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Non-Electrical Engineering Students' Perceived Value of an Engineering Circuits Course

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Abstract

Students can be strengthened as engineers in their field when they have a broad understanding of core engineering fundamental topics outside of their specific discipline. This principle drives the common sophomore engineering curriculum at Louisiana Tech University where courses on statics, thermodynamics, and circuits are required for all engineering students regardless of major.

However, engaging all students across disciplines in concepts that are not directly in their field can be difficult for the instructors of the courses. In an effort to mitigate disinterest from non-electrical engineering students in the circuits course, a pilot curriculum was developed to introduce new elements to the class such as real-world applications, project- and problem-based learning, and practicing engineer testimonials.

Preliminary data for this study was presented in the work-in-progress paper "Work-in-Progress: Perceived Value of Non-Electrical Engineering Students in an Engineering Circuits Course" which only included data from the Fall 2024 quarter of the pilot. This paper is an expansion on the WIP by increasing the dataset to include four additional quarters through Fall 2025.

This paper will present results from a survey based on the expectancy value theory framework that is used to assess the students' perceived value of the course as it relates to their major and careers and an end-of-course survey that asks more specific questions about the course content. Each quarter, the surveys were given to students in the pilot section as well as the concurrent sections that were taught in the traditional manner. The results will provide a baseline understanding of how the initial changes integrated into the pilot section impact the students' perception of the course and its benefit to their general engineering education and their future careers as compared to the students in the traditional sections.

Introduction

Perceived Value

It can be difficult to understand how people perceive the value of items, activities, and experiences. In marketing, value is perceived by the consumer as opposed to being determined by the seller [1]-[5]. Reference [5] notes individual consumers can define value in four different groups: "(1) value is low price, (2) value is whatever I want in a product, (3) value is the quality I get for the price I pay, and (4) value is what I get for what I give." A definition that encompasses these groups is "the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given" [5].

In the educational context, perceived value is difficult to define as well since there are many different factors that could influence a student's perceived value. Authors in [4] note the influencing factors of perceived value can be separated into five different categories, with definitions given by [6] and [7], based on what is known as the theory of consumption values:

1. Functional value – “students’ expectations that their chosen course of study will gain them employment or career advancement”
2. Social value – “value students receive from forming friendships with course colleagues”
3. Epistemic value – “benefits derived through an offering’s ability to arouse curiosity, provide novelty, or satisfy a desire for knowledge”
4. Emotional value – “students’ sense of gladness and self-achievement in taking their course”
5. Conditional value – “value perceived by students in terms of teaching materials such as textbooks”

Therefore, depending on what each individual student hopes to gain, each student’s perceived value of the same course or other academic endeavor could vary widely. Researchers in [7] sought to create a perceived value index to measure students’ perceived value in higher education. After examining four different components, which were future goals, trade-off between price and quality, comparison with alternatives, and emotion, they found the perceived value was best measured by trade-off between price and quality and comparison with alternatives. Researchers in [7] also highlighted the need for institutes of higher education to focus on showing students how they will benefit from their academic studies and reduce the amount of costs they see to engaging in the studies in order to increase the students’ perceived value.

Expectancy-Value Theory

As described in [8], expectancy-value theory (EVT) suggests students’ expectations of success on a given task and the value they place on these tasks influence achievement choices, performance, effort, and persistence [9]. The students’ expectations of success and values, which include attainment value, intrinsic value, utility value, and cost, are influenced by “task-specific beliefs such as ability beliefs, the perceived difficulty of the different tasks, and individuals’ goals, self-schema, and affective memories” [9].

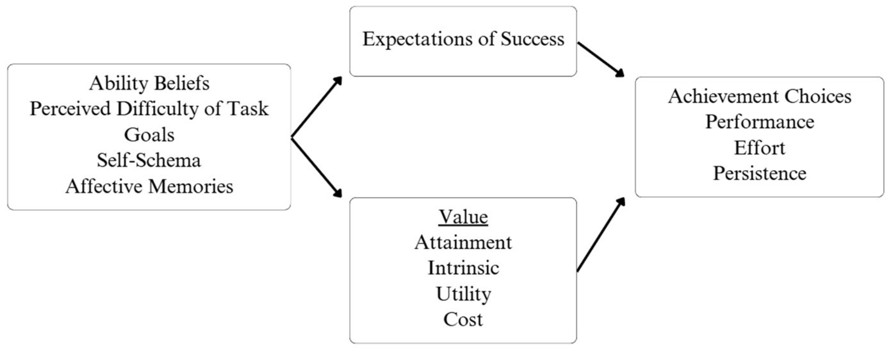

Fig. 1**:** Overview of Expectancy Value Theory

EVT has been applied to engineering education and other STEM fields as a way to predict students' choices, effort, persistence, and success in these fields [10], [11]. Reference [10] found "students' valuing of their coursework (interest and utility values) was the strongest unique predictor of their end-of-term study program satisfaction." Researchers suggested EVT-related interventions early in a student's undergraduate career could help "support [their] motivation, achievement, and retention in STEM fields." Reference [12] had similar findings and suggested that machine learning and EVT could possibly be combined to aid in deciding which students would benefit from intervention to increase the chances of persisting in engineering.

The EVT framework has also been used to directly impact students' motivations by attempting to increase the value a student perceives to be gaining from an academic endeavor. Utility-value interventions (UVIs) have been introduced in an attempt to improve students' perceptions of course content [13], [14]. The UVIs encouraged students to reflect on how math could be applicable in their everyday lives which effectively "[improved] students' motivations and achievements" and increased the utility value they saw in the course content. However, authors in [14] noted telling students how content might be applied to their lives as opposed to letting them discover it on their own could seem threatening and demotivating to those who are low performers in the course or to those who dislike the course content.

Background and Motivation

Louisiana Tech University offers seven ABET accredited, degree-awarding engineering programs, including Biomedical, Chemical, Civil, Cyber, Electrical, Industrial, and Mechanical Engineering. Students in each discipline are required to take a three-course sophomore sequence, which includes Statics and Mechanics of Materials, Electrical Engineering and Circuits, hereafter referred to as Circuits, and Thermodynamics.

Motivation for this research was described in [8], which included some students' responses to an End-of-Course survey:

- *Civil engineering students should not have to take this course because it doesn't [sic] not apply even in the slightest.*
- *Split course into two sections, Circuits for mechanical, electrical, and comp sci, and a circuits for Civil and chemical. I don't know about chemical engineering, but circuits feels less useful for Civil engineers to know.*
- *It was taught very well, I just don't think it is all that relevant to industrial engineering.*

Therefore, the focus of this paper is to assess the impact on the non-electrical engineering students' perceived value of Circuits via a pilot version during the 2024-2025 academic year and Fall Quarter 2025.

Overview of Circuits and Pilot Course

As previously stated, Circuits is part of a three-course sophomore series that all engineering majors are required to take. The class covers circuit theory topics such as Kirchoff's Laws, Thevenin equivalent circuits, and basic operational amplifier circuits. Included in the course are homework sets via the online platform WeBWorK, in-class assignments, "minilabs," and three multiple choice exams. The in-class assignments are two to three problems that relate to the lecture that are worked on by the students at the end of class to ensure understanding of the material and receive assistance from fellow students or the instructor if needed. The minilabs are eight small labs dispersed throughout the quarter that simply prove the theory discussed in class, such as a voltage divider circuit proving KVL.

The pilot version of Circuits was created with strategic components to increase the non-electrical engineering students' perceived value of the course. Table I gives a brief overview of the new elements in the course. For a more detailed explanation of the current Circuits course as well as the elements added to the pilot version, refer to the work-in-progress paper [8].

TABLE I

CIRCUITS PILOT COURSE ELEMENTS

Pilot Course Element	Description
Engineer Testimonials	Testimonials from non-electrical engineers describing why they think Circuits knowledge is important and/or how they have used electrical concepts in their career
Demo and lecture on ideal transformers	Demonstration of a simple transformer using a toroidal core and two pieces of wire; lecture on transformer circuits and uses in industry/real-world
Introduction to AC power lecture	Lecture of AC power in real-world including generator basic at power plants, transmission/distribution, and in our homes
Motor starter circuit components with hands-on elements	Explanation of basic motor stater circuit while learning about cable sizing, breakers/fuses, push buttons, and electromechanical relays. Different size cables and a breaker brought to class with which students could touch and interact
Minilab problem-based learning prompts	Prompts added to minilabs to encourage students to think more deeply about the circuits and how they might be encountered in industry. Actual activities performed in minilabs kept the same as non-pilot sections
Problem- and project-based learning op amp design project	Students designed and tested an op-amp circuit to convert a triangle wave into a square wave to solve a given dilemma then wrote a memo to their "boss" explaining the process

Data Collection

Table II shows the different sections of the Circuits course offered from Fall 2024 through Fall 2025 and the number of students enrolled prior to the drop date. Note that "ETO" designates the sections that were classified as "Engineer Testimonial Only" in that the only change between that section and the non-pilot (traditional) sections was engineer testimonials being presented to the students. All other course content remained the same.

TABLE II

CIRCUITS SECTIONS OFFERED BY QUARTER

Quarter	Sections Offered	Number of Students
Fall 2024	Pilot	45
	Non-Pilot (2 sections)	73 (combined)
Winter 2025	Pilot	46
	Non-Pilot (2 sections)	83 (combined)
Spring 2025	ETO	43
	Non-Pilot	34
Summer 2025	ETO (Online)	44
Fall 2025	Pilot	42
	Non-Pilot (2 sections)	82 (combined)

As described in [8], three surveys were administered to students in all sections. A Pre-Circuits EVT and Post-Circuits EVT survey were given at the beginning of the first day of class and the end of the last day of class, respectively. The prompts that are analyzed for this paper are the three related to the course's utility value as defined by EVT:

1. [Circuits] is valuable because it will help me in the future.
2. [Circuits] content will be useful for me later in life.
3. Being good in [Circuits] will be important for my future (like when I get a job or for graduate school).

The third survey was an End- of-Course (EOC) survey on the last day of class that posed statements/questions such as:

- I believe the content in [Circuits]…
  - Is relevant to my career path.
  - Is beneficial in my development as an engineer.
  - Relates to industry applications.
- For the lecture topics listed, rate the level of value you feel each has on your future as an engineer.

- The Engineer Testimonials led me to believe that [Circuits] is more valuable for my future than I initially thought at the start of the quarter. (This question was not presented to the non-pilot version students as they did not see the engineer testimonials.)
- What did you like most/least about the course?

Results

EVT Survey

To analyze the Pre/Post-Circuits EVT survey responses, the responses were filtered by students in the pilot sections, the non-pilot sections, and the ETO sections of the course who were non-electrical engineering majors. This gave a sample size of 69 for the pilot sections, 120 for the non-pilot sections, and 28 for the ETO sections.

Jamovi version 2.6 was utilized to conduct the tests. Portions of the results can be seen in Table III. All tests were conducted using the Wilcoxon Rank-Sum test (non-parametric version of paired samples t-test) with rank biserial correlation r_{rb} for the effect size. The Likert responses were assigned the following values which were used to conduct the tests:

- Strongly disagree – 1
- Disagree – 2
- Neither agree nor disagree – 3
- Agree – 4
- Strongly Agree – 5

TABLE III

WILCOXON RANK-SUM TEST RESULTS

EVT Prompt	Class Section	Pre-Circuits Mean	Post-Circuits Mean	Mean Difference	p-value	Effect Size r_{rb}
[Circuits] is valuable because it will help me in the future.	Non-Pilot	3.392	3.308	- 0.084	0.261	0.152
	Pilot	3.507	3.725	+ 0.218	0.113	- 0.278
	ETO	3.643	3.679	+ 0.036	1.000	0.000
[Circuits] content will be useful for me later in life.	Non-Pilot	3.425	3.317	- 0.108	0.211	0.178
	Pilot	3.551	3.638	+ 0.087	0.627	- 0.092
	ETO	3.500	3.571	+ 0.071	0.849	- 0.048
Being good in [Circuits] will be important for my future (like when I get a job or for graduate school).	Non-Pilot	3.250	2.975	- 0.275	0.003*	0.400
	Pilot	3.232	3.435	+ 0.203	0.223	- 0.205
	ETO	3.429	3.393	- 0.036	0.742	0.092

* Significance level $p < 0.01$
r_{rb} effect size = 0.2-0.5 – small; 0.5-0.8 – medium; > 0.8 – large

As seen in Table III, one test was statistically significant. On average, non-pilot students were less agreeable to "being good in [Circuits] will be important for my future (like when I get a job or for graduate school" at the end of the quarter (M = 2.975, SD = 1.170), than at the beginning of the quarter (M = 3.250, SD = 1.169). The test indicated this difference, -0.275, 95% CI [-0.098, -0.463], was significant T = 1455.5, p = 0.003 and represented a small effect size, r_{rb} = 0.400.

EOC Survey

To analyze the EOC survey responses, the responses were again filtered by students in the pilot sections, the non-pilot sections, and the ETO sections of the course who were non-electrical engineering majors. This gave a sample size of 69 for the pilot sections, 93 for the non-pilot sections, and 30 for the ETO sections for the prompts analyzed in Table IV. These responses were tested using the Mann-Whitney U Test with rank biserial correlation r_{rb} for the effect size. The Likert responses had the same values for the tests as previously stated for the EVT surveys.

TABLE IV

MANN-WHITNEY U TEST RESULTS

I believe the content in [Circuits]…	Comparison (1) vs. (2)	(1) Mean	(2) Mean	Mean Difference‡	p-value	Effect Size r_{rb}
Is relevant to my career path.	Non-Pilot vs. Pilot	3.097	3.391	- 0.295	0.152	0.124
	ETO vs. Pilot	3.467	3.391	+ 0.076	0.935	- 0.010
	ETO vs. Non-Pilot	3.467	3.097	+ 0.370	0.224	- 0.140
Is beneficial in my development as an engineer.	Non-Pilot vs. Pilot	3.570	3.783	- 0.213	0.178	0.111
	ETO vs. Pilot	3.900	3.783	+ 0.117	0.391	- 0.097
	ETO vs. Non-Pilot	3.900	3.570	+ 0.330	0.077	- 0.196
Relates to industry applications.	Non-Pilot vs. Pilot	3.527	3.913	- 0.386	0.006*	0.221
	ETO vs. Pilot	3.867	3.913	- 0.046	0.964	0.006
	ETO vs. Non-Pilot	3.867	3.527	+ 0.340	0.077	- 0.195

‡ – Mean difference is calculated by subtracting (2) from (1). For example for the first row, the Pilot mean is subtracted from the Non-Pilot mean
* Significance level $p < 0.01$
r_{rb} effect size = 0.2-0.5 – small; 0.5-0.8 – medium; > 0.8 – large

In general, the ETO and pilot version students' mean levels of agreeableness to each of the prompts were higher than the non-pilot sections; however, only one mean comparison can be considered statistically significant. As seen in the table, on average for "I believe the content in [Circuits] relates to industry applications," the pilot course students had a higher level of agreeableness (M = 3.913, SE = 0.105), than the non-pilot course students (M = 3.527, SE = 0.101). This difference of -0.386, 95% CI [-0.678, -0.094], was significant T = 2498, p = 0.006, and it represented a small effect, r_{rb} = 0.221.

When the ETO and pilot students responded to the statement "The Engineer Testimonials led me to believe that [Circuits] is more valuable for my future than I initially thought at the start of the quarter," 68% (n = 97) of them "agreed" or "strongly agreed" with the statement, with another 11.3% stating they already believed the course was valuable at the start of the quarter.

Discussion

Based on the EOC data presented in Table IV, the non-electrical engineering students in the pilot were more agreeable to the fact that the content in Circuit relates to industry applications.

Responses related to the engineer testimonials show they were impactful to the students. The different perspectives from practicing non-electrical engineers were beneficial, and the frequency of the testimonials (every lecture day) potentially helped them affect the non-electrical engineering students' perceived value of the course.

However, from the EVT data, it can be inferred that the overall perceived value the students saw in the course was not changed positively by the pilot, ETO, or non-pilot course. While the changes made through the pilot course were impactful, the lack of statistical significance indicated the changes were not enough. Aside from the testimonials, the new content only affected five out of 26 lectures along with the eight minilabs.

Nevertheless, it could also be inferred that making no changes or improvements to future sections of the Circuits course could allow for negative impacts to students' perceived value of the course to continue. This is evidenced by the statistically significant mean reduction to the third EVT prompt, which states "being good in [Circuits] will be important for my future (like when I get a job or for graduate school)." This result is unfortunate as these students seemingly don't recognize that their careers could have many paths that include cross-discipline work or teams. Notably, this analysis does show that the pilot course elements prevented the non-electrical engineering students' perceived value from decreasing overall.

Conclusion

A pilot version of a sophomore-level Circuits was implemented in an attempt to increase the non-electrical engineering students' perceived value of the course. The pilot elements led the students to be more agreeable to the fact that the course was related to industry applications, and the elements prevented the pilot, non-electrical engineering students' perceived value of Circuits from decreasing as seen in the non-pilot section. While the changes to the course did not have a large, positive impact, the engineer testimonials were a free and easy intervention added to the course that positively influenced many of the students. Testimonials like these could be solicited and implemented in any general engineering course.

Future Work

Given these findings, more work is anticipated for this research. The pilot version's impact on student performance in post-requisite courses (courses for which Circuits is a prerequisite) will be examined. Additionally, the EVT data will be divided by different markers (ACT, GPA, etc.) to provide insights on how students with varying academic achievement levels were affected by the changes.

As this research only utilized student responses related to utility value, the responses for interest value, attainment value, opportunity cost, effort cost, and/or psychological cost could be used to determine whether the pilot course impacted students in these realms.

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