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Embedding Equity in an Undergraduate Introductory Course through Experiential Learning

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Embedding Equity in an Undergraduate Introductory Course Through Experiential Learning

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Abstract

Equity has been newly introduced as an outcome that needs to be addressed and assessed in undergraduate engineering programs in North America. In Canada, the Canadian Engineering Accreditation Board has been emphasizing that equity and ethics be embedded in the curriculum through their accreditation visits. This required several programs within our institution to work on methods that can be included to make students more aware of equity issues and assess their understanding on the above subjects.

This paper discusses how courses were changed to include equity as part of the curriculum. Equity discussions were focused through the introduction of universal design as applied in building design- making students experience first-hand what the implications of design choices are on a diverse (age, physical / cognitive ability, race, gender) user group. Three different first year engineering groups were assessed in their knowledge of equity. Group 1 was the group that were prompted with a presentation in class about the different aspects of requirements for building design to address mobility issues followed by an audio recording prompting the students to do a tour on campus and experience first-hand these effects. The second group has done a campus tour without the audio and have been exposed to only the presentation in class. The third group is the control group who has only done the campus tour with no prompts and did not have the presentation. All three groups were assessed later in their knowledge of equity issues in building designs. This paper will share these findings and the details of what the students were exposed to in the three different groups. It also discusses recommendations for future changes that could be done to better include equity discussions and assessments in the curriculum. The paper also states how this could be modified for any undergraduate program.

Introduction

Engineers play an essential and unique position in the society as their influence over resources will have long-term consequences on the communities they service. They are uniquely placed to address systemic obstacles, but to do so, they need to have a nuanced grasp of social aspects. To accomplish this, engineering education must include topics that investigate equality, diversity, and inclusion. (EDI). Students will be able to gain a grasp of how their future work may either maintain an unfavourable status or resolve social inequities to promote a more just society. Engineering classes are typically focused on technical methods and finite responses, which makes teaching equity challenging because it does not have a definite solution. Even though the integration of EDI notions into engineering educating is generally recognized to be beneficial, there is no agreement on the most effective method of implementation, which creates numerous obstacles. [1]

The promotion of equity in educational institutions is considered as a crucial aspect of ensuring equal opportunities for all students regardless of their background and disabilities. Providing students with resources that are adapted to their individual needs enhances not only the educational experience of the students with disabilities, but for the entire classroom. Moreover, the significance of equity extends beyond the school system to embrace larger society. In an equitable community, every individual has the chance to flourish, independent of their prior circumstances [2]. There exist different approaches that can be implemented in classrooms that could help with the advancement of equity such as offering multiple teaching techniques for students to engage with a topic and exhibit their knowledge. Additionally, creating an environment that values diversity and acceptance of differences, as well as embracing diversity and inclusion, can also play a significant role in promoting equity [3] [4].

[5] conducted a literature review summarizing the findings of 58 articles from 13 different countries about the different equity-oriented approaches in education from 2010 to 2020. The papers were categorized into 4 different education interventions: programmatic configurations, curricular settings, pedagogical approaches and learning activities. The programmatic configuration category refers to integrating equity methodically into the most important elements of education programs, for instance curriculum design, admission process, internships, and teaching. The program curricula category refers to off-campus experiences and academic courses. The pedagogical approaches category refers to fundamental rules, models, or educational teaching strategies. The specific teaching and learning activities refer to activities used while teaching courses or during any other academic opportunity. The papers related to this category discussed different presentation forms that could be used to teach equity. The literature review emphasized on the fact that the teachers and professors need to increase their knowledge and understanding of equity to be able to incorporate it in their classes and help students understand it [5].

Equity is a diverse topic that can be taught in different ways and applied in different domains. The goal of this study is to test 3 different ways to teach equity to engineering student whose focus is on the built environment. By taking into consideration the nature of their program, which is more of a technical content, it was found that one way of teaching them about equity and make it related to their program is through building design, which is found in the universal design, with a focus on accessibility.

Universal design principles have been used in buildings to ensure the creations of spaces that ensure equitable access to everyone, regardless of any disability they may have. In educational institutions, the built environment students should be aware of these principles to encourage the development of a more diverse and inclusive community. In the United States, the Architectural Barriers Act of 1968 was the first legislation that created a minimum standard of protection against discrimination for those with disabilities was the, in The United States. That law included designated parking spots, elevators in buildings, restrooms, etc. While such legislation established a minimum requirement for accessibility, Universal Design strives to improve accessibility of the built environment for a wider range of users, not just the disabled. [6] [7] [8].

The notion of Building Design was first introduced by an American architect named Ronald Mace. During his undergraduate studies in North Carolina State University in the US, he faced significant difficulties moving around campus since it was not wheelchair friendly. After graduating, he decided to become an advocate for accessible buildings. Even though Mace takes most of the credits for the origin of the concept, Selwyn Goldsmith, an architect from the United Kingdom was the first one who introduced the idea of "curb cuts". In early 1960s, he conducted a study with 284 wheelchair users and developed the concept of "dropped kerbs". The City of Norwich in the United Kingdom became the first town to implement curb cuts at intersections, and this design feature has since been adopted and integrated into cities worldwide [9] [10]. In 1997, The 7 Principles of Universal Design was established in the North Carolina State University by a group of architects and engineers, led by Mace. The seven principles are: Equitable Use, Flexibility in Use, Simple and Intuitive Use, Perceptible Information, Tolerance for Error, Low Physical Effort, and Size and Space for Approach and Use [11]. While the principles of universal design seem beneficial to all, there is a huge association with addressing disability issues with this framework. This makes the concepts seem restrictive. There needs to be a wider vision on this issue to ensure that it is more inclusive [12]. Persson et al discuss the purpose and justification of the universal design stating that it should be a “barrier-free design” and a “design for all”. Then they specify the different approaches and design thinking initiated by different countries/groups: inclusive design initiated in the UK; design for dynamic diversity made by a research group in Dundee; accessible design derived from the American Disability Act Standard; universal access that influences the design in Asia, especially in Japan; and cooperative design spreading from the Scandinavian culture. Persson et al conclude that there are consequences of having multiple, single or no definition of accessibility. Thus, the definition of accessibility should be revised to make it clearer. It is also important when measuring accessibility not to focus on identity [13].

Including universal design in undergraduate engineering courses resulted in attracting more women and under-represented groups into the engineering program [14]. Research has found that the women and under-represented groups are attracted to disciplines where they can clearly see how they can benefit the society around them [15] [16]. In addition, adding Universal Design to the curriculum allow the education process to become more inclusive, as it now applies to a wide group of students in the program [14].

This paper will focus on the importance of introducing equity to undergraduate engineering programs in in North America as well as discussing some methods that can be included in the curriculum in order make students more aware of equity issues and assess their understanding of building design in general. The study was conducted on first year engineering students at the University of Waterloo. 226 students from different engineering programs were tested on their knowledge of equity with a focus on accessibility, which is considered as an important part of equity. It is important to note that the aim of this study is to test and compare the efficacy of three different methods to deliver equity material: experiential learning, traditional lecture style, and pre-test without experiential learning nor traditional lecture style. The methodology and results will be discussed further in the paper.

Equity Case Study at the University of Waterloo

In this social experiment, 226 students from different engineering programs were taught differently to check if it changed their perception of how to design equitable buildings, and if they understood the different equity aspects. The students were divided according to their programs:

- Architectural Engineering (AE) students: This group of students had the opportunity to discuss what constitutes a good design in class and did their own tour in person with an audio allowing them to visualize the equity access problems in each of the buildings on campus. The audio tour can be accessed in [17].

- Civil Engineering (CivE) students: This group of students was given a presentation in class about what constitutes a good design and how to be inclusive without any audio prompts to help them with their walk through the buildings.

- Environmental and Geological Engineering (EnvE/GeoE) students: These students didn't have access to the presentation and the audio tour and were just tested for their preconceived knowledge.

The presentation that was given to the AE and CivE groups in class discussed Universal Design, starting with the definition and the seven principles as stated by [11]. We then discussed the historical context highlighting the problematic fact that most earlier designs were based on the European adult man that represented the "universal standard" [18]. We continue by shedding light on the research that was done in 1950 at Wright Air Force Base in Ohio measuring the different dimensions of 4,063 pilots at the time to try to design a better cockpit that would fit most pilots. The researcher at the time came up with the average dimensions and then noticed that this average dimension pilot does not exist as it did not fit one single pilot [19]. We point out to the students that this research was done in 1950 when there were not as much diverse pilots, and not as many female pilots as well. This shows how even more diverse the measurements of pilots are now. Then the presentation continues to discuss the seven elements in details with examples that the students can link to. This is to show that the seven principles of universal design will make life better to all not just to a small group of people.

The understanding of the different aspects was done by answering the following four survey questions:

1. List as many ways as you can in which a designer can facilitate easy use of a building entrance for people who live with a disability (physical, mental, developmental, etc.).

2. One of the principles of universal design is equitable access. Describe one place on campus that you know does not provide equitable access to people who use mobility devices. Is there a less desirable or difficult way to access it, or is it completely inaccessible? Is this a problem- why or why not?

3. Consider a visitor to campus who has low vision, is hearing impaired, or is extremely sensitive to lights and noises. They are visiting a building where you take your first-year courses. Choose and name one building, and name one way in which a building designer could make a common space easy to use for this visitor.

4. Add gender/race to analyze effects later

It is important to note that questions 1, 2, and 3 were open-ended questions and students had to input their own answers.

Results and Discussions

This section of the paper will present the results of the case study. Table 1 represents the percentage of students in each department while Table 2 represents the gender. Out of the 226 students, 56% identify as males and 39% as females, with most of the students being from CivE and AE programs representing 39% and 35%, respectively, of the total number of students.

Table 1 Program Selection of the Students

Program	Percentage %	Count
Architectural Engineering	35.40%	80
Civil Engineering	38.94%	88
Environmental Engineering	20.80%	47
Geological Engineering	4.42%	10
Other	0.44%	1
Total	100%	226

Table 2 Gender

Gender	Percentage %	Count
Female	39.00%	78
Male	56.50%	113
Prefer another term	2.50%	5
Prefer not to say	2.00%	4
Total	100%	200

Table 3 Racial Background

Racial Background	Percentage %	# of students
Indigenous	0.91%	2
Black	1.82%	4
East Asian	23.18%	51
Latino/a	1.36%	3
Middle Eastern	7.27%	16
South Asian	17.73%	39
Southeast Asian	5.45%	12
White	38.18%	84
Another race/ethnic category	1.82%	4
Prefer not to answer	2.27%	5
Total	100%	220

Table 3 represents the racial background of the students. 84 students out of the 220 answered that they are White, which makes up 38.18% of the total population. 51 belong to the East Asian category, which makes up 23.18% of the total population. The minority being the Indigenous (0.91%), Latino (1.36%), and Black (1.82%). In general, including racial background within a survey is vital for evaluating whether the initiatives are adequately meeting the needs of diverse racial groups and ensuring adherence to anti-discrimination regulations and laws [20]. But for this study, as it is a single source of data, it is not sufficient to make overarching conclusions on which race is less likely or more likely to think of a certain universal design solution. This information was included in the survey because it is interesting to know the different racial background of the participants. The gender and race questions were added towards the end of the survey as not to affect the students' responses.

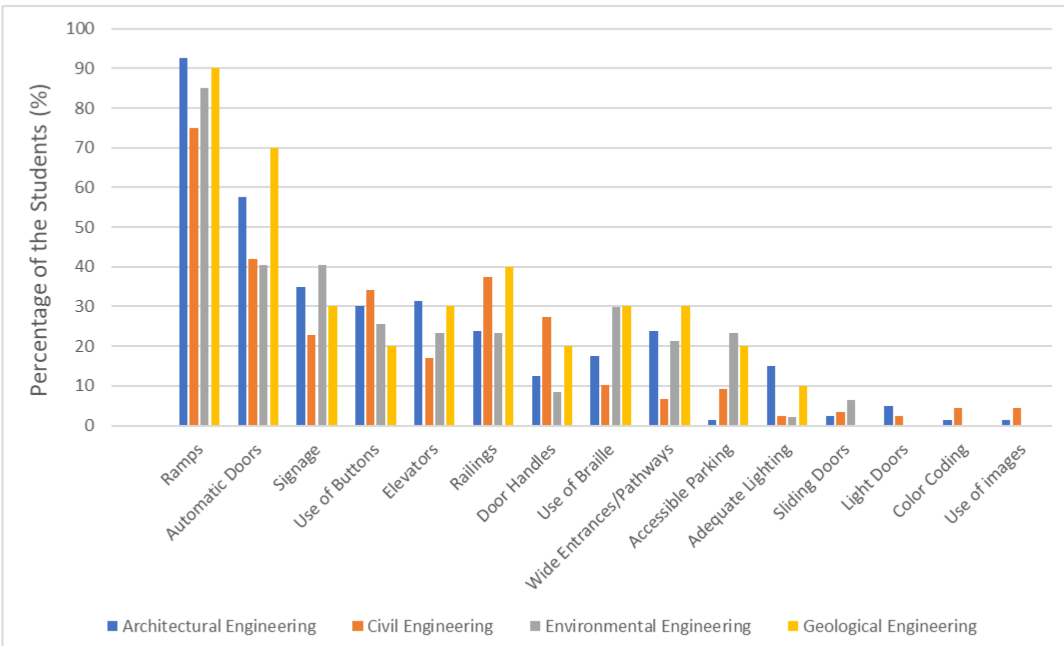

Figure 1 Facilitation ways by program

Figure 1 shows the results to question 1 stated above. It represents the survey answers of the facilitation ways in which a designer can facilitate easy use of a building entrance for people with a disability. Most of the students thought of the most common ways that they are familiar with such as ramps, automatic doors, signage, etc. From the chart, EnvE and GeoE students didn't think of light doors, color coding, and use of images. This can be explained by the fact that AE and CivE students had the chance to get familiar with more ways since they were provided with a tour, a presentation, and had the chance to discuss about it in class.

Table 4 below shows the results of all programs by gender. It still shows that students irrespective of their gender specified ramps as the main facilitation way.

Table 4 Facilitation ways by gender for all programs

	Total	Female	Male	Prefer another term	Prefer not to say
Accessible Parking	11.0%	7.7%	14.2%	0.0%	0.0%
Adequate Lighting	7.5%	7.7%	8.0%	0.0%	0.0%
Automatic Doors	51.0%	53.8%	51.3%	40.0%	0.0%
Color Coding	2.5%	1.3%	2.7%	20.0%	0.0%
Door Handles	19.0%	23.1%	15.9%	0.0%	50.0%
Elevators	26.0%	24.4%	24.8%	60.0%	50.0%
Lightweight Doors	2.5%	2.6%	2.7%	0.0%	0.0%
Railings	32.5%	30.8%	33.6%	40.0%	25.0%
Ramps	90.0%	94.9%	86.7%	80.0%	100.0%
Signage	34.5%	38.5%	33.6%	0.0%	25.0%
Sliding Doors	4.0%	3.8%	3.5%	20.0%	0.0%
Unknown	1.5%	2.6%	0.9%	0.0%	0.0%
Use of Braille	19.5%	23.1%	16.8%	0.0%	50.0%
Use of Buttons	32.5%	32.1%	31.9%	40.0%	50.0%
Use of images	2.5%	2.6%	1.8%	0.0%	25.0%
Wide Entrances/Pathways	18.5%	26.9%	14.2%	0.0%	0.0%

Table 5 shows the facilitation ways by program and gender. Most of all programs and genders specified ramps as the facilitation way used for entrances. Looking at the EnvE program that was not exposed to the presentation or the tour we can see that female students mentioned the uncommon facilitation ways while male students didn’t think of them. This includes adequate lightings, door handles and sliding doors.

Table 5 Facilitation ways by program and gender shown in percentages. The following abbreviations are used: PAT = Prefer another term; PNS = prefer not to say; A P = Accessible parking; A L = Adequate lighting; A D = Automatic Doors; C C = Color coding; D H = Door Handles; E = Elevators; L D = Light Doors; R = Railings; Ra = Ramps; S = Signage; S D = Sliding Doors; U = unknown; U B= Use of Braille; U of B = Use of Buttons; U I = Use of Images; W E/P = Wide Entrance/Pathways

		AE				**CivE**				**EnvE**				**GeoE**			
	Total	**Female**	**Male**	**PAT**	**PNS**	**Female**	**Male**	**PAT**	**PNS**	**Female**	**Male**	**PAT**	**PNS**	**Female**	**Male**	**PAT**	**PNS**
A P	11	0	3	0	0	0	13	0	0	25	31	0	0	0	40	0	0
A L	7.5	14	18	0	0	0	3	0	0	4	0	0	0	0	20	0	0
A D	51	71	51	100	0	40	47	0	0	37	50	100	0	50	100	0	0
C C	2	0	3	0	0	7	3	50	0	0	0	0	0	0	0	0	0
D H	19	20	6	0	0	47	25	0	100	12	0	0	50	25	20	0	0
E	26	28	39	0	100	20	15	100	0	17	31	100	50	50	20	0	0
L D	2	3	6	0	0	7	2	0	0	0	0	0	0	0	0	0	0
R	32	17	33	100	0	40	41	50	100	37	12	0	0	75	20	0	0
Ra	90	97	100	100	100	87	80	100	100	96	81	100	100	100	100	0	0
S	34	40	39	0	0	13	29	0	100	54	37	0	0	25	40	0	0
S D	4	0	3	100	0	0	5	0	0	12	0	0	0	0	0	0	0
U	1	0	0	0	0	7	2	0	0	4	0	0	0	0	0	0	0
U B	19	11	24	0	100	13	12	0	0	42	19	0	50	50	20	0	0
U of B	32	31	27	100	0	40	39	0	100	33	12	100	50	0	40	0	0
U I	2	0	3	0	0	13	2	0	100	0	0	0	0	0	0	0	0
W E/P	18	34	18	0	0	0	10	0	0	29	19	0	0	50	20	0	0

Figure 2 shows the results to questions 2 from above. It represents the survey answers of the description of one place on campus that does not provide equitable access to people who use mobility devices. Most of the students from different departments agreed that RCH and Residence buildings don't provide equitable access. It is important to note that the EnvE, GeoE and CivE students took the majority of their classes in RCH and they were familiar with the building. AE students pointed CPH as well as RCH as their classes are held in the CPH building so they are familiar with it and experience it everyday during their term. The fact that the AE students went through the campus tour prompted by the audio video allowed them to located other buildings on campus that lack equitable access, and these were not pointed out by the students from the other programs such as the POETS in the Physics building.

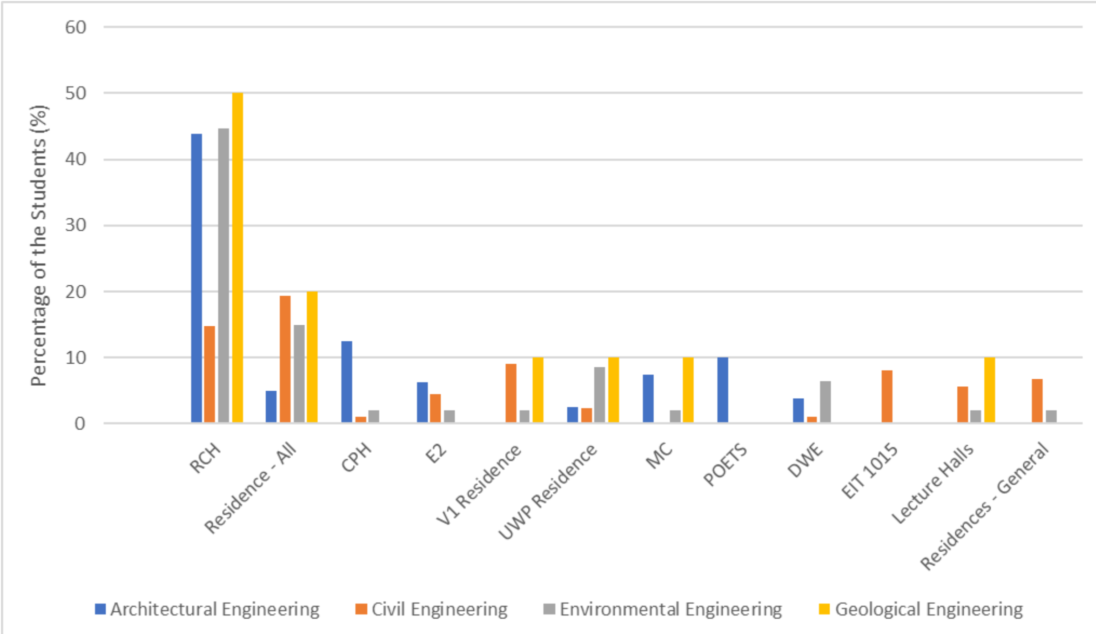

Figure 2 Buildings with no Equitable Access by Program

Figure 3 represents the survey answers to question 3, where students were asked to name a building where the common space can be made easier for a campus visitor that has low vision, is hearing impaired, or is extremely sensitive to lights and noises. From the chart, EnvE/GeoE students suggested the buildings that they are familiar with while AE and CivE students suggested a most diversified range of buildings. In the same question students were asked to point out one aspect in which the designer would make it more accessible for the specified visitor, all programs answered mostly "vision & light control" as well as "hearing & sound control" as shown in Table 6. It is believed that the way the question was raised prompted the students to these answers.

Table 6 Suggested modifications to building by program

	Total	Architectural Engineering	Civil Engineering	Environmental Engineering	Geological Engineering
Hearing & Sound control	27.9%	35.0%	22.7%	25.5%	30.0%
Navigation	20.8%	17.5%	21.6%	21.3%	40.0%
Room Equipment	1.8%	0.0%	3.4%	2.1%	0.0%
Vision & Light Control	58.0%	55.0%	54.5%	68.1%	70.0%

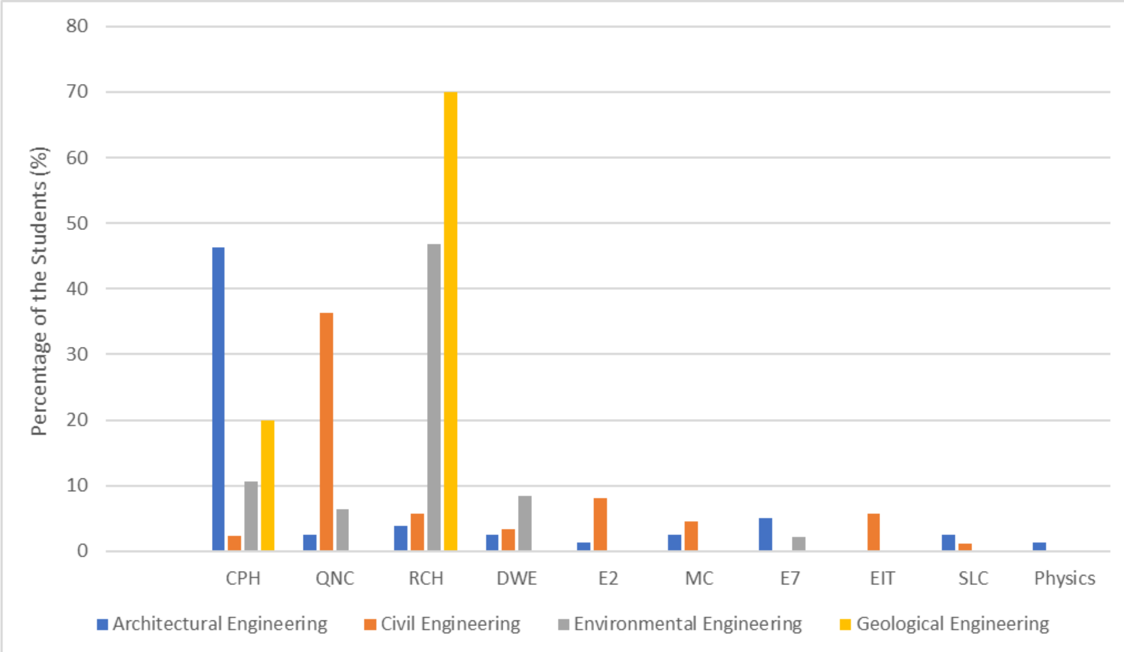

Figure 3 Building Choice for Suggestion by Program

The survey results show that different groups have different perspectives. In general, most of the students are aware and show an understanding of equity. Nevertheless, the results also show that AE and CivE students had more diverse answers and had different perspectives on the subject because they were introduced to it by either the presentation, the audio tour, or both. This shows that introducing equity in class can help the students' perspectives change.

Conclusion

The objective of this study was to test and compare the efficacy of three different methods to deliver equity material to first year engineering students from different programs. The result showed that students who had more experiential learning, with the issues directly pointed out to them in-situ, were better able to recall and notice issues of inequity in the built environment. In overall, AE students who went on a campus tour had a more diverse perspective and a better understanding of equity than the students from the other programs who were not part of the tour. In universities, offering a more equal access to a diverse range of users is important. Introducing first year students to equity as part of the curriculum could be a great opportunity to provide the students with a valuable experience and turn them into informed and proactive citizens, who are equipped to work towards and advocate for a fairer and more equitable society. It is important to note that universal design is not just about the design of buildings: It is also about user-experience in everything from software to product uses to human-machine interfaces. The students in this study are in a department where they are concerned about the built environment, however, as an interesting future study, mechanical or systems or computer engineering first-years could be exposed to a similar experiential "tour" of different designs to test for their accessibility and compare it with the civil and environmental engineering students.

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