The Development of a Model to Promote Predict, Observe, Explain Strategies for Teaching about Electric Circuits in Virtual Environments

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Abstract

The paper presents a virtual model to promote Predict, Observe, Explain (POE) strategies for helping students overcome misconceptions about electric circuits. Vocational educational students preparing to be electric technicians often have misconceptions about electric circuits. Yet, knowledge of such circuits is basic to their training. This paper outlined a model that relies on PDOE strategies, we added DO in second process that involve students predicting results, doing a virtual simulation of the prediction, observing the results and subsequently explaining any difference between what they predicted versus what they observed. Such models exist for high-school and university students but not for vocational learners. Furthermore, the challenge with using POE strategies in the classroom is providing students with opportunities to observe scientific phenomenon in a way that is real, authentic and, most importantly, safe. The models do not provide an opportunity to "do" because it is often not feasible or possible to carry out experiences in the real classroom. This paper demonstrated a PDOE model developed specifically for vocational students and that operated in a virtual environment. Such environments rely on technology such as simulations to do experiments that are not possible in the real classroom.

Keywords: POE strategy, virtual environment, vocational education, electric circuits, misconceptions, PDOE model

Introduction

The purpose of this paper is to present a model to promote Predict-DO-Observe-Explain (PDOE) strategies in a virtual learning environment for helping students overcome misconceptions about electric circuits. Predict-Observe-Explain (POE) strategies are considered as constructivist-oriented strategies (White & Gunstone, 1992) that help students put forth and test hypotheses (Kibirige, Osodo & Tlala, 2014). POE strategies are also useful for helping teachers identify students' misconceptions (Boo & Watson, 2001; Kibirige, Osodo & Tlala, 2014). Teachers need to recognise students' misconceptions and modify their strategies to adjust (Kibirige, Osodo & Tlala, 2014). The strategies can help teachers find out about "learners' prior knowledge and thought processes" which they can then use to "find sustainable solutions to overcome such misconceptions" (Kibirige et al., 2014, p. 301). Misconceptions can take the form of incorrect understandings (Martin, Sexton, and Gerlovich, 2002) and may be resistant to change (Eggen and Kauchak, 2004). For example, Kibirige et al.'s (2014) study showed how POE strategies had "a positive effect on learners' misconceptions about dissolved salts" (p. 305) and helped students to improve. The use of the strategies also provided an opportunity for teachers to identify new misconceptions.

POE strategies help "students to support their predictions through benefiting their existing knowledge and experiences of similar events that they encountered in their daily life" (Ayvaci, 2013, p. 549). These strategies involve learner-centered teaching that "acknowledges the social construction of knowledge" (Kibirige et al. 2014, p. 304). Karamustafaoğlu and Mamlok-Naaman (2015) explained that POE strategies typically involve three tasks. In the first task, students are given a physical situation for which they should predict "the result of a specific change to the physical situation" and explain their prediction (p. 924) or use if-then logic "IF the system behaves as expected IF...THEN my Prediction (my logical expectation) is that…will happen and…will be observed" (Rusbult, 2013). In task two, students must describe what they see as they conduct a physical experiment (Rusbult, 2013). In the final task, they must explain the contradiction between what they predicted versus what they observed. These tasks can help students engage in inquiry and critical thinking, enhance conceptual understanding and informal reasoning skills, and develop students' independence, motivation, interest and ability (Perver, 2015).

POE strategies and technology

The challenge with using POE strategies in the classroom is providing students with opportunities to observe scientific phenomenon in a way that is real, authentic and, most importantly, safe. Kearney (2004) used multimedia with POE to provide students with opportunities to observe "difficult, expensive, time consuming or dangerous demonstrations of real, observable events" (p. 427). Banky and Wong (2007) described advantages of use of simulation software in terms of the capacity to let users observe outcomes without harm and without the inconvenience of equipment failure. Kearney (2016) summarized the advantages of assigning POE tasks for completion in a computer-based environment. These include opportunities for small-group work, computer scaffolding, student pacing and autonomy, opportunities for discussion and reflection. In addition, Kearney noted that computer-based

demonstrations “can reveal interesting science phenomena that… go beyond our temporal,
perceptual or experiential limits” (p.427).

Paper purpose and objectives

In spite of the value of using technology for this purpose, there are few examples of use of technology with POE strategies particularly at the post-secondary level. Hussain et al. (2013) used virtual simulations with POE strategies in an undergraduate basic electric circuits course. The authors explained that the topic is abstract therefore simulations can help students visualize these abstractions. Kearney and Wright (2002) used a computer program to help science teachers build and photographic, sound or video-based (digital) demonstrations. However, this study did not take place at the post-secondary level. There are few studies of use of POE strategies with technology for post-secondary learners. Our review of the literature did not uncover any studies of POE strategies and models using technology with vocational learners. This may be partly because, in general, POE models exist for high-school and university students but not for vocational learners. Vocational educational students preparing to be electrical technicians often have misconceptions about electrical circuits. The high-school models typically emphasize theory. University-based models tend to emphasize activity without theory. What is first needed in order to use POE strategies in a technology-based environment with vocational students is a model of such learning. This paper will demonstrate a model developed specifically for vocational students that can operate in a technology-based, virtual environment. The presentation will also include some implications for practice and for research.

Methods

To develop the model for vocational learners at the post-secondary level, we completed the following steps:

1. Identify previous models of POE;
2. Identify the common misconceptions related to electric circuits;
3. Create a model to promote PDOE strategies for teaching about electric circuits in virtual environments

Objective 1. Identify previous models of POE

The POE strategies were redesigned from the Demonstrate-Observe-Explain (DOE) strategy (Champagne, Klopfer and Anderson, 1979). DOE is about real-world situations or real-world experiences. The strategy involves formulating a question for prediction of the results of situation and then observing the effect of the change and explaining results. Champagne, Klopfer and Anderson (1979) used this strategy to assess students’ understanding of force in first year physics students. The advantage of DOE strategies includes a reduction in the quantity of verbal description and a reliance on open-ended questions which provide data to make inferences about students' conceptualizations (p. 25). White and Gunstone (1992) redesigned the DOE strategies and developed the first POE model in elementary science. According to their model, students must first predict the outcome, justify their prediction, describe their observation and then reconcile contradictions between what they predicted and what they observed.

More recently, Ebenezer et al. (2010) used Prediction-Explanation-Observation-Explanation (PEOE) strategies for constructing and negotiating ideas after student predictions. The PEOE is practiced by the teacher to promote students' conceptual understanding and make teaching plans. Costu, Ayas and Niaz (2012) developed the Predict-Discuss-Explain-Observe-Discuss-Explain (PDEODE) model to investigate students' understanding of science. This strategy involves motivating students' prior knowledge and solving the contradiction between their beliefs and observations. Hilario (2015) developed the Predict-Observe-Explain-Explore (POEE) model which is designed to stimulate students' interest and curiosity between their knowledge of Chemistry and their life. Sales (2015) developed Predict-Explain-Observe-Explain strategies (PEOE) for exploring metacognitive awareness of students to improve conceptual understanding and problem-solving skills also in Chemistry. The PEOE focuses on students' explanation. The difference between PEOE and POE is that students have to explain both after their prediction and again after their observation.

There are very few virtual POE models. Kearney (2004) focused on the use of POE tasks in a technology-based multimedia environment with peer conversation to probe students' understanding in science. His model used student motivation with digital video clips in a physics' lesson on force. The computer-based digital video clips replaced real experiments. Kearney, Treagust, Yeo, and Zadnik (2001) found three affordances of multimedia-based POE tasks. First, students can control the pacing of POE tasks and control the presentation of video-based demonstrations. Next, the student can make detailed observations of physical phenomenon in using digital, video-based demonstrations in the observation phase. Last, students must describe the virtual, real-life physical setting in the video-clips. The advantages of using computer-based video clips are that students can control and observe experiments as many times as they want. In addition, the virtual video clips provide content for the "reflective discussions" that take place during the observation step of the model (Kearney, 2004).

Objective 2: Identify common misconceptions related to electric circuits

Electric circuits are fundamental to the study of electricity and must be known in depth. If knowledge is lost in a particular session or class it will lead to misconceptions. Because electricity is abstract, intangible and difficult to understand, many students form incorrect understandings and fail to grasp the concepts (Frederiksen, White & Gutwill, 1999). The body of knowledge on electric circuits is a broad, focusing on current, resistance, voltage, series and parallel-circuits (Duit & Von, 1997). However, those who study about the circuits must deeply understand the properties, specific characteristics and behavior of the circuits. In addition, students sometimes rely on intuitive conceptions to understand electricity and electric circuits (Ding et al, 2006; Duit & Von, 1997; Kollöffel & Jong, 2013).

Turgut, Gurbuz and Turgut (2011) conducted a study in Turkey with 10th grade students. They found that the most common misconceptions were that students thought that current does not flow and none of bulbs are lit when the switch is closed. A study of high-school students in Romania found that they believed that current decreases when it passes through the bulb which is a misconception (Korganci et al., 2015). Similarly, Engelhardt and Beichner (2003) in the USA found that students misunderstood that a battery provides a constant source of current. Other common misconceptions are as follows:

1. Current decreases when it passes through the bulb.
2. Light bulbs use up current.
3. The current is stored in the battery/generator.
4. Resistance is the force applied to the opposite direction of the electric current.
5. Resistance is the obstacle applied to the electric current.
6. Potential difference is a force.
7. The battery always supplies the same current to the circuit.
8. The brilliance of the bulb that is far from the battery is less than the brilliance that is close to the battery.
9. Current which passes on a simple electric circuit is partially consumed by the bulb.
10. A battery provides a constant current source rather than a constant voltage source.

Objective 3: Create a model to promote PDOE strategies for teaching about electric circuits in virtual environments.

To create a model we first relied on POE strategies as outlined by Champagne, Klopher & Anderson (1980) and by Gunstone, Champain and Klopfer (1981) to promote conceptual understanding (Tao & Gunstone, 1999). We added one step to conform with the needs of vocational learners. Vocational learners need more than theory. They need opportunities for hands-on, real experiences. In normal models, the actual enactment (the doing) of the scenario is not possible or feasible in a real environment because it might be dangerous or costly. However, in a simulated environment, the enactment of the scenario (the experiment) is possible. Therefore, we added DO process to the model to make it PDOE. Thus, instead of only POE, our model relies on Predict, Do, Observe, Explain (PDOE).

Figure 3 outlines the model. The PDOE model includes a virtual environment in which the student acts as an electrician. As in Kearney's (2004) virtual model, this model also relies on a technology-based environment with peer conversation. The conversation takes place using CHAT boxes. The technology is specifically simulations. The centre of the model shows PDOE as a four-step process. Corresponding with the Predict step, students will see a web-based interface that offers them ten different scenarios. These scenarios correspond to 10 common misconceptions. An example of a choice is as follows:

Please choose one of the following scenarios and make your prediction using the CHAT box:

If I have three circuits as below, then which bulb is brightest (same battery)

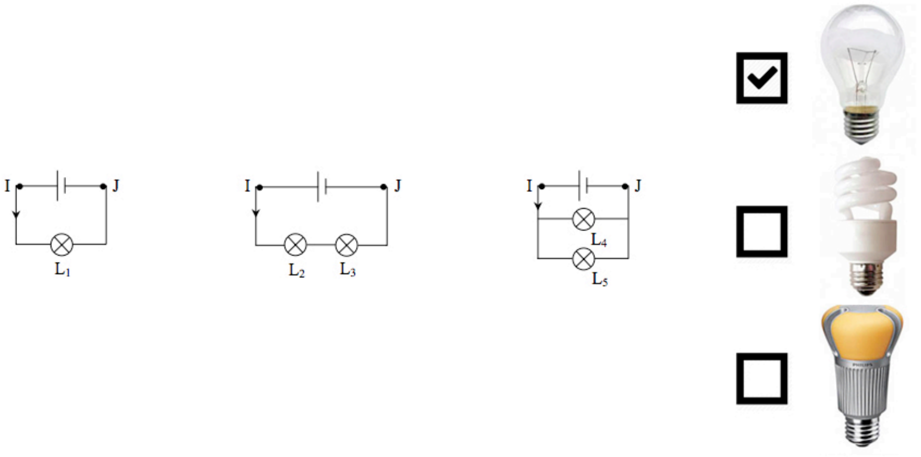

Figure 2: Example of an if-then scenario

In step 1, students have to predict using an if-then scenario. They use an interactive CHAT box to input their choice. The CHAT element reflects Piaget's (1936) and Vygotsky's (1978) emphasis on social interaction, constructivism and conversation as a means of learning. The content is automatically available to the teacher but students can choose to make it available to other students. After they complete their prediction, they automatically move to a second interface (Step 2). In this DO step, students are given the opportunity to carry out a simulation of the scenario. For example, if the student selects the above scenario, the current decreases when it passes through the bulb. The student will be able to simulate connecting the battery either in series or parallel circuits with bulb. Then, they can select a type of bulb such as an incandescent bulb to compare the brightness.

Next (step 3), the student can observe the result (i.e., in this case, which bulb will be brightest). The virtual simulation can demonstrate for easy observation the direction of the flow of current in the wire. In this scenario, the most common misconception is that students think that L3 and L5 will not light (see figure 2) because they believe that current decreases when it passes through the bulb. However, in actual fact, every bulb has equal brightness except that L3 is dimmer. This is because of the current divider and voltage divider are in series and parallel circuits. The student will use a CHAT box to describe what he/she observed. The student can then move to the following step 4 of Explain where he/she can once again use the CHAT box to explain why there was a difference between the prediction and what actually occurred. Each students' input into the three different chat boxes (predict, observe, explain) can all be stored for future viewing by the teacher. The teacher can then comment and the student can view and respond to their teacher's comments.

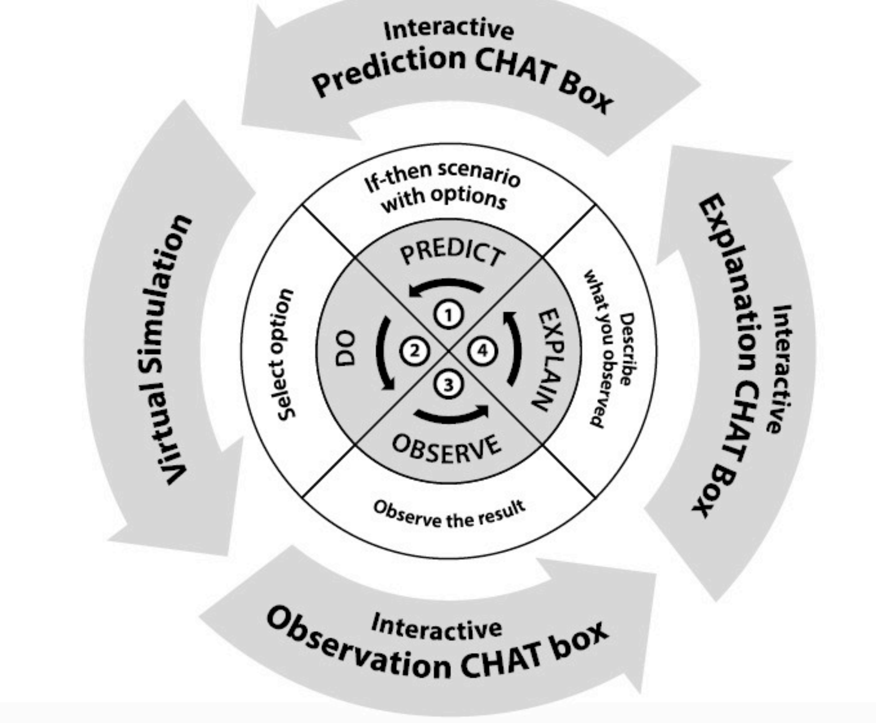

Fig. 2 PDOE model in virtual environment

Conclusion

The paper presented a virtual model to promote Predict, Do, Observe, Explain (PDOE) strategies for helping students learn about electric circuits. Vocational educational students preparing to be electric technicians often have misconceptions about electric circuits. Yet, knowledge of such circuits is basic to their training. This paper outlined a model that relies on PDOE strategies that involve students predicting results, doing a simulation of the prediction, observing the results and subsequently explaining any difference between what they predicted versus what they observed. Such models exist for high-school and university students but not for vocational learners. The high-school models typically emphasis theory and do not provide opportunities to carry out experiments. University-based models tend to emphasize activity without theory. This paper demonstrated a PDOE model developed specifically for vocational students and that operated in a virtual environment.

In terms of implications for research, future research can involve the design, development and testing of a virtual PDOE environment with vocational students based on this model. Instructors and designers can experiment with new technologies especially those available online for free such as Android or IOS apps that students can use to observe the actual “do” phase. These apps could be used in combination with social media such as Facebook groups or other such tools to engage students in conversation with others about their predictions and observations.

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