WIP: Investigating the Impact of Community-Inspired Design Projects

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Abstract

This WIP paper describes ongoing efforts to better understand the impact of a community-inspired design project for first-year engineering students. Given the impact of authentic experiences, we sought include a community-inspired design project within our first-year engineering program. During spring semester 2023, students sought to develop something to aid a person with some kind of disability. In order to help students identify the needs from that group, students were given the opportunity to travel to local care facilities, schools and employment locations to take tours and talk to critical stakeholders. These community partners also served as resources during the semester, and as evaluators during the end-of-semester design showcase. This work seeks to better understand the impact of this experience on students. This is currently being investigated through quantitative and qualitative measures, including the Engineering Design Expectancy Value Scale (EDVES) and focus groups. Additionally, the work will inform further research regarding this and other community-inspired design projects.

Introduction & Background

Engineering programs often seek to provide their students with authentic experiences in their engineering curriculum. Beyond broad calls for authentic experiences (e.g., [1], [2]), these experiences have been found to be broadly beneficial to students. In one meta-analysis of engineering education research, Strobel, Weng, Weber and Dyehouse [3] found that the key outcomes of authentic engineering experiences include promoting inquiry, self-construction of knowledge, higher order thinking, and more. While there are many facets to 'authenticity' [3], these experiences often feature ill-structured problems, in real-world (or simulated real-world) contexts, where there is not "one right answer". While there are noticeable benefits to authentic experiences, there are also significant challenges to engaging students in these authentic experiences, particularly with less experienced students, such as those in first-year engineering programs.

When considering authentic engineering experiences within their courses, first-year instructors are often concerned about how their students' limited technical abilities will impact their ability to complete an authentic engineering design experience. Concerns regarding the quality of the product, if any product at all, that first-year students can deliver to an external client are often raised as well. Additionally, there are often wide-ranging and varied course outcomes for first-year engineering courses [4], so, even given the apparent benefits of authentic experiences, the question of appropriate time and place for these authentic experiences.

This Work in Progress paper will describe an attempt to better understand how one attempt at a more authentic first-year engineering design project impacted students' expectancy, value, and engineering identity. These constructs have been identified as critical to predicting success and career plans in engineering fields [5], thus were chosen as the constructs to investigate. Initial data was gathered using the Engineering Design Expectancy Value Scale (EDVES) [6], and the

results of that survey will be used to inform the development of a focus group protocol. Together, it is hoped that these data will allow for a better understanding of the impact of authentic engineering experiences on novice engineers.

Context

Ohio Northern University (ONU) is a small, private, primarily undergraduate institution. There are approximately 700 students enrolled in the college of engineering and approximately 200 first-year engineering students each year. ONU employs a common first-year engineering curriculum [7] via a two-semester course sequence. These courses, Foundations of Design 1 & 2 (FoD), focus on introducing students to the engineering design process, as well as engineering tools and skills including as teamwork, project management, computer-aided modeling, experimentation, and basic circuits. During the first semester, students complete a series of small design projects focused on a hypothetical family's residence in rural China. During the second semester, the students complete a semester-long team-based design project. During this project, they identify a need, scope the problem, ideate possible solutions, build prototypes, test, refine, and ultimately present their design and functional prototype at an end-of-semester design showcase. The context has historically varied but has included hypothetical contexts such as hurricane rescue and recovery, toy design, and aid for senior citizens.

During spring semester 2023, in efforts to further increase the authenticity of the design project, we partnered with disability service providers in the surrounding region, including work training, care, and educational facilities. Students were given opportunities to tour the facilities and interact with both providers and participants. These tours sought to allow students to identify real needs in the community for which they could provide an engineering solution. Additionally, as the end of the semester, many of our project partners sent staff members to judges in the final design showcase. While it was not expected that the designs were ready to be delivered to a partner at the end of the semester, several promising projects were identified by our project partners and are currently under further development.

Research Question

We are seeking to better understand the impact of the second semester community-inspired design project, especially compared to the hypothetical design project that students experienced during their first semester. To this end, the following research questions are being investigated:

1. What, if any, changes in can be seen in students' response to the EDVES survey?
2. What impact, if any impact do students describe based on their experiences, particularly in regards to engineering identity, career goals, expectancy value, and others that emerge.

This work is ongoing, and this work in progress paper describes the current data analysis and plans to continue to investigate these questions.

Methods

As part of a larger survey, the EDVES survey [6] was administered electronically and consisted of 38 questions Likert-like question, plus demographic questions. The Likert-like question

responses were on a 7-point scale, from strongly disagree to strongly agree. A link was sent to all student enrolled in FoD three times during the school year: during the first week of fall semester 2022, during finals week of fall semester 2022, and during finals week of spring semester 2023. The EDVES survey has three sub scales: the expectancy scale, the value scale, and the engineering identity scale [6]. Due to the focus of this project, the focus of this analysis will be on the second and third administration of the survey. The questions, with associated scales are listed in Table 1:

Table 1: EDVES Survey Items

#	Question	Scale
1	Compared to other students in my class, I usually do better in science courses	Expectancy
2*	Compared to other students in my class, I usually do much worse in science courses.	Expectancy
3	Generally, I think I do well in science courses.	Expectancy
4*	Generally, I find science courses to be difficult.	Expectancy
5	Compared to other students in my class, I usually do better on engineering activities.	Expectancy
6*	Compared to other students in my class, I usually do much worse on engineering activities.	Expectancy
7	Generally, I think I do well on engineering activities.	Expectancy
8*	Generally, I find engineering activities to be difficult.	Expectancy
9	I am confident in my ability to identify problems which could be solved through design.	Expectancy
10	I am confident in my ability to identify individuals who are affected by a situation/problem.	Expectancy
11	I am confident in my ability to identify conditions for a design to be successful.	Expectancy
12	In general, I find working on engineering activities to be interesting.	Value
13*	I do not like working on engineering activities.	Value
14	I lose track of time working on engineering activities.	Value
15	I have fun working on engineering activities.	Value
16	I enjoy talking about engineering outside of class.	Value
17	I feel that the amount of effort it takes to do well on engineering activities is worth it.	Value
18	It is important to me to be good at solving engineering-related problems	Value
19	It is important to me to get good grades on engineering-related assignments	Value
20*	I would rather learn about something else instead of engineering.	Value
21*	Learning about engineering is a waste of my time.	Value
22	I would be successful working in an engineering-related career.	Value
23	Being good at engineering is an important part of who I am.	Identity
24	I have a role model who is an engineer.	Identity
25	I know of someone in my family who is an engineer.	Identity
26	I can see myself as an engineer.	Identity
27	Learning about engineering will be useful to me in my work after I finish school.	Value
28	Learning about engineering will be useful to me in my daily life after I finish school.	Value
29	If I learn about engineering, it will help me succeed in many different types of careers.	Value
30*	I do not think that learning about engineering will help me achieve my career goals.	Value
31	When I finish school and go to work, it will be useful for me to be able to identify problems which can be solved through design.	Value
32	When I finish school and go to work, it will be useful for me to be able to identify individuals who are affected by a situation/problem.	Value
33	When I finish school and go to work, it will be useful for me to be able to identify conditions for a design to be successful.	Value
34	Someone close to me (e.g. relative, mentor) is encouraging me to pursue an engineering career.	Identity

35	I feel like I am expected to pursue an engineering career.	Identity
36	I plan to use engineering skills in my future career.	Identity
37*	I do not think engineering will be the right career for me.	Identity
38	I would enjoy working in an engineering-related career.	Identity

*Items which were reverse coded

Results

Approximately 50% of the students enrolled in the course responded to the 2nd and 3rd surveys. Demographics for each survey are shown in Table 2:

Table 2: Respondent demographics

Demographic	Post Fall 2022 (n=97)	Post Spring 2023 (n=104)
Male	81.4%	77.9%
Female	16.5%	20.2%
Choose not to answer	2.1%	1.9%
Primary Race	White (96.9%)	White (95.2%)
First Generation	5.1%	1.0%

Using the responses gathered, an average response for each item was found. This was giving the responses the numerical value shown in Table 3:

Table 3: Response value

Response	Numerical Value
Strongly Agree	3
Agree	2
Somewhat Agree	1
Somewhat Disagree	-1
Disagree	-2
Strongly Disagree	-3

Several questions were reverse coded, as indicated in Table 1. These are questions those in which the statement was given in the negative, for example Question 37 says “I do not think engineering will be the right career for me.” Strongly agreeing with one of these questions would indicate a lower level of the construct of interest, thus, in order to ensure that a higher average indicated a higher level of the construct, the responses for the questions were flipped. For example, “Strongly Agree” was given a numerical value of -3, “Agree” was given a numerical value of -2, and so on. Blank responses were also removed from each item.

In order to better understand how participants’ views related to expectancy, value, and engineering identity may have changed across the semester, the results were analyzed using independent-samples *t*-tests. A *t*-test assumes that the sample under analysis is normally distributed, however, at relatively large sample sizes (30 or greater), a non-normal distribution would have minimal on the results [8]. After an F-test to determine equality of variance for each item, a two-tailed independent-samples t-test was performed on each question to determine if

there was a difference at α=0.05. Several questions were found to be statistically significant, as shown in Table 4

Table 4: Comparing mean values between post-fall and post-spring

Q	Post Fall 2022 *M (SD)*	Post Spring 2023 *M (SD)*	Mean Difference	*t*	*df*	*p*
16	1.660 (1.205)	2.009 (0.956)	-0.349	-2.257	177	.025
34	1.032 (1.589)	1.636 (1.239)	-0.604	-2.973	175	.003
37	1.602 (1.595)	2.103 (1.140)	-0.501	-2.519	164	.013

Discussion & Future Work

Additional work is needed to better understand the results of the EDVES survey. Initial analysis indicates that students may exhibits slightly higher engineering identity (Q34 & Q37) and slightly higher engineering value (Q16) following completion of FoD 2 and associated design project. Additional statistical analysis, such as ANOVA, is currently being considered to better understand how students of various demographic profiles may differ. Additionally, these results will inform the development of a focus group protocol. This focus group will focus on the constructs measured in the EDVES survey and will seek to gain a deeper understanding of how students perceive their experience with the community-inspired design project. The information gained from the data analysis and focus group analysis will be used to inform the recommendations for engaging first-year engineering students in authentic engineering design.

References

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