Investigating Subdiscipline Interest Among First Year Civil Engineering Students

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Introduction

Civil engineering (CE) is a broad field with a wide variety of subdisciplines spanning all facets of infrastructure. ABET's Engineering Accreditation Commission (EAC) requires that accredited Baccalaureate Level Civil Engineering degree programs include a "solution of complex engineering problems in at least four specialty areas appropriate to civil engineering" [1]. The most common specialty areas include structural, transportation, water resources, environmental, geotechnical, and construction. Programs must include a broad set of topics across their chosen specialty areas to ensure graduates can solve complex problems in various contexts.

The authors of this paper are transportation and water resources engineers, respectively. Despite the breadth of the profession, the authors continually observe a perception that civil engineering can be primarily described as a field whose focus pertains to "structures". In their personal lives, a common response to both authors, upon sharing that they are civil engineers, is, "Oh! You design buildings and bridges!" In the classroom, both instructors anecdotally observe a higher percentage of incoming students who claim to be interested in structural engineering compared to the other subdisciplines offered by the program. This is primarily evidenced through informal conversations with students early on in their civil engineering coursework. It is worth noting that until a few years ago, the lab of the introductory Civil Engineering course at the authors' institution focused entirely on structural engineering, which may have reinforced an initial limited understanding of the breadth of the field. While it is not uncommon for incoming first-year students to have little understanding of their chosen discipline [2], many of our students who were exposed to the civil engineering discipline at the high-school level were exposed to it in the structural engineering context, which is a common observation amongst outreach programs at that level [3],[4].

With this work, the authors seek to fill gaps in existing literature in which analysis is either broadly focused on different engineering disciplines [2],[4], rather than on subdisciplines of civil engineering, or focused on changes in student knowledge or awareness between freshman and senior year of a civil engineering program [3], rather than before and after taking an introductory course in civil engineering.

The authors of this paper co-teach a newly revised Introduction to Civil Engineering course for first year students in the CE program at Oregon Institute of Technology. At this institution, students are able to declare a major upon entrance to the university and do not undergo a common first-year experience alongside other engineering majors. Thus, in the authors' program, the incoming CE student population is generally comprised of students who developed their perception of the civil engineering discipline prior to their arrival to the university & civil engineering program.

A broader guiding motivation for this work is the idea that students have the potential to be interested in many different aspects of the civil engineering discipline and that those interests can

change upon exposure to those differing aspects. If it is true that most people perceive civil engineering and structural engineering as synonymous, and outreach and educational efforts reinforce that idea, then it is possible that our field is largely alienating students who may otherwise be interested in civil engineering by not introducing them to everything that the field has to offer. A first step in remediating this assumed phenomenon is to understand whether this perception is observable.

This study seeks to validate whether incoming students' knowledge about the field of civil engineering is more biased towards the structural subdiscipline. To explore this idea, a mixed-methods analysis was conducted on students enrolled in Introduction to Civil Engineering I (CE 101) at Oregon Institute of Technology in the Fall of 2025. This analysis seeks to gain a deeper understanding of first-year civil engineering students' knowledge of and feelings towards the field before and after taking a discipline specific introduction to engineering course through the following research questions:

- RQ1 With which aspects of civil engineering are incoming first-year civil engineering students familiar?
- RQ2 To what degree do incoming first-year students perceive personal knowledge of the subdiscipline of structural engineering compared to other subdisciplines?
- RQ3 Is structural engineering the CE subdiscipline the majority of first-year CE students consider the most interesting when starting out in the program?
- RQ4 How does student subdiscipline interest change after taking the introductory civil engineering course?

Methodology

This section presents an overview of the study group to which surveys were administered, the processes of survey development and administration, and the mixed methods used to analyze survey responses to answer the authors' research questions.

Study Group

This study was conducted on students enrolled in CE 101 – Introduction to Civil Engineering I at Oregon Institute of Technology in the Fall of 2025. Enrollment in this course consists of either first-year CE students or transfer students in the CE program who have not met introductory engineering coursework requirements elsewhere. CE 101 is the first of two introductory courses in the CE program at Oregon Institute of Technology, and it serves as a broad introduction to the civil engineering discipline, including specific modules for each of the specialty areas of focus within the degree program (geotechnical, structural, transportation, water resources). In the Fall of 2025, 31 students were enrolled in the course – of those, n=28 students participated in the voluntary study.

Survey Development

Survey questions were developed to answer the four research questions, as shown below in Table 1, which outlines and pairs each survey question with the research question(s) it targets.

Table 1. Overview of Survey Questions and Their Targeted Research Questions

Survey Question	Question Type	Targeted Research Question
1. What is civil engineering?	Open Ended	RQ1
2. What do civil engineers do?	Open Ended	RQ1
3. Please indicate your level of confidence in accurately explaining each of the following subdisciplines to a friend a. Geotechnical Engineering b. Structural Engineering c. Transportation Engineering d. Water Resources Engineering	Likert Scale	RQ2
4. Rank the following subdisciplines in order of interest (1 is most interested, 4 is least interested) a. Geotechnical Engineering b. Structural Engineering c. Transportation Engineering d. Water Resources Engineering	Likert Scale	RQ3, RQ4

Survey Administration

Surveys were administered via voluntary Qualtrics forms at the beginning and end of the academic term. Students completed the pre-term and post-term surveys during the first and last lab periods, respectively, under the supervision of the lab teaching assistant. The teaching assistant maintained informed consent forms signed by the students until the time at which the course and survey process were completed.

Mixed Methods Analysis

Qualitative and quantitative data were collected in a single survey, administered two times to the same group of study participants. The mixed methods design is exploratory in nature, in that it explores a phenomenon which lacks a guiding theory and for which instruments are not available [5],[6].

Qualitative Analysis

For the qualitative portion of the mixed methods analysis, the authors utilized in vivo coding [7] to pull key words from written survey responses, which were then grouped into nine aspects of civil engineering which emerged following keyword identification, presented in Table 2. A consensus coding strategy [8] was used to identify and group keywords, ensuring the authors completed the coding process collaboratively. Groupings were identified based on the frequency of keywords in all pre-term and post-term survey responses. For example, if a keyword related to a unique grouping only appeared once throughout all responses, the grouping was not considered in the analysis. It is worth noting that, because this paper is focused on four identified subdisciplines of civil engineering, groupings related to each of the subdisciplines would have been included in the analysis even if there were no observed keywords related any one of the

subdisciplines. Written survey responses were reviewed for the presence of each of the nine aspects of civil engineering.

It is important to note that there is ambiguity present in the grouping of some of the keywords. The keyword "structure" or "structures" was grouped with those pertaining to the subdiscipline of structural engineering (aspect 7). The authors recognize the ambiguity of the word and that there are physical structures associated with all civil engineering subdisciplines. The authors maintain that the keyword(s) belong with aspect 7 and acknowledge that this grouping is one of multiple ways categories could be defined from a qualitative perspective. Furthermore, the keyword "foundation", when used pertaining to infrastructure, was grouped into the geotechnical category. The authors recognize that, while some students may associate foundations with buildings and therefore with structural engineering, it is worth noting when a foundation is mentioned as a separate unique aspect of a structure.

Table 2. Aspects of Civil Engineering Used for Qualitative Analysis

	Aspect of Civil Engineering	Key Words for Identification
1	Pertaining to Design	*Design, plan*
2	Pertaining to Serving the Public	*Public, community, civilization, society, human*
3	Pertaining to Construction	*Construction, construct, build*
4	Pertaining to Infrastructure	*Infrastructure, facilities*
5	Pertaining to Maintenance and Operation	*Maintenance, maintain, operate, keep up, manage*
6	Pertaining to Geotechnical Engineering Subdiscipline	*Geotechnical, foundation(s), soil, ground*
7	Pertaining to Structural Engineering Subdiscipline	*Structural, structure(s), building(s) (noun), bridge(s)*
8	Pertaining to Transportation Engineering Subdiscipline	*Transportation, road(s), highway(s)*
9	Pertaining to Water Resources Engineering Subdiscipline	*Water, water resources, dam(s), waterway(s), sewage*

The outcome of the qualitative analysis is a prevalence score for each of the nine identified aspects of civil engineering, based on the number of responses in which key words were identified. The prevalence score is expressed as follows.

$$Prevalence\ Score_i = \frac{\#\ of\ Responses\ Containing\ at\ least\ 1\ Keyword\ Related\ to\ Aspect\ i}{Total\ \#\ of\ Responses}$$

The use of multiple key words in a single aspect (i.e., design and plan) did not inflate the prevalence score for said aspect. The context in which key words were used impacted the prevalence score for aspects. For example, "foundation" used in reference to a building was

counted as a reference to geotechnical engineering, whereas “foundation” used in reference to society was not counted as a reference to geotechnical engineering.

Quantitative Analysis

Due to the nature of the quantitative survey questions, the quantitative analysis portion of the project was relatively simple. The last two survey questions (shown in Table 1) were used to collect ordinal, quantitative data on a Likert scale. Mode and interquartile ranges were determined for pre-term and post-term survey responses. Review of frequency data assisted in drawing insights into how responses changed before and after respondents took an introductory civil engineering course. Wilcoxon Signed Rank Tests were used to determine statistical significance of how student subdiscipline interests changed before and after taking an introductory civil engineering course. The Wilcoxon Signed Rank Test is a nonparametric test used to analyze matched-pair data [9]. Thus, the Wilcoxon Signed Rank Test is appropriate to compare pre-term and post-term responses to the fourth survey question. A test was completed for each of the four subdisciplines, each with a null hypothesis stating there was no statistically significant change in student subdiscipline interest from pre-term to post-term survey responses. Due to the exploratory nature of this work, the authors decided to use a 90% confidence level to quantify statistically significant changes in survey responses. Outcomes of the tests are presented in the results section of this paper in support of the fourth research question.

Results

The results section is divided into four sections, each section dedicated to answering one of the four research questions proposed previously in this work.

Research Question 1

To answer the first research question, with which aspects of civil engineering are incoming first-year civil engineering students familiar, qualitative analysis of the first two survey questions was completed. The goal of the analysis was to determine the prevalence of nine aspects of civil engineering observed in responses to the first two survey questions, outlined previously in Table 1. Prevalence of each of the nine aspects of civil engineering is presented in Table 3.

Table 3. Number of Observations of Nine Identified Aspects of Civil Engineering in Survey Responses to "What is Civil Engineering?" and "What do Civil Engineers do?"

Aspect of Civil Engineering	*What is Civil Engineering?*				*What do Civil Engineers do?*			
	Pre Term		**Post Term**		**Pre Term**		**Post Term**	
Design	6	22%	13	46%	19	73%	18	64%
Serving the Public	8	30%	11	39%	3	12%	11	39%
Construction	9	33%	9	32%	11	42%	8	29%
Infrastructure	6	22%	8	29%	3	12%	8	29%
Maintenance and Operation	0	0%	3	11%	3	12%	9	32%
Geotechnical Engineering	1	4%	7	25%	3	12%	2	7%
Structural Engineering	18	67%	14	50%	16	62%	15	54%
Transportation Engineering	10	37%	12	43%	7	27%	8	29%
Water Resources Engineering	4	15%	7	25%	2	8%	8	29%

The most prevalent aspect of civil engineering observed in pre-term responses to "what is civil engineering?" was the aspect pertaining to the structural engineering subdiscipline. Key words related to structural engineering appeared in 67% of responses. The least prevalent aspects observed were those pertaining to maintenance and operation and the geotechnical engineering subdiscipline, receiving scores of 0% and 4%, respectively.

The most prevalent aspect of civil engineering observed in pre-term responses to "what do civil engineers do?" was the aspect pertaining to design. Key words related to design were observed in 73% of responses. Structural engineering prevalence was almost as high in responses to "what do civil engineers do?" as in responses to "what is civil engineering?", with a 62% prevalence score in the former. The least prevalent aspect in pre-term responses to "what do civil engineers do?" was that pertaining to the water resources engineering subdiscipline, with a prevalence score of 8%. The aspects pertaining to serving the public, infrastructure, maintenance and operation, and the geotechnical engineering subdiscipline received the next lowest prevalence scores, each with 12%.

To answer the first research question, incoming first-year civil engineering students are most familiar with the aspects of civil engineering pertaining to design and to the subdiscipline of structural engineering and are least familiar with the aspects pertaining to maintenance and operation of facilities and the subdisciplines of geotechnical engineering.

Research Question 2

To answer the second research question, to what degree do incoming first-year students perceive personal knowledge of the subdiscipline of structural engineering compared to other subdisciplines, responses to the third survey question were reviewed and analyzed.

Student perceived confidence in each of the identified subdisciplines measured at the beginning of the term is presented in Figure 1. In general, respondents were the least confident in their

ability to explain geotechnical engineering to a friend, with over 70% of respondents indicating a negative level of confidence. Respondents were the most confident in their ability to explain transportation engineering to a friend, with nearly 50% of respondents indicating a positive confidence level. It is worth noting that students were not asked to explain each of the identified subdisciplines as a part of the survey, and the confidence levels discussed are self-perceived by the students.

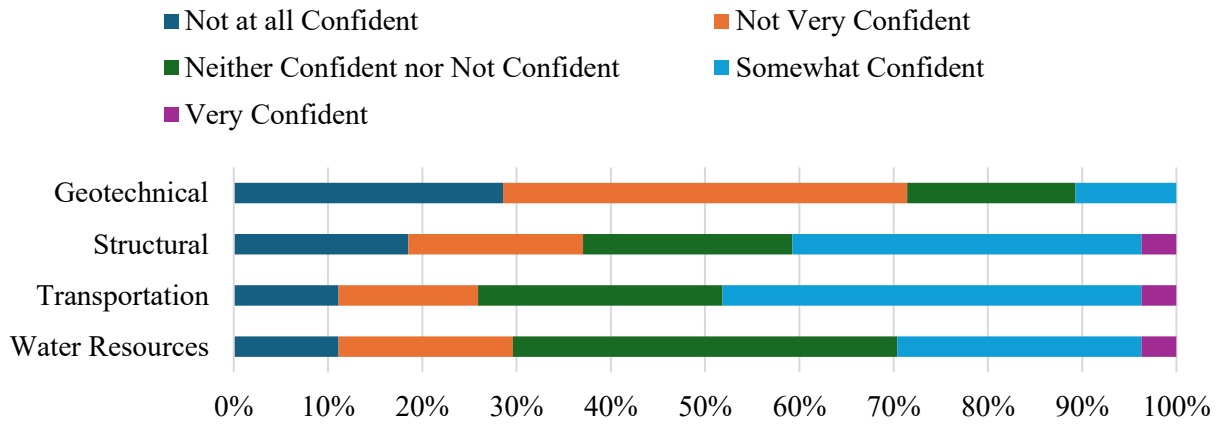

Figure 1. Student Perception of Confidence in Explaining Each Identified Subdiscipline to a Friend Before Taking an Introductory Civil Engineering Course

As expected, respondents overwhelmingly indicated an increase in confidence level after taking an introductory civil engineering course, as shown in Table 4. Because change in perceived confidence of the four subdisciplines was not a focus of any of the research questions in this paper, the authors did not complete Wilcoxon Signed Rank Tests to compare pre-term and post-term responses to the third survey question.

Table 4. Change in Student Perception of Confidence in Explaining Each Identified Subdiscipline to a Friend Before and After Taking an Introductory Civil Engineering Course

Subdiscipline	Increase	No Change	Decrease
Geotechnical	93%	7%	0%
Structural	70%	22%	7%
Transportation	78%	19%	4%
Water Resources	81%	11%	7%

Research Question 3

Question four of the survey was a four-part question, in which students were asked to rank each of the four identified subdisciplines in order of most to least interesting, with 1 being most interesting and 4 being least interesting.

A review of pre-term responses to the survey question about subdiscipline interest was

completed to answer the third research question. Is structural engineering the CE subdiscipline the majority of first-year CE students consider the most interesting when starting out in the program?

Mode and interquartile ranges for student interest in each identified subdiscipline are presented in Table 5. The mode data shows that the majority of respondents ranked geotechnical engineering as least interesting, structural and transportation as most interesting, and water resources as third most interesting. The percentage of responses is shown to add context to the mode values and show what "majority" means for each subdiscipline. Interquartile ranges reveal that, at the beginning of the term, the middle 50% of respondents ranked geotechnical engineering between third and fourth, structural between first and second, transportation between first and third, and water resources between second and third most interesting.

Table 5. Summary Statistics of Student Interest in each Identified Subdiscipline Before Taking an Introductory Civil Engineering Course

	Mode		Interquartile Range
Subdiscipline	**Ranking**	**% Responses**	**Pre Term**
Geotechnical	4	61%	[3,4]
Structural	1	52%	[1,2]
Transportation	1	35%	[1,3]
Water Resources	3	48%	[2,3]

In tandem, the mode and interquartile range information reveals an answer to the third research question. Yes, structural engineering is the subdiscipline most students consider the most interesting when starting out in the program, followed by transportation, water resources, and geotechnical engineering.

Research Question 4

Comparison of pre-term and post-term survey responses to the question about subdiscipline interest was completed to answer the fourth research question. How does student subdiscipline interest change after taking the introductory civil engineering course?

Table 6 shows how student ranked interest changed before and after the term. The largest increase in interest was observed for geotechnical engineering, with 52% of respondents ranking the subdiscipline at a higher level of interest after completing the course. The largest decrease in interest was observed for structural engineering, with 48% of respondents ranking the subdiscipline at a lower level of interest after completing the course. The respondents that did not decrease their interest level for structural engineering were evenly split between maintaining the same interest and increasing interest. Roughly a third of respondents indicated no change in interest level for transportation or water resources engineering.

Table 6. Change in Student Interest in each Identified Subdiscipline Before and After Taking an Introductory Civil Engineering Course

Subdiscipline	Increase	No Change	Decrease
Geotechnical	52%	30%	17%
Structural	26%	26%	48%
Transportation	39%	35%	26%
Water Resources	26%	35%	39%

Wilcoxon Signed Rank Tests were used to determine whether survey responses changed with some degree of statistical significance before and after students were exposed to all four subdisciplines through the introductory civil engineering course. The results of those tests are presented in Table 7.

Table 7. Results from Wilcoxon Signed Rank Tests Presenting the Statistical Significance of Change in Subdiscipline Interest

Subdiscipline	P Value
Geotechnical	0.1161
Structural	0.05024
Transportation	0.1826
Water Resources	0.3116

The Wilcoxon Signed Rank Test results in Table 7 indicate that student interest in the structural engineering subdiscipline saw statistically significant changes at a 90% confidence level. Student interest in geotechnical, transportation, and water resources subdisciplines did not see statistically significant changes at the previously identified 90% confidence level. Quantified change in student interest in the geotechnical subdiscipline appeared to be approaching significance, which adds important statistical context to the results shown in Table 6 and Figure 2. These results lend support to the notion that student subdiscipline interest changed after taking an introductory civil engineering course.

Changes in specific rankings are summarized in Figure 2, showing how student subdiscipline interest changed after taking an introductory civil engineering course and helping to answer the fourth research question. Figure 2 shows clearly the shift in the number of respondents who ranked structural engineering as most interesting before taking the course versus after. Trends in student interest are observed in two groups: geotechnical and transportation, and structural and water resources. Both geotechnical and transportation engineering saw an increase in number of #1 rankings and a decrease in number of #4 rankings, albeit the differences are greater for geotechnical than they are for transportation. Conversely, structural and water resources engineering both saw decreases in number of #1 rankings and increases in number of #4 rankings. Structural engineering had a larger decrease in number of #1 rankings than water resources. Water resources had a larger increase in number of #4 rankings than structural engineering.

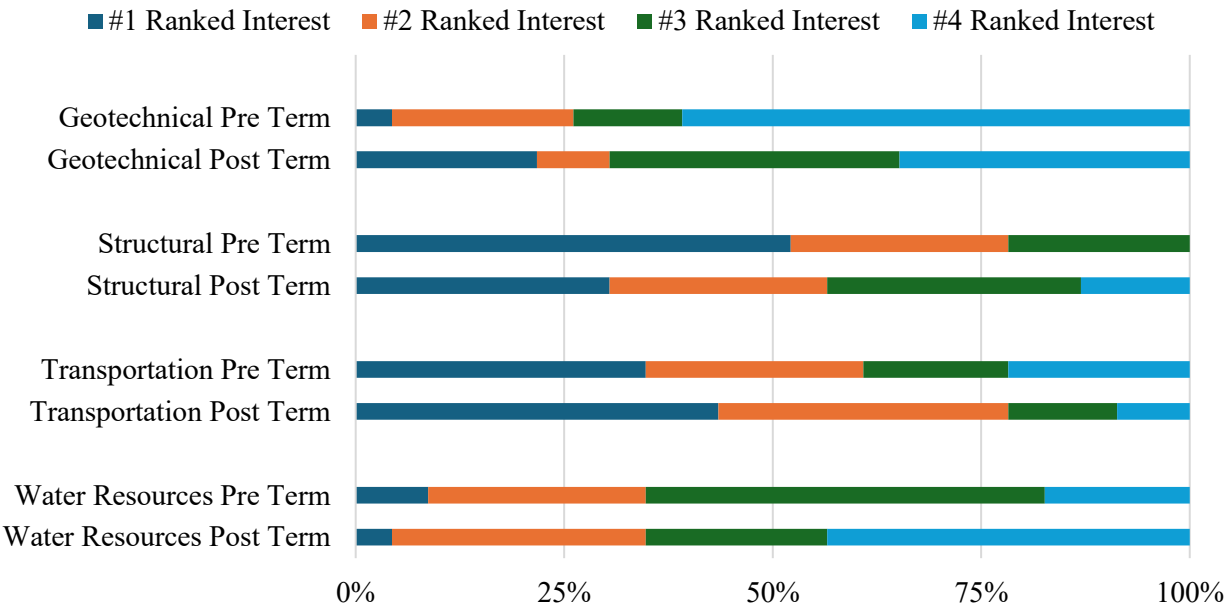

Figure 2. Student Interest in each of the Four Subdisciplines Before and After Taking an Introductory Civil Engineering Course

Discussion

Surveying first-year civil engineering students at the beginning and end of an introductory civil engineering course offered insights into students' prior knowledge of and feelings towards four subdisciplines within the field. The surveys asked about civil engineering in general and about the four subdisciplines included in the civil engineering program at Oregon Institute of Technology, geotechnical, structural, transportation, and water resources engineering.

In open-ended responses to questions about the field, responses indicated incoming first-year students most frequently used language describing civil engineering as it pertains to design, and the subdiscipline of structural engineering. This observation, coupled with the fact that most respondents ranked structural engineering as the subdiscipline in which they were the most interested at the beginning of the term, supports the author's motivations leading this work. Incoming first-year students do appear to be the most knowledgeable about and most interested in the subdiscipline of structural engineering compared to three other subdisciplines within the field of civil engineering. Additionally, structural engineering was the subdiscipline in which the highest confidence level of statistically significant change in interest was observed across the pre-term and post-term survey responses. These results have implications for curriculum design and outreach and inform the future of this work. Future work and broader impacts are presented in the remainder of this section, following a discussion of the limitations of the work.

Limitations

There are a few limitations to the work presented in this paper. This sub section will address the small sample size, narrow scope of the work, and subjectivity of the qualitative analysis. First, with a sample size of 28 students, it is difficult to draw statistically significant conclusions from

collected data because fewer observations require larger differences in response values to garner such conclusions. Second, the scope was limited to a single class section during one academic term at a single academic institution, restricting the ability to generalize findings or establish causal, longitudinal trends. Finally, subjectivity is inherent in the qualitative analysis of this work because the authors were responsible for grouping the keywords. As stated previously, the ambiguity present in certain words (i.e., "foundation" as a Geotechnical vs. a Structural term) required a decision to be made regarding the categorical relevance for those words and under which theme they should be grouped. While the authors attempted to account for contextual clues to aid in this categorization, it is acknowledged that there could be multiple approaches to grouping these keywords, which may impact the outcome of the analysis.

Future Work & Broader Impacts

Future work for this study includes continued efforts to survey students in the introductory civil engineering course at Oregon Institute of Technology to verify whether the trends observed with the cohort surveyed in this study are consistent with other groups. A cross-sectional study would be beneficial in resolving limitations due to small sample sizes and in establishing causal trends and generalized findings present in first-year civil engineering students at Oregon Institute of Technology. The authors will also consider collecting demographic data from survey respondents and information on whether the students in the introductory civil engineering course are transfer students or in their first year of university.

The authors are further interested in how student interest in subdisciplines changes throughout their time in the baccalaureate civil engineering program, from the time they are enrolled in introductory courses all the way through upper-level, discipline-specific coursework. This warrants a longitudinal study of a civil engineering cohort as they progress through the different phases of the program. Additionally, future work includes efforts to broaden the target audience of these research questions to study groups outside of the introductory civil engineering course. The authors are interested in how incoming students in other engineering programs perceive the civil engineering discipline based on knowledge they have developed through prior experiences like high school outreach programs or engineering curriculum. Finally, this work could also be broadened via collaboration with researchers at other universities to investigate whether findings at Oregon Institute of Technology are likewise observed at other institutions.

Support of the assumptions that students are introduced to the field of civil engineering through the context of the structural subdiscipline, and that individual interests can change after being exposed to different aspects of the field of civil engineering, allows for the development and implementation of targeted recruitment and outreach strategies. Outreach to younger audiences and prospective students introducing the field in broader terms, which include all four subdisciplines, is a potential remedy to the current imbalance which favors structural engineering. An even introduction to the field gives the most opportunity to the next generation of civil engineers to discover their passion for the field when it is introduced, rather than when they are either already enrolled in a civil engineering program or have chosen a different path.

Another potential impact of this work lies in the implications it may have for instructors of

introductory engineering courses, as well as for the instructors of CE101 at Oregon Institute of Technology. First, an instructor of a general or civil specific introductory engineering course may currently solely introduce the field of civil engineering in the context of the structural subdiscipline. This work, and the future work it initiates, may serve as motivation for instructors to broaden their introduction of the field of civil engineering to include more than one subdiscipline. Second, continued surveying of students before and after taking the introductory civil engineering course allows the instructors to check for holes in their curriculum pertaining to the four subdisciplines that are introduced. For example, if a significant portion of respondents indicate they are unfamiliar with one of the subdisciplines even after taking the introductory course, that could trigger a review of the curriculum to address any imbalances.

In conclusion, civil engineering is a broad field with workforce needs across all sectors. As civil engineering educators, it is our duty to ensure that we prepare future engineers to meet these diverse needs. This work and any future associated work aim to better understand the trends that allow us to do so by ensuring the field is introduced broadly and evenly.

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