Understanding potential misconceptions shared between instructors and students in fundamental electric circuits

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Abstract

There has been a need to innovate instructors' ways of capturing and assessing student learning in order to align their teaching strategies with the learners' current understanding. The early detection of errors in knowledge among students allows the instructors to be dynamic and proactive in strategizing instruction. However, instructors presume that their own mental models are error-free. These presumptions need systematic validation to ensure that misconceptions do not propagate from learner to learner and to provide mutual benefit to both instructors and students as main participants of the learning process. The purpose of this pilot study is to examine prior and current knowledge in basic electric circuit concepts and to investigate the potential existence of shared misconceptions among teaching faculty and students. A 20-item concept inventory was designed and used in this study to methodically identify errors in fundamental electric circuit concepts as a means to inform instruction. This study addresses the following questions, "What misconceptions in fundamental electric circuits are potentially present in both instructors and students? How are these potential misconceptions shared between instructors and students?" The concept test that we developed was administered via Qualtrics, and semi-structured interviews were conducted among instructor and undergraduate student participants in electrical and electronics engineering departments. This study used thematic and comparative analyses to explain intersections and differences in responses among instructors and students through the concept instrument used. Results highlight how misconceptions associated with basic electric circuit concepts described in previous literature are manifested in the thought processes of instructors and students, such as the operation of a first-order circuit involving time constant, capacitor and inductor operations, and individual behaviors of electric devices in an AC circuit in steady-state conditions. This work has implications for educators, curriculum designers, and researchers who seek to improve student learning of difficult engineering concepts. The outcomes of this study will provide the opportunity for research to interrogate why these misconceptions continue to exist and how we can use instructional practices and curriculum design methodologies to uncover and repair these misconceptions.

Keywords: electrical engineering, electric circuit concepts, misconceptions, concept inventory

Introduction

Engineering core concepts do not necessarily change in time, yet innovations in accessing, capturing, and assessing mental models of learners are needed to guarantee that pedagogical approaches align with the learners' current understanding [1]–[3]. Abstract concepts such as *electricity* require varied approaches that effectively facilitate both teaching and learning [3]. According to the theoretical framework of conceptual change, students' role in navigating and learning these difficult concepts should include extensive engagement in the construction of their own knowledge and skills, i.e., with the help of multiple and effective approaches to the design of learning environments where students are exposed to [4], with particular focus on proper assessment of student learning [5], [6].

Several assessment instruments have been designed in the past to check student's understanding of basic concepts [7], [8]. Research suggests that students feel the need to have access to and feedback on any identified misconceptions early so that they can plan on making a move to correct them [9]. Bull et al. (2010) used a computer-based method called the open learner model as a means of highlighting first-year introductory electrical circuits students' interest in acknowledging their misconceptions as a first move towards dealing with their difficulties in learning as opposed to just receiving general feedback. The early detection of errors in knowledge among students allows the instructors to be dynamic and proactive in strategizing instruction [10], [11].

However, instructors presume that their own mental models are error-free. These presumptions need systematic validation to ensure that misconceptions do not propagate from learner to learner [12]. We need to be intentional about treating inaccuracies and errors in conceptual knowledge in engineering among, not just students, but also teachers as they both play an important role in the learning process [13].

The purpose of this pilot study is to explore the existence of potentially shared inaccuracies in fundamental electric circuit concepts between instructors and students with the use of a 20-item concept inventory that we drafted to examine prior knowledge and errors associated with it in the field of electrical engineering. This instrument is intended to continuously inform instructional approaches by methodically checking prior knowledge for acceptability, offering mutual benefit for both instructors and students as participants of the learning process [14]. So, this pilot study intends to address the following questions:

- *What misconceptions in fundamental electric circuits are potentially present in both instructors and students?*
- *How are these potential misconceptions shared between instructors and students?*

In addition, through these questions, we also plan to constantly improve the concept inventory that we developed to ensure that we are not just doing assessments for the sake of assessing student learning of basic electric circuit concepts but also using the appropriate metrics and communication style tailored for the audience for us to further identify potential misconceptions that students, teachers, or both of them share.

Methodology

This pilot study was a result of our ongoing interest in pinpointing misconceptions among electrical engineering students; thus, the development of our own instrument. There is not much research in the use of concept inventory for instructors because concept inventories, as an assessment tool, is supposed to be designed by the instructors for the students. However, we sought to validate and use this instrument adaptively for both students and teachers who are involved in the learning and teaching of these engineering concepts. For this pilot study, we used a qualitative approach of inquiry to give us a better and in-depth understanding of how misconceptions could exist and be shared by both students and instructors using the concept inventory as our main tool then followed by inquiry on participants' responses to the test.

Participants

Eighteen (18) undergraduate students and three (3) instructors from the electrical and electronics engineering departments at a large university in the southern Philippines were chosen on purpose to participate in the study because these students were all past (or present) students of the selected instructors in at least one circuit course that the students had previously taken or currently taking. The circuit courses in the said institution typically have 10-15 students in each class per semester. The general demographic information includes the participants' institution, year-level, gender, whether they are transfer students or not, whether they are student or faculty, the number of circuit courses the students have taken, and the number of years the instructors have taught circuits courses. All participants are Filipinos and all provided consent to participate. The medium of instruction used within the university is English as a requirement for teaching these courses. See table 1 for the demographic summary of the participants.

Table 1. Demographic information

Demographic information	Students	Faculty
Participants	Non-transfer: (17) Transfer student: (1) Male (15) Female (3)	Male (2) Female (1)
Institution	Same institution	
Number of circuit courses taken	1-2 courses: (14) 3-4 courses: (3) 5 or more: (1)	
Number of years teaching circuit courses		2-5 years: (1) 5-10 years: (1) Ten or more: (1)

Data Collection

We have developed a 20-item concept inventory [7], [15] to assess knowledge in electrical circuits operating in transient DC and steady-state AC. These areas of knowledge are determined to be core concepts of electrical engineering across the undergraduate years [2], [16]. The data collection for this pilot study consisted of two parts: the concept test and the semi-structured interview.

A. Concept test:

The draft of the concept test was tested in the form of a survey. It was administered to the participants online via Qualtrics. We decided to conduct it on Qualtrics to initially limit the interaction between the researchers and the participants. The concept test was proofread twice before administering it. All items were assigned equal weights for scoring. The participants were given at most 40 minutes to respond to the test through the assistance of one of the researchers. The survey was held online throughout the Fall 2019 semester.

The concept inventory aims at inquiring the respondents about the following basic concepts:

1. What do they understand about circuit elements that store energy?
2. How do they differentiate:
    a. A capacitor and an inductor?
    b. Energy storage and energy source?
    c. Energy storage and load?
3. How do they analyze:
    a. A first-order circuit?
    b. A second-order circuit?
    c. A higher-order circuit where the source is an AC signal?
    d. Circuit transformation where the source is an AC signal?

The concept test is composed of 20 multiple choice questions with four choices in each item. The questions were based on the theoretical foundations of steady-state AC and transient DC, with no numerical values involved in all the questions; thus, no need for a calculator to be able to respond to the test. Moreover, the table of specification below shows the distribution of questions based on the defined objectives.

Table 2. Table of specification (TOS)

Specific objectives	Question item no.
A. Identify and explain a capacitor’s behavior.	9, 11, 14, 15
B. Identify and explain an inductor’s behavior.	10, 12, 16
C. Explain the process of storing and delivering energy in a first-order circuit with a DC source.	17, 20
D. Explain how the variables that determine the operation of a first-order circuit’s time constant.	4, 6
E. Distinguish between a complete response and forced response in first- and second-order circuits.	2, 3

F. Explain individual behaviors of electric elements in a circuit with an AC signal as a source, in steady-state conditions.	1, 7, 8, 14, 19
G. Explain the behavior of an electric device, in terms of power delivery and dissipation, in a circuit with AC source.	5(RMS), 7, 8, 13, 18

B. Semi-structured interview:

Among all the participants who responded to Qualtrics, only the ones who opted or interested to participate in a follow-up inquiry were selected for the interview. Five (5) students and (1) faculty agreed to be interviewed through our interview protocol (see Appendix 1). See the summary of the interview participants' information in the table below.

Table 3. Interview participants

Pseudonym*	Demographics	Assigned questions
Alexa	Senior non-transfer student, female, took 3-4 circuits courses	3 (C), 4 (I)
Daniel	Senior non-transfer student, male, took 1-2 circuits courses	8 (C), 14 (I)
Prof. Duke	Instructor, male, taught circuits for 5-10 years	2 (C), 13 (C), 6 (I), 7 (I)
Mark	Senior non-transfer student, male, took 3-4 circuits courses	12 (C), 6 (I)
Phil	Senior non-transfer student, male, took 1-2circuits courses	1 (C), 7 (I)
Randy	Senior non-transfer student, male, took 1-2 circuits courses	5 (C), 10 (I)

*assigned by researchers

We purposely framed the interview questions in a way that participants could freely speak up about their answers, and that would avoid misleading them or making undue prompts from the research team. Participants were allowed to pause and think more thoroughly about the questions and their answers, considering that English is not their first language.

The student interviewees were asked to expound their answers on two questions in the concept test: one of which they got the correct answer and the other incorrect (we used I and C to denote incorrect and correct answers, respectively, see the third column in table 3) based on their responses to the concept test. Among the five (5) students, the distribution of questions based on specific objectives was, as much as possible, spread across the objectives to cover all the concepts. The faculty we interviewed was assigned four questions to explain: two of which he got the correct answer and the other two incorrect. He was also asked to critique the concept test in terms of the appropriateness of questions and the choice of communication and technical words.

The individual interviews were conducted towards the end of the Fall 2019 semester and lasted approximately 20 minutes each. Interview data were collected using Google's native recorder app with an auto-transcribe feature and can only be accessed through an encrypted Google Drive cloud storage.

To provide transparency on our potential influence as researchers towards the participants, we made it clear that all team members had an interest in addressing the research questions because of our background in electrical and electronics engineering and our interest in improving how stakeholders of learning would effectively learn difficult engineering concepts. We, therefore, understand our position as researchers and how we could influence in conducting the interview, analyzing the data, and interpreting the results of this research.

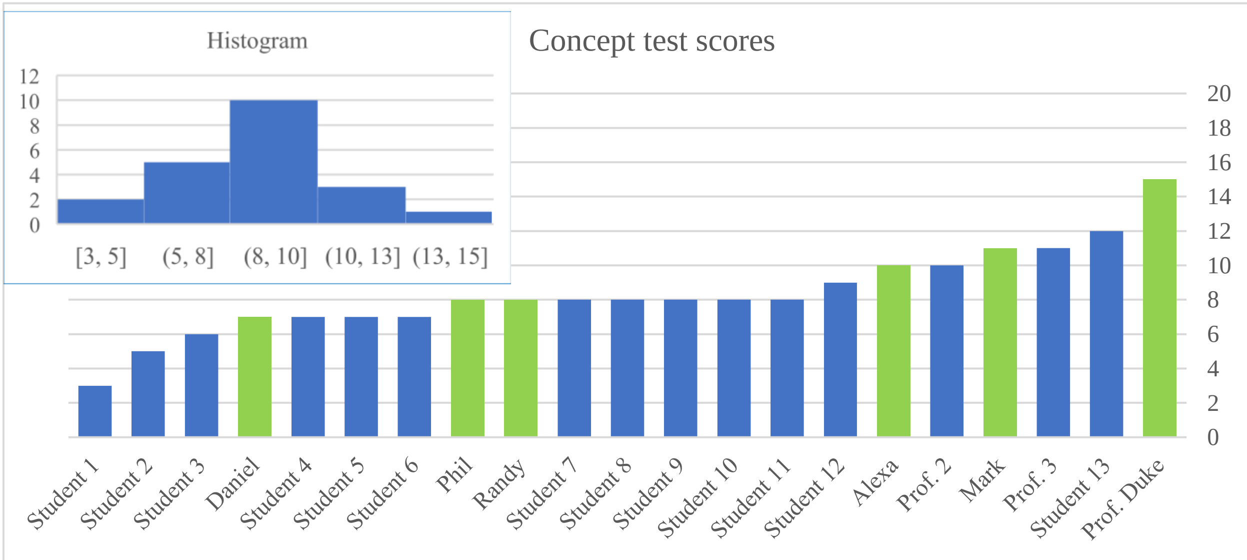
Analysis

Thematic analysis was used to analyze the qualitative data [17], [18]. The participants' audio recordings from the interview sessions were auto transcribed by the software used and were rechecked manually for accuracy. The collected data from the interview were organized through two iterations of in vivo coding to capture emergent themes [19]. Specifically, the transcripts were analyzed for different and similar patterns from which they were merged into themes. Multiple and recurring themes across interview data were used to characterize and identify potential misconceptions. The use of these multiple sources of data, the survey results and the interview transcripts, helped us to further locate possible errors of learned concepts among the participants and how these were potentially being shared by them. As the final step in the analysis, findings were shared back with the participants as a way of validating their responses and amending our interpretation.

Findings

Concept test responses

The test scores of all participants, including the interviewees (in green bars), are shown in Fig 1.



Green bars represent the interviewees' scores

Figure 1. Concept test scores with histogram

Looking at the histogram, 47.62% of the participants scored between 8 and 10 out of 20; 19.05% got scores above that range while 33.33% scored below that. The histogram shows an almost normal distribution relative to the central tendency of overall actual participants' scores but a little skewed to the right in relation to the mean score (average) of 10 out of a total of 20. This findings meant that their test scores were close to the average score.

By quantitatively examining the interviewees' scores (green bars), Prof. Duke, as an instructor who taught circuits for 5-10 years, clearly scored above the rest, followed by Mark and Alexa who experienced taking 3-4 circuit courses in the past, and lastly by Randy, Phil, and Daniel who took just 1-2 circuit courses. At this point, we could not conclude yet whether the incorrect answers that the students and the instructor got from answering the concept test would mean misconceptions; we need to breakdown these data by coalescing the interview data containing the justification of their responses to the test.

Table 3 shows a matrix of responses from the participants based on correct (cells highlighted in green) and incorrect (non-highlighted cells) answers from items 1 -20 of the concept inventory. Also, the matrix shows the specific objectives covered by each question. As mentioned earlier, two questions were selected to be discussed in each individual student interview, and four questions for the instructor wherein these are denoted in the matrix as C and I (correct and incorrect responses). This matrix served as a guide for the interviewer in conducting the interview and in analyzing the intersections for apparent accuracies and inaccuracies that could be possibly shared among the students and the instructor. Besides, this matrix also allowed us to inspect which concepts, based on the specific objectives, in transient DC and steady-state AC where misconceptions occurred.

Table 3. Concept inventory matrix with interviewees' responses

Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Score
Specific Objective *	F	E	E	D	G	D	G	F G	A	B	A	B	G	A F	A	B	C	G	F	C	
Prof. Duke		C				I	I						C								15
Alexa			C	I																	10
Daniel								C						I							7
Mark						I						C									11
Phil	C						I														8
Randy					C					I											8

C and I are correct and incorrect answers chosen for the individual interview
Green cells are correct answers
*refer to table 2 (TOS)

From the matrix, we can initially determine that questions 5, 6, and 9 involving concepts on power delivery and dissipation of electrical elements in an AC-source circuit, variables involved in first-order circuit time constant, and capacitor's operation, respectively, were possibly shared conceptual errors among student and faculty participants, with the exemption of Randy in question 5. On the other hand, questions 10, 11, 12 and 19 involving concepts about capacitor and inductor's behavior, and circuit elements' behavior in steady-state AC, respectively, were found to be generally shared accurate conceptual knowledge, except for Mark in question 10 and Daniel in question 11. Questions 14, 16 and 18 about capacitor and inductor's behavior, individual behaviors of electric elements in a circuit with AC-source in steady-state conditions, and power delivery and dissipation of electrical devices in an AC-source circuit may show inaccuracies in conceptual knowledge of the subject among students but not necessarily shared with the instructor.

Emergent themes

We would be taking a closer look at these findings as we discuss the themes that emerged from the interview data.

A. *Correct answer but with an inaccurate justification*

Randy, being the only participant who correctly answered item 5 that talked about power delivery and dissipation of electrical elements in an AC-source circuit, was asked to describe the lamp's behavior for circuit A having a DC source and circuit B having an AC source operating at a frequency we have at home, see Fig 2. He answered both in the concept test and the interview that the lamp in circuit A will be less bright than the one in circuit B. He was asked to justify his answer and said,

> "I believe that frequency may affect the brightness of the bulb. Maybe on the power? I forgot about the formula. But I think the frequency has to do with the brightness. The fluctuations will cause the increase in brightness." (Randy)

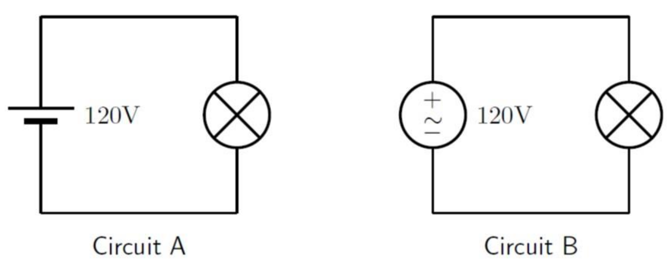


Figure 2. Circuit comparison for question 5

Although Randy got the correct answer in this question, he had difficulty expounding the phenomenon using circuit theory. He needed to consider the rms and peak voltage values in AC operation with the same load in order to justify the situation. This could count as a potential misconception but not necessarily something that was shared with his peers or his instructor.

However, as we discussed how the questions were stated and the conditions given for each element in the circuit, we found out it was difficult to answer the question without providing specific conditions for the type of lamp – whether it was an incandescent, a CFL, or other types.

B. Incorrect answer shared between students and instructor

Question 6 tackles variables that determine the operation of a first-order circuit's time constant. The concept test returned all incorrect answers to this question between students and the instructor. The question was:

In the following circuit (shown in Fig 3, the capacitor does not have stored energy before closing the switch for the first time. Once the switch is closed, there is a delay until the capacitor's voltage reaches its steady state. This elapsed time is called t_1. Then, the switch is opened. Next, there is another delay until the capacitor's voltage reaches its steady state. This second elapsed time is named t_2. The whole process is repeated from the beginning. How is the time t_1 (after closing the switch) compared with the time t_2 (after open the switch)?

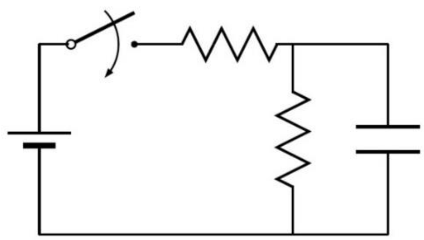


Figure 3. Circuit diagram for question 6

The options were:

(a) Time t_1 is greater than time t_2.
(b) Time t_1 is equal to time t_2.
(c) Time t_1 is less than time t_2. <u>(correct answer)</u>
(d) When the switch is opened, the stored energy in the capacitor does not flow to other elements in the circuit. Then, the process does not occur.

Mark, one of the students chosen to discuss his answer to this question, with an incorrect answer (even though he answered (a) in the concept yet he answered (b) in the interview), responded:

> "My answer for number 6 is (b), t_1 is equal to t_2. Because I believe that the capacitor has equal time to store its charge up to its steady-state. The possible option here is (a) time t_1 is greater than time t_2 because the time t_1 waited for the capacitor to reach its steady-state while time t_2 is already at its steady state. Letter (c) and (d) are not options because of the fact that in (d) the stored energy in the capacitor does flow to the other elements in the

circuit while C, time t_1 is less than t_2, is not an option because t_2 already is at its steady state." (Mark)

In addition, Prof. Duke was also asked to provide an explanation for his response to this concept test question. He said,

> "I suppose the answer is (b), t_1 is equal to time t_2, and the reason is due to the time constant. So, the time it takes for a certain element, I mean, the time it takes for a capacitor to charge and discharge can be related to the time constant. Thus, I conclude that t_1 is equal to t_2; the time it takes to charge, and discharge is equal for the capacitor. Though it depends on the circuit parameters. So, as far as I know, the performance of the capacitor may depend on the resistance involved in the circuit. So, the time constant may vary, depending on the values in the circuit." (Prof. Duke)

Although Randy and Prof. Duke had the same answer and provided a solid explanation of their responses, they might have missed on the foundational theory behind time constants. This particular question does not only require visual inspection but a theoretical formula to solve time constants operating in DC state. When analyzed using the formula, the answer, in theory, should be (c), t_1 is less than t_2. With the belief that time constants can readily be assessed by just looking at the circuit diagram or assuming that capacitors have equal charge and discharge rates, a potential misconception may arise, and this particular error in conceptual knowledge may have been shared between the students and instructors.

C. Correct answers shared between students and instructors

By not just looking at potential errors in conceptual knowledge in fundamental circuit concepts, we also found shared accurate beliefs among them, particularly in questions 11 and 19 that talked about the capacitor's behavior and individual behaviors of electric elements in a circuit with AC source in steady-state conditions.

D. Inaccurate beliefs shared among students

Questions 14 and 16 showed that there was a possible sharing of inaccurate beliefs among the student participants, provided that on those questions, only Prof. Duke was able to give a correct answer. The concepts involved in these questions include capacitor and inductor's operations and individual behaviors of electric elements in a circuit with AC-source in steady-state conditions. Considering question 14,

In the following picture (Fig 4), a circuit is shown, and to the right, the circuit voltage source waveform.

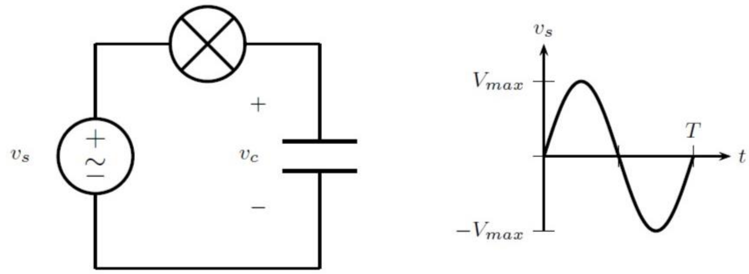


Figure 4. Circuit and waveform diagram for question 14

Which one of the following pictures (Fig 5) better represents the capacitor's voltage waveform?

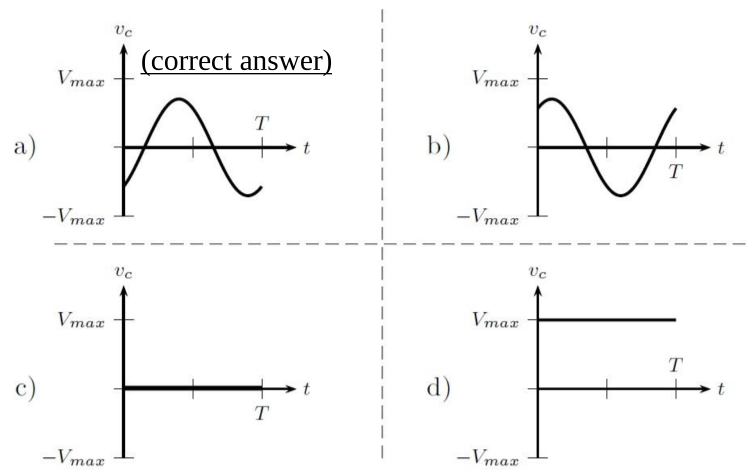


Figure 5. Choices for question 14

Daniel was asked to explain his answer to this question. We found that Daniel changed his answer from (b) to (d), although he still got the wrong answer. He explained,

> "My answer is (d) because the capacitor should clip the output; it has more DC than AC. (a) and (b) are in sine waveform, so I need more of a DC output. Or (c), I don't think it has an amplitude, so I decide to choose (d)." (Daniel)

Looking into the content of electric circuit courses in electronics engineering in the <university>, we found that the topics involving the particular concepts in question 14 and 16 were not covered. It made sense why students might have gotten this wrong because they had limited encounters with solving circuit problems involving both AC and DC sources at the same time. Although, a strong foundation on electric circuits theory can be used to deduce the answer from the problem stated in question 14.

The abovementioned themes were emergent in both concept test results and interview transcripts. These intersections provided us a better understanding of the data we collected. It is also important to note that some participants subconsciously changed their answers when compared to their initial responses to the concept test since we intentionally did not show them their concept test results during the interview sessions to allow us to know the factors that could change their answers, i.e., actual circumstances such as the effect of the limited time in taking the concept test or they were more conscious in the interview because they were required to justify their answers.

We believe that the instrument that we used has a huge potential in identifying misconceptions in electrical engineering core concepts. To make our instrument dynamic and adaptive, we propose that this tool be developed with having both quantitative and qualitative parts (concept test and analysis) that can be used by the department administrator to ensure that the misconceptions found in the students and those that are shared with the instructors are addressed promptly and methodically. We believe that this is a necessary supplemental move towards effectively assessing student learning. Including the instructors in the assessment practice may gain significant resistance from them; however, with proper delegation and information drive, we believe that it will benefit the instructor, and all the stakeholders of learning, in the aspects of safeguarding the sharing and propagation of correct conceptual knowledge in engineering.

Limitations and Future Work

We will use the findings from this pilot study to further improve the instrument that we developed. We also want to emphasize that for the instrument to be adaptive, we propose it to compose of quantitative (concept test) and qualitative measures (inquiry and analysis) to ensure that instructors share accurate knowledge and give suitable feedback, including some corrective actions corresponding to the identified misconceptions among students.

From the feedback we gathered among the participants, the concept inventory as an instrument needs to be refined further. For instance, specifying the conditions of the electric devices used in the circuit. Moreover, the use of language in the concept test need to be simplified in order to effectively communicate to a broader audience with various backgrounds and ethnicity, for instance, the Filipino participants in this pilot study. Some of them had a difficult time comprehending the terms and graphics used (e.g., stimulus, which is being used often in physiology) and how the questions were stated (e.g., presence of double-barreled questions).

Since the instrument used in this pilot study was aimed to pinpoint conceptual errors, the data, findings, and results are entirely and solely representational of the participants' perceptions and beliefs. This study does not intend to generalize to any student and instructor populations in electrical engineering across different universities except for the chosen participants for this study.

We emphasize that this is a pilot study. We recognize that despite the constraints such as the small number of participants, they, in fact, constitute a significant number to the overall population of undergraduate students and teaching faculty of the electrical and electronics engineering departments of the university of interest. For our future work, we look forward to considering all the participants to take part in both concept test and interviews with their performance analyzed for all the problems they solved. We also recognize that we will be using a similar research design but to a broader number of student and teaching faculty participants to ensure that we are able to reach data saturation for allowing us to replicate the entire full study. However, for this pilot study, we intend to report out our results and arrive at conclusion that is scoped entirely within the constraints of available data sources in the research locale of interest.

Conclusion

The number of studies lacks on assessment strategies that can be used for both students and instructors and that are dynamic and adaptive in nature. This pilot study used an adaptive instrument that has two parts: quantitative (concept test) and qualitative (inquiry and analysis), that aimed at identifying accurate beliefs and misconceptions in fundamental electrical engineering. With this instrument, we wanted to address the questions: *"What misconceptions in fundamental electric circuits are present in both instructors and students? How are these misconceptions shared between instructors and students?"* Among the 18 student participants and three faculty members from the electrical and electronics engineering departments at the university who responded to the concept test administered via Qualtrics, five students and one faculty agreed to be interviewed.

Recurring patterns were combined into themes which are: *correct answer but inaccurate justification, incorrect answer shared between students and the instructor, correct answers shared between students and the instructor, and incorrect beliefs shared among students.* From these themes, we identified that potential misconceptions shared by the students and the instructor were evident in the operations of a first-order circuit involving time constants. However, some inaccurate beliefs were apparent among the students only; for instance, parts of the capacitor and inductor's operations, and individual behaviors of electric elements in an AC circuit in steady-state conditions. Moreover, accurate conceptual knowledge was also seen being shared by students and the instructor on some of the concepts involving the capacitor's behavior and individual operations of electric elements in a circuit with AC source operating in steady-state conditions.

We also would like to highlight that in this study, incorrect responses in the concept test were not immediately interpreted as a misconception. That is why we propose to use this two-part adaptive concept test, involving the concept test itself and a follow-up inquiry and analysis, in order to capture and identify the errors fairly and systematically. On the question of how students and instructors share misconceptions, we encountered difficulty in pointing this out except for the fact that the student participants were previous students in the electric circuits courses taught by the instructor participant; the connection is indeed limited to this information. We hope to acquire more data in our future studies to be able to address this question soundly.

Student and faculty perceptions on the concept inventory will be used to further improve the design of the instrument, particularly in the use of technical and syntactical language to communicate with the learners' mental models. This work has implications for educators, curriculum designers, and researchers who seek to improve student learning of difficult engineering concepts. The results of this pilot study can be used to advance the instructional methods in teaching electrical engineering concepts through the use of the data produced through the adaptive instrument that we developed. More importantly, the outcomes of this study will provide the opportunity for research to interrogate why these misconceptions continue to exist and how we can use instructional practices and curriculum design methodologies to uncover and repair these misconceptions.

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Appendix 1

Interview protocol

Introduction

- Introduce interviewer.
- Allow the participant to introduce himself/herself.
- (State the purpose) We are conducting this interview to know how engineering students understand some electric circuits concepts regarding AC and transients.
- (State the interest) We are interested in knowing how engineering students understand some electric circuits concepts regarding AC and transients to help them improve their comprehension of electric circuits analysis.

Interview questions:

- Let’s start with this question (point to a specific question of interest with this particular student or faculty member)
- I would like to hear what your thoughts about this question are.
- I like to hear what you think the right answer is and why you think the alternative options are incorrect.
- Alternative questions (use as necessary):
    - If the person considers there is more than one correct option, ask which options s/he considers the correct ones are and why. Which options do you think the correct ones are?
    - If the person considers there is no correct option, ask what the correct option must look like. What must the correct option look like?
    - If they are confused by the wording, ask how they would word the question or the options. How do you word the question? How do you word the (a specific) option(s)?

Closing:

- Do you mind if we contact you for some follow-up questions or clarifications that we may have?
- Thank you for your time.