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Work in Progress: A Study of Transparent Assignments and Their Impact on Students in an Introductory Circuit Course

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ABSTRACT

Previous studies have revealed that students' academic confidence and sense of belonging can be improved by incorporating transparent assignments in introductory classes. However, little is known about the effectiveness of such techniques in engineering courses with multiple prerequisites in mathematics and physics. Preliminary data from this study demonstrate that after implementing transparent assignments in Electrical Engineering Fundamentals, 61.3% of students reported being more confident of their ability to succeed in their field of study, 38.7% of students had a stronger sense of belonging to the school's community, and 67.7% of students were more confident about learning effectively on their own. Furthermore, a 12.7% increase was observed in the number of students who scored more than 80 points on a 100-point final exam, and a 20.8% decrease was observed in those who scored less than 60 points on the exam.

I. INTRODUCTION

Recent studies have identified transparent assignments—that is, assignments with a clearly defined purpose, clearly specified tasks, and well-defined criteria for success [1]—as a simple, replicable teaching-intervention technique that enhances students' success. [2] reported that the benefits of transparent assignments are especially noticeable among first-generation, low-income, and underrepresented college students. These benefits are measured by the amount of transparency students perceive in the course, their self-ratings of academic confidence, sense of belonging, and improved mastery of skills that employers value, and direct assessment of the students' work.

The most conclusive experimental evidence to date on the benefits of transparent assignments comes from a large-scale pilot study of seven minority-serving institutions, including 1,180 students, 35 faculty members, and 61 courses, of which most were introductory-level courses and 12 were intermediate-level [2]. Even though some courses in science, technology, engineering, and mathematics were included in the study in [2], the aggregate data failed to clearly demonstrate the extent to which students of introductory engineering courses (which often have multiple prerequisites in mathematics and physics) benefited from transparent assignments.

This study aims to collect preliminary data that clarify the extent to which prerequisite courses in mathematics and physics affect students' perception of transparency, and hence, their ability to derive benefits, such as academic confidence and sense of belonging, from transparent assignments. A brief background to the course in this study is provided in Sec. II. The method used to collect preliminary data is described in Sec. III. Section IV presents the results of this study, while the conclusions are discussed in Sec. V.

II. BACKGROUND

Electrical Engineering Fundamentals is a calculus-based course that introduces students to the fundamental concepts of electronic circuits (Appendix A). It is required for all engineering students and requires satisfactory completion of three semesters of calculus, one semester of general chemistry, and two semesters of engineering physics.

This course has been designated a graduation bottleneck course by the university because many students do not pass the course at the first attempt and need to take it multiple times. As a result, many students do not graduate on time. The percentage of students who received repeatable grades (D, F, and W) across all sections in the fall of 2015 was 23%. A pre-semester survey of students enrolled in the fall of 2017 revealed that 53% of students were less than confident about their chances of successfully passing this course. A similar survey conducted in the summer of 2017 revealed that 21 and 19 out of 27 students had received a lower grade than B in Calculus III and Physics 220, respectively.

III. METHOD

A. Faculty Training in Transparent Assignments

The instructor of the course in this study attended a transparent assignment workshop in the summer of 2017 and was provided with a transparent assignment template and a checklist, and previously revised assignments. The instructor reviewed sample assignments and learned to identify differences between a less and a more transparent assignment [4]. As practice, one assignment was revised during the workshop.

B. Indirect and Direct Assessment

A pre-semester survey consisting of questions initially developed at the University of Chicago and later revised at the University of Illinois ([2]-[3]) was conducted in the first week of the fall semester of 2017 to establish a baseline. The assignments were revised (Appendix B) for greater transparency based on student feedback collected through two transparency checks conducted during the semester. For each transparency check, students were asked to assign a score based on the extent they agreed with each statement below:

1. I knew the purpose of the assignment.
2. Each assignment included a section that explained how the assignment was related to the objectives of the course.
3. My instructor identified a specific learning goal for the assignment.
4. I knew the steps required to complete my assignments.
5. The assignment included a detailed set of instructions for completing it.
6. My instructor provided detailed directions for each learning activity that was assigned.
7. I knew how my work would be evaluated.
8. My instructor provided annotated examples of past students' work.
9. My instructor provided tools I could use to assess the quality of my and others' work.

The instructor used feedback from these checks to improve transparency in the assignments. The post-semester survey from [3] was then conducted on students in the last week of the semester before the final exam.

The final exam distribution from fall of 2017 was used as a direct measure of students' learning and compared to the final exam distribution from fall of 2015—that is, the last time the *same* instructor taught the course in a regular semester.

IV. RESULTS

A. Indirect Assessment

1. Perceived Transparency

Statistics on students' perceived transparency of the course are presented in Table 1. 93.6% of the students reported that each assignment *often/always* included a section that explained how the assignment was related to the objectives of the course. 93.6% also reported that the instructor *often/always* identified a specific learning goal for each assignment. 83.9% *often/always* knew the purpose of each assignment.

Of the total number of students, 64.5% reported that each assignment *often/always* included a detailed set of instructions for completing it. 67.8% reported that the instructor *often/always* provided detailed directions for each learning activity that was assigned. 58.1% *often/always* knew the steps required to complete the assignments.

The statistics in Table 1 suggest that even though assignments had been revised to incorporate specific learning goals, the assignments' relationship to course objectives, and detailed instructions required to complete each assignment, 38.7% of students *sometimes* struggled with the steps required to complete the assignment.

Table 1. Perceived transparency in the course
The scale is defined as follows: 1=Never, 2=Sometimes, 3=Often, 4=Always. The final column represents the sum of *Often* and *Always*.

	% of Students in Each Category				
Questions	**1**	**2**	**3**	**4**	**3+4**
In this course, I knew the purpose of each assignment.	0	16.1	32.3	51.6	**83.9**
Each assignment included a section that explained how the assignment was related to the objectives of the course.	3.2	3.2	22.6	71.0	**93.6**
My instructor identified a specific learning goal for each assignment.	3.2	3.2	32.3	61.3	**93.6**
In this course, I knew the steps required to complete my assignments.	3.2	38.7	32.3	25.8	**58.1**
Each assignment included a detailed set of instructions for completing it.	3.2	32.3	29.0	35.5	**64.5**
My instructor provided detailed directions for each learning activity that was assigned.	3.2	29.0	32.3	35.5	**67.8**

2. Confidence to Succeed

Statistics on students' self-reported confidence to succeed as a result of taking this course are included in Table 2. 61.3% of the students were *somewhat more confident* or *much more confident* about their ability to succeed in school or in their field of study. 35.5% reported *no difference* in their confidence to succeed in their school or field of study.

Table 2. Confidence to succeed
The scale is defined as follows: 1=Much less confident, 2=Somewhat less confident, 3=No difference, 4=Somewhat more confident, 5=Much more confident. The final column represents the sum of *Somewhat more confident* and *Much more confident.*

	% of Students in Each Category					
Questions	**1**	**2**	**3**	**4**	**5**	**4+5**
As a result of taking this course are you more or less confident about your ability to succeed in school, or has the course made no difference?	0	3.2	35.5	45.2	16.1	**61.3**
As a result of taking this course are you more or less confident about your ability to succeed in your field of study, or has the course made no difference?	0	3.2	35.5	51.6	9.7	**61.3**

3. Sense of Belonging

Statistics on students' self-reported sense of belonging from taking this course are included in Table 3. 54.9% of the students felt they were members of their school's community—an increase of 35% from 23.1% in the pre-semester survey. 38.7% reported that this course helped them feel they were members of the school's community.

Table 3. Sense of belonging
The scale is defined as follows: 1=Never, 2=Sometimes, 3=Often, 4=Always. The final column represents the sum of *Often* and *Always*.

	% of Students in Each Category				
Questions	**1**	**2**	**3**	**4**	**3+4**
I feel that I am a member of my school's community.	12.8	32.3	35.5	19.4	**54.9**
How much did this course help you feel you are a member of your school's community?	38.7	22.6	25.8	12.9	**38.7**

4. Skills Valued by Employers

Statistics on students' self-reported growth in skills valued by employers are included in Table 4. 61.3% of students reported that this course helped them improve their ability to separate and examine the pieces of an idea, experience, or theory. 60% believed this course helped them learn how to apply theoretical concepts to practical problems or in new situations. 67.7% of students reported that this course helped them improve their ability to learn effectively on their own.

In addition, 30% of students reported that this course helped them collaborate effectively with others. 35.5% reported that it helped them learn how to connect information from a variety of sources.

Table 4. Perceived improvement in skills valued by employers
The scale is defined as follows: 1=Not at all, 2=A little, 3=A moderate amount, 4=A lot, 5=A great deal. The final column represents the sum of *A lot* and *A great deal*.

	% of Students in Each Category					
Questions	**1**	**2**	**3**	**4**	**5**	**4+5**
How much has this course helped you in collaborating effectively with others?	10	26.7	33.3	13.3	16.7	**30**
How much has this course helped you in improving your ability to separate and examine the pieces of an idea, experience, or theory?	0	16.1	22.6	45.2	16.1	**61.3**
How much has this course helped you in learning how to connect information from a variety of sources?	3.2	16.1	45.2	22.6	12.9	**35.5**
How much has this course helped you in learning how to apply concepts to practical problems or in new situations?	0	0	40	46.7	13.3	**60**
How much has this course helped you in improving your ability to learn effectively on your own?	0	9.7	22.6	51.6	16.1	**67.7**

5. Perception of Course Work

Statistics on students' overall perception of course work are presented in Table 5. 73.7% of students reported that the submitted work for the course (including the examination) reflected *a lot* or *a great deal* of their understanding of the course content. 77.5% of students reported that the course work and course activities benefited their learning *a lot* or *a great deal*.

Table 5. Perception of course work
The scale is defined as follows: 1=Not at all, 2=A little, 3=A moderate amount, 4=A lot, 5=A great deal. The final column represents the sum of *A lot* and *A great deal*.

	% of Students in Each Category					
Questions	**1**	**2**	**3**	**4**	**5**	**4+5**
How accurately does your submitted work for the course (including exams/quizzes) reflect your understanding of the course content?	0	3.2	22.6	48.4.	25.8	**73.7**
Did the coursework and course activities benefit your learning?	0	6.5	16.1	45.2.	32.3	**77.5**

B. Direct Assessment

Students generally struggled with end-of-semester topics such as frequency response, Bode plot, and filter design. Hence, the final exam (Appendix C) was used as a direct measure of students' mastery of difficult topics covered in this course. This exam was designed such that 60% of it consisted of problems similar to those in the assignments. Distributions of the final exam scores from fall of 2017 and fall of 2015 are shown in Figure 1. The average and the median from fall of 2017 were 74 and 80, respectively, out of 100 points—an improvement from fall of 2015, when the average was 67 and the median was 62. 46% of students scored 80 points or above on the final exam in the fall of 2017, compared to 33.3% in that of 2015. 19.2% of students scored less than 60 points in the fall of 2017, compared to 40.6% in that of 2015.

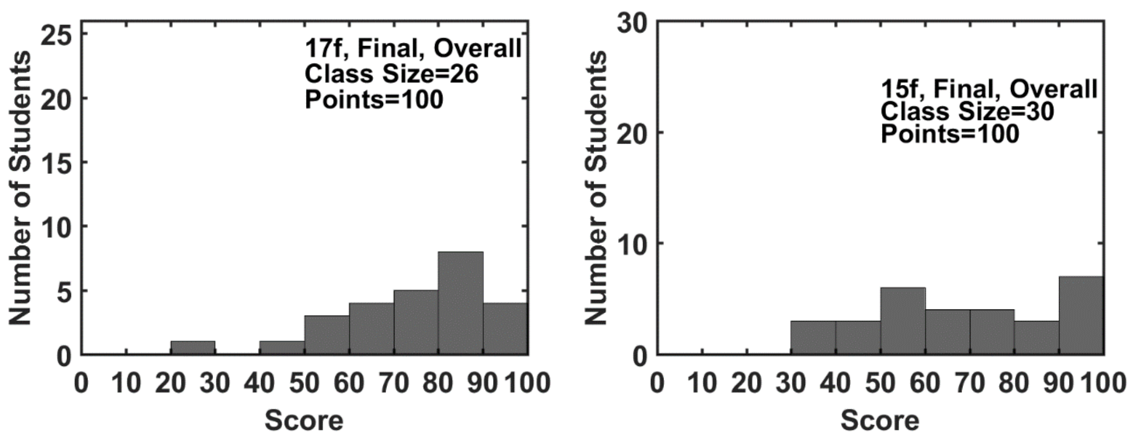


Figure 1: Distribution of final exam scores from fall of 2017 (left) and fall of 2015 (right).

V. CONCLUSION

As a result of implementing transparent assignments in Electrical Engineering Fundamentals, 93.6% of students reported greater perceived transparency in learning goals for each assignment and each assignment's relationship to the course objectives. 77.5% of students reported that the course work and course activities benefited their learning. 61.3% of students were more confident of their ability to succeed in their field of study. 38.7% of students felt a stronger sense of belonging with the school's community. 67.7% of students felt that this course helped them improve their ability to learn effectively on their own. The average and the median scores of the final exam were improved by 7 and 18 points, respectively, on an exam scored out of 100 points. A 12.7% increase in the number of students who scored 80 points or above on a 100-point exam was observed, and a 20.8% decrease in those who scored less than 60 points on the exam was observed.

REFERENCES

[1] Winkelmes, Mary-Ann, "Transparency in Teaching: Faculty Share Data and Improve Students' Learning," *Liberal Education,* vol. 99, no. 2, 2013.

[2] Winkelmes, Mary-Ann et al., "A Teaching Intervention That Increases Underserved College Students' Success," *Peer Review,* Winter/Spring, 2016.

[3] University of Nevada, Las Vegas, "Transparency in Learning and Teaching in Higher Education." [Online]. Available: https://www.unlv.edu/provost/teachingandlearning [Accessed: Feb. 3, 2018].

[4] California State University Northridge, Northridge, "Teaching Transparently." [Online]. Available: https://www.csun.edu/undergraduate-studies/faculty-development/teaching-transparently [Accessed: March 28, 2018].

APPENDIX

A. Course Outline

Topics

- Circuit elements
- Resistive circuits
- Methods of analysis of resistive circuits
- Circuit theorems
- The operational amplifier
- Energy storage elements
- The complete response of *RL* and *RC* circuits
- The complete response of circuits with two energy storage elements
- Sinusoidal steady-state analysis
- Frequency response
- Filter circuits

B. Sample Assignment

1. Cover Page

ECE 240 **Name (Print):** ________________________

Electrical Engineering Fundamentals

Homework 7

Due date: 10/30/17

Homework policy:
Homework submissions must be *stapled* and have a *cover sheet*, otherwise they will *not* be accepted. Due to the sheer volume of assignments that must be processed, late submission of an assignment will not be accepted. Assignments are collected in the beginning of the class, placed in an envelope, and handed over to the grader. Only *one* homework assignment will be excluded from the computation of homework grade.

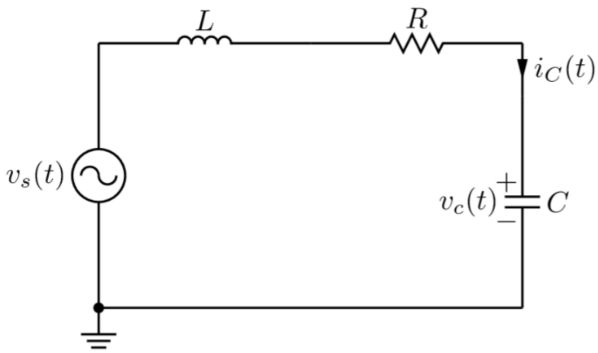
Concepts: Second Order circuits
Purpose: In the previous assignment, we considered the response of RL and RC circuits to abrupt changes. The abrupt change might be a change introduced to the circuit when a switch is opened or closed. Alternatively, the abrupt change might be a change to the input (e.g. $v_s(t)$) to the circuit when the input source is characterized by a step function.

In this assignment, second-order circuits (i.e. circuits containing a total of two capacitors, two inductors, or one capacitor and one inductor) are modeled by second order differential equations. In general, there are three possible solutions to the second order differential equations depending on the damping coefficient (α) and the resonant frequency (ω_o).

In the first three problems, you are provided with step-by-step instruction on determining the second order differential equation. In the last two problems, you are invited to use a combination of circuit technqiues (e.g. Ohm's law, KCL and KVL), and defining equations such as $i = Cdv(t)/dt$ and $v = Ldi(t)/dt$ in determining the second order differential equations on your own.

You may find it helpful to watch a lab demo of a RLC circuit, as well as a circuit analysis example before you start working on this assignment (`https://goo.gl/WQSs8P`).

2. *Sample Question*



Let $x(t)$ be $v_c(t)$. $v_s(t) = u(t)$.

A "typical" assignment

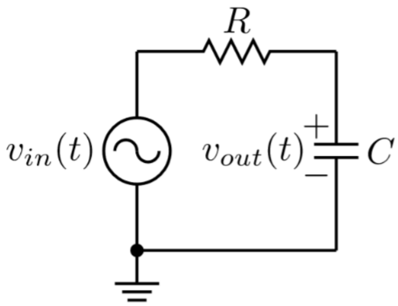
- Let $R = 100\Omega$, $L = 3.3$ mH, and $C = 0.01\mu$F. Is there ringing (i.e. ripples) in the step response of $v_c(t)$?

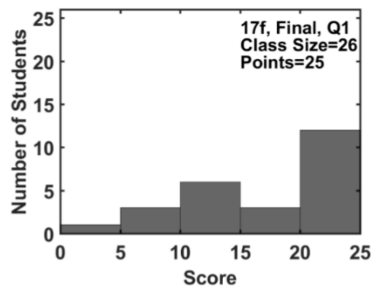
A "revised" assignment

- Analyze the circuit above to show that $x(t)$ satisfies $\frac{d^2}{dt^2}x(t) + 2\alpha\frac{d}{dt}x(t) + \omega_o^2 x(t) = f(t)$.
- Determine α and ω_o.
- Let $R = 100\Omega$, $L = 3.3$ mH, and $C = 0.01\mu$F. Is there ringing (i.e. ripples) in the step response of $v_c(t)$? (*Hint*: α and ω_o).

C. 2017 Final Exam Questions

1. Question 1



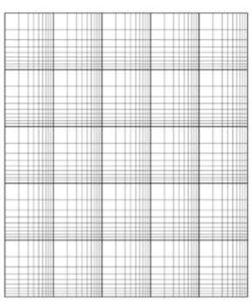


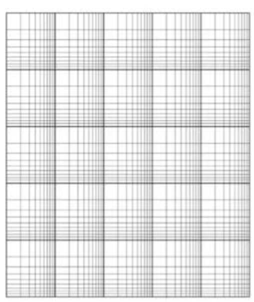
Question: Let $v_{in}(t) = 10\cos(\omega t - \pi)$.

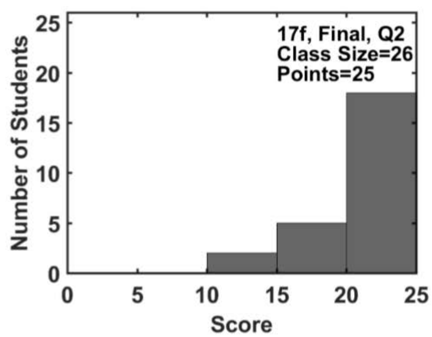
1. Determine $v_{in}(\omega)$, the phasor representation of $v_{in}(t)$.
2. Determine $H(\omega)$.
3. Evaluate $H(\omega)$ at ω_o, where ω_o is $1/(RC)$.
4. Determine $v_{out}(\omega_o)$.
5. Determine $v_{out}(t)$ with $v_{in}(t) = 10\cos(\omega_o t - \pi)$.

52 % of students score 15 or above (out of 25 points).

2. Question 2





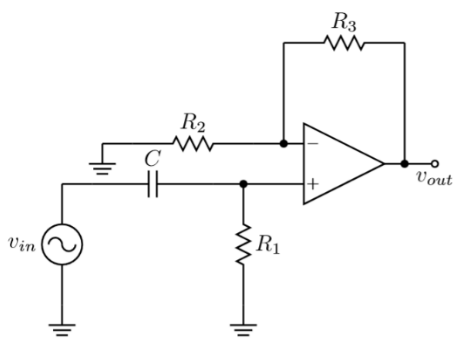


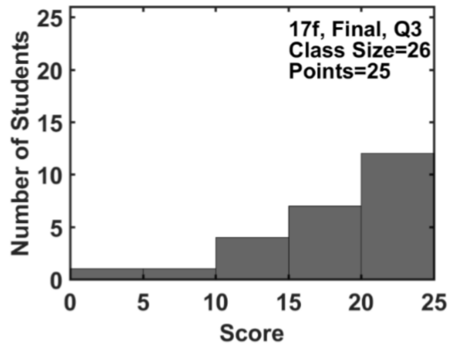
Question: Let $H(\omega) = \frac{1+j\omega/\omega_z}{(1+j\omega/\omega_{p1})(1+j\omega/\omega_{p2})(1+j\omega/\omega_{p3})}$, where ω_{p1}, ω_{p2}, ω_{p3} and ω_z are 10 rad/s, 100 rad/s, 1,000 rad/s and 1 rad/s respectively.

1. What are the critical frequencies of ω_z?
2. What are the critical frequencies of ω_{p1}?
3. What are the critical frequencies of ω_{p2}?
4. What are the critical frequencies of ω_{p3}?
5. Determine $|H(\omega)|_{\omega=0.1\text{rad/s}}|$.
6. Determine $\angle H(\omega)|_{\omega=0.1\text{rad/s}}$.
7. Draw Bode plot for ω between 1 rad/s and 10,000 rad/s.

88 % of students score 15 or above (out of 25 points).

3. Question 3



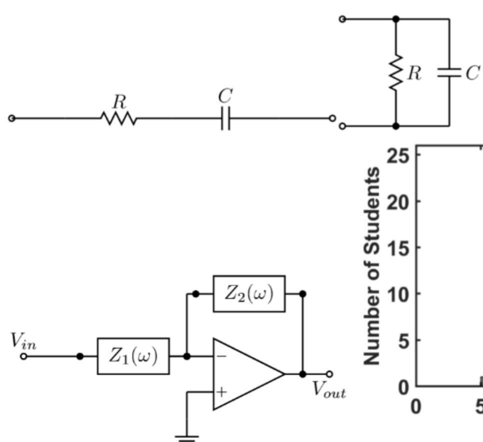


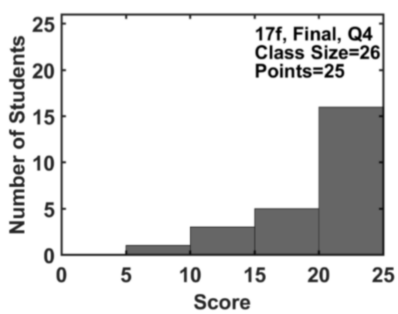
Question:

1. Determine $H_1(\omega) = v_+(\omega)/v_{in}(\omega)$.
2. Determine $H_2(\omega) = v_{out}(\omega)/v_-(\omega)$.
3. Determine $H(\omega) = v_{out}(\omega)/v_{in}(\omega)$.
4. Determine $H(\omega = 0)$.
5. Determine $H(\omega = \infty)$.
6. What type of filter is this? A lowpass or high pass filter.

72 % of students score 15 or above (out of 25 points).

4. Question 4





Questions:

1. Determine the impedance associated with the series circuit in (a).
2. Determine the impedance associated with the parallel circuit in (b).
3. Determine the voltage gain associated with the circuit in (c).
4. Let $H(\omega)$ be defined as $-\frac{j\omega/\omega_o}{(1+j\omega/\omega_{p1})(1+j\omega/\omega_{p2})}$. Determine a schematic that implements $H(\omega)$.

64 % of students score 15 or above (out of 25 points).