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Sustainability-Related Issues among Architecture and Construction Students: Analyzing Perception of Sustainable Design and Construction

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Analyze Perception of Sustainable Design and Construction among Architecture and Construction Students

This research aims to analyze the perception of sustainability-related issues, specifically in the area of sustainable design and construction (SDC), among architecture and construction management students. The study focuses on what students think about sustainability and how education affects their thought relative to SDC. The perceived importance of sustainable design and construction is analyzed based on students' source of knowledge, university education, and future aspirations toward sustainability goals. A survey designed to collect both quantitative and qualitative data was distributed among architecture and construction management students at different levels to investigate their perception of sustainability.

In addition to providing insight into students' perception of courses taken that have components of SDC, this study examines students' aspiration of earning a LEED certificate, interest to continue the study of SDC after graduation, and career aspirations in SDC after graduation. Based on their major, this study also explored the degree to which students have made decisions about the potential relationship between knowledge gained and students' perception of the impact of sustainable design and construction options. Findings also indicate how perceptions compare between population groups, such as students of architecture and students of construction. Students seem to be best equipped to explain their understanding of the listed options based on their experiences. Such research outcomes can help educators better to implement SDC into respective curricula in the future. In addition, analysis of these perceptions is a crucial tool for educators in improving students' understanding of sustainability goals.

Keywords: Sustainable Design and Construction; SDC teaching; curriculum development; Architecture; Construction Management, Sustainability, Student Learning

Introduction

This study involved determining architecture and construction management students' perceptions of sustainable design and construction options to evaluate sustainability preparation obtained through university education. The main focus of this research is to find the perception of sustainable courses in higher education, students' aspirations of continuing to pursue sustainability after graduation, and students' observations of sustainability benefits and challenges into the future.

Sustainable design is the approach to creating products and services considering the environmental, social, and economic impacts from the initial phase to the project's end of life. Sustainable building design and construction is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout the life cycle of a building from selecting the site, to design, construction, operation, maintenance, renovation, and finally, deconstruction [1]. The United Nations Sustainable Development Goals (SDGs) adopted by 193 countries at the Paris Accord (COP21) encompass the pressing issues of Sustainability, to be addressed holistically on the social, environmental, and economic fronts [2].

Sustainable construction means using renewable and recyclable materials when building new structures and reducing energy consumption and waste. The primary goal of sustainable building is to reduce the industry's environmental impact [3]. Sustainability, at its core, is simply about making sure that what we use and how we use it today doesn't have negative impacts on current and future generations' ability to live comfortably on the planet [4].

Background

Sustainable design creates structures and environmentally responsible and resource-efficient processes throughout the project's life cycle [5]. As described in ISO14040:2006 Life-Cycle Assessment – Principles and Guidelines, the Life cycle includes all stages from the time materials are extracted through manufacture, transportation, storage, use, recovery, reuse, and disposal. Buildings and construction consume resources, generate waste, create potentially harmful emissions, and fundamentally change the function of land, including its ability to capture water and absorb it into the ground. Thus, Sustainable Design and Construction practices seek to limit or control adverse impacts from these processes. In addition to including green spaces, sustainable design includes examples such as minimizing non-renewable energy consumption, using as many recycled products as possible, and using environmentally preferable products.Examples include utilizing materials manufactured from recycled products and local sources, taking steps to conserve water and include dual-flush toilets and low-flow faucets, and retrofitting existing structures, which eliminates the need for demolishing and rebuilding.

The term "sustainability" has been widely used in the fields of architecture and construction [6] and it is not just a short-term goal but is a long-term, industry-wide project which can help humans to have a better quality of life. Sustainability in construction includes both design and materials. Recycling, reducing waste, minimizing negative and maximizing positive impacts are the goals for sustainable design.

Sustainable development education is the journey of sustainable life and work and deals with changing environmental conditions [7]. On the other hand, education enables students to think and act independently and understand the application of knowledge. In recent years, many professional organizations have agreed on the need to incorporate sustainability into engineering education, and the need for sustainability engineering education has been widely recognized. Reflecting the concept of sustainability in the course content and providing sufficient sustainability education standards are also issues that need to be considered [8]. Some higher education institutions have added sustainability courses to their construction curricula and made them compulsory courses for students [9] [10]. But there is a challenge in sustainable design education, which is to recognize the need for change and apply it to the whole enterprise [11]. Therefore, the need still exists to discover an appropriate way to improve sustainability education. Appropriate engineering activities and education can increase students' understanding of the world and their commitment to sustainable development. On the other hand, while sustainability education equips future engineers with sustainable thinking and knowledge, findings also show that it promotes international cooperation between universities as they seek a common academic framework for sustainability education [12].

Students should be able to understand and explain the sustainable features in the design of sustainable design education. Education will strengthen students' understanding of sustainability and help them develop a positive attitude toward sustainability. It can also help students to have a deeper understanding of sustainability issues and the ability to think critically. Sustainability education outcomes include both knowledge and capacity for students, meaning that students need to be aware of sustainability issues and have skills that enable them to cope with rapidly changing industries [7]. The ability of construction professionals to create or design sustainable buildings is closely related to the skills, knowledge, and ability students acquire in the subject during the education process [13]. There is a growing movement to transform our educational system to prepare students better to live in and address this changing world [12].

This study helps to analyze architecture and construction students' knowledge of sustainable design and construction and what role education plays in the perception of sustainable construction. The survey is evaluated through quantitative and qualitative data analysis to support these aims.

Methodology

In this study, the researchers surveyed architecture and construction management students from Kennesaw State University (KSU) to determine student experiences and perceptions of the importance of sustainable design and construction and evaluate sustainability preparation obtained through university education. The survey's objective is to find out how students think about sustainable design and construction and how sustainable education affects students. The most relevant questions asked of students are: 1) demographic data - self-identify gender, race, industry experiences, and level in their program; 2) courses which have the component of sustainability; 3) LEED accreditation experience; 4) aspiration of continuing to pursue sustainability after graduation; 5) Short term vs. Long term benefits of SDC; 5) Short term vs. Long term challenges of SDC; and 5) SDC educational methods needed for the near future.

The online survey was selected because the method allowed documentation of responses at a faster rate compared to other survey methods. The survey consisted of multiple-choice, Likert scale, and slider scale questions. The survey questions were designed so that the respondents could complete the study within 5 minutes. The survey time was April 2021 and was to the students through Qualtrics Software. After the students finished the survey, data were exported to excel, and then tables and graphs were developed. Data for both architecture and construction management programs was then compared and analyzed for differences and similarities.

Data Analysis

This research analyzes data on the students' perception of Sustainable Design and Construction (SDC) in the architecture (Arch.) and construction management (CM) program at Kennesaw State University (KSU). The survey had a total of 108 participants, 64 were architecture students, and 44 were construction management students.

In the Architecture respondent group, the majority of students (38 students) were male (59.38%), 25 (39.06%) students were female, and one (1.56%) student identified as other. 25 students self-identified as Caucasian (39.06%), 15 (23.44%) students identified as African American, 12 (18.75%) identified as Hispanic, and four (6.25%) identified as Asian. Also, four (6.25%) students self-identified as two races, two (3.13%) students indicated a preference not to state, and two (3.13%) identified as "other". All students were undergraduates in the architecture program.

In the construction management group, the majority of students (32 students) were male (72.73%), 10 (22.73%) students were female, and two (4.55%) students identified as other. 20 students self-identified as Caucasian (45.45%), 13 (29.55%) students identified as African American, four (9.09%) identified as Hispanic, four (9.09%) identified as Asian. Also, one (2.27%) student indicated a preference not to state, and one (2.27%) identified as "other". Most students were undergraduates (63 or 98.44%), and one (1.56%) participant was a graduate student in the construction management program.

For work experience, the construction management students were higher (65.90%), as compared to architecture students (31.25%). Table 1 shows the demographic data of student respondents of Arch. and CM programs.

Table 1: Demographics Data

	Arch.	**CM**
Male	39.06%	72.73%
Female	59.38%	22.73%
African American	23.44%	29.55%
Caucasian	39.06%	45.45%
Hispanic	18.75%	9.09%
Have Work Experience	31.25%	65.90%
No Work Experience	68.75%	34.10%

(64 Students Responded from Architecture and 44 Responded CM)

To understand students' perceptions of the source of their SDC knowledge in university education, the survey asked, "Which of the following courses have you taken that have components of sustainable design and construction?" As shown in Table 2, students in both programs most frequently selected a focused set of courses to identify as has having taught components of SDC. Other courses across each curriculum were identified by students as teaching SDC, but at a much lower rate. 14.29% (27) of architecture students identified SDC content in Architecture Studio courses and 100% (64) of respondents had taken Architecture Studio courses. 11.11% (21) of students selected Environmental Technology I, and 10.05% (19) selected Environmental Technology II. 70.32% (45) of architecture student respondents had progressed to or beyond Environmental Technology I and 51.57% (33) of respondents had progressed to or beyond Environmental Technology II in the architecture curriculum.

20.90% (14) of construction management students identified SDC content in their Residential & Light Construction Methods course and 72.72% (32) of construction management respondents had progressed to or beyond Residential & Light Construction Methods in the curriculum.

11.94% (8) of students selected Sustainable Construction, and 10.45% selected Building Codes. These two courses are electives that 61.36% (27) of respondents had the opportunity to take, but the total number of respondents who completed those courses is unknown.

Looking at the top courses identified by students per program, significant gaps exist between the curriculum progression of respondents and the number of students identifying SDC content in their current and past courses. These gaps may suggest that student learning and retention of SDC content needs improvement or that SDC content needs to be more clearly framed and identified for students. Addressing these gaps could have a significant impact on students' ability to apply learning between courses and across the curriculum. Further study to expose students' perceptions of the source of their SDC knowledge more precisely in university education could be conducted by limiting survey respondents to graduating students and comparing student perceptions with those of faculty per course.

Table 2: Architecture and CM courses that has have the component of sustainability.

Architecture Courses	Responses	CM Courses	Responses
Arch - Architecture Studio	27	CM - Residential & Light Construction Methods	14
Arch - EnvTech I:Systems Selection & Materials	21	CM - Sustainable Construction	8
Arch - EnvTech II:HumanCom&Bldg Syst	19	CM - Building Codes	7
Arch - EnvTech III:Light,Elec&Acoustic	13	CM - Mech & Elec Building Systems	6
Arch - Arch Culture I:Early Civil&Medi	10	CM - Const & Property Law	4
Arch - Architecture Structures I	10	CM - Design/Build MEP Systems	4
Arch - Design Communication	9	CM - Sustainable Oper&Maint	4
Arch - Introduction to Architecture	9	CM - Cons Project Management	3
Arch - ArchCulture II:Renaissance-1850	7	CM - Construction Safety	3
Arch - Architecture Structures II	7	CM - Strategic Facilities Management	3
Arch - Urban Theory	7	CM - Codes and Loads	2
Arch - ArchCulture III:1850 through 1945	6	CM - Emerging Trends in Residential	2
Arch - Arch Cultures IV:DevArch21stCentury	6	CM - Facilities Management	1
Arch - Architecture Structures III	6	CM - Real Estate Develop Practices	1

The survey also examined students' future intentions and interest in pursuing SDC with three separate questions. The first question, "Do you have any LEED accreditation (Certification)?", offered "I am planning to get accredited" and "I am not interested" as response options. Figure 1 shows that "I am planning to get accredited" received a higher response rate from construction management students at 33.33%, compared to 29.41% from architecture students. Correspondingly, the option "I am not interested" received a higher response rate from architecture students at 8.82%, compared to 4.67% from construction management students.

Figure 1: LEED accreditation respondents (Architecture vs. Construction Management)

The survey then asked "Do you aspire to continue the study of sustainable design and construction after graduation?" Figure 2 shows that a majority of respondents in both programs selected "Yes", with architecture students responding at a significantly higher rate of 70.59%, compared to 52.38% for construction management students.

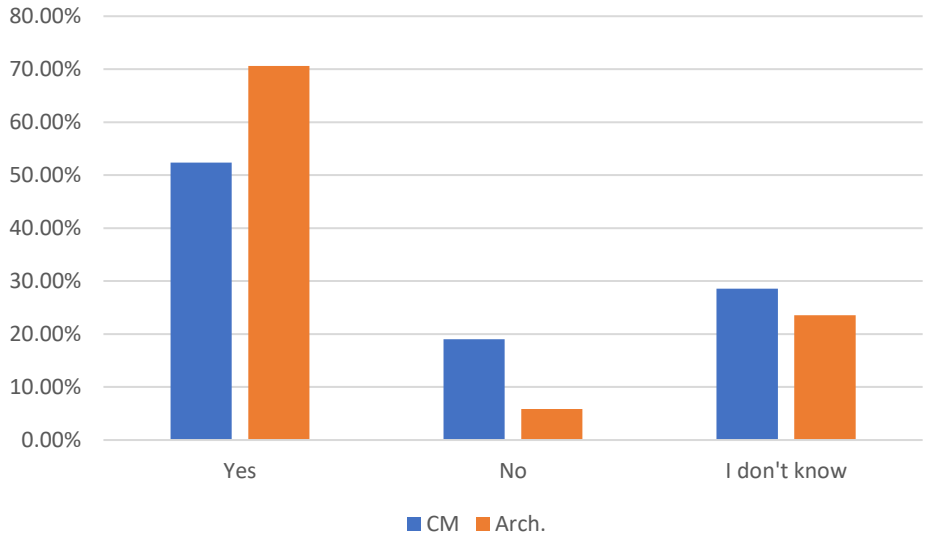

Figure 2: Aspiration of Sustainable Education after graduation

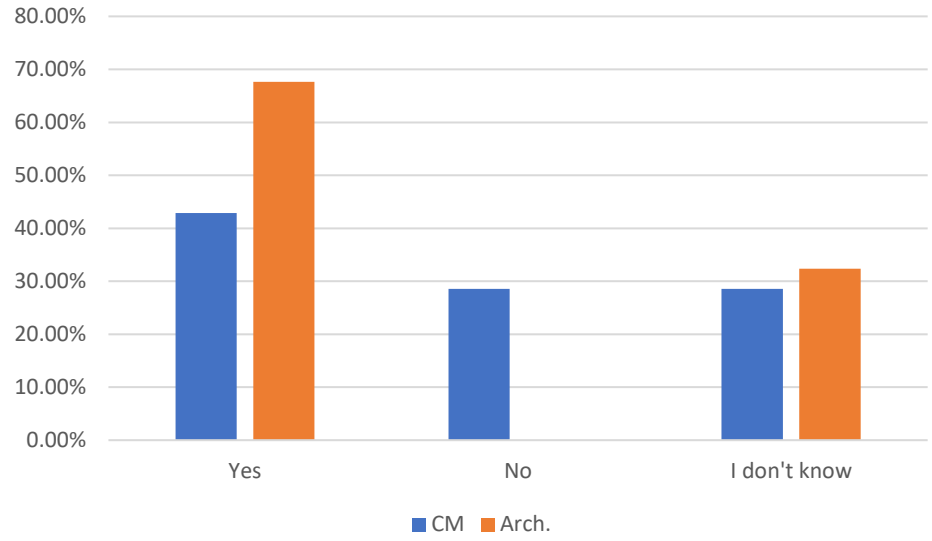

Figure 3: Aspiration of Sustainable Education Career after graduation

The third question to examine students' future intention and interest in pursuing SDC was "Do you aspire to have a career related to sustainable design and construction after graduation?" Figure 3 shows the gap in "Yes" responses widening between the two programs with 67.65% of architecture students responding "Yes", compared to 42.68% of construction management students.

The responses to these three questions combined show a relatively consistent intent and interest among construction management students in pursuing LEED certification, SDC education after graduation and a career in sustainable design and construction. However, among architecture students, responses show a much higher interest in both pursuing SDC education after graduation and a career in sustainable design and construction than in attaining LEED certification. Further study is needed to understand whether this gap is due to skepticism of LEED certification, student intention to pursue other certifications, or a need to better understand the benefits of pursuing LEED certification.

The survey further questioned student perception of the time horizons for both benefits of and challenges to sustainable design and construction.

Figure 4 shows student response rates to the question "What is the time horizon of the main benefits of Sustainable Design and Construction?" This question asked students to "Check all that apply". While response rates match between the two programs for SDC benefits being "Medium-term", differences exist between architecture and construction management students for short- and long-term durations. Response rates increase with each increment of time for architecture students, from 5.66% selecting "Short term" to 41.51% selecting "Long term". On the other hand, no construction management students selected "Short term" and the highest response rate was for "Somewhat Long term" at 41.38%.

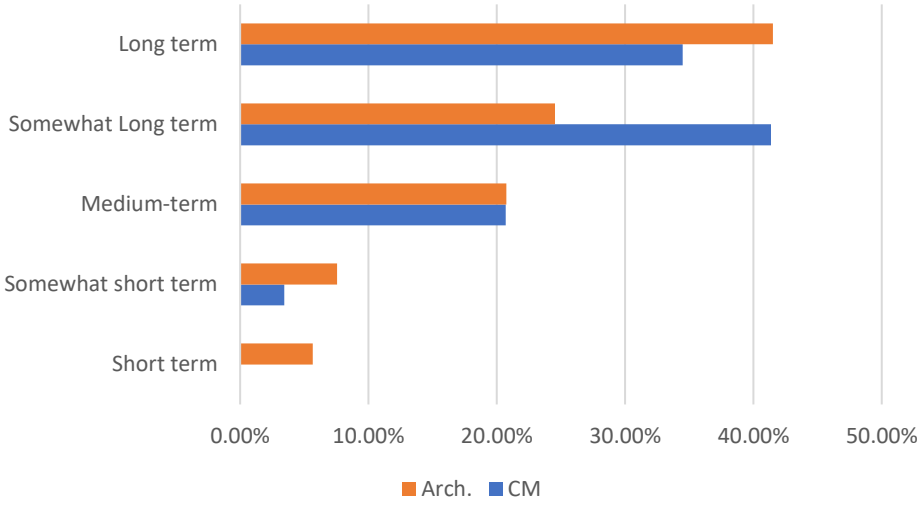

Figure 4: SDC benefits based on the time horizon

Figure 5 shows student response rates to the question "What is the time horizon of the main challenges facing Sustainable Design and Construction?" This question asked students to "Check all that apply". For this item, response rates match for challenges being "Short term" and nearly match for challenges being "Long term", but differences exist in student perception of the time horizon for challenges facing SDC between the two extremes. Most construction management students selected "Somewhat short term" for the time horizon of challenges and most architecture students selected "Medium-term". Significant numbers of students of students in both programs selected "Long term" indicating that students perceive the challenges facing SDC to be on-going, increasing with the impact of climate change, or difficult to resolve.

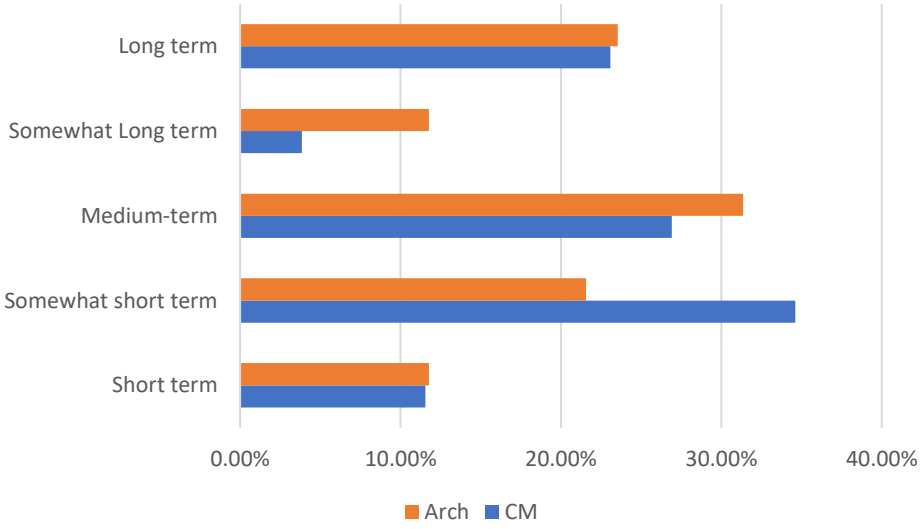

Figure 5: SDC challenges based on the time horizon

Discussions

The most significant finding of this study is perhaps that both construction management and architecture students think incorporating sustainability concepts into their studies is crucial for their future careers. In looking at the demographic distribution, a majority of students in construction management have higher work experience as compared to architecture students. However, regardless of this distribution and the respondents' discipline, most students in both programs are interested in pursuing a sustainable education after graduation, with architecture students taking the lead in this area. This concept is also reaffirmed when looking cumulatively at the results from Figures 1, 2, and 3, where the survey shows consistent intent and interest for construction management students in pursuing LEED certification, SDC education after graduation, and a career in sustainable design and construction. However, results from students in architecture show a much lower interest in pursuing a LEED certification. More research is needed in order to understand this finding.

A second significant point is noticeable discrepancies between the curriculum progression of the respondents and the number of students who identified SDC content in their current and previous courses when examining the top courses selected by students for each program. These gaps indicate that there is definitely room for both departments to improve students' understanding and retention of SDC material or that SDC material needs to be better framed and identified by students. The extent to which students can apply what they learn across the curriculum and between courses may be significantly impacted by closing these gaps. By restricting survey participants to graduating students and comparing student perceptions with those of faculty per course, further research should address more precisely students' perceptions of the source of their SDC knowledge in the curriculum. Construction Management and Architecture Departments should understand that students feel that sustainable design will have an important role in their careers, as they will be more involved in designing sustainable systems than past students. Departments that recognize this will be able to offer curricula that serve these students more effectively. Lastly, this study asked, “What educational methods are required in Sustainable Design and Construction that you foresee for the near future?" Table 3 provides responses from both programs.

Table 3: Perception of future SDC educational methods

CM	Architecture
Better trained teachers	Having an actual course for sustainable design
Create a separate curriculum in CM for this discipline	Students participate in sustainable design-related projects.
Providing more classes or incorporating SDC into more class scopes to spread the importance of sustainability.	Learning how to manage sustainability without going over budget or just harming the environment in a different way
make it a law to ensure and reinforce its acceptance.	Classes teach about the relationship between designing an aesthetically pleasing building while also being sustainable.

A practical study or workshop with experienced experts in Sustainable Design and Construction industry.	more special topics class like the SHED project that shows real-world application vs. just hypotheticals allows people to see the real-life effects and possible benefits.
A greater understanding of the site's history dating back 100 years.	Learning the low-tech and high-tech strategies which can be implemented in different scales of design.
Need to start teaching this in Highschool and Continued education after graduation	Globally: A social sphere dedicated to raising concern for pressing issues that have the potential to impact our environment in a positive manner. Locally: A LEED certification course here in the ARCH & Construct. Mgt. Program
Keeping up to date with new products, new processes, and enhanced benefits of the use of Sustainable Design and Construction practices.	We need way more concern shown to the topic of Sustainability in the future, and having an organization or mandates made to ensure that the topic is addressed would be suitable, or maybe a course that goes over sustainable design.
This will be very important in the near future. I believe that in the next 10 years, this will be mandatory knowledge that people in our field will be required to have.	I believe a better way of getting recycled tools and materials at cheaper prices.
A broad understanding is needed with the big picture so that every people can understand, not only experts in these areas.	Architecture schools should make it mandatory in every studio, plus make one of the environmental classes 100% about LEED and sustainable construction methods.
Trained workforce to challenge the problems of now and the future regarding sustainable construction	Educate about the processes of creating materials that use. And how much energy these processes use so that it can tackle the issues of sustainability deeper than just the design level.

Conclusion

In order to assess the level of sustainability preparation students in architecture and construction management received during their university education, this paper looked at how students perceived sustainable design and construction options. Specifically, the goals of the study were to ascertain students' perceptions of sustainable courses in higher education, their intentions to continue studying sustainability after graduation, and their observations of sustainability benefits and challenges in the future.

Both Construction Management and Architecture Departments at Kennesaw State University need to address how students identify, understand, and retain SDC material in their academic careers. Many students indicated that investing in sustainability-based courses benefits their

long-term careers, jobs, design challenges, and opportunities. A common sentiment expressed is that respondents believe that SDC challenges will rise on a relatively short time horizon. The Construction Management and Architecture Departments both have a tremendous opportunity to incorporate new curricula at all levels of the program that will prepare students for skills that they themselves believe they need. While the scope of this study focused on quantitative data, the next step would be to include a qualitative assessment of the issue in order to capture educational methods that are required in SDC in the near future.

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