DESIGNING AN ELECTRICAL CIRCUITS LESSON PLAN REGARDING INQUIRY-BASED LEARNING THROUGH 5E LEARNING CYCLE

Selçuk ŞAHİNGÖZ

Research Assistant Dr., Kastamonu University, ssahingoz@kastamonu.edu.tr
ORCID Number: 0000-0003-4884-7588

Received: 17.10.2017 *Accepted: 20.03.2018*

ABSTRACT

The purpose of this study is to help science teachers teaching an electrical circuits science lesson through inquiry-based learning. A lesson plan based on inquiry-based learning techniques has been prepared to inspire teachers. In addition, computer simulations and websites were used to suggest new applications for teachers. Transferring energy within a system as electrical energy is explained through electrical circuits science concept. Meanwhile, designed lesson plan is following an approach for supporting inquiry-based learning with using 5E learning model, gaining to construct simple electrical circuit ability by students, and eliminating common student misconceptions. The study is concluded to indicate possible objection about the structure of the lesson plan in the argument section.

Keywords: Electrical circuits, physical science education, inquiry-based learning, lesson plan.

5E ÖĞRENME DÖNGÜSÜ ARACILIĞIYLA SORGULAMAYA DAYALI ÖĞRENMEYE YÖNELİK BİR ELEKTRİK DEVRELERİ DERS PLANI TASARLAMA

ÖZ

Bu çalışmanın amacı fen bilimleri öğretmenlerinin sorgulamaya dayalı öğrenme aracılığıyla elektrik devreleri fen konusunu işlemelerinde yardımcı olmaktır. Öğretmenlere ilham vermesi için sorgulamaya dayalı öğrenme tekniklerine dayalı bir ders planı hazırlanmıştır. Ayrıca, bilgisayar simülasyonları ve web sitelerinden faydalanılarak öğretmenler için yeni uygulama önerilerinde bulunulmuştur. Elektrik devreleri fen konusuyla enerjinin bir sistem içinde elektrik enerjisi olarak aktarılması açıklanmaktadır. Bununla birlikte, oluşturulan ders planı 5E öğrenme modelini kullanarak, öğrencilerin basit bir elektrik devresini kendi başlarına düzenleyebilme becerisini kazandırarak ve olası öğrenci kavram yanılgılarını gidererek sorgulamaya dayalı öğrenmeyi destekleyen bir yaklaşım izlemektedir. Çalışma tartışma kısmında ders planının yapısıyla ilgili olası karşı görüşler üzerinde durularak sonuca bağlanmıştır.

Anahtar Kelimeler: Elektrik devreleri, fizik eğitimi, sorgulamaya dayalı öğrenme, ders planı.

INTRODUCTION

Electrical Circuits

The concept of electrical circuits is a broad issue includes electrical current, basic components for a complete loop, electrical conductors and insulators, and types of electrical circuits which are called series or parallel circuits. This study focuses on how electrical circuits contribute to energy transformation. The simple electric circuit helps students to learn the basic concepts of electricity and electrical circuits. The process provides them with experience in building a light circuit powered by a battery and controlled by a switch. In addition, they are able to understand that there are different ways energy can be transferred from one system to another.

One of the most common explanation methods of electrical circuits is conducting a simple electrical circuit. When charged particles build up in an object, it is called static electricity. Another kind of electricity occurs when electrons flow in a current. A battery and wires can make current flow. The process is shown when looking at the simple electric circuit illustration in Figure 1. It consists of four parts which are a battery, a switch, a light bulb, and a wire.

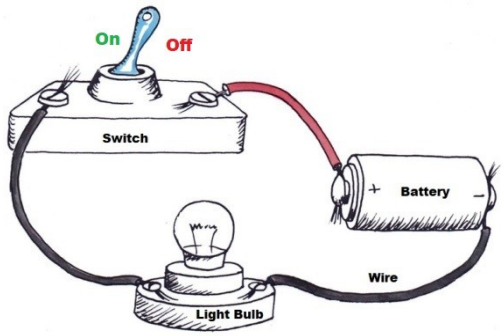

Figure 1: Simple Electrical Circuit (Open Circuit)

Source: http://www.mstworkbooks.co.za/technology/gr7/gr7-technology-14.html#toc-id-9

Inquiry-Based Science Teaching

There are many ways to apply inquiry-based teaching in science education (Alberts, 2008). Accordingly, National Research Council (2000) emphasizes inquiry instruction has broad range from teacher guided to student-centered discovery. Science inquiry reflects “making observations, posing questions, examining books and other sources of information, planning investigations, reviewing what is already known in light of evidence, using tools to gather, analyze and interpret data, proposing answers, explanations and predictions, and communicating the results” (National Research Council 1996: 23) in actual classroom practices. Cobern et al. (2010) define inquiry instruction as involving student investigations when discovering and constructing new knowledge through empirical techniques. Teachers need to properly relate inquiry instruction methods with

science concepts. Unfortunately, many science teachers have limited opportunities to learn science through inquiry or to conduct scientific inquiries themselves (National Research Council, 2000).

Therefore, this study purposes to inspire science teachers to design specific science lesson plan through inquiry-based learning classes. As an example, electrical circuits lesson plan has been designed considering inquiry instruction techniques and methods.

LESSON PLAN

Unit Title & Subject Area: Electrical Circuits, Physical Science

Grade Level: Middle school level physics science course (The grade level varies from 6th to 8th grade depends on the differences of national science education standards for each country.)

Class Size: Approximately 25 students

Unit Rationale

A thorough knowledge of electrical circuits is necessary to understand how energy can be transferred within a system as electrical energy. This unit introduces students to the topic of electrical circuits, and it is one of the major mechanisms electrical energy is associated with an electrical current in a circuit. The students need to be equipped essential information relevant to electricity through understanding the working principle of a simple electric circuit or an electronic device.

Learning Objectives

- *The students will learn the concept of electricity by electrical circuits.*
  The students will be able to explain that electrical circuits provide a means of transferring electrical energy from sources such as batteries to devices.
- *The students will explain that why energy flows in a complete circuit.*
  They will be able to understand electrical current which pushes electrons from the negative terminal through the switch, the light bulb, and the wire into the positive terminal causes energy flow.
- *The students will recognize how to generate a complete loop for passing electrical current in an electrical circuit.*
  The students will be able to identify the basic components (i.e., battery, wires, bulbs, and switch) of an electric circuit and understand their functions. They will be also able to connect these parts respectively.
- *The students will describe what materials are conductors and which are insulators.*
  The students will be able to test objects for their conductivity and classify the materials based on whether or not they permit electrons to flow through them.
- *The students will learn what are a series and parallel circuit.*
  The students will be able to compare or contrast a series and parallel circuit. (AAAS, 1993)

Instructional Procedures

The Unit takes place over the course of six computer laboratory class periods, each of which is 1 hour and 20 minutes (40 minutes per lesson and two lessons equal to one class period) in duration.

This is a computer-based course; therefore, teachers benefit from not only handouts but also online sources during the learning process. All classes will be in the computer laboratory and all individual students have their own computers. The concept of the electrical circuits will be conducted by considering based on inquiry, meaningful learning, schema theory, and constructivism. During previous lessons in the Electrical Circuits unit student have learned how to create a simple electrical circuit and explain the knowledge relevant to electricity as to be a form of energy.

In the first class, at the beginning of the class, the diagnostic test (Circuits Diagnostic Test[1]) will be applied as a pre-assessment. Therefore, students' pre-knowledge concerning scientific concept of the electrical circuits is evaluated. The unit content will be introduced before beginning the class. The teacher will indicate essential topics/concepts which are component of a simple electrical circuit, conductor/insulator, and serial and parallel circuits. The attention is drawn to identifying what electricity is and its relation with simple electrical circuits. It is purposed to expose students' previous knowledge relevant to electricity. The teacher will begin the first part of the lesson by encouraging the students to ask creative and provocative questions about electricity. For instance, "can energy be transferred another forms?", "is it possible energy converts to electrical energy?", "have you ever heard electrical circuits before?", "how might a relationship between electricity and electrical circuits be?", "what kind of pathways might be set up to an electrical circuit?", and "what kinds of components are necessary for building a simple electrical circuit?" After helping to remember their previous knowledge and put some ideas on students' mind about basic definition of the electricity and electrical circuits, the students fill out the K-W-L chart (Ogle, 1986) (see Handout One) (The handouts are provided in the Appendix). A K-W-L chart can be used for all subjects in a whole group or small group atmosphere. The chart is a comprehension strategy used to activate background knowledge prior to reading and is completely student-centered. Students will bring this chart during the whole six classes. They complete the K-W-L chart in order to know what they already know, what they want to learn, and what they learned about the electrical circuits. In addition, K-W-L chart will help the teacher to understand students' typical misconceptions, manage the lessons in order to eliminate these misconceptions, and accomplish assimilation and accommodation. Meaningful learning will be able to gain due to students create completely new schema which replaces or incorporates old ones. In the second part of the class, the teacher will present "Electricity and Energy" website (Website 1) (The websites are provided in the Appendix). Individually students gather information relevant to electricity and electrical circuits from the website through their own computers. This activity will provide an independent study platform for each student. After visiting the website, the teacher will arrange discussion groups in the classroom. During the

[1] The diagnostic test is provided May 25, 2017, from http://www.doe.k12.de.us/infosuites/staff/ci/content_areas/files/science/4%20Magnetism%20and%20Electricity%20Unit%20Template.pdf

discussion process students will be led by thinking questions. At the same time group discussion draws attention to the generality of the problem of physics and energy knowledge behind the electrical circuits unit. Both discussions encourage independent thought (critical thinking) of the students and they individually should try to understand what electrical circuits are.

In the second class, students will understand electricity movement in a simple electrical circuit. Based on distributed "Electrical Circuits Reading[2]", students will have information concerning electricity flow. After reading the handout the teacher will organize discussion groups in the classroom and students share ideas with their classmates. That's the first step to how electricity flows. Then, in order to attract students' attention on electricity flow, the teacher shows students some images which are entitled "Electricity Flow" (Handout Two) which demonstrates how electricity flows in the wire. In this part of the class, the teacher will benefit from traffic flow metaphor for explaining electricity flow via prepared images. The main purpose of this activity is to illustrate the correlation between students' prior and new knowledge. Thus, students will be able to deeply construct their knowledge. Until the end of the first part of the class, students will independently visit websites which deal with electricity flow. With this way students might make predictions and consider how electricity flows through different styles. The teacher will frequently check each student for keeping their attention. In the second part of the class, the teacher represents an online game which is called "The Blobz Guide to Electric Circuits" (Website 2). Each student will have a computer with connected internet. They will easily go to the game page. Through this enjoyable game, students will learn components of a simple electrical circuit and their symbols. While playing the game, students will learn parts of a simple circuit and relate them with their symbols. The teacher will support online games and simulation during the learning process because these kinds of activities are very interesting for defined age group considering their interests and curiosity. Students also will find trial and error opportunity their learning process through The Blobz Guide to Electric Circuits game. The game includes necessary directions for students. Therefore, the teacher just takes place as to be guidance in the classroom during the game.

In the third class, after the first two classes students will have had information concerning a simple electrical circuit. The teacher will plan to mention about conductor and insulator topics in this class. During the class period, students will benefit from their internet access. The teacher will apply BBC Science Clips activity. The class starts with watching a video which is called "Electrical conductors" (Website 3). Students will describe what materials are conductors and which are insulators. In addition, they will be able to test objects for their conductivity and classify the materials based on whether they conduct electricity (conductors) or do not conduct electricity (insulators). Then, BBC Science Clips activity presents an online quiz (Website 4) for testing new knowledge. Each question of the quiz has 1 point and students could do the quiz several times. The quiz questions also include voice answers. Students will pay more attention to the topic because they will have an opportunity to compete with their classmates. Finally, the teacher will provide another quiz website which is

[2] The reading by Brandi Waters has been retrieved November 12, 2017, from http://www.edhelper.com/ReadingComprehension_54_2620.html

entitled “Review Online Quiz” (Website 5). Students will test their conductors and insulators topic knowledge with similar questions. Thus, new knowledge will be reinforced by students.

In the fourth class, the class continues with PhET interactive simulation “Circuit Construction Kit” (DC Only) handout[3] and simulation[4]. The activity invites students to consider the phenomena. They will easily go to PhET interactive simulation page, and start to investigate electrical circuits by following directions. The teacher provides the material and introduces simulation before applying the activity. The handout consists of a lot of questions relevant to topics and concepts of electrical circuits. While answering the questions, students will find an opportunity testing, investigating, and observing electrical circuits. They will also revise previous classes through the simulation. On the other hand, PhET interactive simulation provides to eliminate the common student misconceptions about electrical circuits.

In the fifth class, students will continue to use PhET interactive simulation, but this time they will fill out “Serial & Parallel Circuits” activity handout by benefiting from the application. Students focus on serial and parallel electrical circuits during the whole class time. In this part of the class, students find an opportunity to compare the similarities and differences of two electrical circuit types. They will be able to demonstrate a variety of ways to construct open, closed, simple parallel and series circuits. They will be able to list the advantages and/or disadvantages of series and parallel circuits. In this simulation, students find an opportunity to add new component (ammeter, voltmeter, etc.) into the circuit. Thus, they will be able to measure electric current in the wire and remove their possible misconceptions. Meanwhile, students will be able to use diagrams to illustrate ways that two light bulbs can be attached in simple series and in parallel to a battery to make a complete circuit. For instance, students will be able to explain any differences that will result in the brightness of the bulbs, depending upon the way they are connected to the battery.

In the sixth class, the teacher will briefly revise prior classes and get students’ questions concerning the unit. Then, the K-W-L chart is completed by the students, and the teacher reaffirms the concept of the electrical circuits. Finally, students’ knowledge relevant to the concept will be evaluated through post-assessment (Electrical Circuits Test) end of the class.

Assessment

Two separate instruments will be used to pre- and post- assess student understandings of issues associated with how electricity flows in an electrical circuit.

***Pre-assessment*.** In order to pre-assess whether the students in the class have typical alternative conceptions regarding electrical circuits, the teacher will use the assessment instrument entitled “Electrical Circuits

[3] The handout is retrieved November 12, 2017, from https://phet.colorado.edu/en/contributions/view/4012
[4] PhET interactive simulation was created by the University of Colorado faculties and the website link is http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc

Diagnostic Test" (see Appendix). The teacher uses this information to tailor his/her instruction of the unit considering where the students are coming from.

***Post-assessment*.** The goal of the post-assessment stage is to primarily evaluate whether or not students are able to use the concept of electrical circuits while describing electrical current and its flow in the circuit. Thus, "Electrical Circuits Test" (which includes classic test questions) is prepared to see whether students still entertain the misconceptions the teacher intend his/her instruction to address. (Note the test administered to students has more space for answers.)

ARGUMENT

The argument gives three reasons for why the unit promotes inquiry-based learning of electrical circuits. This part of the study is concluded by considering the strengths and weaknesses of a possible objection.

1. The unit has been developed in accordance with an accepted planning method in science education that is consistent with how students learn.

First, the lesson is planned instruction using 5E learning cycle generally described as having five parts: engage, explore, explain, elaborate, and evaluate, but they are not discrete from one another. The following discussion of the learning cycle is based Bybee (2006).

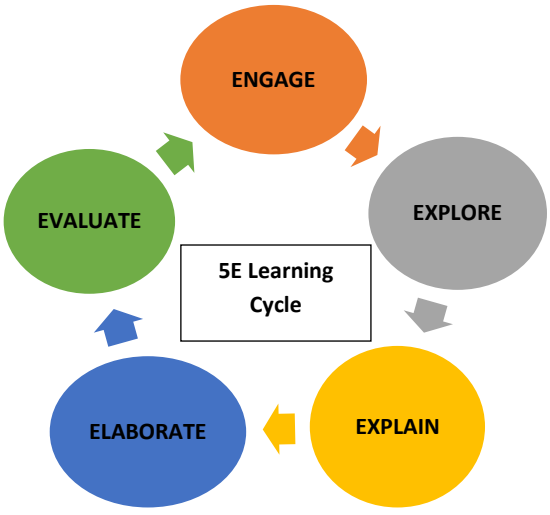

Figure 2. 5E Instructional Model

The engage phase is a stage which "makes connections between past and present learning experiences and anticipates activities and focus students' thinking on the learning outcomes of current activities" (Bybee, 2006: 8). The instructor can gain some insight into what sorts of misconceptions students have about the topic. In the lesson plan, this occurs during Class 1 when the teacher first encourages the students to ask creative and provocative questions about electricity (verbally) for sharing their ideas concerning the phenomenon of

electricity and electrical circuits. The teacher also provides the same step in Class 2 when students read "Electrical Circuits Reading". During the explore phase, students "identify and develop current concepts, processes, and skills" (ibid: 8). They actively explore their environment or manipulate materials. In the lesson plan, this occurs during Class 2 when students do the "Electricity Flow" activity (Handout Three) and discuss about the activity with their classmates. During the explain phase, "the instructional model focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities for them to verbalize their conceptual understanding or demonstrate their skills or behavior" (ibid: 8). In the lesson plan, it occurs during the second part of Class 1 when teacher presents "Electricity and Energy" website (Website1) and arrange discussion groups in the classroom. Both discussions encourage independent thought (critical thinking) of the students and they individually try to understand what electrical circuits are. Students should be invited to explain concepts in their own words and provide evidence for their explanation. At this point, students relate their previous knowledge (from Electricity Units - Based on the course schedule, these units have been learned by students before the Electrical Circuits Unit) with new knowledge (Electrical Circuits Unit). This is an experimental learning style for students. They should predict the relation between their new knowledge and the activity. Students explain their experiments with their own words. During the elaborate phase, the instructional model "challenges and extends students' conceptual understanding and allows further opportunity for students to practice desired skills and behaviors" (ibid: 8). Thus, the students develop deeper and broader understanding, more information, and adequate skills. In the lesson plan, this especially occurs during the Class 4 and 5, when students use the applications "Circuit Construction Kit (DC Only)" and "Circuit Construction Kit (Serial-Parallel Circuits) through PhET interactive simulations. The evaluation phase is an important part of the learning cycle that should take place throughout the unit. The instructional model "encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives" (ibid: 8). In the lesson plan, this occurs during each class. In the first Class the handout (Handout One) (Handouts are provided in the Appendix) is distributed for filling out individually. The handout includes K-W-L chart and it provides an opportunity for sharing students' ideas about what they already know, what they want to learn, and what they learned about the electrical circuits. Students use this chart each classes. In Class 6, the K-W-L chart is completed by the students.

Second, the concept of the electrical circuits will be conducted by considering technologies for supporting an inquiry-based method in science education. Inquiry-based science teaching promotes students learn science by observing their environment, asking proactive and thinking questions, discussing with their classmates, reading, writing, and drawing conclusion together. Accordingly, it is explained and how these skills are provided in the lesson plan to the 5E Instructional Model above. In addition, the lesson plan emphasizes how the teacher integrates an inquiry-based teaching method aspect of supported technologies.

Novak and Krajick (2006) point out the importance of learning technologies for supporting an inquiry based method. They claim that technologies when used as learning tools can be an essential component of an

inquiry-based classroom that promotes students towards developing integrated knowledge that allows them to build strong links between ideas. These strong links allow students to transfer their understanding to new contexts. According to Novak and Krajick, computer, software, and internet all have the potential to assist students toward in-depth and integrated understanding. They provide dynamic visuals to represent abstract concepts. In the lesson plan, this occurs during Class 1, 2, and 3 when the teacher first provides students with basic knowledge relevant to electricity, electrical circuits and conductors through website 1, 2, and 3. Students should be given opportunities to get images and information concerning previous discussions.

Meanwhile, visual learners get more information from visual images (pictures, diagrams, graphs, schematics, demonstrations) than from verbal material (written and spoken words and mathematical formulas), and vice versa for verbal learners (Felder, 1993). Learning technologies for supporting an inquiry-based model is a rich source aspect of visual facilities. In the lesson plan this occurs during Class 1 and 3 when students visit websites 1, 3, 4, and 5. They watch “Circuits and Electricity”, “BBC Science Clips - Electrical conductors”, “BBC Science Clips - Circuits and conductors”, and “Conductors & Insulators” animations. Students should illustrate their knowledge relevant to circuits and conductors and their effect on how electrical current flows in a circuit. This illustration is gained deeply learning because students should set up a correlation among electricity, simple electrical circuit, and conductors. Thus, students should learn the movement process of electricity by following a pathway.

On the other hand, game proponents visualize a future in which people learn academic content and skills from playing games: ‘‘Enthusiasts have claimed that games can increase student engagement and motivation, lead to transfer and complex problem solving, and support spatial skills” (Hannifin and Vermillion, 2008: 213). In the lesson plan, this especially occurs during the Class 2 when students visit website 2 and play “The Blobz Guide to Electric Circuits Game - Components of a simple electrical circuit”

2. The unit focuses on helping students appreciate three conditions upon which electrical energy is based by a simple electrical circuit and the probabilistic conclusion that follows from it.

During previous lessons in the Electrical Circuits unit students have learned how to create a simple electrical circuit and explain the knowledge relevant to electricity as to be a form of energy.

Electrical energy by electrical circuits can be summarized as follows:

1) Electrical circuits provide a means of transferring electrical energy from sources such as batteries to devices.
2) Generating a complete loop for passing electrical current in an electrical circuit.
3) The basic components (i.e., battery, wires, bulbs, and switch) of an electric circuit have important effect on flowing electricity.

Over the course of the unit students learn of the existence and ubiquity of all three of the conditions (identified as 1-3 above). During the Class 4 and 5, students use the applications "Circuit Construction Kit (DC Only)" and "Circuit Construction Kit (Serial-Parallel Circuits) through PhET interactive simulations. Both simulations summarize all three conditions, drawing attention to their ubiquity by constructing a simple electrical circuit.

3. How the Lesson Plan Addresses Common Misconceptions about Electrical Circuits

It's well known that students often come into the classroom with fundamental misconceptions about electrical circuits. Misconceptions associated with the concept of the electrical circuits are heavily associated with misconceptions students have about the working principle of electrical circuits in general. Students could misunderstand electrical current while they are learning the concept of electrical circuits.

Students may not know the existence of a current is associated with the condition of a closed circuit. Therefore, they could think that electrons can jump freely through the air to a positively charged atom and they do not need a circuit to move. Another misconception is students may think energy exists only when it is visible. They accept as true if the bulb does not light, there is no energy in the circuit. Students will learn the working principles of electrical circuits during each class. Especially when they apply interactive simulations in Class 4 and 5 and after finishing the unit, students should eliminate their misconceptions. Thus, they recognize that electrons do not jump freely through the air and the existence of current is associated with the condition of a complete loop. Moreover, connecting an ammeter or a voltmeter to the wire is able to shown the electrical current amount in the circle and it is the evidence electrical current existence in the circuit even though it is invisible. Then, in the lesson plan, students will watch many animations and simulations concerning electrical circuits.

Possible Objection

There are, of course, many ways to teach the concept of electrical circuits, one of the most common is conducted using a simple electrical circuit by students in the real physics laboratories.

Therefore, some teachers and educators ignore benefiting from computer-based laboratories instead of real physics laboratories. They believe that traditional physics laboratory activities are more eligible for teaching the concept of electrical circuits, due to the assumption that students would be more interested in the scientific concept by doing the activities by hand. However, many investigations show that students' achievement level concerning the concept of electrical circuits exhibit similarities in both laboratory styles.

For instance, Bayrak et. al. (2007) emphasized that a significant difference was not determined between the effect of laboratory-based learning on student success and the effect of computer (simulation) based learning at the end of their study. According to the research for the student's academic success, it can be said that computer (simulation) based physics learning is as effective as laboratory based physics learning.

In addition, Tarekegn (2009) supports Bayrak et. al. with another study. The findings of his study suggest that real equipment can be replaced by simulation. Students who only watched the experiments when done via computers had better conceptual understanding of DC circuit than REL (Real Equipment Laboratories) groups based on their result of "direct", achievement, which is measured using a conceptual test called direct. It is a conceptual test used to assess conceptual understanding of DC circuit. According to the study, the students also present that they can manipulate and use real instruments as do the real laboratory group.

Even, computer-based laboratory activities include several advantages during the learning process, such as aspect of safety and time management. Electrical circuits simulations keeping from the hazardous effect of electricity during the experience process of students relevant to electrical circuits. They also simplify the observation and measurement process through helpful applications. That is an essential point because time limitation could be a big barrier while applying the planned curriculum.

On the other hand, because of the grade level of the students (6th - 8th grade), the teacher does not need to teach electrical circuits like growing up electric engineers. Therefore, using real physics laboratory activities are not mandatory to integrate the lesson plan. Moreover, it is assumed that students have had previous knowledge concerning electricity from 4th grade and they must have experienced real physics laboratory activities relevant to electrical circuits then. This circumstance is also helpful by easily adapting the simulations for the students. Because of all the above reasons, the lesson plan has been organized through computer-based laboratory activities.

CONCLUSION AND SUGGESTIONS

This study presents some strategies and activities for science teachers to design their electrical circuits lesson considering inquiry-based learning. The lesson plan provides each component of 5E learning cycle and relates with the class activities. The plan also provides to learn content through eliminating common misconceptions about electrical circuits science concept. There are many physical science lesson plan designs favor of technology supported, in other word, computer-based science laboratory classes through software programs. Accordingly, simulations and websites are used in this lesson plan. There are many studies and research to emphasize the importance of computer-based classes. For instance, Bayrak et. al (2007) indicate that computer-based learning is as effective as the laboratory based learning on students' achievement when teaching electric circuits lesson. Ekmekci and Gulacar (2015) also suggest using computer-based activities as much as hands-on activities for learning electrical circuits. Çetin (2016) specifically supports positive effect of using simulations when applying 5E learning cycle to another physics lesson static electricity.

However, the purpose of this study is not to introduce and suggest a simulation program or support computer-based learning. There are many similar computer-based programs and websites. The simulations and websites in the study were preferred because they included appropriate content and they were easy accessible free online sources. The main purpose of the study is to benefit from these sources for guiding how to design a

study plan with inquiry-based learning rather than choosing them. Since there is no computer laboratory, it is possible to benefit from smart board or individual tablets and rearrange individual student tasks and group activities.

REFERENCES

American Association for the Advancement of Science (AAAS). *The Benchmarks for Science Literacy*. Published by Oxford University Press in 1993. New York: NY.

Bayrak, B., Kanli, U., & Ingec S. K. (2007). To compare the effects of computer based learning and the laboratory based learning on students' achievement regarding electric circuits. *The Turkish Online Journal of Educational Technology – TOJET*, 6(1), 15-24.

Bybee, R. W. (eds.) "Scientific Inquiry and Science Teaching" pp. 1-12. In Flick, L. B. and Lederman, N. G. (2006) Scientific Inquiry and Nature of Science: Implications for Teaching, Learning, and Teacher Education. Published by Springer. Printed in The Netherlands.

Cobern, W. W., Schuster, D., Adams, B., Applegate, B., Skjold, B., Undreiu, A., Loving, C. C., and Gobert, J. D. (2010). Experimental comparison of inquiry and direct instruction in science. *Research in Science & Technological Education*, 28(1), 81-96.

Çetin, A. (2016). Fizik Dersi Durgun Elektrik Konusunda 5E Öğrenme Yöntemi ve Simülasyonlar İle Bir Dersin Planlanması (Designing a Lesson with 5E Learning Cycle and Simulations for Static Electricity Subject in Physics). *Academia Eğitim Araştırmaları Dergisi,* 1(1),36-41. http://academiadergi.com

Ekmekci, A., & Gulacar, O. (2015). A Case Study for Comparing the Effectiveness of a Computer Simulation and a Hands-On Activity on Learning Electric Circuits. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(4), 765-775.

Felder, R. (1993). Reaching the Second Tier: Learning and Teaching Styles in College Science Education. *Journal of College Science Teaching*, 23(5), 286-290.

Hannifin, R. D., & Vermillion, J. R. (2008). "Technology in the classroom". In T. L. Good (Ed.), 21st Century education: A reference handbook (vol. 2) (pp. 209–218). Thousand Oaks, CA: SAGE.

National Research Council (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

National Research Council (2000). *Inquiry and the National Science Education Standards*. Washington, DC: National Academy Press.

Novak and Krajick (eds.) "Using Technology to Support Inquiry in Middle School Science" pp. 75-101 in Flick, L. B. and Lederman, N. G. (2006) Scientific Inquiry and Nature of Science: Implications for Teaching, Learning, and Teacher Education. Published by Springer. Printed in The Netherlands.

Ogle, D. (1986). K-W-L: A Teaching Model That Develops Active Reading of Expository Text. *The Reading Teacher*, 39, 564-570. http://dx.doi.org/10.1598/RT.39.6.11

Tarekegn, G. (2009). Can computer simulations substitute real laboratory apparatus? *Latin-American Journal of Physics Education* 3(3), 506-517.