

The Perception of Sustainable Design and Construction: Case Study of Construction Students at Two Universities

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Abstract

Sustainability can be an idea, the nature of a living system, a production method, or a way of life. It has become a complex term that can be used in a variety of ways. In the 21st century, environment and energy utilization have become a critical concern. Excessive energy use and rapid urban development have caused significant problems in our living environment. Air pollution, the greenhouse effect, climate change, a series of environmental issues, make people think about saving our community and the environment. Environmental awareness is a driving force behind sustainable design and construction. Sustainable design seeks to reduce negative impacts on the environment and the health and comfort of building occupants. It is a design method that conforms to the sustainable management of the economy, society, and ecology. Sustainable design and construction are the practice of creating structure and using environmentally responsible and resource-efficient processes throughout the life cycle.

This research aims to analyze the students' perception of the Sustainable Design and Construction (SDC) in the construction management program at two universities. This study investigates the perceptions of construction management students: what they think about sustainability and how education affects their thought relative to SDC. This study involved conducting surveys with different levels of construction management students. As a case study, this research relies on a questionnaire-based approach and statistical analysis. Survey data were collected using a convenience sample of construction students at two universities. Initial findings suggest that students' value on SDC. However, they perceive that the primary sources of information are work and social media rather than formal higher education. Such research outcomes can help educators to better implement SDC into respective curricula in the future.

Keywords: Sustainable Design and Construction; Environment, Energy, SDC teaching; curriculum development; construction management

Introduction

There is a direct relationship between construction and the environment, and both factors play an essential role in meeting a basic human need [1]. Environmental issues are global and far-reaching. They are critical for establishing a sustainable development policy in the common interest of all countries. Environmental, economic, and social aspects are the three pillars of sustainability. The sustainability theme is further improved according to society [2].

Environmental awareness is a driving force behind sustainable design and construction. Sustainable design seeks to reduce the negative impacts of the built environment on the environment and the health and comfort of building occupants. It is a design method that conforms to the sustainable management of the economy, society, and ecology. Today, designing sustainable environments is understood as a shared responsibility [3]. It includes establishing sustainable materials in the construction sector by promoting recycled building materials in construction [4]. Sustainable design and construction are the practice of creating structure and using

environmentally responsible and resource-efficient processes throughout the life cycle. The resulting built environment, in turn, affects and contributes to our lifestyles.

This survey includes 26 questions in three-part: basic background, perceptions around sustainability questions, and open-ended questions. The survey subjects are the construction students in college, and the purpose of the survey is to figure out how construction students define and understand sustainable design. Demographic information about the survey subjects includes gender, race, what they study, which year they are enrolled in, work experiences, and their classes. In addition, the survey instrument has three open-ended questions, including 1) experience with sustainable design experience, 2) benefits of sustainable design, and 3) sustainable design in the future. Other questions collected data regarding family experience, ranking sustainable design issues, sources of information, and how education will help in the future. Therefore, the survey explores construction students' perception of sustainable design and construction and what role education plays in this perception. To support these aims, survey evaluation includes both quantitative and qualitative data analysis.

Background

In recent years, many professional organizations have agreed on incorporating sustainability into engineering education, and the need for sustainability engineering education has been widely recognized. However, reflecting the concept of sustainability in the course content and providing sufficient sustainability education standards are also issues that need to be considered. Some higher education institutions have added sustainability courses to their construction courses and made them compulsory courses for students. But there is a challenge in sustainable design education: recognizing the need for change and applying it to the enterprise [5]. Therefore, it still needs to discover an appropriate way to improve sustainable education. Through appropriate engineering activities and education, students can increase their understanding of the world and their commitment to sustainable development [6]. On the other hand, sustainability education equips future engineers with sustainable thinking and knowledge. It is also finding that international cooperation between universities promoted a common academic framework on sustainability education [2].

Students should be able to understand and explain the sustainable features in the design at sustainable design education. Education will strengthen students' understanding of sustainability and help them develop a positive attitude towards sustainability. It can also help students to have a deeper understanding of sustainability and the ability to think critically. Sustainability education is a skill for students, which means that students not only need to be aware of sustainability issues but also need to have skills that enable them to cope with rapidly changing industries [7]. So, it is more efficient in the early study to help students build their skills and abilities. The ability to create or design sustainable buildings is closely related to the skills, knowledge, and ability they acquire during the education process [8]. The education of sustainability effectively promotes understanding of sustainability and future professional life. Thus, more and more construction graduates have become agents of social and environmental changes in the industry. Students can have a broader understanding of sustainable development from education and have a deeper connection with sustainable development [9]. On the other hand,

there is a growing movement to transform our educational system to better prepare students to live in and address this changing world [10].

Methodology

In this study, the researchers conducted a survey of undergraduate and graduate students from two universities, Kennesaw State University (KSU) and the University of Colorado Denver (CU Denver), in construction. The objective of the survey is to figure out how students think about sustainable design and construction, also how sustainable education affects students. The survey time was October 2020 and conducted a survey to the students through Qualtrics Software. After the students finish the survey, data were exported to excel, and then tables and charts was developed. And compare the data for both universities and analysis the difference and similarities for that.

The steps involved in creating this survey are 1) thinking about was what kind of survey questions to ask the students and 2) what kind of results wanted to know. Then survey questions are prepared with relevant documents by ensuring that it sends the survey to the students. This study involved conducting surveys from construction students to determine their perception of eight sustainability options. These sustainability options are environmental sustainability, societal sustainability, economic sustainability, energy sustainability, water sustainability, material choice sustainability, zero-emission sustainability, and lean zero-waste sustainability. The survey aimed to explore construction students' perception of sustainable design and construction and what role education plays in this perception. It took about two to three weeks to get a response to the survey from students. The survey questionnaire also used a 5-Likert scale on some survey questions that include five means extremely important and one means not at all important. For comparing part, the Friedman test was used to analyze the data. All Friedman tests are one-tailed tests because it uses the chi-square distribution to obtain a p-value. Data were compared with the independent variables, and if the p-value is greater or equal to 0.01, then all the issues for each independent variable are not the same.

Result and Discussion

Demographics

This research analyzes data of the students' perception of the Sustainable Design and Construction (SDC) in the construction management program from two universities, Kennesaw State University (KSU) and the University of Colorado Denver (CU Denver), in construction major or minor. The majority of survey respondents were from construction or civil engineering major. But there was one student from CU Denver who was in a dual degree program. Table 1 shows the demographics data of both universities. Most students (75%) who study in construction at both universities were male and did not have a minor. The most significant difference in demographics between the students at KSU and CU Denver was related to ethnicity. For the work experience, the similarities are there were about 50% to 60% of students in both universities had one to four years of work experience, and 25% to 30% of students do not have any experience. The differences are more students in KSU had five to ten years of work experience and only CU Denver students who had worked for more than ten years. Most of the students do not have any experience in sustainable

design and construction area at both universities. Just a few students had specific experiences in the sustainable design area, including working on a LEED project.

Table 1: Demographics Data

	KSU	CU Denver
Construction Major	94.4%	41.4%
Non-Construction Major	6.9%	58.6%
Male	87.5%	74.1%
Female	12.5%	25.9%
Minority	65.3%	40.7%
Non-Minority	34.7%	59.3%
Graduate Students	4.2%	33.3%
Undergraduate Students	95.8%	66.7%
Have Work Experience	75%	77.8%
No Work Experience	25%	22.2%

(72 Responded for KSU and 29 Responded for CU Denver)

Perceptions of sustainability between two university students

Most students think water sustainability is an extremely important issue related to sustainable design and construction in both universities. But in KSU, there is the same number of students who think environmental sustainability is extremely important. Therefore, environmental sustainability is the second choice for extremely important in CU Denver. On the other hand, CU Denver students think economic sustainability is extremely important, but KSU students think energy sustainability is the second choice for extremely important.

Analyzing average data suggests that all treatments are the same for students at KSU. In KSU, there was a total of 58 males, and nine females answered this question. From the data, most of the male students think environmental sustainability (31 students, 53.45%) and water sustainability (31 students, 53.45%) are the most important issues related to sustainable design and construction. About 30 (51.72%) students believe that energy sustainability is extremely important for sustainable design and construction. Unlike males, female students think that environmental sustainability, energy sustainability, water sustainability, and lean zero-waste sustainability (seven students) were extremely important for sustainable design and construction. Six students think material choice sustainability is an important issue related to sustainable design and construction (as shown in Table 2).

Both male and female students believe environmental sustainability and water sustainability were extremely important issues related to sustainable design and construction. The difference was that most female students think lean zero-waste sustainability and material choice sustainability are also important issues. These two options have the least number of male students selected. After statistical data, both male and female students think environmental sustainability, energy sustainability, and water sustainability are the top three important sustainable design and construction issues. For female students, lean zero-waste sustainability is an extremely important issue related to sustainable design and construction. Minority students believe environmental

sustainability is important and non-minority students think energy sustainability and water sustainability are the most important issues. But these three options are the top three choices for minority and non-minority students. Students who had work experience feel environmental sustainability is the most important one. Students who have never worked believe energy sustainability is the most important issue related to sustainable design and construction. Whatever they had work experience, all the students think water sustainability is the second important issue for sustainable design and construction.

Table 2: Average Score of sustainability along with the diversity from KSU students

	Overall	Male	Female	Minority	Non-minority	Have Work Experience	No Work Experience
Environment Sustainability	4.4	4.3	4.8	4.3	4.6	4.4	4.4
Societal Sustainability	4.2	4.2	4.2	4.1	4.4	4.2	4.2
Economic Sustainability	4.3	4.3	4.4	4.2	4.5	4.3	4.3
Energy Sustainability	4.4	4.3	4.8	4.3	4.6	4.4	4.5
Water Sustainability	4.4	4.3	4.8	4.3	4.6	4.4	4.5
Material choice Sustainability	4.2	4.1	4.7	4.0	4.4	4.1	4.2
Zero-emission Sustainability	4.1	4.1	4.6	3.9	4.5	4.1	4.2
Lean Zero-waste Sustainability	4.1	4.0	4.8	4.0	4.5	4.1	4.1
Average	4.3	4.2	4.6	4.1	4.5	4.2	4.3

For CU Denver data, male students think about water sustainability, and female students believe environmental sustainability is the most important issue related to sustainable design and construction. There was a total of 20 male and seven female students who had taken this survey. From the data, most of the male students (11 students) think water sustainability is the most important issue related to sustainable design and construction. Ten male students believe economic sustainability is an extremely important issue. All-female students think that environmental sustainability is the most important issue related to sustainable design and construction. Four students think water sustainability is important for sustainable design and construction. Three students believe that energy sustainability and lean zero-waste sustainability are important for that. Thus, both male and female students think water sustainability and environmental sustainability are the most important issues. And the difference is only female students think lean zero-waste sustainability is extremely important, but this option has the lowest average score for male

students. On the other hand, all the students, whether they are minority or non-minority, have work experience or no work experience, undergraduate or graduate, all think that water sustainability is the most important issue and environmental sustainability is the second important issue related to sustainable design and construction (as shown in Table 3).

Comparing the average score between overall and independent variables, figure 1 shows that the average score of the two universities is the same, which is 4.3. In KSU, the average score of have and no work experience is the same as the overall score. The score of males and minorities are lower than the overall average. And the averages of females and non-minority are higher than the overall. On the other hand, females have the highest average score. For CU Denver data, have, and no work experience also have the same score as the average. The independent variables of male, minority, and undergraduate have a lower average score. And the score of females, non-minority, and graduate students are higher than the average score. And in CU Denver, the graduate group has the highest average score.

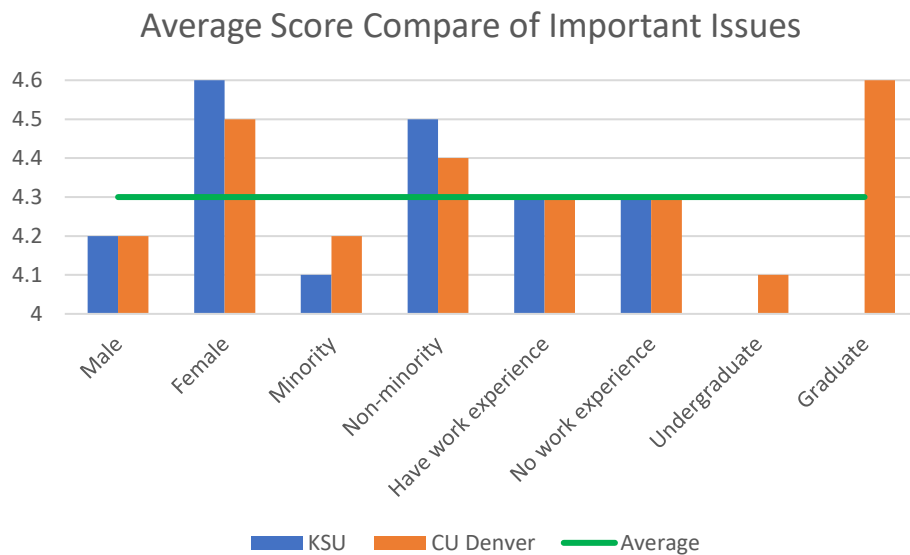


Figure 1: Comparison of the average score on important issues of sustainability

According to this survey, about 80% of university students are the first person in their family aware of sustainable design and construction. For those whose family members know this area, their knowledge is in environmental sustainability and material sustainability for KSU students and water sustainability for CU Denver students.

The overall data shows that students in KSU think environmental sustainability is the most important issue related to sustainable design and construction, whether they are male or female, minority or non-minority, have work experience or not. From the data, it is found that that over half of the male students (31 students, 56.36%) think environmental sustainability has the most

significant impact on them in the future, and 14 male students (25.45%) think economic sustainability will impact them the most in the future. On the other hand, most of the students (seven students, 77.78%) believe environmental sustainability will affect them the most in the future for female students. The difference between male and female students is that some male students think economic sustainability will impact them, but only one female student feels about that. But the similarity is that whether male or female students, everyone believes that environmental sustainability will affect them the most in the future. After statistical data, both male and female students think environmental sustainability has the most significant impact in the future. But the difference is more male students think societal sustainability has the most significant impact than female students.

CU Denver students think societal sustainability is the most important issue and same as male students. But the female students believe environmental sustainability is the most important issue related to sustainable design and construction. The minority students think societal sustainability and non-minority students feel environmental sustainability is the most important issue. Students who had work experience believe in water sustainability, and students who do not have work experience think environmental sustainability is an important issue related to sustainable design and construction. The graduate students also think environmental sustainability is the most important issue, but the undergraduate believes economic sustainability is the most important (as shown in Table 3).

Table 3: Average Score of sustainability along with the diversity from CU Denver students

	Overall	Male	Female	Minority	Non-minority	Have Work Experience	No Work Experience	Undergraduate	Graduate
Environment Sustainability	4.5	4.4	5.0	4.4	4.6	4.5	4.8	4.4	4.8
Societal Sustainability	4.2	4.3	4.2	4.2	4.3	4.3	4.0	4.1	4.5
Economic Sustainability	4.3	4.2	4.4	4.2	4.4	4.2	4.5	4.1	4.6
Energy Sustainability	4.3	4.2	4.6	4.2	4.4	4.3	4.5	4.1	4.6
Water Sustainability	4.7	4.6	4.8	4.6	4.7	4.6	5.0	4.5	4.9
Material choice Sustainability	4.1	4.1	4.2	4.2	4.1	4.2	3.8	4.1	4.3
Zero-emission Sustainability	4.1	3.9	4.5	3.8	4.3	4.1	4.0	3.8	4.6
Lean Zero-waste Sustainability	4.0	3.9	4.4	3.8	4.3	4.1	3.8	3.9	4.4
Average	4.3	4.2	4.5	4.2	4.4	4.3	4.3	4.1	4.6

Figure 2 shows that the primary source of their knowledge in education, around 30% of the students in both universities responded they got their knowledge from college. But the difference is some of the KSU students bring their expertise from mass media such as TV, radio, website, and social media. And the CU Denver students mostly get their knowledge from work experience. On the other hand, 11%-13% of students in the two universities said they do not know sustainability. Data show the primary source of their knowledge in education, around 30% of the students in both universities responded they got their knowledge from college. But the difference is some of the KSU students bring their expertise from mass media such as TV, radio, website, and social media. And the CU Denver students mostly get their knowledge from work experience. On the other hand, 11%-13% of students in the two universities said they do not know sustainability.

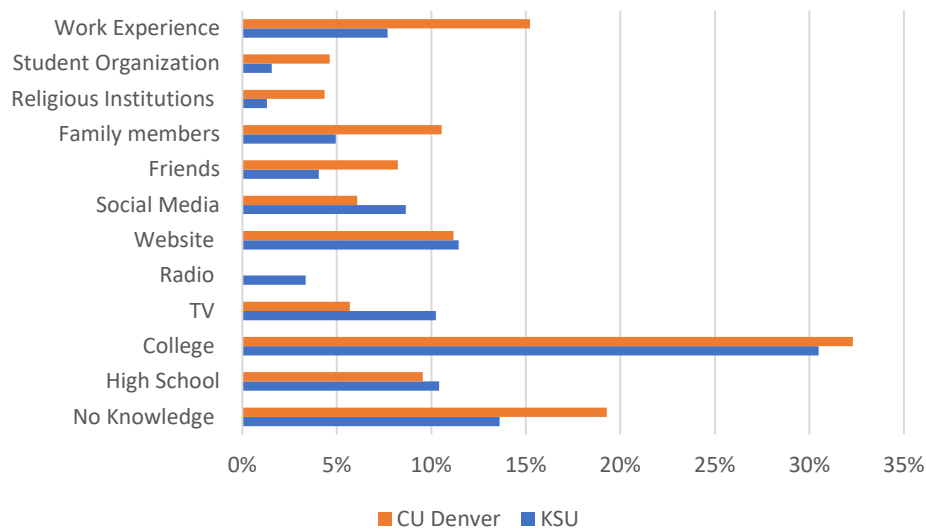


Figure 2: Comparison of Source of Knowledge of sustainability between two universities

Through this survey, most of the students in both universities think the education will provide their major to practice sustainable design and construction in the future. The differences are some KSU students think it might or might not offer, but just a few CU Denver students select this option. And there is one student in CU Denver who thinks education is not provided. In both universities, most of the students believe there is a lot of impact on them from their sustainable design and construction courses.

The survey asked students the main benefits they think sustainable design and construction can bring to this world. From the result, it is found that most of the students believe it is better for the environment, the future of our country, and the people in it (figure 3). In addition, some students think that sustainable design also has an economic benefit, eco-friendly benefit, and less footprint from the new construction. Figure 3 shows the bar chart of the time horizon of the main benefits for the two universities. From the bar chart, most of the CU Denver students think the benefits are somewhat long-term or long-term, but none of them think it is short-term. In KSU, most students believe the benefits are long-term, but some students feel the time horizon of the main advantages of sustainable design and construction is short-term.

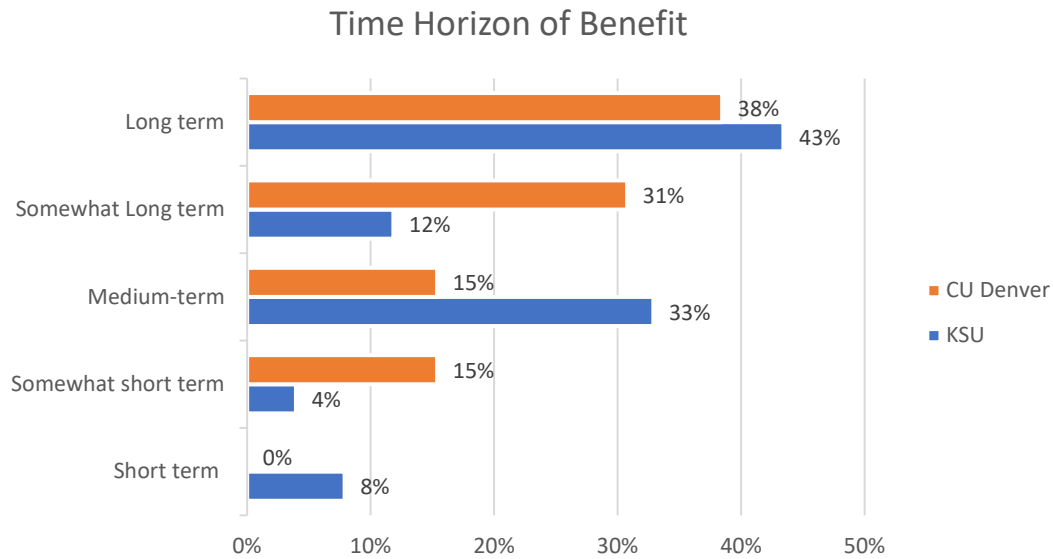


Figure 3: SDC benefits based on the time horizon

For the main challenges facing sustainable design and construction, most students think it will make more money and more time, so some construction industries are reluctant to use sustainable design or materials because they do not have much to gain and fewer profits. On the other hand, it might be hard to convince some to add it to the building methods and get everyone on board with sustainable design and construction. For this question, a bar chart was used to analyze the data. From figure 4, it is found that most of the students in both universities think the challenges are medium-term or long-term. On the other hand, some students in two universities feel the time horizon of sustainable design and construction challenges is short-term. So, the data shows for this question, the student's choices are scattered.

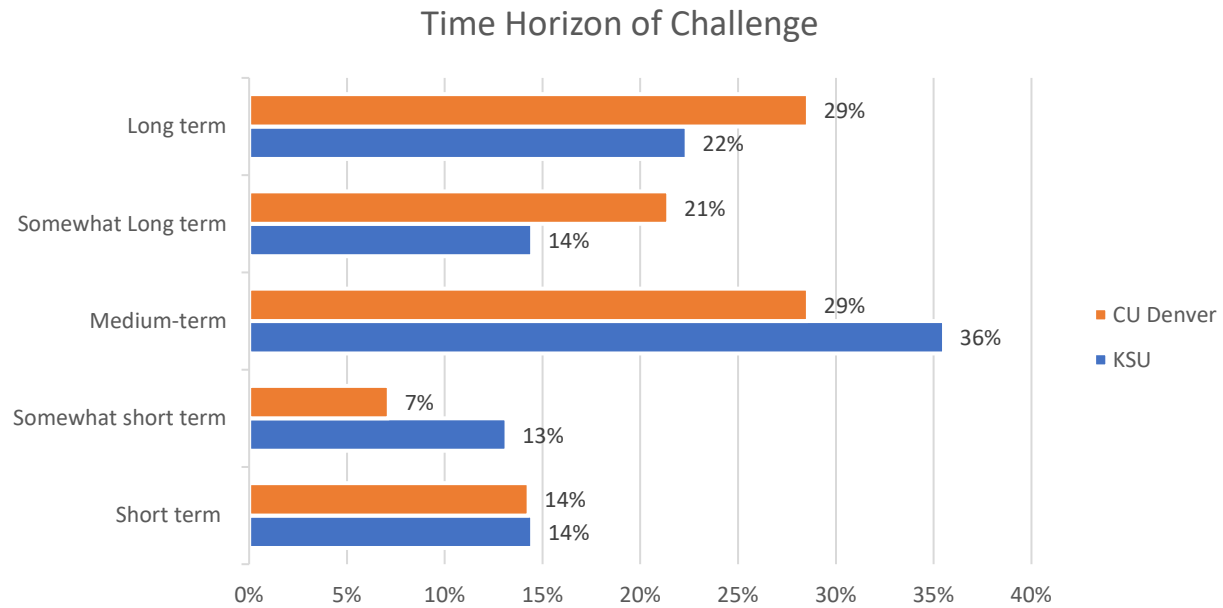


Figure 4: SDC challenges based on the time horizon

Most of the students in both universities think that not only in their school but also in colleges and universities need to offer more courses about sustainable design or sustainability. Since they believe everyone should be somewhat educated on improving the environment. From that, people will get to know the state of our lives, try to make a difference, and protect our living environment.

Recommendations and Conclusions

According to the survey, it is found that there is no specific course in both universities that teaches sustainable design and construction. Still, some classes include related sustainability. Survey respondents were undergraduate, and graduate students at KSU and CU Denver were relatively evenly distributed across levels with students. Students in both universities perceive that the environment, energy, and water are the most important issues related to sustainable design and construction. In addition, environmental sustainability has the most significant impact in the future. Survey data also suggest that students' perceptions of sustainable design and construction are mainly consistent at the two universities, although they vary somewhat along with gender, ethnicity, and education. Most students perceive the main advantage of sustainable design and sustainability is to protect the environment and promote less waste. On the other hand, sustainable design and construction disadvantage is that sustainable projects will take more money and time.

The survey suggests many students seek to get their knowledge is from education, so it is important for universities to offer some related courses about sustainable design and sustainability. However, the survey also suggests that most students believe sustainable design and sustainability are long-term goals and have a long-term impact. Therefore, future studies are

recommended to learn more about student perceptions of sustainable design and construction, educate the best, and the most important topics related to sustainability.

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