GENDER DIFFERENCES IN STUDENTS' ACHIEVEMENTS IN LEARNING CONCEPTS OF ELECTRICITY VIA STEAM INTEGRATED APPROACH UTILIZING SCRATCH

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Abstract

The main aim of the presented research was to examine the interaction between student's gender and achievements in learning concepts of electricity via STEAM integrated approach utilizing Scratch. This research was aimed to determine the gender disparity for lower-secondary school students in learning about the concepts of electricity. Quasi-experimental design involving male and female groups was used in this research. Students were required to utilize Scratch to design games and animated stories on electricity concepts. The Electricity Achievement Test (EAT) was administered for pre- and post-test. The findings proved that the STEAM integrated approach via Scratch could narrow the gap between male and female in learning concepts of electricity. The findings of ANCOVA indicated that the intervention had similar positive effects on male and female students' achievement in learning concepts of electricity. This research also provided a new method and an alternate connective framework for learning concepts of electricity via art and showed that both males and females were able to understand the topic of electricity, which reduced gender biases and disparity in the field of science.
Keywords: *electricity achievement level, Gender gap, Scratch, STEAM integrated approach.*

Introduction

Modern human life has been made more convenient and luxurious with the presence of electricity. From the lightning in homes to charging the electrical cars (Moodley, 2013), electricity is relevant to existence; therefore, it is a vital, demanding, and essential science topic at the slightest degree of school levels, from primary to tertiary institutions (Jaakkola & Nurmi, 2004). Moreover, electricity topic had been the subject of many research and conferences (Duit et al., 1985, Moodley, 2015; Psillos, 1998). Although the knowledge of electricity has already been developed from primary schools and became complex at secondary and tertiary levels, students still face conceptual and reasoning difficulties in learning electricity concept (Guisasola, 2014; Gunstone et al., 2009; Mulhal et al., 2001). In order to reduce the conceptual and reasoning difficulties, a STEAM integrated approach via Scratch (technology) that is based on the connectivism theory was applied in this research. Connectivism theory explains the link between individual and organizational learning by using the technology (Sa'adi, 2016) in learning electricity concepts. Technology is developed to enhance the modern way of life, communicate and learn in the digital era (Sa'adi, 2016). Such application of connectivism theory in electricity concepts learning connects science, technology, engineering, art and mathematical elements in educational activities. Having said this, less focus was put to research on gender disparity (Çakiroglu, 1999; Kerkhoven et al., 2016) in understanding and achievement in the topic of electricity. Some previous results indicated that males had achieved higher scores in science results compared to females, and these gender disparities grew as students progressed further in school (Çakiroglu, 1999; Kerkhoven et al., 2016). As reported, lots of females had low performance and lost interest toward science (Kerger et al., 2011; Kerkhoven et al., 2016) whereas males performed better than their female counterparts and they dominated the science field (Çakiroglu, 1999; Kerkhoven et al., 2016). Thus, in order to attract the interest of female students in the topic of electricity, to instill their positive attitudes toward electricity, and to increase their achievement in the electrical concepts, the STEAM integrated approach via Scratch (technology) based on the connectivism theory was applied in this study.

Research Problem

Among many science topics in science syllabus, it was reported that students complained that the electricity topic was the most difficult to understand (Choi & Chang, 2004). It was proven by the significant gap between the students' achievement in electricity (Choi & Chang, 2004; Jaakkola & Nurmi, 2008). This gap such as understanding abstract concepts and long existed misconceptions (Osman, 2017) indicated that students had learning difficulties in topics with regards to electricity concepts (Jaakkola & Nurmi, 2008; Moodley, 2015).

The highly abstract and complex concepts of electricity had caused plenty of wrong interpretations of electricity concepts that occurred among students (Osman, 2017). The complexity of the idea also had caused confusion between electricity concepts and the vocabulary used such as "electricity energy", "voltage", "electric power" (Guisasola, 2014). Indirectly, these confusions in the electricity concept had caused misconceptions that were often the outcomes of the student's own construction process of understanding (Gunstone et al., 2009). According to Moodley (2015), students had already developed a broad range of wrong ideas and beliefs about electricity concepts from their everyday experiences before they entered science classrooms (Moodley, 2015; Shipstone, 1984) from a young age (Fredette & Clement, 1981). However, these direct experiences were misleading and did not provide accurate basic concepts of electricity and the principles associated with it (Jaakkola & Nurmi, 2004; Ronen & Eliahu, 2000). Students were found mistakenly using the term such as "power" and "electric current" in explaining electricity (Gunstone et al., 2009); thus, the researcher proposed a new method to change these misconceptions among students in this research.

In addition, numerous research found in the scholarly articles did not include gender disparities in achievement for electricity knowledge even though it was reported that severe gender differences did exist in other fields of science achievement (Christidou, 2006; Snyder et al., 2013). Females were found far falling behind males (Jovanovic et al., 1994), and males performed better than females in science education (Kerkhoven et al., 2016) Female had a keen interest in topics that related to science of life, healthcare, food, and art; while males were more concerned in science, technology, and especially the challenging parts of technology and science, and as well as pursued more in technical work and computer application (Christidou, 2006). Previous research findings had indicated that gender differences were related to learning capacity.

Moreover, interaction using the STEAM integrated approach via Scratch between female and male for increasing learning concept electricity achievements has not been well examined yet. Subsequently, it was a challenge to study the interaction using the STEAM integrated approach via Scratch and genders for learning electricity concept achievements. That was the reason why the current teaching strategies need to be revised with the intention to facilitate students' studying and understanding on subject matter with the hope to reduce misconceptions and reduce the gender gap in learning concepts of electricity achievement. Based on these concerns, this research aimed to address the above-mentioned gap in the research.

Research Focus

The analogies and metaphors are an excellent helper to facilitate students in realizing the comprehension of the electricity concepts to resolve the problematic electricity questions (Mulhall et al. 2001). Various attempts had been conducted to overcome these problems of concepts of electricity learning difficulties, but the useful and effective methods are still being in question in the researchers' mind (Jaakkola & Nurmi, 2004). Jaakkola and Nurmi (2004) had recognized that teaching methods using the text or carried out the hand-on experiments with the real apparatus were ineffective in teaching electricity lessons. For instance, using the fluid metaphor as the motion current (Rosencwajg, 1992) and electric current left the battery at one end and showed the electric current on the different part of electric components within a circuit.

It was reported that most of the efforts to address the learning gap in the electricity topic might be the result of lacking art integration in learning. The art is found to facilitate science learning and enables the science idea to be more meaningful and easier to grasp (Dawkins, 1998). Kim et al. (2012) stated that science and arts complement one another because science provided a working tool within the art, while art provided a creative ideal within the evolution of science. Moreover, within the planet, people dominated and applied the characteristics of either side of science and art (Oner et al., 2016). The components of cultures, art, and science had in common for human curiosity and creativity, and the desire to know and represent the unknown (Rose & Parker, 1994). Thus, with the integration of arts in the teaching concepts of electricity concepts lessons, students should see connections between every component in electricity with art and reduce the learning issue especially among the female groups.

Besides that, the gender gap was also being the topic of discussion in this research. It was found that many researchers have discussed the gender gap issue in science for some period (Alvarado et al., 2012; Patitsas et al., 2014). This problem of gender imbalance, such as low participation of females and underrepresentation of females in using computer sessions, always come to debate (Shillabeer & Jackson, 2013; Utting et al., 2010). For instance, some 'hidden curriculum' was found to express those females being less important than males. This results in decreasing confidence and anticipation that caused educational failure among females (Clarricoates, 1978; Cruickshank et al., 2002). Spender (1981) also acknowledged that some educational models (Spender, 1981) and teaching material generated by men had the intensity to neglect females (Northam, 1987). There were similar considerations about the poor representation of females in the field of computing and science (Howland & Good, 2015; Klawe et al., 2009; Qian & Lehman, 2016; Simard et al., 2010). That is why it is a vital equity issue in science education in secondary and tertiary education similarly, especially in the information technology industry and applied science course (Acker & Oatley, 1993). So, this research involved male and female groups in learning electricity concepts via Scratch (the visual programming) and the achievement of learning electricity concepts between genders were studied in this research.

Connectivism Theory and Achievement in Learning Concepts of Electricity

It is reported that connectivism theory advocates organizing skills (Siemens, 2005). In constructing the new knowledge of electricity concepts, the organizing skills are needed to help the students organize the abstract concept and form their different patterns, behavior, and structure of the electricity concepts to make it easier to understand. Indirectly, these organizing skills could reduce the number of difficulties in understanding the necessary practice of simple electrical circuits such as electric resistance, electric current and voltage as reported by lots of research scholars (Sengupta & Wilensky, 2009). Siemens (2005) also defined self-organization as the spontaneous formation skills that enable students to have the capability to well-organize the structures, patterns, or behaviors, with the interaction with the environment. Hence, the difficulties in constructing formal concepts of electric circuits, the symbol of the electric component in electric circuit and characteristic of the electric circuit (McDermott & Shaffer, 1992; Urban, 2017) as well as difficulty in reasoning the elements of the electric circuit or reasoning the formula (Viennot, 2001) could be solved with the self-organized skill in connectivism theory.

Furthermore, according to Siemens (2005), connectivism provided guidance in relating and connecting the knowledge that are required for students to succeed in a digital age. By understanding the issues of students in interrelating, connectivism theory promoted interrelation to the students in relating and connecting the concepts of sciences applied in understanding the different sub-topics in electricity concepts. Students need to be equipped with the ability to relate, link and combine all the knowledge learned in the subtopic of electricity topic. Hence, the meaning-making and forming connections between every lesson on electricity topic based on the connectivism theory to interpret the concepts of electricity and connect the behavior of electrics.

The quality instructional teaching did not only facilitate conceptual change but also reduce misconceptions and enhanced understanding and achievement (AlDahdouh et al., 2015). It was crucial to remedy students' alternative conceptions on electricity concepts that might have developed from their own experience (Moodley, 2015; Shipstone, 1984). Such changes could be made by using connectivism theory where students learn by constructing new knowledge from time to time when interacting with the environment; using this way they might not persist in having the wrong concept. Under the connectivism theory, it could enable students to develop and review their understanding of electricity concepts by relating and utilizing the different disciplines of content knowledge of Science, Mathematics, and Engineering when handling concepts of electricity in daily life. In short, connectivism theory shows that knowledge is built based on the combination of different subjects. Therefore, learning was the capability to build and navigate those different subjects together (Downes, 2012).

The advance in technology has evolved the knowledge on electricity concepts. Even the new generation of researchers such as the connectivists, they had proposed a new method of constructing knowledge based on connectivism theory (AlDahdouh et al., 2015). AlDahdouh et al. (2015) argued that enormous changes were taking place along the educational processes, and the learning was impossible to construct on the former methods and experience. According to the connectivists, they claimed that the former educational environment had changed (AlDahdouh et al., 2015). Therefore, it is beneficial to carry out learning concepts of electricity lessons and processes based on the connectivism theory even though the previous experience had long been treated as the best teacher of knowledge; however, not all the learners could experience many things at all the time (Makina, 2016).

Besides, those meaning making and making connections, relationships between every subtopic of electricity topic will be more meaningful with the help of digital learning tools like computer education applications. Digital learning tools played a powerful tool in shaping and defining learner thinking, especially by introducing innovative learning methodologies (Shrivastava, 2018), especially in this advanced digital era. Different views of learning contribute to different perspectives on knowledge development. Those meaning-making processes by organizing the abstract concept, patterns, behavior, and structure of the electricity appeared to be more comfortable with the help of these digital learning tools. Moreover, learning with digital learning tools also advocated in the connectivism theory (Siemens, 2005). Technology played a leading role in determining (AlDahdouh et al., 2015) as technology made learning more adapted in the digital age as well as making the interrelation between the content knowledge. The usage of technology required the learner to be entirely involved and active in the lessons. As the full participation paid by the students, students will be critical, creative, algorithmic thinking, and problem-solving, all of which were the actions in Bloom's Taxonomy's higher level (AlDahdouh et al., 2015). Hence, Scratch was used in this research in order to carry out the STEAM integrated approach via Scratch. In this view, connectivism prepared the transition in learning experience and works to achieve a motivated and conducive educational environment using technology tools and resources (Siemens, 2005).

STEAM integrated approach via Scratch based on Connectivism Theory

Connectivism theory was the learning theory for the digital age (Şahin, 2012) as it provided the necessary change in learning experience and activities from the conventional method to ensure a motivated and advanced educational environment with computer (Makina, 2016; Siemens, 2005). This could also be used in explaining STEAM literacy. According to Sahin (2012), connectivism theory reflected the types of knowledge and parallel with the fast changing of the new information in an information age (2012). Besides that, it emphasized the usage of media or technology as a powerful tool in learning in this digital age (Shrivastava, 2018). In other words, connectivism reflects that the society is developing swiftly, complicated, socially interconnected, worldwide, and intermediated by increasing advance of technology (Makina, 2016). So, connectivism could be used as the guidance in the way to prepare the whole rounded students across disciplines, which is parallel with the STEAM integrated approach via Scratch in this research.

It can be said that connectivism theory is a useful theory in guiding the learning of electricity as the theory integrates previous information to current information by incorporating technology. A mix and integration of computer program application, content knowledge, and social networks on students, environment, systems, and entities could be interrelated to experience an integrated whole experience (Goldie, 2016) in learning the concepts of electricity. The comprehensive and rounded development of expertise among students could be achieved by interrelating and combination of different subjects and knowledge to interpret knowledge and hold the experience (Siemens, 2008) in electricity topic. In other words, connectivism theory enables students to construct their understanding by connecting all the knowledge gained as it recognized these issues along with the knowledge of electricity with lots of subtopics. It was parallel with the STEAM integrated approach via Scratch across disciplines as it connected computer applications, people, and among group members in creating their understanding of electricity. It also described the ways that students require knowledge (Muelheck et al.,2017).

In learning concepts of electricity, students used the STEAM integrated approach via the Scratch-visual programming language in constructing their understanding. STEAM integrated approach via Scratch prepared students comprehensively to cultivate not only skill in one discipline, but also across all disciplines (Bahrum, 2017) for holistic and rounded development of students from the perspective of knowledge, skills, and values, spiritual and emotional which parallel with connectivism theory. Connectivism theory promoted transdisciplinary learning across the different discipline lessons (Quigley & Herro, 2016), which is parallel with the application of the STEAM integrated approach via Scratch in this research.

One of the disciplines in the STEAM integrated approach was integrating art and the aesthetic framework in the art could be applied either interdisciplinary or transdisciplinary framework (Hammer, 1996). Artistic method is always being used when facing the unfamiliar setting-social or physical or a set objects or concepts in solving the problem. STEAM integrated approach via Scratch was applied in designing games and animated stories activities on electricity to appreciate the aesthetic value and aesthetic experience via the creations. The application of art into the science lessons same as the scientists and artists also had the same similarity methodologies in solving the problems. From a behavioral view, both scientists and artists apply observation, inspection, and reflection to analyze abstract environmental signals (Quigley & Herro, 2016). As students observe, inspect, reflect, and play, they visualize and make sense of abstract concepts like voltage, current, and so on. By reflecting on students' practice of designing games and animated stories, students enhanced and gained their understanding by using the aesthetic tool to abstract reasoning and critical thinking (Hammer, 1996) in the electricity learning.

Art Integration in Game and Animated Stories Designing with Scratch

In this study, the students were required to design two projects, namely designing games and animated stories. STEAM integrated approach via Scratch was used in the designing based on the connectivism theory to enhance the achievement in learning electricity concepts. Scratch was used to design games and animated stories, which was parallel with Kalelioğlu and Gülbahar's (2014) study where they used Scratch as the tool in research. Scratch features are user friendly such as it has different blocks (sound effect block, string operator block, pen block, glide block, music blocks etc.), front, type of extensions, type of support, and sprites/ characters make the games and animated stories designing more accessible and interactive. From the perspectives of arts as well as the sciences, the projects represented a unique quantum of interpretation that made sense of external abstract signals. The projects were unique in their presentation as they combined works of art, formulas, electricity theories, or diagrams, but all of them have the similarities in which those projects communicated abstract ideas in electricity content. It was parallel with Hammer (1996) who incorporated art and aesthetics in his STEAM laboratories to enhance science education in an aesthetic framework.

In designing games, the main focus of students was on the usage of art in delivering electricity concepts in order to enhance their achievement in the topic of electricity. The game designing project focused on the way of students infused the art element together with engineering and technology artistically in designing games. Students were needed to apply science and mathematics concepts to compute and modify the spirits steps (the character in Scratch) in the STEAM integrated approach via Scratch. Along the designing process, students had to integrate the content knowledge across science, technology, engineering, art, and mathematics as parallel with connectivism theory identified the connection of all the content knowledge (Gleick,1987) in electricity topic as well as the meaning-making and forming interrelation between lessons on electricity concepts. Self-organization in connectivism theory was needed in the process of designing the games on electricity. Students had to organize and control every movement and motion of the spirit and design the new and attractive flow of the games by using different media like music and sound effects. Applying art in a real situation often leads to deeper learning (Jolly, 2014) of the content of electricity as the students had the opportunity to communicate content knowledge and information artistically. Therefore, games designing required creating and forming connections and making connections, especially the abstract nature of electricity concepts and reasoning required in learning concepts of electricity (Clements & Nastasi, 1999; Gibbons et al., 2003; Jabot & Henry, 2004) that is parallel with the connectivism theory.

Next, in designing animated stories, connectivism theory enables students in relating, combining, and connecting the theories, thinking, and electricity content knowledge learned in the classroom with their daily real-life. Indirectly, the designing process had created a significant influence on students' life and their ability to construct their understanding and insight (Siemens, 2004). Through this animated story project, students started to explore the concept of electrostatic, the flow of electric current or voltage to have the necessary comprehension and understanding of the content knowledge before constructing the stories. Then, students started to design the flow of the story and learned about the usage of Scratch in helping them to create the flow of the stories. Students were also required to control every movement and motion of the spirit and they also had to design the impressive, attractive and smooth flow of the stories by using different blocks in Scratch, like music and sound effects.

Research Significance

Connectivism theory reflected the character of information and aligned it with the fast-developing information in the digital advance (Şahin, 2012). Connectivism theory is used as the guidance in the way to prepare the whole rounded students across disciplines through the STEAM integrated approach via Scratch. Throughout the research, the literacy level of the males and females was enhanced, and this might create the gender-balanced science field as the young generations today are more exposed to the innovative and new knowledge with the presence of technology. Indirectly, the STEAM literacy level among females will be increased to improve the achievement in TIMSS and PISA as the achievement in science and mathematics associated with the achievement in TIMSS and PISA (Wiberg & Rolfsman, 2019). This kind of research can be used to motivate the students by using a STEAM integrated approach in increasing the TIMSS results over the world.

This research also provided a prediction on the evolution of multimedia within the classroom. Therefore, an upgrade of the education process could set the direction for future learning within the context of this new interactive era. Curriculum planners could integrate the STEAM integrated approach by using Scratch into the electricity content teaching curriculum in order to reduce the misconceptions in electricity concepts. With guidance from the constructivism theory, the method of teaching and learning in schools may be transformed and given a new driving force to the students in learning concepts of electricity in an exceedingly more fun method. Students had the better grip on the electricity understanding.

In this research, the arts integration in learning science is highlighted on the application of the arts-based activity which employed the knowledge content from other disciplines as the art-based activities meet the art and non-art syllabus goal coincident. Accordingly, students could visualize the electricity's abstract concepts. The STEAM integrated approach via Scratch allows students to participate and make connections between art and non-art in learning concepts of electricity activities in order to achieve a fully understanding of the electricity concepts. In this research, the art is designed with Scratch. It is created by students when they used Scratch (the visual programming tools) to create and design (use the Engineering and Mathematics) the Scratch product (Art). Engineering and technology allow students to test students' emerging scientific knowledge and apply it to practice. Most teachers realize that integrating technology into the curriculum is the most appropriate way to create constructive change in education (Smaldino et al., 2008). At the same time, many scholars also admitted that lots of specific approaches could be applied to integrate technology to the curriculum (Sezer et al., 2013). Hence, arts activities in the STEAM integrated approach via Scratch equally interrelated the academic curriculum, electricity content knowledge and artistic lessons which guided by the lesson plans contain state curriculum standards for content areas and the arts, well planned art-based activities with Scratch, assessments with rubrics (Mishook and Kornhaber, 2006).

The purpose of this research was to study the gender differences in learning concepts of electricity achievement through STEAM integrated approach via Scratch. Therefore, the findings from this research were aimed to assist students in understanding and to be more motivated toward the electricity topic to reinforce the mastery of the fundamental abstract key concept, and to address misunderstanding between the male and female groups. Thus, the questions for the research included: a) What is the male students' learning concept of electricity achievement score after the STEAM integrated approach intervention?; b) What is the female students' learning concept of electricity achievement score after the STEAM integrated approach intervention? and c) Is that any difference on learning concept of electricity achievement scores between male and female students?

Research Methodology

General Background

Quasi-experimental design engaging male and female group were used in this research with the intention of studying the gender differences in learning concepts of electricity achievement. For both groups, the lessons on the electricity were taught using the STEAM integrated approach by using Scratch. A pre-test was carried out before the intervention to both groups. The objective of the pre-test was to identify students' prior knowledge and level of comprehension of the concepts of electricity. After the pre-test, they were given the intervention for two months from October to November. After the lessons, the students were required to design the games and animated stories based on the electricity topic by using Scratch. Also, a post-test was carried out to both groups after the intervention. The objective of the post-test was to identify the effect of the teaching approach in increasing students' learning concepts of electricity achievement.

Sample

In this research, a total of 59 lower-secondary school students had participated. There were 30 females and 29 males in this research. When samples were broken into sub-samples (male and females), a minimum sample size of 30 for each category was necessary (Sekaran, 2003) and may ease the research (Martínez-Mesa et al., 2014). Also, both groups were taught by experienced science teachers.

Instrument

Electricity Achievement Test (EAT) was utilized to evaluate the samples' theoretical knowledge of electricity concepts and EAT were numerous structured question tests that consisted of seven questions. The EAT was developed after the analysis of the misconception study by Ramnarain and Moosa (2017) and based on the learning standards and performance standards given in the KSSM secondary lower Science and the format of Lower Secondary Assessment. Each question in the test contained four to five sub-questions under the same subtopic. The test covered four subtopics under the second lower science syllabus, which were: 1) Electricity, 2) Method in Measuring Electricity, 3) Relation between electric current, voltage plus resistance, and, 4) Electric current flow in a series circuit and parallel circuit. The EAT was administered to the students before and after the intervention. The EAT was validated by two expert science teachers. Both teachers ensured that the EAT was aligned with the Malaysian syllabus and was suitable for lower secondary students in terms of the more straightforward language used. The time allocation to answer these questions was about 60 minutes. The EAT was piloted with five students from another school who were not involved in this research. The reliability of EAT was .964 and this showed that the EAT was reliable to be applied in this research.

Research Context

In Malaysia, electricity is one of the important physics concepts within the science subject for years (CDC, 2017; CDC, 2016). Since the current issues of students' learning difficulties in electricity is mainly on the content knowledge and abstract concept. Hence, starting at a young age at Year 2 in school, the topic of electricity has been included in the science curricula until the college level (CDC, 2017; CDC, 2016). Meaning the exposure of scholars on electricity is earlier in Malaysia.

The Malaysian school system is divided into primary school, secondary school, and tertiary institution. The students are taught the topic of electricity since their primary school years. From Level I in primary school, which is from Year 1 to Year 3, the pupils learn Physics under the theme "Learning about the World Around Us." They learn the batteries, properties of magnetism, and a complete circuit. They also learn the method to make a bulb in a circuit brighter or dimmer, identify an electricity conductor, and use a switch to complete or break a circuit (Syllabus for Integrated Curriculum for Primary Science, 2003). For Level II in the primary school, which is from Year Four to Primary Six, the curriculum contents are organized under the theme "Investigating Energy and Force." The pupils learn electricity at a more sophisticated level. The electricity chapter covered the series and parallel circuit, conductor, and insulator and electrical devices that may transform electricity into others. (Syllabus for Integrated Curriculum for Primary Science, 2003).

In 2016, the syllabus content of science for primary school was reformed to the Integrated curriculum for primary schools DKSP KSSM primary Year 2 (CDC, 2016). The topic electricity begins in Year 2 and Year 5, respectively. In Year 2, the students learn to identify the electric component, the function of the element, build the complete circuit, and estimate the reason for the unlighted bulb. In Year 5, the students learn about the electrical sources, how to produce the electric circuit, identify the electrical symbol, and draw the electrical diagram.

Even though the students were exposed to the topic of electricity at a quite early age, there were reports that the educational achievement of students was still below expectations (Atsumbe et al., 2018). This failure to satisfy expected standards was as a result of the continual usage of inappropriate teaching that is mostly a conventional teaching strategy. The conventional teaching strategy caused a poor understanding of electricity among pupils (Aydeniz, 2010; Gibbons et al., 2003). It influenced students' prior knowledge and produced a broad style of learning concept achievements (Guisasola, 2014; Saglam & Millar, 2005). Hence, the connectivism-based instructional approach is utilized in this study that is believed to have the qualities that might facilitate conceptual change which allows understanding among students and increases their achievement in the topic of electricity.

Intervention

The intervention was carried out by using two lessons over one (1) week in three (3) months. Each lesson lasted for 90 minutes. Both groups underwent the same intervention and the differences were the gender of the groups and taught by two different science teachers with a similar background in terms of qualification and years of teaching experience. Both groups of students were instructed with the STEAM integrated approach using Scratch. During the intervention, the teachers used Scratch to present the content knowledge on electricity and the way of using Scratch. After the lessons, the students were grouped into a group of two. Then, students designed the games and animated stories on electricity, which integrated the content knowledge across science, technology, engineering, art, and mathematics. The instrument applied in this research to evaluate students' learning concepts of electricity achievement on electricity is EAT. This instrument was applied to assess the level of learning concepts of electricity achievement.

Data Analysis

The Paired Sample T-test and one-way ANCOVA were used in testing the hypotheses. Paired sample T-test was used to compare the mean scores for either the male or female students on pre-test and post-test. At the same time, one-way ANCOVA was used to explore differences between the male and female students while statistically controlling the pre-test as the covariate.

When the post-EAT scores were compared to the pre-EAT scores of the participants in both groups, the gains of the students in both groups were compared. Besides that, in analyzing the students' games and animated stories, the rubrics were used, which was validated by science teachers and ICT teachers. The rubrics were designed by the researcher based on the learning objectives of the electricity lessons with the purpose of evaluating the students' learning concepts of electricity. The evaluation of the games was based on the topic of the games, flow of the games, usage of color and pattern in Scratch, method in playing the games, and types of music inserted in the games. On the contrary, the animated stories assessment was according to the stories' topics, flow of the story, the smooth movement and motion of the spirit and usage of different media like music, sound effect.

Research Results

Table 1 shows the mean and Standard Deviation on Pre-test and Post-test of Male and Female Students' Achievement in Learning Concepts of Electricity:

Table 1
Mean and standard deviation on pre-test and post-test of male and female students' achievement in learning concepts of electricity.

Gender		*M*	*SD*	*N*
Male	Pre-test	49.79	5.63	29
	Post-test	59.72	7.00	
Female	Pre-test	44.27	6.71	30
	Post-test	59.23	4.26	

The mean and the standard deviation on the pre-test and post-test of males and females were shown in Table 1. A total of 29 male students in the study with the mean and standard deviation of the pre-test (M=49.79, SD=5.63) and post-test (M=59.72, SD=7.00). Similarly, a total of 30 female students with the mean and standard deviation of pre-test (M=44.27, SD=6.71) and post-test (M=59.23, SD=4.26).

Table 2 shows the paired sample t-test between the pre-test and post-test of male students' achievement in learning concepts of electricity:

Table 2
Paired sample t-test between the pre-test and post-test of male students 'achievement in learning concepts of electricity

	Paired Differences							
				95% Confidence Interval of the Difference				
Pre-test Post-test	*M*	*SD*	Std. Error Mean	Lower	Upper	*t*	*df*	*p*
	-9.93	7.71	1.43	-12.86	-7.00	-6.94	28	.01

A paired sample t-test was carried out to test the different effect between the pre-test and post-test scores of achievements in learning electricity concept for male students. The result of the paired t-test, as shown in Table 2, was found significant at t(28) = -6.94, $p <.05$ (two-tailed), η2=.64, since $p< .05$, confirming a substantial difference between the pre-test and post-test score of achievement in learning concepts of electricity for male students. Based on Cohen's guidelines (1988) and Sawilowsky (2009), this effect size was very moderate, implying that there is a significant increase in achievement of electricity scores from the pre-test (*M*=49.79, *SD*=5.63) to the post-test (*M*=59.72, *SD*=7.00) for male. The rise in mean was 9.93, with the 95% confidence level interval for differences between the means of -12.86 (lower bound) to -7.00 (upper bound) so that the hypothesis was rejected. Therefore, it implies that there is a significant difference between the pre-test and post-test of achievement in electricity for male students.

Table 3 shows the paired samples t-test between pre-test and post-test of female students' learning concepts of electricity achievement.

Table 3
Paired samples t-test between pre-test and post-test of female students' learning achievement in electricity

	Paired Differences							
				95% Confidence Interval of the Difference				
Pre-test Post-test	*M*	*SD*	Std. Error Mean	Lower	Upper	*t*	*df*	*p*
	-14.97	7.53	1.37	-17.78	-12.16	-10.89	29	.01

A paired sample t-test was carried out to test the significant difference between the pre-test and post-test scores of achievements in learning concepts of electricity for female students. The result of the paired t-test, as shown in Table 3, was found significant at t (29) =-10.89, $p< .05$(two-tailed), η2=.81), since $p< .05$, confirming a significant difference. This effect size is primarily based on Cohen's guidelines (1988) and Sawilowsky (2009), implying that there is a substantial increase in learning concepts of electricity achievement scores from the pre-test

(*M*= 44.27, *SD*= 6.71) to post-test (*M*= 59.23, *SD*= 4.26). The rise in mean is 14.97, with the 95% confidence level interval for differences between the means of -17.78 (lower bound) to -12.16 (upper bound). This, therefore, implies that there was a significant difference between the pre-test and post-test of concepts of electricity achievement in electricity learning for female students. Since it is already statistically varied in Table 1 that there is a substantial difference between male and female pre-test achievement scores, it is expedient to use the one-Way ANCOVA to evaluate the effect of the STEAM integrated approach intervention on male and female students' concepts of electricity achievement while controlling the pre-test scores. Table 4 shows the one-way ANCOVA for significant difference between male and female students' achievements in learning concepts of electricity at post-test.

Table 4

The result of one-way ANCOVA for significant difference between male and female students achievements in learning concepts of electricity at post-test

Source	Type III Sum of Squares	df	Mean Square	*F*	*p*	Partial Eta Squared
Corrected Model	73.45[a]	2	36.72	1.13	.33	.04
Intercept	2543.97	1	2543.97	77.97	.00	.58
Pretest	69.90	1	69.90	2.14	.15	.04
Gender	3.01	1	3.01	.09	.76	.00
Error	1827.26	56	32.63			
Total	210597.00	59				
Corrected Total	1900.71	58				

R Squared = .039 (Adjusted R Squared = .004)

From Table 4, ANCOVA test was carried out to test the different effect of STEAM integrated approach on male and female performance in electricity concepts achievement after the effect of the pre-test is controlled. After adjusting for the pre-test on students' achievement in electricity, there was no significant difference between male and female students on post-test achievement scores in electricity after the STEAM integrated approach via Scratch intervention since $p > .05$ implying that the researcher failed to reject the null hypothesis $F (1, 56) =.09$, $p= .76$ (two-tailed), ηp2(partial eta squared) =.00. It means that the study intervention has similar positive effects on male and female students' achievement in electricity alike, with a significant increase from pre-test to post-test achievement scores. This, therefore, implies that there is no significant difference between the post-test achievement of male and female students in electricity after the effect of the pre-test is controlled.

Table 5

Estimated marginal means for differences between male and female students' achievement in learning contents of electricity at post-test

			95% Confidence Interval	
Gender	*M*	Std. Error	Lower Bound	Upper Bound
Male	59.22[a]	1.12	56.99	61.46
Female	59.72[a]	1.09	57.53	61.91

a. Covariates appearing in the model are evaluated at the following values: Pre-test (Achievement in electricity) = 46.98

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The estimated marginal means in Table 5, implied that the adjusted means while controlling for the covariate, which was the pre-test on achievement in electricity learning with that of male participants (M= 59.22) almost similar to females (M=59.72) counterparts. Besides, the estimated marginal means showed the adjusted ways on the dependent variable, which was the achievement scores in electricity for each of the male and female students. 'Adjusted' here connoted that the effect of the covariate has been removed statistically (Pallant, 2011).

Discussion

In this research, the effect of the STEAM integrated approach via Scratch on electricity concepts and the gender differences were evaluated. This research evaluated the performance of STEAM integrated approach via Scratch on electricity topic. The research indicates that the STEAM integrated approach via Scratch had successfully supported both male and female students' learning concepts of electricity achievement. Both male and female students showed the increasement in EAT scores and the capability in producing the electricity games and animated stories.

To answer Research Question 1 and 2, the research finding shows that the intervention had a positive effect in increasing both male and female group's concepts of electricity achievement (Table 2 and 3). In the pre-test, both the male and female students failed to answer the pre-EAT well. Most of the students answered EAT with lots of misconceptions, and some of them failed to answer EAT. However, after the intervention, more male and female students showed the capability in designing games and animated stories on electricity. This indicates that students have a good and better theoretical understanding and directly the electricity concepts misconceptions are reduced. The improved understanding among the male and female students might be due to the STEAM integrated approach via Scratch employed by the teacher. The abstract concept in electricity was visualized through art in Scratch and all knowledge across the discipline is connected to the computer in generating the understanding when designing the games and animated stories. The outcome of this research is parallel with the concept of STEAM cultivate not only skills in one discipline, but also across all disciplines for holistic and rounded development of students as reported in the literature (Bahrum, 2017).

The positive results of STEAM integrated approach via Scratch in increasing concepts of electricity achievement are consistent with the principles of connectivism theory (Siemens, 2005) which promote learning across different disciplines (Quigley & Herro, 2016). Students could construct their own understanding on electricity by interrelating and combining the knowledge from different disciplines (Siemens, 2005) in STEAM. Makina (2016) also revealed that students were capable in connecting the data or knowledge learned across different subjects with connectivism theory. The students could maintain the relation between the electricity concepts and theory, and this shows that they were more accessible life-long learning such as constant update and shift of information (Makina, 2016). In another study, Downes (2012) also agreed that connectivism theory enables knowledge interrelated and distributed across a variety of different fields and not just confined in one subject area.

After the intervention, the students had showed the potential to relate, combine and connect the theories, thinking, and content knowledge learned in the classroom with their daily world and indirectly created a significant influence on students' life and their ability to construct their correct understanding and expertise in electricity. Concurrently, those relating, connecting the theories, thinking, and content knowledge capabilities are congruent with the connectivism theory. These capabilities resulted in a significant increase within the post-test means score in electricity achievement in the male and female groups, respectively. It had been proven that by applying artistic elements in the STEAM integrated approach via scratch, it has the possibility to increase male and female group electricity achievement. This shows that arts contribute plenty to learning because arts usually integrate motor skills in designing the projects, in addition to perceptual representation in Scratch and language in understanding. With the integration of art in learning concepts of electricity, the students had the possibility of using their right brain, which is responsible for creativity. The left brain was found to utilize the arts component, which presents the logic tasks (science and mathematics) at the same time (Jacobs & Azmitia, 1992). A combination of both science (left brain) and art (right brain) (Jacobs & Azmitia, 1992) has an excellent possibility to extend students' achievement in electricity.

Furthermore, other problems in learning concepts of electricity were the abstract and complex concepts of electricity, which was considered as an invisible phenomenon (Osman, 2017). These problems seemed to be solved throughout the design during the intervention which the students visualized the abstract concept and formulated the flow of the electron through the circuit, resistance, series circuit, and parallel circuit. The art in the STEAM integrated approach via Scratch had prepared the students' visual attractiveness of electricity. This research had proven that students could create good aesthetics in designing games and animated stories, which lead to better usability and user experience in visualizing the abstract concept. Hence, the STEAM integrated approach via Scratch seemed sensible to unravel the issues because it would scale back misunderstanding by visualizing the abstract idea of electricity during the games and animated story design.

Through games and animated stories as well, the students began to explore the concept of electrostatic which is the flow of electric current or voltage. They gained understanding of the content knowledge before constructing the stories. According to connectivism, learning does not make sense to be considered only by the internal construction of wisdom from the books (Siemens, 2005); instead, what students can gain in the external development of knowledge from the surrounding with the help of digital learning tools, such as Scratch, the block programming as learning. With the experience and practical activities that required the students to implement the knowledge of electricity concepts in designing games and stories, the students seemed capable in organizing the content, especially the abstract one. Furthermore, the user-friendly features of Scratch included sound effect block, and operators that made it easier to figure with text (strings), pen blocks (including support for transparency), and glide block that enabled the animated stories to be designed efficiently.

In response to Research Question 3, the research finding shows that the intervention had a similar effect in increasing both male and female group's concepts of electricity achievement by comparing the post-test (Table 4). The claims in the literature were also consistent with this research finding. It could be observed from the games making process where the students combined knowledge from science, technology, engineering, art, and mathematics. The students also infused the art element together with engineering and technology when designing games that required science and mathematics concepts to calculate and modify the movement of spirits in the STEAM integrated approach via Scratch. The action of the spirit changing in the background, and the music and sound effect also required to enhance students in manipulating their knowledge from the different subject areas. Application of art together with music empowered students applied the systematic and well-organized electricity content knowledge and indirectly broadened the students' self and world understanding by interpreting the different areas of knowledge (Pomeroy, 2012) in completing the designing. In the design, the art refers to the visual beauty of a product (Pomeroy, 2012). The research finding has proven that creating good art in a very product results in better usability and user experience within the STEAM integrated approach via Scratch. This was reflected that the female group can perform as well as male group in the concepts of electricity achievement. The arts have the potential to enhance the engagement of both male and female groups in STEAM projects since the students could integrate artistic mediums that they enjoyed (like visual arts and music) with more technical projects that would seem daunting like building electricity games in this study. The students were ready to accustom to the unfamiliar situation by acquiring new skills and discovering the world of artistic innovation during this study through Scratch as the visual programming tool.

Within the review of the STEAM integrated approach via Scratch in enhancing electricity achievement, the STEAM integrated approach via Scratch is congruent with the connectivism theory. With guidance from the constructivism theory, the method of teaching and learning in schools may be transformed and given the new trust to the students in learning concepts of electricity in a more fun method.

Conclusions

In this research, a quasi-experimental design engaging male and female groups was applied. There were three important findings for concepts of electricity achievement in this research: 1) male students showed improvement in concepts of electricity achievement after the STEAM integrated approach via Scratch; 2) female students showed improvement in concepts of electricity achievement after the STEAM integrated approach via Scratch; 3) the STEAM integrated approach increased both male and female students' concepts of electricity achievement. Indirectly, the approach reduced the gender gap and created the gender balance in learning electricity topic. The STEAM integrated approach via Scratch imposed the positive effect in reducing the difference in gender in concepts of electricity achievement. The connectivism theory has proven as a helpful framework for comprehension and guiding the teaching and learning processes among students. The educational environment based on the connectivism theory has identified the relevant correlation of electricity sub-topic, Scratch, and the context of the situation. However, this research also shows few limitations with regard to the generalization of the findings. Hence, the STEAM integrated approach via Scratch could be carried out with larger samples from different schools throughout the country. Besides that, it is highly recommended that qualitative methods be included in future research as the qualitative interviews had the potentials of deriving views from participants', (Creswell, 2002).

Implications of the Research

The research finding has proven that STEAM integrated approach via Scratch could increase students' achievement in the concepts of electricity. Hence, it is strongly suggested that the STEAM integrated approach via Scratch is incorporated into the planning and development of teaching and learning courseware for all topics. This research shows that STEAM integrated approach via Scratch can be applied to facilitate content and reduce misconceptions in electricity topic. It shows that the students highly valued the interactive Scratch with the STEAM integrated approach. The results have created several impacts on science teachers, educators, and researchers such as on the emerging of the STEAM integrated approach via Scratch in educating students especially in science subject, integration of art into science, application of Scratch in teaching. Therefore, a suggestion will be proposed to the Ministry of Education to implement more in-house training to expose the teachers using this approach. Also, the STEAM integrated approach is highly recommended in teaching and learning other science concepts.

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References

Adamo SA. (2013). Attrition of women in the biological sciences: Workload, motherhood, and other explanations revisited. *Bioscience*, *63* (1), 43–8.

AlDahdouh, A., Osorio, A., & Caires, S. (2015). Understanding knowledge network, learning and connectivism. *International Journal of Instructional Technology and Distance Learning*, *12*(10), http://ssrn.com/abstract=3063495

Alvarado, C., Dodds, Z., & Libeskind-Hadas, R. (2012). Increasing women's participation in computing at Harvey Mudd College. *ACM Inroads*, *3*(4), 55-64. http://dx.doi.org/10.1145/2381083.2381100

Acker, S., & Oatley, K. (1993). Gender issues in education for science and technology: Current situation and prospects for change. *Canadian Journal of Education/Revue canadienne de l'education*, *18(*3), 255-272. https://www.jstor.org/stable/1495386

Atsumbe, B., Owodunni, S., Raymond, E., & Uduafemhe, M. (2018). Students' achievement in basic electronics: Effects of scaffolding and collaborative instructional approaches. *EURASIA Journal of Mathematics, Science and Technology Education*, *14* (8), https://doi.org/10.29333/ejmste/91898

Aydeniz, M. (2010). Measuring the impact of electric circuits kitBook on elementary school children's understanding of simple electric circuits. *Electronic Journal of Science Education*, *14*(2), http://ejse.southwestern.edu/article/view/7304

Bahrum, S., Wahid, N., & Ibrahim, N. (2017). Integration of STEM Education in Malaysia and Why to STEAM. *International Journal of Academic Research in Business and Social Sciences*, *7*(6), 645-654.

Borrelli, A., & Grieser, A. (2017). Recent research on the aesthetics of knowledge in science and in religion. *Approaching Religion*, *7*(2), 4-21. https://doi.org/10.30664/ar.67710

Brna, P. (1988). Confronting misconceptions in the domain of simple electrical circuits. *Instructional Science*, *17*, 29–55. https://doi.org/10.1007/BF00121233

Çakiroglu J., (1999). Gender difference in the science. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *16* (17), 127 – 133.

Choi, K., & Chang, H. (2004). The effects of using the electric circuit model in science education to facilitate learning electricity-related concepts. *Journal of the Korean Physical Society, 44* (6), 1341-1348.

Christidou V. (2006). Greek students' science-related interests and experiences: Gender differences and correlations. *International Journal of Science Education*, *28* (10), 1181-1199. https://doi.org/10.1080/09500690500439389

Clarricoates, K. (1978). Dinosaurs in the classroom— A re-examination of some aspects of the 'children's curriculum in primary schools. *Women's Studies International Quarterly 1*, *1*(4), 353-364. https://doi.org/10.1016/S0148-0685(78)91245-9

Clements, D. H., & Sarama, J. (1997). Research on Logo: A decade of progress. *Computers in the Schools, 14*(1-2), 9-46.

Cohen, J. (1988). *Statistical power analysis for the behavioral Sciences (*2nd ed.*)*. Hillsdale, NJ: Eribaum.

Creswell, J. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. NJ: Prentice Hall.

Cruickshank, M., Deem, R., Kant, L., & Whyte, J. (2002). Girl friendly science and the girl friendly school. In J. Whyte, R. Deem, L. Kant and M. Cruickshank (Eds.), *Girl friendly schooling* (pp.95-110). Routledge.

Curriculum development center (CDC). (2017). *Integrated curriculum for secondary schools DKSP KSSM junior secondary: Science syllabus*. Minister of Education Malaysia. https://bpk.moe.gov.my

Curriculum development center (CDC). (2016). *Integrated curriculum for primary schools DKSP KSSM primary year two: Science syllabus*. Minister of Education Malaysia. https://bpk.moe.gov.my

Dawkins, R. (1998). *Unweaving the rainbow: Science, delusion, and the appetite for wonder*. Teachers College Press.

Dharmadasa, I., & Silvern, S. B. (2000). Children's conceptualization of force: Experimenting and problem solving. *Journal of Research in Childhood Education*, *15*(1), 88-103.

Dorji, U., Panjaburee, P., & Srisawasdi, N. (2015) Gender differences in students' learning achievements and awareness through residence energy saving game-based inquiry playing. *Journal Computer Education.* 2, 227–243. https://doi.org/10.1007/s40692-015-0033-2

Downes, S. (2012*). Connectivism and connective knowledge: Essays on meaning and learning networks.* National Research Council Canada. http://www.downes.ca/files/books/KnowledgeLearning.

Duit R., Jung W., & Rhoneck C. (1985). *Aspects of understanding electricity: Proceedings of an international workshop: An inventory of research results concerning the representation of students' knowledge of electricity and its uses for the improvement of teaching*. Ludwigsburg, Institut für die Pädagogik der Naturwissenschaften an der Universität Kiel, Kiel.

Duit, R., & von Rhöneck, C. (1998). Learning and understanding key concepts of electricity. In A. Tiberghien, E.J. Jossem & J. Barajos (Eds.), *Connecting research in physics education with teacher education.* International Commission on Physics Education.

Fredette, N. H., & Clement, J. J. (1981). Student misconceptions of an electric circuit: What do they mean?. *Journal of College Science Teaching, 10*(5), 280-85.

Gentner, D., & Gentner, D. (1983). Flowing waters or teeming crowds: Mental models of electricity. In D. Gentner & A. L. Stevens (Eds.), *Mental models* (pp. 99–129). Lawrence Erlbaum.

Gibbons, P., McMahon, A., & Wiegers, J. (2003). Hands-on current electricity: A professional development course. *Journal of Elementary Science Education*, *15*(2), 1–11.

Gleick, J. (1987). Chaos: *The making of a new science*. Penguin Books.

Guisasola, J. (2014). Teaching and learning electricity: The relations between macroscopic level observations and microscopic level theories. In M. Matthews (ed), *International handbook of research in history, philosophy and science teaching* (pp. 129-156). Springer.

Gunstone, R., Mulhall, P., & McKittrick, B. (2009). Physics teachers' perceptions of the difficulty of teaching electricity. *Research in Science Education, 39*(4), 515-538.

Hammer, D. (1996). More than misconceptions: Multiple perspectives on student. Knowledge and reasoning, and an appropriate role for educational research. *American Journal of Physics*, *64*(10), 1316–1325.

Howland, K., & Good, J. (2015). Learning to communicate computationally with flip: A bi-modal programming language for game creation. *Computers & Education, 80,* 224-240.

Jaakkola, T., & Nurmi, S. (2008). Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities. *Journal of Computer Assisted Learning*, *24*(4), 271-283.

Jabot, M., & Henry, D. (2007). Mental models of elementary and middle school students in analyzing simple battery and bulb circuits. *School Science and Mathematics, 107*(1), 371-381.

Jacobs, B. L., & Azmitia, E. C. (1992). Structure and function of the brain serotonin system. *American Physiological Society Physiological Reviews*, *72*(1),165-229. https://doi.org/10.1152/physrev.1992.72.1.165

Jovanovic, J., Solano-Flores, G., & Shavelson, R. J. (1994). Performance-based assessments: Will gender differences in science achievement be eliminated?. *Education and Urban Society*, *26*(4), 352-366.

Kalelioglu, F., & Gülbahar, Y. (2014). The effects of teaching programming via scratch on problem solving skills: A discussion from learners' perspective. *Informatics in Education, 13*(1), 33-50.

Kerger, S., Martin, R., & Brunner, M. (2011). How can we enhance girls' interest in scientific topics?. *British Journal of Educational Psychology*, *81*(4), 606-628.

Kerkhoven, A. H., Russo, P., Land-Zandstra, A. M., Saxena, A., & Rodenburg, F. J. (2016). Gender stereotypes in science education resources: A visual content analysis. *PloS One*, *11*(11). https://doi.org/10.1371/journal.pone.0165037

Kim W. (2012). Building conceptual framework to bring up talents capable of creative fusion: From the perspective of fusion between science and technology and art. *The Journal of the Korean Society for the Gifted and Talented, 11*(1), 97-119.

Klawe, M., Whitney, T., & Simard, C. (2009). Women in computing take 2. *Communications of the ACM, 52*(2), 68-76. http://doi.org/10.1145/1461928.1461947

Kop, R., & Hill, A. (2008).Connectivism: Learning theory of the future or vestige of the past?. *International Review of Research in Open and Distance Learning, 9*(3), 1-13.

Makina, A. (2016). The theory of connectivism in enhancing leadership/management competences in e-learning in higher education. *African Educational Research Journal*, *4*(4), 152-159.

Martínez-Mesa, J., González Chica, D. A., Bastos, J. L., Bonamigo, R. R., & Duquia, R. P. (2014). Sample size: How many participants do I need in my research? *Anais brasileiros de dermatologia*, *89*(4), 609-615.

Moodley, K. (2015). The relationship between teachers' ideas about teaching electricity and their awareness of learners' misconceptions. *Doctoral dissertation, University of Pretoria.*

Mueller, J., Beckett, D., Hennessey, E., & Shodiev, H. (2017). Assessing computational thinking across the curriculum. In: Rich, P., & Hodges, C. (Eds), Emerging research, practice, and policy on computational thinking. Educational communications and technology: Issues and Innovations. Springer, Cham. https://doi.org/10.1007/978-3-319-52691-1_16

Mulhall, P., McKittrick, B., & Gunstone, R. (2001). Confusions in the teaching of electricity. *Research in Science Education*, *31*, 575–587.

Newell, A. (1999). *Unified theories of cognition*. Cambridge, MA: Harvard University Press.

Northam, J. (1987). Girls and boys in primary maths books. In G. Weiner & M. Arnot (Eds.), *Gender under scrutiny*. Unwin Hyman.

Oner, A. T., Nite, S. B., Capraro, R. M., & Capraro, M. M. (2016). From STEM to STEAM: Students' beliefs about the use of their creativity. *The STEAM Journal*, *2*(2), 6.

Osman K. (2017). Addressing secondary school students' misconceptions about simple current circuits using the learning cycle approach. In M. Karpudewan, A. Md Zain, A. Chandrasegaran (Eds.), *Overcoming students' misconceptions in science* (pp. 223-242). Springer.

Patitsas, E., Craig, M., & Easterbrook, S. (2014). A historical examination of the social factors affecting female participation in computing. In ITICSE (Ed.), *Proceedings of the 2014 conference on Innovation & technology in computer science education* (pp. 111-116). Association for Computing Machinery. https://doi.org/10.1145/2591708.2591731

Peter, O. I., Abiodun, A. P., & Jonathan, O. O. (2010). Effect of constructivism instructional approach on teaching practical skills to mechanical related trade students in western Nigeria technical colleges. *International NGO Journal*, *5*(3), 059-064.

Pomeroy, S. R. (2012). From STEM to STEAM: Science and art go hand-in-hand. *Scientific American Guest Blog*. http://blogs.scientificamerican.com/guest-blog/from-stem-to-steam-science-and-the-arts-go-hand-in-hand/

Psillos, D. (1998). Teaching introductory electricity. In A. Tiberghien, E.J. Jossem & J. Barajos (Eds.), *Connecting research in physics education with teacher education.* International Commission on Physics Education. http://www.physics.ohio-state.edu/~jossem/ICPE/E4.html

Pugh, K. J., & Girod, M. (2007). Science, art, and experience: Constructing a science pedagogy from Dewey's aesthetics. *Journal of Science Teacher Education*, *18*(1), 9-27.

Qian, Y., & Lehman, J. D. (2016). Correlates of success in introductory programming: A study with middle school students. *Journal of Education and Learning*, *5*(2), 73.

Ramnarain, U., & Moosa, S. (2017). The use of simulations in correcting electricity misconceptions of grade 10 south african physical sciences learners. *International Journal of Innovation in Science and Mathematics Education (formerly CAL-laborate International)*, *25*(5).

Ronen, M., & Eliahu, M. (2000). Simulation A bridge between theory and reality: The case of electric ciruits. *Journal of Computer Assisted Learning, 16*, 14-26

Rose, P., & Parker, D. (1994). Nursing: An integration of art and science within the experience of the practitioner. *Journal of Advanced Nursing*, *20*(6), 1004-1010.

Rosencwajg, P. (1992). Analysis of problem-solving strategies on electricity problems in 12 to 13 year olds. *European Journal of Psychology of Education, 7*(1), 5–22.

Saglam, M., & Millar, R. (2005). Diagnostic test of students' ideas in electromagnetism. *Research Paper Series University of York (UK).* University of York, Department of Educational Studies. https://www.academia.edu/30594142/Diagnostic_Test_of_Students_Ideas_in_Electromagnetism

Şahin, M. (2012). Pros and cons of connectivism as a learning theory. *International Journal of Physical and Social Sciences, 2*(4), 437-454.

Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach*. John Wiley & Sons.

Sawilowsky, S. S. (2009). New effect size rules of thumb. *Journal of Modern Applied Statistical Methods, 8*(2), 597-599. http://digitalcommons.wayne.edu/jmasm/vol8/iss2/26

Scheer, A., Noweski, C., & Meinel, C. (2012). Transforming constructivist learning into action: Design thinking in education. *Design And Technology Education: An International Journal*, *17*(3), https://ojs.lboro.ac.uk/DATE/article/view/1758

Sengupta, P., & Wilensky, U. (2009). Learning electricity with NIELS: Thinking with electrons and thinking in levels. *International Journal of Computers for Mathematical Learning*, *14*(1), 21-50.

Sezer, B., Karaoglan Yilmaz, F. G., & Yilmaz, R. (2013). Integrating technology into classroom: The learner-centered instructional design. *Online Submission*, *4*(4), 134-144.

Shrivastava, A. (2018). Using connectivism theory and technology for knowledge creation in cross-cultural communication. *Research in Learning Technology*, *26*, 1-16. https://doi.org/10.25304/rlt.v26.2061

Shillabeer, A., & Jackson, K. (2013). Gender imbalance in undergraduate IT programs–A Vietnamese perspective. *Innovation in Teaching and Learning in Information and Computer Sciences*, *12*(1), 70-83.

Shipstone, D. M. (1984). A study of children's understanding of electricity in simple DC circuits. *European Journal of Science Education, 6*, 185-198.

Siemens, G. (2005). Connectivism: Learning as network-creation. *ASTD Learning News, 10*(1). http://www.astd.org/LC/2005/1105_seimens.htm

Simard, C., Stephenson, C., & Kosaraju, D. (2010). *Addressing core equity issues in K-12 computer science education: Identifying barrier and sharing strategies*. The Anita Borg Institute and the Computer Science Teachers Association.

Snyder T. D., & Dillow, S. A. (2013). *Digest of education statistics*. United States Department of Education, Institute of Educational Sciences; 2015. https://nces.ed.gov/pubs2015/2015011.pdf

Spender, D. (1981). Education: The patriarchal paradigm and the response to feminism. In M. Arnot & G. Weiner (Eds.), *Gender and the politics of schooling*. Unwin Hyman.

Stohr-Hunt, P. M. (1996). An analysis of frequency of hands-on experience and science achievement. *Journal of Research in Science Teaching*, *33*(1), 101-109.

Urban, H. (2017). Sequential reasoning in electricity: Developing and using a three-tier multiple choice test. *Scientia in Educatione*, *8*(Special issue), 285-292. https://doi.org/10.14712/18047106.755

Utting, I., Cooper, S., Kölling, M., Maloney, J., & Resnick, M. (2010). Alice, greenfoot, and scratch--a discussion. *ACM Transactions on Computing Education (TOCE)*, *10*(4), 17. https://doi.org/10.1145/1868358.1868364

Quigley, C. F., & Herro, D. (2016). Finding the joy in the unknown: Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, *25*(3), 410-426.

Viennot, L. (2001). *Reasoning in physics. The part of Common Sense*. Kluwer Academic Publisher.

Wiberg, M., & Rolfsman, E. (2019). The association between science achievement measures in schools and TIMSS science achievements in Sweden. *International Journal of Science Education*, *41*(16), 2218-2232.

Appendix: Some Items from EAT

Question 1

1. Name the type of circuit in the empty boxes provided in Diagram 1.1

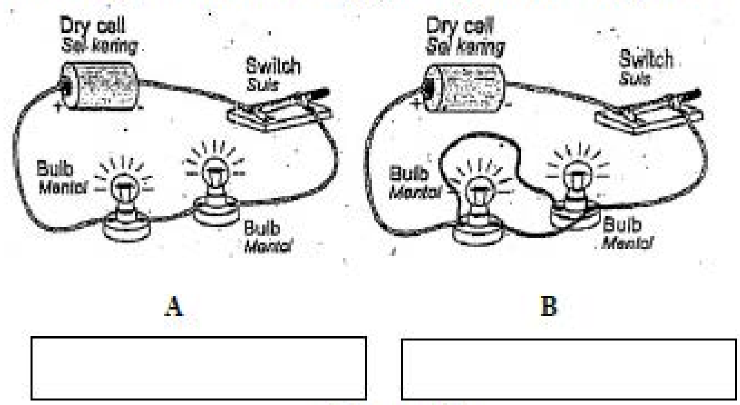

Diagram 1.1

(2 marks)

(b) The Diagram 1.2 below shows a parallel circuit with three identical bulbs, P, Q and R.

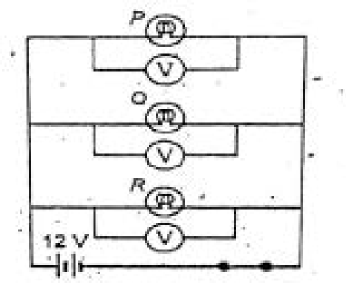

Diagram 1.2

(i) Based on the Diagram 1.2, state the brightness of all the bulbs. Explain.

____

____

____

(2 marks)

(ii) If the resistance of bulb P is 3 ohms, what is the voltmeter reading across R if bulb Q burns out? Then, state the effect on bulb P and bulb R.

____

____

____ (2 marks)

(c) The Diagram 1.3 shows a complete electrical circuit. The metal paper clip is moved along the wire from K to L.

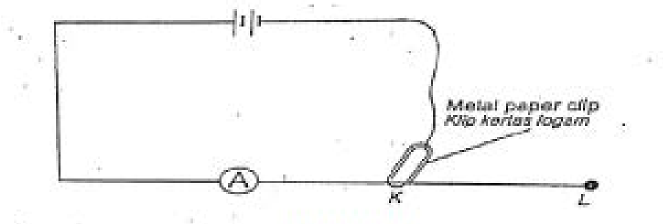

Diagram 1.3

What happens to the ammeter reading as the clip moves along the wire from K to L? Explain your answer.

____

____

____ (2 marks)

(d) Diagram 1.4 shows the circuit A, B , C and D. Which circuit will light the bulb?

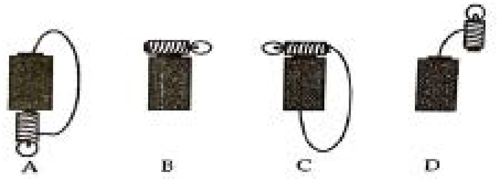

Diagram 1.4

____ (2 marks)

(e) Diagram 1.5 shows a complete electric circuit.

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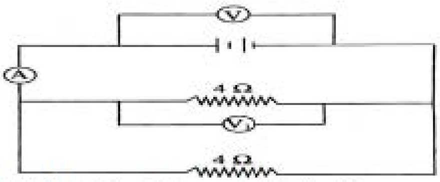
Diagram 

1.5

(i) Calculate the total resistance of this circuit.

Answer:

(2 marks)

(ii) What is the voltage of V_1 if the voltage of V is 3 volts?

____

(1 mark)

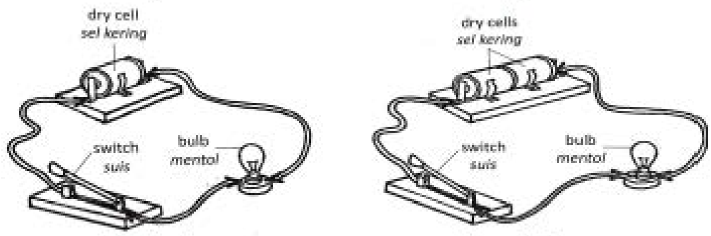
(iii) Give one advantage of the circuit shown in Diagram 1.5 if it is used in a house.

____

(1 mark)

Question 2

2 Two students set up two electric circuit as shown in Diagram 2.1



Circuit A **Circuit B**

Diagram 2.1

(a) What is the difference between circuit A and circuit B?

____

____

(1 mark)

(b) The circuit in Diagram 2.1 can be used to study the relationship between voltage and the brightness of the bulb. Explain how to get the result from the set-up of the component in Diagram 2.1

____

____

____

____

____
(4 marks)

(c) The brighter the bulb means more current flows through the circuit. What component can be added to measure current in the circuit?

____
(1 mark)

(d) Compare the brightness of bulb A in circuit 1 with bulb A in circuit 2 as shown in Diagram 2.2. Which bulb is dimmer?

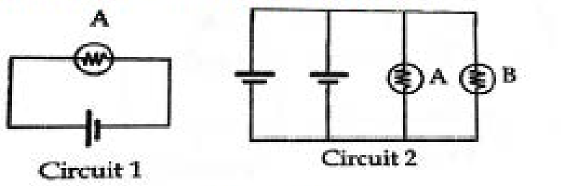


Diagram 2.2

____
(1 mark)

(e) Bulbs B1, B2 and B3 and switches S1, S2 and S3 are connected in a circuit shown in Diagram 2.3. All the bulbs are functioning properly.

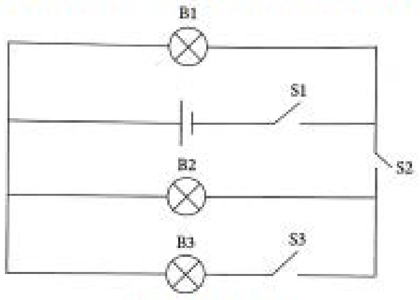


Diagram 2.3

(i) Identify the bulb if any that will light uo when

- SI is closed: ______________________
- S2 is closed: ______________________
- S3 and S1 are closed: ______________________

(3 marks)

(ii) Between serial and parallel circuit, which one would you use for decoration lights during festive seasons? Justify your answer.

____

____

____

____

(3 marks)

Question 3

3 (a) The Diagram 3.1 shows a control knob which controls the speed of a ceiling fan. The control knob consists of wires of different thickness.

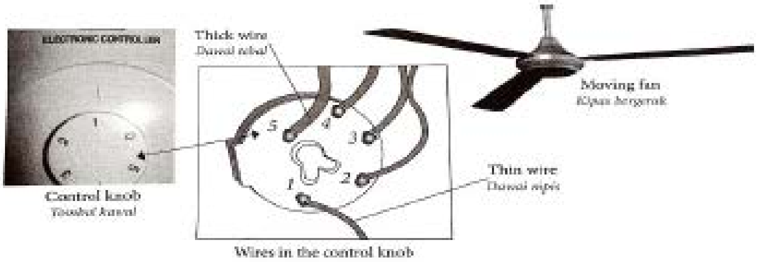


Diagram 3.1

(i) State a relationship between the thickness of the wire in the control knob with the speed of the fan.

____

(1 mark)

(ii) Explain how the thickness of the wires in the control knob controls the speed of the fan.

____

____

____

____

____

(3 marks)

(b) A student wants to carry out an experiment to study the relationship between resistance and current.

(i) Draw a circuit diagram that can be used in this.

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(2 marks)

(ii) Based on the circuit diagram drawn in b(i), explain how you can determine the relationship between resistance and the current flowing in the circuit. In your explanations, state all the variables involved in the experiment.

____

____

____

____

____

(4 marks)

(c) Based on the Diagram 3.2, draw schematic diagram to represent the realistic circuit shown below.

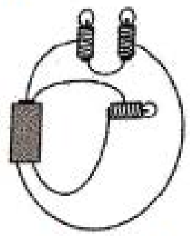

Diagram 3.2

(2 marks)

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