

Predict-Observe-Explain Tasks Using Simulation to Assist Students' Learning in Basic Electric Circuits

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ABSTRACT

The goal of this work-in-progress is to investigate how simulations can assist students grasping concepts understanding in Basic Electric Circuit course. This study involved first-year Electrical Engineering students in Malaysia. Students were administered a pretest prior to the intervention. During intervention, each student was assigned to one computer station with NI Multisim installed. The incorporation of predict-observe-explain (POE) tasks during intervention was to monitor how students' involvement in learning while doing the simulation. Students' conversation during the POE task were recorded and analyzed qualitatively. Students were administered again on posttest at the end of the semester. Both pretest and posttest data were analyzed quantitatively. Findings show that students' performance on concept test improved from pretest to posttest. Their conversation with peers during the POE tasks does help them verbalize their understanding and assist them to have in-depth grasped of the concept. Since learning Basic Electric Circuit is very abstract, therefore assisting students' to learn through simulation does help them to visualize the working of the circuit. By being able to verbalize shows that students have good grasp on the concept taught. Students having difficulty in understanding basic concept of electric circuit is a global issue. Finding ways to assist them grasping the concept is very much needed. Simulation can assist them to be able to visualize the working of the circuits. Furthermore, by incorporating POE tasks can assist them to verbalize their concept understanding. This finding will be useful in developing new teaching and learning activities or adapting available ones to assist students grasping conceptual understanding of any courses.

Keywords: *Predict-Observe-Explain (POE) tasks, Basic Electric Circuit, Conceptual understanding, NI Multisim, Simulation, Visualize, Verbalize.*

INTRODUCTION

The advancement in graphics and processors has allowed computer simulated environments to also advance significantly. Promising research and development in areas of virtual reality and simulation engines are yielding glimpses of creation of realistic electronic environments that closely replicate the job environment. In leisure and entertainment, video games can be viewed as simulations of real and/or imaginary sistem (Banky & Wong, 2007).

In education, software simulators have assisted with the detail understanding of the behaviour of the devices. Many instructors have included computer simulation into instructional materials. As stated by Banky and Wong (2007), the advantages of using simulators software include:

- Allowing the user to modify system parameters and observe the outcomes without any harmful side effects,
- Eliminating component or equipment faults that may have an undiserable effect on outcomes,
- Supporting user paced progress in discovery and understanding of issues,
- Facilitationg deep learning by illustrationg "dry theory" in another way.

In order to keep student as active learner, the Predict-Observe-Explain tasks is suitable to be incorporated with the simulator. The use of POE in this study with an aim of eliciting students' conceptions of open and short circuit and encourage discussion about thise topics (Kearney & Dalziel, 2012). It involves students predictiong the result of a drawing and discussing the reasons for their predictions; observing the simulation and finally explaining any discrepancies between their predictions and observations (Haysom & Bowen, 2010).

Interaction between the student and the content, and interaction between the student and others about the content are necessary for efficient, effective and affective learning (Berge, 2000); that also identified as "deep learning" (Ramsden, 2003).

METHODOLOGY

The study was carried out in Malaysia and involved 47 first-year Electrical Engineering students in Malaysia. The study was conducted during the second semester of their study where they have completed the Electric Circuits course in their first semester. Data were collected through concept test as the quantitative data; and during intervention as the qualitative data.

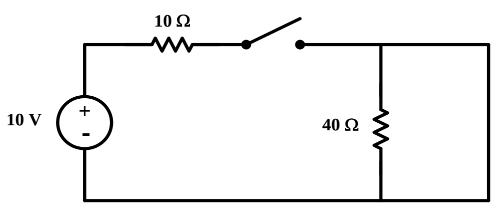
Prior to intervention, the pretest was administered to students during the first week after the semester began with the aim of gathering information about their proir conceptual understanding; while the posttest was administered during the final week before the semester ends.

During the intervention, a PowerPoint presentation of the questions was displayed on the screen. Each student was assigned to one computer station installed with Multisim. Each student has to draw the circuit and simulate it. Students' had to verbalize their understanding on their simulated output to the researcher before they proceeded to the next question. The simulation answer sheet was given to the students for them to write their answers once their verbalization had been endorsed as correct by researcher. The tasks of POE were incorporated throughout the simulation session. The researcher acted more like a facilitator than a lecturer. Students' verbalizations with peers and with researcher were recorded for later transcription. For the purpose of this paper, only Exercise 2 will be discussed.

TEACHING AND LEARNING ACTIVITIES

The lesson plan for Exercise 2 is a DC circuit consisting of a switch and short circuit as shown in Table 1.

Table 1: Lesson plan of Exercise 2

Exercise 2	**Teaching and Learning Activities**
	
a. Can this circuit works? b. Give reasons to your answer in a. c. What devices can you use to make sure that the circuit really works? d. Draw all circuits containing the devices as mentioned in c. e. Explain the value of current flow through each resistor. f. Explain the value of voltage drop across each resistor. g. Explain the working of the circuits according to the bulbs lighted. h. Explain the steps needed to measure the total resistance. i. What is the total resistance of the circuit?	**Predict:** For question **a-c** **Observe:** Simulation output for question **d** **Explain:** Verbalize circuits operation for question **e-i**.

RESULT AND DISCUSSION

Once the circuit is drawn on their computer, students were ready for the prediction task. The verbalization among peers during prediction task was monitored by researcher that acted as a facilitator. Once the prediction is done, they have to write their answer for **a to c.** They have to draw on computer the circuits with all the mentioned predicted devices saperately. Then they have to simulate the circuits and observe the output as in part **d**. Each student has to explain out loud to the researcher the operation of each circuit for part **e to i**. Once the explaining session ends, they have to write their answer based on what they have understood from the verbalization session. Results and discussion are divided into two parts, namely the POE tasks for qualitative data and results for pretest and posttest for quantitative analysis. The coding used was R for researcher an S for students.

POE TASKS

The findings from students' verbalization when dealing with Exercise 2 show that student easily neglect the effect of the shorted arm in a circuit. Their surface understanding of conception about short circuit persists as was found from the conversation as shown in Table 2. Based on the conversation below, S16 assumed that the current is divided into two when it reaches the node, even though one of the branches at the node has a shorted branch. This alternative conception confirms that students neglected the effect of short circuits.

Table 2: Short circuits alternative conceptions

Sample	Descriptive Codes	Categories
R: Now explain about circuits with ammeter. **S16:** Ammeter is connected in series, and then the current is divided into two.	See the correct simulation result but cannot verbalize	Verbalize the simulated output
R: Why the current has to divide into two? **S16:** *Yes into R and into short.*	Current flow	Circuits operation
R: You said there is current flowing through 40 ohm resistor? **S16:** Yes there is current flow… **R:** Ok now look at your same circuit but now with the bulb….why the bulb is not light up?	Students ask question for clarification	Learning by inquiry
S16: O yes.... **R:** Any comment? **S16:** *Means that there is no current here (at 40 ohm resistor)?*	The effect of short circuits	Short circuits

Table 3 shows conversation on determining voltage at the shorted arm. Based on the conversation below, Both S1 and S17 assumed that the current flow will determine the existence of the voltage. This alternative conception confirms that students relied solely on Ohm's Law.

Table 3: Conception about voltage and current

Sample	Descriptive Codes	Categories
R: Can you explain why there is no voltage drop at short circuits? **S17:** I don't know…maybe because … hmm I cannot explain. *For sure I know there is current flow.* **R:** There is current flow, so why there is no voltage? **S17:** *When there is a current, is there should be a voltage also?*	See the correct simulation result but cannot verbalize Contradicting questions	Verbalize the simulated output Deep understanding
R: Any current or voltage at short circuits? **S1:** No voltage and no current. **R:** Can you explain why? **S1:** *When there is short, current flow through short.* **R:** If there is current then why there is no voltage? **S1:** Because there is no resistor. **R:** How do you justify that? **S1:** *Because when use V=IR, then V is zero*.	See the correct simulation result but not confident to verbalize Current flow Rely on Ohm's Law	Verbalize the simulated output Circuits operation Current is the prime concept

Sources of their alternative conception is sought based on conversation shown in Table 4 as mentioned by S12 and S14 where they cannot define the number of branches in circuits, which will affect their prediction of current flow in the circuits.

Table 4: Conception about branches

Sample	Descriptive Codes	Categories
R: Can you define how many branches we have in question 2. **S12:** Two branches **R:** Look carefully… two only? **S14:** Yes **R:** Ok let us count….. **S14:** *Ooo yea three branches*	Define the number of branches in a circuit	Circuits operation

One unexpected finding emerged during the intervention sessions was that students cannot verbalize their simulated output. They faced problem in verbalizing their conceptual understanding. Unable to verbalize can prevent students from copying the simulated output right onto their answer sheet. It will also hinder their deep understanding. This finding shows that they have surface understanding of the basic concept. As shown in Table 5, S10 was worried about their non-lighted bulb instead of worrying why he cannot explain the output.

Table 5: Engage in inquiry-based

Sample	Descriptive Codes	Categories
R: What do you understand about your output? **S10:** *Is my circuit right? Why this bulb is not light up?*	Students ask question for clarification	Deep understanding

However, S10 felt comfortable in asking questions, which shows that they are comfortable with the inquiry learning. This could enhance his surface understanding. Table 6 below shows how student as S12 and S16 can become a good inquirer if they were given opportunity. This capability will diminish their surface understanding and develop a deep understanding.

Table 6: Inquiry capabilities

Sample	Descriptive Codes	Categories
R: How do you understand about your circuits with the bulb? **S12:** *This bulb is brighter than the second one.* **R:** Any reason for that? **S16:** *Hmm, it cannot be brighter?* **R:** Look at your bulb circuits. Any current flowing through 40 ohm? **S16:** *0 A.* **S12:** *What does that mean?* **S16:** *Means that no current at all through 40 ohm branch…understand?*	Current distribution The effect of short circuits	Circuit operation Short circuits

Table 7 shows another finding emerged from the total resistance exercise. They were trying to calculate manually based on their procedural knowledge from the previous course. However, when faced with short circuits, many answers were given. S18 assumed all resistors in the circuits were taking part in the operation of the circuit regardless of its connection.

Table 7: Conception about resistance

Sample	Descriptive Codes	Categories
R: Is this 40 ohm active in this circuit? **S18:** *Ooo we have to figure it that way? Does for total R we have to consider all R in the circuits?* **R:** Look back and try to figure out from your simulated circuits.	Students ask question for clarification	Learning by inquiry
R: How to measure total resistance? **S23:** Remove the source. **R:** Then… **S26:** Remove devices **R:** Then what is your finding? **S25:** Ooops…*Does open circuits has resistance?*	Students ask question for clarification The effect of open circuits	Learning by inquiry Open circuits

Students then again were requested to simulate their circuits to obtain the value of total resistance. Total resistance cannot be calculated if students cannot figure out which resistor is active and which is not in an open or short circuit. Furthermore, where to place the devices in the circuit is important in measuring the desired value as shown in Table 8.

Table 8 Individual work with inquiry-learning

Sample	Descriptive Codes	Categories
R: Try to simulate on your own, once done we will discuss together. **S16:** *Where to connect the multimeter?*	Insist on individual work Students ask question for clarification	Own the learning Learning by inquiry

Another finding was students really depend on Ohm's Law to predict circuits operation. As shown in Table 9 below, S26 relied heavily on V=IR. By relying on Ohm's law will caused their alternative conception on open and short circuits concepts higher. This is the reason why they cannot grasp open and short concept even though this concept is a very basic concept in Electric Circuit.

Table 9: Dependent upon Ohm's law

Sample	Descriptive Codes	Categories
R: What is your conclusion about short circuits? **S24:** *No resistance*. **S25:** *No voltage.* **S24:** *Has current.* **R:** How about during open circuits? **S26:** *Short circuits…no voltage, because V=IR because no I, so no R. But why here (short circuits), no R but still has current?*	Students ask question for clarification	Learning by inquiry

There are cases when student know how to explain but he/she was not confident in doing so as shown in Table 10. S4 seems to explain well but the final sentence shows that he/she has only surface understanding.

Table 10: Not confident to verbalize

Sample	Descriptive Codes	Categories
R: Can you explain to me **S4:** *Ooopss why this bulb is not light up?* **R:** Try to figure it out…. and explain to me. **S4:** *Current flows, not entering branch with resistor, all go into short circuits* **R:** Are you sure? **S4:** *More or less…(not sure)*	See the correct simulation result but not confident to verbalize	Verbalize the simulated output

Students can execute the POE tasks easily for Exercise 2. This is because enough time was spent on clarifying the POE task on Exercise 1. However, they have problem in observing and explaining the open and short circuits operation.

RESULTS OF PRETEST AND POSTTEST

Table 11 shows the paired-sample t-test for the posttest score and the pretest score. There is significant evidence that their mean are not the same with the gain difference of 2.44. The probability value *p* of 0.000 gave significant improvement from pretest to posttest after learning with the POE tasks using simulation. To justify the significant changes, the effect size was calculated using Cohen's *d* which gives the value of 0.79 which indicated a large effect size in the differences of mean (Cohen, 1992).

Table 11: Paired-sample t-test of posttest and pretest

Test	N	Mean	Standard Deviation	*p*	Cohen's *d*
Posttest	47	16.70	2.53	0.000	0.79
Pretest	47	14.26	3.53		

After the simulation-supported approach intervention session, there was clear evidence that POE tasks for teaching and learning instruction, enriched with computer simulation and collaboration, promoted students' conceptual understanding of BEC concept and understandings of scientific inquiry. Students willingly involved in inquiry learning based on POE tasks. After the lab session, students understood the concept, and can apply the concept as shown in the posttest data as described in Table 11.

Data from the intervention session shows that students can engage well in inquiry learning activities. However, based on data transcribe, students verbalization were still not concrete. This is due to the fact that this is the only intervention class using POE tasks that they have gone through. In addition their BEC course before does not insist on students' verbalization. Students' performance in inquiry showed that it can help their conceptual understanding if lecturers incorporate it into the course to make the class more students centered with active learning.

CONCLUSION

This research demonstrated that the benefits of self-explanation can be achieved with a relatively simple simulation approach that can be fit well to any approach. By engaging in verbalize explanation, students acquired better-integrated visual and verbal conceptual knowledge. The effectiveness of the implementation of the POE tasks with simulation-supported approach was assessed. It shows that student achievement for open circuits, short circuit and resistance were significantly improved.

The gradual improvement in students' knowledge in verbalizing and their positive attitude towards the simulation with POE tasks for teaching and learning approach may indicate that the instructional approach should be developed and implemented more widely in undergraduate studies. Factors that stimulate a good question and answer are engaging problems, and a facilitator at hand to answer questions, to give instant feedback and to discuss with the students.

After students have gone through this approach, the findings show that they have tried to evaluate the circuits first by verbalizing it before trying to find mathematical solutions. As what was also found by (Getty, 2009) that state that student should be encouraged to develop an ability to qualitatively evaluate electric circuits. Therefore, the implementation of POE tasks approach with simulation-supported has proved to be significant in improving students' verbalization ability. In addition the use of the simulation helped students visualize the operation of the electric which are very abstract in nature. Seeing the bulbs light has rectify their alternative conceptions on the working of the circuits. As a result, the integration of simulation activities into the classroom provides an innovative learning environment that allows more interactive and effective applications for students to gain valuable experiences through hand-on.

The findings from the research state that the alternative conceptions reported in the literature (Streveler et al., 2006) were found among students' at this local public university. Results showed that the implemented POE tasks with simulation incorporated was successful in enhancing students' conceptual understanding of open and short circuits concepts. However, findings from students' verbalizations indicate that changes in teaching and learning approaches are required to better support learners in developing scientific inquiry that enable learning of the intended conceptual knowledge.

REFERENCES

Banky, G. P., & Wong, K. K. (2007). Troubleshooting exercises using circuit simulator software: Support for deep learning in the study of electronic circuit. *International Conference on Engineering Education - ICEE2007, Coimbra, Portugal*.

Berge, Z. L. (2000). Components of the Online Classroom. *New Directions for Teaching and Learning, 2000*(84), 23-38.

Cohen, J. (1992). Quantitative methods in psychology: A power primer. *Psychological Bulletin, 112*(1), 155-159.

Getty, J. C. (2009). Assessing inquiry learning in a circuits/electronics course. *39th ASEE/IEEE Frontiers in Education Conference, San Antonio, TX*.

Haysom, J., & Bowen, M. (2010). *Predict, Observe, Explain : activities enhancing scientific understanding*. Arlington, Virginia, USA: National Science Teachers Association Press

Kearney, M., & Dalziel, J. (2012). Predict-Observe-Explain Learning Design Retrieved June 21st, 2012 from http://implementinglearningdesigns.lamsfoundation.org/page6/page8/page8.html

Ramsden, P. (2003). *Learning to Teach in Higher Education* (2nd ed.). London: RoutledgeFarmer

Streveler, R., Geist, M., Ammerman, R., Sulzbach, C., Miller, R., Olds, B., & Nelson, M. (2006). Identifying and investigating difficult concepts in engineering mechanics and electric circuits. *113th Annual ASEE Conference and Exposition, 2006, Chicago, IL*.