THE EFFECTIVENESS OF STEAM INTEGRATED APPROACH USING SCRATCH MODULE ON ACHIEVEMENT AND COMPUTATIONAL THINKING IN LEARNING ELECTRICITY CONCEPTS

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LIST OF ABBREVIATIONS

ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BPK	*Bahagian Pembangunan Kurikulum*
BPPDP	*Bahagian Perancangan dan Penyelidikan Dasar Pendidikan*
CT	Computational Thinking
CTS	Computational Thinking Survey
CA	*Cerita Animasi*
CFIT	Culture Fair Intelligence Test
CLES	Constructivist Learning Environment Survey
DSKP	*Dokumen Standard Kurikulum dan Pentaksiran*
EAT	Electricity Achievement Test
HOTS	Higher Order Thinking Skills
ICC	Intraclass Correlation Coefficient
ITEAA	International Technology and Engineering Education Association
JPN	*Jabatan Pendidikan Negeri*
KBSM	*Kurikulum Bersepadu Sekolah Menengah*
KPM	*Kementerian Pendidikan Malaysia*
KSSM	Secondary School Standard Curriculum
MANCOVA	Multivariate Analysis of Covariance
MANOVA	Multivariate Analysis of Variance
MEB	Malaysian Education Blueprint
MKO	More Knowledgeable Other
NAEP	National Assessment of Educational Progress report
NGSS	Next Generation Science Standards
NSF	National Science Foundation

OECD	Organisation for Economic Co-operation and Development
RBT	*Reka Bentuk dan Teknologi*
RPH	*Rancangan Pengajaran Harian*
PT	*Permainan Tekanan*
Pdp	*Pengajaran dan pembelajaran*
PIPP	*Pelan Induk Pembangunan Pendidikan*
PISA	Programme for International Student Assessment
PPD	*Pejabat Pendidikan Daerah*
PPPM	*Pelan Pembangunan Pendidikan Malaysia*
PT3	*Pentaksiran TingkatanTiga*
SPM	*Sijil Pelajaran Malaysia*
STEM	Science, Technology, Engineering and Mathematics
STEAM	Science, Technology, Engineering, Art and Mathematics
TIMMS	Trends in International Mathematics and Science Study
ZPD	Zon Proximal Development

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KEBERKESANAN PENDEKATAN INTEGRASI STEAM MODUL SCRATCH TERHADAP PENCAPAIAN DAN PEMIKIRAN KOMPUTASIONAL DALAM PEMBELAJARAN KONSEP ELEKTRIK

ABSTRAK

Kajian ini bertujuan untuk mengkaji keberkesanan pendekatan integrasi STEAM modul Scratch terhadap pencapaian, pemikiran komputasional (CT) dan lima subkonstruk CT dalam pembelajaran konsep elektrik dalam kalangan 29 pelajar lelaki dan 30 pelajar perempuan sekolah menengah Tingkatan Dua melalui modul Scratch di mana modul ini dibentuk berdasarkan reka bentuk Model ASSURE. Lima subkonstruk CT ini termasuk pemikiran algoritma, kerjasama, kreativiti, pemikiran kritis dan penyelesaian masalah. Kajian ini menggunakan reka bentuk kajian kuasi-eksperimen yang menggunakan ujian pra, ujian pasca dan ujian pasca lanjutan bagi *'Electricity Achievement Test'* (EAT) dan *'Computational Thinking Survey'* (CTS) dalam mengutip data kuantitatif. EAT yang mengandungi tujuh soalan struktur, digunakan dalam mengukur pencapaian pelajar dalam konsep electrik manakala CTS yang mengandungi dua puluh sembilan soalan dari lima subkontruk CT, digunakan untuk mengukur CT dan lima subkonstruk CT pelajar. Sementara itu, data kualitatif juga dikutip melalui penggunaan program Scratch dalam mereka cerita dan permainan mengenai konsep elektrik pada akhir intervensi. Hipotesis kajian ini diuji secara statistik inferensi menggunakan Ujian T Sampel Berpasangan, Ujian ANCOVA, Ujian MANCOVA, Ujian ANOVA Pengukuran Berulang dan Ujian MANCOVA Pengukuran Berulang. Selain itu, cerita dan permainan yang direka dinilai dengan rubrik yang dibangunkan oleh penyelidik. Hasil kajian menunjukkan bahawa

pendekatan integrasi STEAM modul Scratch dapat mengurangkan jurang antara pelajar lelaki dan perempuan dalam pencapaian, CT dan lima subconstruk CT dalam pembelajaran konsep elektrik. Penyelidikan ini juga menyediakan kaedah baru dan kerangka penghubung alternatif dalam pembelajaran topik elektrik dan penggunaan CT dalam pembelajaran sains.

THE EFFECTIVENESS OF STEAM INTEGRATED APPROACH USING SCRATCH MODULE ON ACHIEVEMENT AND COMPUTATIONAL THINKING IN LEARNING ELECTRICITY CONCEPTS

ABSTRACT

This study examined the effectiveness of STEAM (Science, Technology, Engineering, Art, Mathematics) integrated approach via Scratch module in enhancing and retaining achievement, computational thinking (CT) and five subconstructs of CT in learning electricity concepts among 29 male and 30 female Form two secondary school students through Scratch module, which was developed based on ASSURE model. The five subconstructs CT was algorithmic thinking, cooperativity, creativity, critical thinking and problem solving. In this research, a quasi-experimental design was employed with pre-test, post-test and delayed post-test of Electricity Achievement Test (EAT) and Computational Thinking Survey (CTS) to collect the quantitative data. The EAT, which consisted seven structured questions, was utilised to measure the students' achievement in the electricity concepts while CTS, which consisted twenty nine question on the five subconstruct of CT, was administered to assess the CT and five subconstructs of CT. In the other hand, qualitative data was also collected through the designed animated stories and games on electricity concepts by students at the end of the intervention. The hypotheses were tested based on inferential statistics using Paired Sample T Test, ANCOVA test, MANCOVA test, ANOVA Repeated Measure test and MANCOVA Repeated Measure test. Besides that, the developed animated stories and games were evaluated with the developed rubric by the researcher. The findings indicated that the STEAM integrated approach via Scratch module could reduce the gap between males and females in achievement, CT and five subconstruct

of CT in learning electricity concepts. Both male and female students showed the similar positive effects and no obvious significant difference. This research also provided a new method and an alternate connective framework for learning concepts of electricity, CT and five subconstruct of CT.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In STEAM education, Art (A) was integrated into STEM become STEAM, and it enhanced students' science learning through the STEM concepts visualization in the viewpoint of the art (Belbase et al., 2021; Jolly, 2014) with art experience. In the effort to further the interdisciplinary nature one step further, the STEM subjects were expanded to include the arts (Platz, 2007; LaForce et al., 2016) whereby the science learning was based on the aesthetic value of art in aesthetic learning experience. The apparent difference between STEM and STEAM education was the art discipline (Kang, 2019). So, STEAM education was chosen to increase the students' achievement and computational thinking (CT), especially in learning electricity concepts in this research.

Electricity topics was the science element in STEAM, whereby the electricity concepts were enhanced thorough the art experience in order to reduce the alternate conception on the electricity concepts. Among the identified alternative conceptions were "bulb in parallel were brighter than those in series", "batteries were constant currents source" and "none of the bulbs was lit when the switch is closed" (Kucukozer & Kocakulah, 2007). Nevertheless , students undergo aesthetically formed judgment, attitude, understanding, emotion, and value (Hekkert, 2006) in Scratch, the visual programming language. The aesthetic learning environment can be achieved through visual art in Scratch, which posed the great potential to enhance students' thinking skills in improving academic achievement and promoting thinking skills (Korkmaz, 2018) especially in the achievement in electricity concepts.

Even though students had the prior knowledge and exposure on Scratch since Year four through the "*Reka Bentuk dan Technologi*" (RBT) subject (Year four, five and six) in primary school Malaysian curriculum (Minister of Education, 2017), but it was not emphasis fully and due to the lacked of support such as internet (Loganathan et al., 2019), computer lab (Wang, 2016) and parental support; these had posed challenges to the teachers to integrated Scratch in their teaching and learning. Therefore based on the prior knowledge and Scratch did not require high proficiency (Korkmaz, 2018), the Scratch could be easily applied to design the animated stories and games during science learning activities (Loganathan et al., 2019) in the aesthetic learning experience to improve electricity concepts and CT rather than consume energy and time in using other unfamiliar programming language with stress and worry.

CT was proposed to advocate solving problem skills among students during the learning process (Nur Lisa et al., 2018) as the application of CT was usually linked to science subjects (Weng & Wong, 2017). The CT and the five subconstruct of CT, namely algorithmic thinking, cooperativity, creativity, critical thinking and problem solving (Korkmaz et al., 2015) were enhanced and retained in this research in order to close the gap between male and female students in learning electricity concepts. Even though Malaysia had successfully overcome gender inequality (Aminah et al., 2012), the gender equality was based on all the social fields (Aminah et al., 2012) not specified in the science, especially electricity topic.

In order to ensure both gender students had an equal opportunity to develop positive attitudes towards learning electricity, the Scratch module was developed in this research to study the effectiveness of the Scratch module. Under the STEAM integrated approach via Scratch module, the animated stories and games activities at

the end of the intervention provided the art-based aesthetic science learning environment, which enabled the students to use CT and five subconstruct CT skills to solve the learning problems.

1.2 Research Background

The STEAM and STEM integrated approach integrated a transdisciplinary epistemology whereby different disciplines' knowledge were taught and applied in one subject (Moore et al., 2014; Yakman, 2008) and students employed multidisciplinary knowledge and practices at one time (Kelley & Knowles, 2016). Nevertheless, in STEAM education, the art integration into the STEM disciplines strengthens the STEM education (Bahrum et al., 2017) as the potential of art in opening up new ways of interpreting, analyzing, and learning science (Bahrum et al., 2017). Art is aesthetics (Dewey, 1996).

The aesthetic value of art was the determining factor in scientific knowledge progress and revolution (McAllister, 1996) as both science and art shared the same characteristic in the aesthetics characteristic and theory (Root-Bernstein, 1997). So the role of aesthetics value of art as a scientific inquiry tool in seeking abstract scientific reasoning (Hammer, 2014) was undeniable. In the aesthetic learning experience, Scratch posed the potential in motivating and retaining students' achievement scores (Loganathan et al., 2019). The aesthetic learning experience was achieved in this research through the creation of the Scratch module in this research which provided the animated stories and games designing activities to create the process of sensation beauty in products which leaded to a happier and exciting learning experience (Hekkert, 2006). The sensation happy learning experience did pose the significant effect in increasing the achievement and application of CT skills in learning electricity concepts

(Hekkert, 2006) and finally retaining the concepts with attractive visual effect in Scratch.

Through the Scratch's spontaneous attractive visual effect (Armoni et al., 2015), user-friendly and free syntax error (Saez-Lopez et al., 2015), the secondary school Form two students in this research focused on application of CT in creating the algorithmic and simple programming language in designing the animated stories and games. Hence, the opportunity of implement CT and five subconstruct of CT skills in reusing, applying, and integrating the concepts from various disciplines (Altanis et al., 2018) was created in overcoming learning difficulties and alternate conceptions of electricity concepts. The difficulties in visualising the abstract concepts (Psillos, 1998) and correcting the alternate conception on current and voltage of simple circuits and electricity characteristic (Jaakkola & Nurmi, 2004; Roren & Eliahu, 2000; Duit & von Rhoneck, 1998; McDermott & Shaffer, 1992) was solved through problem-solving skills with critical thinking in the five subconstructs of CT skills.

This was totally different with the current teaching strategy mode in teaching and learning electricity that emphasizes theory (Wang, 2016) and paid little attention to practice and team cooperation without the application of five CT subconstruct. This method focused on individual academic performance, stressed theory knowledge learning, and lacked the team cooperation spirit (Wang, 2016). Hence, the integrated STEAM education was to expose students to practice the CT, which required them to formulate the sequence of steps in learning electricity concepts (Doleck et al., 2017) in designing the animated stories and games at the end of the intervention. This animated stories and games served as the supporting evidence data on approving the

effectiveness of Scratch module on achievement and CT besides using the Electricity Achievement Test (EAT) and Computational Thinking Survey (CTS).

1.3 Problem Statement

The fast development and advancement of technology nowadays played a significant impact on the quality of education. In providing a good quality of education, the art integration in STEM education played a vital role in providing students with art-based learning situations that required science knowledge with exploration, discovery, cooperation, and other channels (Mengmeng et al., 2019). However, there was hardly any research of the aesthetic sides of science in science education, and often aesthetics was pictured in other subjects rather than science (Wickman, 2006). Only a small number of research based on the aesthetic experience that comprised the aesthetic objectively, as a universal phenomenon, was carried out (Van Maanen, 2010).

Hence, it was undeniable that the aesthetic sides of science have been greatly neglected in science educational studies. Most students have the concept of science as the reproduction of history or a solipsistic individual construction (Wickman, 2006). This caused the knowledge regarding aesthetics' contribution to science education has not advance much (Hammer, 2014). So, the role of these aesthetic experiences in doing science in class through the art element in the STEAM integrated approach was studied in this research.

Nevertheless, most of the research on STEAM basically on the importance of STEAM education, the method of teaching STEAM education, and teaching materials in STEAM education (Metz, 2007, Papanikolaou, 2010; Yakman, 2008). Most STEAM education studies utilized the model as the teaching method (Papanikolaou,

2010; Yakman, 2008) and focused on the significance of STEAM education (Conde et al., 2019). Moreover, fewer STEAM researchers developed problem-solving skills in solving science learning lessons problems (Metz, 2007). In addition, Conde et al. (2019) acknowledged that integrating the STEAM approach in the present educational background is complicated.

In the present Malaysia educational system, Malaysia Education Blueprint (2013-2025) (Ministry of Education, 2013) promoted the high-order thinking skills (HOTs) in every subjects (Ministry of Education, 2013). However, students still faced the difficulty in applying the HOTs and CT skills to solve the problems (Jonassen, 2009; Mayer & Wittrock, 2006). Scholar education has proven that students employed computational methods blindly without comprehending the computational concepts (Rubinstein & Chor, 2014). The CT was lacking among students nowadays, especially in science (Korkmaz et al., 2015).

The science learning environment was getting worse with passive learning environment (Doleck et al*.,* 2017). It caused students hardly have the chance to construct their knowledge or voice out their suggestions creatively. As a result, students tend to be excellent passive learners and listeners (Thanh, 2010) in receiving all the scientific skills and facts without inquiry, creativity, or experimentation (Madden et al*.*, 2013). Indirectly, students who underwent this passive learning experiment become helpful concept memory learners rather than comprehend and utilize the concepts to solve high-order thinking skill problems in standardized tests (Land, 2013). Hence, students were only exposed to basic facts, scientific skills, and knowledge but rarely were evaluated and identified on the method in nursing scientists' creative skills to solve the problems (Madden et al*.*, 2013).

Hence, the calling to reduce the passive learning environment in science subject and create the fun aesthetic art integrated STEAM learning, the Scratch as the visual programming language posted a significant contribution to improving classroom teaching (Papert, 1993). Scratch was proven its applications in different subjects (Armoni et al., 2015; Colon & Maroto Romo, 2016; Gadanidis et al., 2017; Meerbaum-Salant et al., 2013) and in promoting critical thinking, problem solving, cooperation and creativity (Kordaki, 2021; Korkmaz, 2018; Land, 2013; Mladenović et al., 2017). But, all this previous research were only being conducted on a single CT skill and limited number of research found on the implementation of these five CT subconstruct namely algorithmic thinking, cooperativity, creativity, critical thinking and problem solving (Korkmaz et al., 2015) by the study samples in one time. Nevertheless, not many study on the suitable method to enhance and retain the CT skills among secondary school Form two students was conducted. Therefore, there was a urged to close the gap by using the Scratch and designed Scratch module that integrated STEAM elements to amplify the impacts on learning the science especially the electricity concepts.

Seeing today's students' problems in science learning was mainly on the facts, content knowledge and lack of problem-solving skills, especially in learning electricity concepts among males and females. Typically, the low achievement in electricity concepts was due to the students' difficulty was to visualize the abstract concept like the electrons flow within the circuit, current, and potential difference (Choi & Chang, 2004) in learning electricity without observing the actual situation (Kamilah Osman, 2017). Most students found difficulty in explaining the changes of current, brightness, voltage, and power in the circuit even though those students can calculate the potential difference with the formulae provided (Mazur 1997). On the other hand, direct

experience with everyday life may not always be efficient for forming students' basic concepts on electricity concepts and principles (Jaakkola & Nurmi, 2004; Ronen & Eliahu, 2000) as it lead to the wrong alternate conceptions. The basic electricity concepts were so weak as the students had problems constructing the concepts to electric circuits and were hard to build the functional electric circuit (Ronen & Eliahu, 2000; Duit & von Rhöneck, 1998; McDermott & Shaffer, 1992) and finally with the low achievement in learning electricity concepts.

Students were seldom given the opportunities to apply creative, critical thinking in problem-solving to design and carry out efficient problem-solving (Yadav et al., 2017). Whereas it was found that most of the attempts to overcome these electricity concepts learning difficulties and problems were lacking in art integration. Research proved that art more accessible science learning by visualizing and picturing out the science idea to be more meaningful and fruitful to comprehend and experience the world (Dawkins, 1998). Many efforts have been suggested to overcome these learning electricity concepts difficulties problems; limited number of methods have proven particularly useful (Jaakkola & Nurmi, 2004). Then, it was essential to develop an organized and systematic teaching procedure in the modules. The appropriate modules with systematic well-planned learning processes boosted motivation, learning stimulation, enhanced thinking ability, and provided sound psychological effects for learners (Novitasari et al., 2016).

Besides the unhealthy style of the learning environment, research also indicated that particular topic interest in school worldwide appears to be gendered (Chebunet et al., 2012) even though Malaysia had showed the gender equality in learning (Aminah et al., 2012) but not specifically in achievement and CT in learning

electricity concepts. The disparities in the low performance in mathematics and science between males and females have been insignificant for several years (OECD, 2018). Males always be the leader with the high scoring in science assessment (Kerkhoven et al., 2016). Previous research found that gender differences contribute to learning capacity (Christidou, 2006), achievement in science education, conditioning study choices, and defining beliefs and interests (Jiménez Iglesias et al., 2018). So in this research, the STEAM integrated approach teaching was carried out using the Scratch module on achievement and CT skills that included five CT subconstructs among the male and female students.

1.4 Research Objective

This research presented pleasant and creative learning approach via STEAM integrated approach. In this context, students designed and developed animated stories and games while having fun aesthetic learning environment in learning electricity concepts and CT. Specifically, the research was carried out to examine the followings:

1. To compare the effect of STEAM integrated approach via Scratch module on achievement in learning electricity concepts among male and female Form Two secondary school students.
2. To compare the effect of STEAM integrated approach via Scratch module on retention of achievement in learning electricity concepts among male and female Form Two secondary school students.
3. To compare the effect of STEAM integrated approach via Scratch module on level of CT and five subconstruct of CT in learning electricity concepts among male and female Form Two secondary school students.

4. To compare the effect of STEAM integrated approach via Scratch module on retention of level of CT and five subconstruct of CT in learning electricity concepts among male and female Form Two secondary school students.

1.5 Research Questions

Based on the research objectives 1 and 2, research questions 1 and 2 were generated in order quantitative and qualitative approach were implemented out to evaluate the effectiveness of STEAM integrated approach using Scratch module in achievement in learning electricity concepts. The following research questions were formulated to guide the study:

Research Question 1

1a. Is there any significant difference between the pre-test and post-test of achievement in learning electricity concepts for male students who follow STEAM integrated approach via Scratch module?

1b. Is there any significant difference between the pre-test and post-test of achievement in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module?

1c. Is there any significant difference on the post-test of achievement in learning electricity concepts between male and female students who follow STEAM integrated approach via Scratch module after the effect of pre-test is controlled?

Research Question 2

2a. Is there any significant difference between the post-test and delayed post-test of achievement in learning electricity concepts for male students who follow STEAM integrated approach via Scratch module?

2b. Is there any significant difference between the post-test and delayed post-test of achievement in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module?

2c. Is there any significant difference on the delayed post-test of achievement in learning electricity concepts between male and female students who follow the STEAM integrated approach via Scratch module after the effect of pre-test is controlled?

Based on the research objectives 3 and 4, research questions 3 and 4 were generated in order quantitative and qualitative approach were implemented out to evaluate the effectiveness of STEAM integrated approach using Scratch module in the level of CT and five subconstruct of CT, namely algorithmic thinking, cooperativity, creativity, critical thinking and problem solving (Korkmaz et al., 2015; Doleck et al., 2017) in learning electricity concepts. The following research questions were formulated to guide the study.

Research Question 3

3a. Is there any significant difference between the pre-test and post-test in the level of CT and five subconstruct of CT in learning electricity

concepts for male students who follow STEAM integrated approach via Scratch module?

3b. Is there any significant difference between the pre-test and post-test in the level of CT and five subconstruct of CT in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module?

3c. Is there any significant difference on the post-test in the level of CT and five subconstruct of CT in learning electricity concepts between male and female students who follow STEAM integrated approach via Scratch module after the effect of pre-test is controlled?

Research Question 4

4a. Is there any significant difference between the post-test and delayed post-test in level of CT and five subconstruct of CT in the learning electricity concepts for male students who follow STEAM integrated approach via Scratch module?

4b. Is there any significant difference between the post-test and delayed post-test in the level of CT and five subconstruct of CT in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module?

4c. Is there any significant difference on the delayed post-test in the level of CT and five subconstruct of CT in learning electricity concepts between male and female students who follow the STEAM integrated approach via Scratch module after the effect of pre-test is controlled?

1.6 Research Hypotheses

The study was guided by the following hypotheses formulated at 0.05 significance level whereby the qualitative approach and quantitative approach were carried out the research questions 1,2,3 and 4.

In an attempt to answer the research question 1, the following hypotheses were tested in the study.

$H_{01(a)}$: There is no significant difference between the pre-test and post-test of achievement in learning electricity concepts for male students who follow STEAM integrated approach via Scratch module.

$H_{01(b)}$: There is no significant difference between the pre-test and post-test of achievement in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module.

$H_{01(c)}$: There is no significant difference on the post-test of achievement in learning electricity concepts between male and female students who follow STEAM integrated approach via Scratch module after the effect of pre-test is controlled.

In an attempt to answer the research question 2, the following hypotheses were tested in the study.

$H_{02(a)}$: There is no significant difference between the post-test and delayed post-test of achievement in learning electricity concepts for male students who follow STEAM integrated approach via Scratch module.

$H_{02(b)}$: There is no significant difference between the post-test and delayed post-test of achievement in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module.

$H_{02(c)}$: There is no significant difference on the delayed post-test of achievement in learning electricity concepts between male and female students who follow the STEAM integrated approach via Scratch module after the effect of pre-test is controlled.

In an attempt to answer the research question 3, the following hypotheses were tested in the study.

$H_{03(a)}$: There is no significant difference between the pre-test and post-test in the level of CT and five subconstruct of CT in learning electricity concepts for male students who follow STEAM integrated approach via Scratch module.

$H_{03(b)}$: There is no significant difference between the pre-test and post-test in the level of CT and five subconstruct of CT in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module.

$H_{03(c)}$: There is no significant difference on the post-test in the level of CT and five subconstruct of CT in learning electricity concepts between male and female students who follow STEAM integrated approach via Scratch module after the effect of pre-test is controlled.

In an attempt to answer the research question 4, the following hypotheses were tested in the study.

$H_{04(a)}$: There is no significant difference between the post-test and delayed post-test in the level of CT and five subconstruct of CT in learning electricity concepts for male students who follow STEAM integrated approach via Scratch module.

$H_{04(b)}$: There is no significant difference between the post-test and delayed post-test in the level of CT and five subconstruct of CT in learning electricity concepts for female students who follow STEAM integrated approach via Scratch module.

$H_{04(c)}$: There is no significant difference on the delayed post-test in the level of CT and five subconstruct of CT in learning electricity concepts between male and female students who follow STEAM integrated approach via Scratch module after the effect of pre-test is controlled

1.7 Research Significance

STEAM education plays a vital role in keeping up with today's education developments. STEAM education's scope, theory, and practices in all educational levels can reorganize the instructional programs in compliance with the approach (Ceylan, & Ozdilek, 2015). Even though STEAM is still very new in Malaysia, introducing STEAM awareness in this new millennium is essential and urgent as the importance and high benefits of art incorporated into STEM developments (Sousa & Pilecki, 2013) in Malaysia.

For this reason, a STEAM integrated education via Scratch module was developed for the topic of electricity. The module acts as the teachers' guidance in guiding the teachers in integrating the STEAM integrated approach via Scratch in their lessons. That will also be the sample teaching module for other science topics with

STEAM integrated education using Scratch. Through this research, the intervention helped teachers in carrying out the explanations to students using the Scratch. The goal was to keep the teachers' alternative teaching method in educating the students within the syllabus while providing proper encouragement and motivation through new technologies such as Scratch in learning electricity. Teachers were exposed to the knowledge on using the STEAM integrated approach to improve the students' achievement in learning electricity concepts and CT. The research prepared a prediction on the usage of different multimedia in the classroom in the science evolution for future learning processes within this new interactive era.

The research posed the competency in helping students enhance and retain their achievement in electricity through the aesthetic art experience whereby students undergo the aesthetic judgment under the Scratch and analyze the possible solutions for the risen questions during electricity concepts learned. It provided a forecast in the multimedia evolution within the classroom, which will set the basis for future learning processes and a new driving force in learning the electricity concepts and other science concepts in a more fun method. Besides that, the aesthetic way of science learning creates a new innovative way of learning electricity concepts—artworks with science. Therefore, the findings from this research aimed to help students understand and get motivated toward the subject by mastering the primary key concept quickly, particularly the abstract concepts in fun.

In Malaysia, the STEM integrated approach gained attention in the KSSM 2017 and KSSR revision in the latest curriculum (Bahrum et al., 2017). Nevertheless, the different efforts were still being carried out to integrate more innovative practices into the science curriculum (Bahrum et al., 2017). With the integration of art into STEM,

students are motivated to become technology designers rather than users of the technology. This is because the power of arts creates a subjective view of science, creating an objective view of the world (Sousa & Pilecki, 2013). Arts and sciences do not compete; they are interrelated (Sousa & Pilecki, 2013). The aesthetic value of art plays the primary influencer in the science concepts improvement (McAllister, 1996).

Students have to be actively involved in learning the electricity concept via the Scratch module in the STEAM classroom. This was because students were involved in hands-on activities. By this, the students will not remain passive in the classroom. This research helped to enhance the low-ability learners' in learning the electricity concepts. If the previous was achieved, it also stimulated the students' interest in learning electricity in a fun and pleasing aesthetic science learning. The aesthetic learning experience provides an interactive visualization learning experience. So, the intervention was expected to offer additional option instruction medium to the science learning process to enhance students' science STEAM environment of learning and achievement in electricity and CT.

CT is a fundamental skill for everybody (Bocconi et al.,2016) besides the primary and reading skills (Riley & Hunt, 2014). So, introducing STEAM integrated education with the integration of art has a high probability of increasing the achievement in TIMSS and PISA by engaging in authentic mathematical and scientific practices and technology, engineering, and art. This research was essential to develop 21st-century competencies and essential digital citizen skills, especially for our future generation. Those 21st-century competencies were computational thinking, problem-solving, critical thinking, productivity, and creativity (Dede et al., 2013). Wing (2006) argued that this new problem-solving should be added to every child through STEAM

learning. Students are trained to be the creator of the technology rather than just consumers of technology (Dede et al., 2013). This will impose a significant impact on society.

Hence, indirectly, STEAM literacy level can boost the ranking in TIMSS and PISA as Malaysia has been at the almost bottom of all countries involved (Bahrum et al., 2017). Connectivism was used as guidance to the STEAM integrated approach. Through the research, society's literacy level will be lifted as most young people are more exposed to innovation and excited about gaining knowledge with technology. Connectivism theory reflects the nature of the knowledge-intensive era (Şahin, 2012). In other words, connectivism reflected our fast-growing and changing society into a technology-advancing society (Makina, 2016).

1.8 Limitation of the Study

This study was only involved a small number of Form Two samples (N= 69) from two different secondary school (one male school and one female school) in the district of Timur Laut in Pulau Pinang. The topic used in this study was Science Chapter 7 Electricity. The limitations of this study were:

i) The study was only involved Form Two students in two different secondary schools, so this study's results can only be applied in that particular school. Hence, the assumption based on the study result cannot be made on the complete Form Two students in Malaysia's secondary school. The number of samples should be enlarged to other forms and other schools, so the general generalization on the secondary

schools' students in STEAM education can be generated more accurately.

ii) The study was also limited to the curriculum and syllabus of the learning objectives and performance standards stated in the KSSM secondary lower science. The result will be different if a different subject was studied.

iii) The study period was only three months as students involved needed their time in doing their lesson study in school and prepared for their school examination. Then, a more extended period of study should be used to obtain an reliable result.

iv) This study was restricted to study the effect of the STEAM integrated approach via Scratch module on achievement in EAT and CTS in Form Two students.

v) Instructional design model used in this study was the ASSURE Model. Result might be different when the different model was used to carry out a similar study. Same with the operational definition of the STEAM integrated approach via Scratch in this study might achieved different definition in other study.

vi) The specific instruments (EAT and CTS) that contained specific questions were used in the study. The results may be different if different questionnaires were used. Therefore, different questions produced different results.

vii) The Scratch module was only being used to teach electricity concepts. The learning was carried out via Scratch. A different method of learning wills probability produced different results. The same results may not be generalized to other subject areas either in primary or upper secondary school. There may be a problem with generalizing the result of this study across subjects.

1.9 Operational Definitions

In this study, different terms were used in giving the detail and specific meaning in explaining the study.

1.9.1 STEAM Integrated Approach

The study adopts Yakman and Lee's (2012) definition on integrated STEAM approach as the transdisciplinary learning approach (Yakman & Lee, 2012), where the five different disciplines namely Science, Technology, Engineering, Art and Mathematics were apply during the lessons, animated stories and games development process. Transdisciplinary learning is an approach in which the concepts and skills are learned from different disciplines to deepen knowledge. Based on this approach, the Scratch module was developed in assisting the students apply the STEAM integrated approach learning which across the disciplines.

1.9.2 The Topic Electricity

Electricity topic is the seventh topic under the theme energy and sustainability of life in Form two textbook (CDC, 2017). There were four subtopic in the electricity topic, namely electricity, method in measuring electricity, relationship between current, voltage and resistance and the flow of current in series and parallel circuit. In

evaluating the achievement in learning electricity concepts, the EAT were developed. The Scratch activities in the Scratch module were based on these four subtopic.

1.9.3 Scratch

Scratch was a visual programming tool that blocks structures through drag-and-drop graphical tools to create a visual way of creating code (Weintrop & Wilensky, 2016). This study used Scratch as the tool and the Scratch module to deliver the electricity lessons and design the Scratch project (games and animated story design). With Scratch, students were exposed to creative visual animation learning (Armoni, 2015; Maloney et al., 2010) with instant visual respond likes sounds and attractive images.

1.9.4 Scratch Module

The Scratch module was developed for the purpose to learn the electricity concepts with STEAM integrated approach whereby the systematic and organised artistic learning methods were explained. Through the Scratch module, students were guided on the steps on the programming with Scratch using the STEAM integrating approach, method in visualizing the electricity concepts and the method in applying the CT in solving problems. The Scratch module consists of three submodules: Submodule 1: Introduction to Scratch programming; Submodule 2: Scratch Concepts and classroom application in learning electricity; Submodule 3: Putting Scratch and Electricity Concepts Together. The Scratch module guides students in applying the STEAM integrated approach in learning the electricity concepts and CT with Scratch.

1.9.5 Electricity Achievement Test (EAT)

EAT was the study instrument in evaluating the achievement in learning electricity concepts. EAT was developed by researcher based on the learning and performance objective stated in the KSSM secondary lower science. EAT contained seven structure questions on the four subtopic in Chapter 7: Electricity . Each questions in the test contained four to five sub-questions under the same subtopic. EAT was used as the pre-test, post-test, and delayed post-test as the measurement instrument.

1.9.6 Computational Thinking Survey (CTS)

CTS was the study instrument in evaluating the level of CT and five subconstructs of CT in learning electricity concepts. CTS consisted of twenty-nine items on five CT subconstructs namely algorithmic thinking, cooperativity, creativity, critical thinking, and problem-solving. In this study, the CTS was adapted from Korkmaz et al. (2017) whereby sentences structure in 17 items out of 29 items were corrected to prevent any alternate conception on the sentences' meaning. validated by the science lecturer in the matriculation college.

1.9.7 Scratch Projects

In this study, Scratch projects include animated stories and games as another assessment instrument. Students were required to design the animated story and game in group work at the end of the intervention to measure the achievement, level of CT and five subconstruct of CT in learning electricity concepts. The Scratch projects were evaluated based on STEAM element, CT component, animated stories or games programming with Scratch component with the rubric. Using the rubric, different

quality levels for the Scratch projects were determined, and the evaluation process can be more accurate (Capella-Peris et al., 2018).

1.9.8 Computational Thinking (CT)

In this study, definition of CT by Korkmaz et al. (2015) was applied which define CT as algorithmic thinking, cooperativity, creativity, critical thinking, and problem-solving. CT was refer to the types of problem solving skills. Computational Thinking (CT) was a fundamental skill in problem-solving process whereby human beings start to understand and analyse the problem first in the way of thinking of the solutions in solving problem (Curzon, 2015).

1.9.9 Aesthetic Value of Art

In this study, the art element was integrated into STEM education. The art element hold the aesthetic value of the art (Dewey,1996) whereby students underwent the art experience during the intervention. Through the art experience, students went through the aesthetic judgment, analysis (Hekkert, 2006) and create the aesthetic products. Students learn the electricity concepts through the aesthetic representation in visualization, the abstract concept out in games, and animated stories development using Scratch.

1.10 Summary of Chapter 1

This chapter explained overall what the research was comprised of. The research questions were apparent, and the objectives were aligned with the problem statement stated, then it was worth researching the application of Scratch in science learning, answered the EAT and CTS and finally, the students' achievement, level of CT and five subconstruct of CT were tested and proven through designing the

animated story and games. In general, this study aimed to study the effectiveness of the STEAM integrated approach via the Scratch module in helping students enhanced and retained achievement and CT level in learning electricity concepts through designing the animated stories and games by integrating the content knowledge learned in the classroom among the Form Two students.