluminium paper and the electric wire to let students link the activity with the real electrical fire situation. Students took an open-ended question as “How does the electrical short circuit cause a fire?” after the end of the activity.

4. Results and Discussions

The number of students who were able to explain each part of a fire caused by an electrical short circuit is shown in table 1.

Table 1. Result of students’ response related to each part of a fire caused by an electrical short circuit.

| Understanding | First part | Second part | Third part |
|---------------|------------|-------------|------------|
| Class A | 0 | 2 | 10 |
| Class B | 2 | 2 | 8 |
| Total | 2 | 4 | 18 |

Two students got the first part that is the electrical short circuit cause the overload current. Four students explained the second part that is a large amount of current can cause high heat and eighteen students mentioned the third part that is the high heat increase the temperature until it reaches over the Ignition Temperature and burn the surrounding materials.

Table 2. Missing link of students’ response between 2 parts.

| First part | Second part | Third part | Missing link |
|------------|-------------|------------|--|
| | ✓ | ✓ | Short circuit causes the high amount of current. |
| ✓ | | ✓ | High amount of current causes high heat. |
| ✓ | ✓ | | High heat causes the fire. |

To have complete understanding of a fire caused by an electrical short circuit, students have to understand all three parts together. If a student understands only first and second part, it means that he/she still does not know that the high heat increase the temperature until it reaches the Ignition Temperature can cause the fire on materials. Student cannot link between high current and heat, that a large amount of current can cause high heat, if a student gets only first and third part. In addition, if student understands only second and third part, it means that this student doesn’t know that short circuit can cause the high amount of current (See table 2). From the result, there is only one student from 62 students get every part and 2 students who respond only second and third part. Students have to understand all parts in order to fully understand the electrical fire causes in the case of short circuit because they are consequences to each other.

The misunderstanding of DC electric current that were reported by previous researchers also found in this research such as 1) 10 students had the idea of clashing current model; current come from both terminals of a battery and clash at the burning point. This misconception was similar to the one reported by Chambers and Andre [14]. 2) 13 students responded that current stored at the burning point generated the heat to increase the temperature of surrounding materials to reach the Ignition Temperature. This idea was similar to the finding of McDermott and Shaffer [6], Peşman and Eryilmaz [7], and Sencar, Yilmaz [8]; student thought that current was used up in a circuit.

5. Conclusion and Implication

The result of this research revealed that the participants could not understand and get all parts of a fire caused by an electrical short circuit understanding. A few numbers of students could explain the ideas behind the activity. They have learned only some part of the ideas and missing links between parts were found. This might be because the links of all three parts are too difficult for participants. To make the activity be more appropriate for 7th graders, more questions should be added during the activity and provide the relation between the materials used in the activity and real-life situation. However, this activity could enhance and create the curiosity of these participants.

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