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Inclusion of Sustainability into a First-Year Engineering Technology Course

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Abstract

Awareness of sustainability and its incorporation into engineering curricula and engineering design are of paramount importance across all engineering disciplines due to several factors, such as environmental protection, resource management, economic benefits, innovation/ competitiveness, and social responsibility. Furthermore, with the increased focus on accreditation criteria emphasizing engineering ethics and professional responsibilities across all four ABET commissions, the topic of sustainability has been considered an essential addition to the engineering technology curriculum. The engineering department at Cuyahoga Community College (Tri-C) initiated the process to determine how sustainability can be included in the curriculum. The process was executed in the following steps: (1) participation in formal enrichment programs/seminars/trainings, (2) systematic review of course outlines and materials, (3) a monthly series of conversations that examined sustainability in the context of engineering education from academic, social, and personal perspectives, and (4) conducting a student survey to evaluate sustainability awareness. This formal process, along with the ABET accreditation continuous improvement process, deepened the awareness of how and what courses need to be improved. Most importantly, the discussions improved the clarity and understanding of how the same technical material can be delivered in different sections of the course with different course modalities across all engineering programs. In this work-in-progress, an online/in-person survey was conducted and used as the primary data-gathering tool. The survey concluded that while students have a general understanding of sustainability, they lack in-depth knowledge, practical application skills, awareness, and a positive attitude towards it. It is identified that our pathway to bridge the gap between general understanding and areas of deficiency should start with the gateway course, MET-1100 Technology Orientation, as it is common for all Engineering Technology and Pre-Engineering disciplines at the introductory level. Furthermore, the MET-1100 course outline has been revised and teaching materials have been updated to include sustainability along with Life Cycle Analysis (LCA) and renewable energy. This preliminary research explored approaches to curriculum revision, teaching, and learning renewal.

Key words - Sustainability, Engineering Education, Accreditation, Curriculum

Background

The engineering technology programs at Tri-C were established in 1982. The Mechanical Engineering Technology (MET), Manufacturing Industrial Engineering Technology (MIET), Biomedical Engineering Technology (BMET), and Electrical/Electronic Engineering

Technology (EET) programs have been accredited by ABET under the Engineering Technology Accreditation Commission (ETAC) since 2008. The last general ABET review of the programs occurred during AY 2024-25, with the most recent site visit conducted in September 2024.This accreditation is a testament to the quality and rigor of the engineering technology programs at Tri-C. Apart from ABET evaluation, internal curriculum revision has been conducted every three years. Tri-C's engineering technology department implemented a new four-year degree, the Bachelor of Applied Science in Integrated Digital Manufacturing Engineering Technology (IDMET), and a two-year degree, the Associate of Applied Science in Smart Manufacturing to meet evolving industry demands. These programs are well-aligned with the trend towards digitalization and automation in manufacturing and engineering sectors. MET-1100 is the gateway course for all the engineering technology disciplines and pre-engineering, with MATH-0965 Intermediate Algebra or qualified Math placement to place into MATH-1530 College Algebra as a prerequisite. It has been offered to students in both online and face-to-face modalities. In light of curricular review and revision based on internal and external evaluation, the engineering programs have always been responsive to change. ABET includes an ethics criterion within its accreditation standards, requiring programs to ensure graduates can recognize professional responsibilities and make informed judgments, considering ethical, global, economic, environmental, and societal impacts [1]. These updates are designed to better prepare students to meet the demands of an increasingly diverse and global workforce[1]. Ethics is of utmost important for sustainability and it refers to the inclusion and representation of individuals from a wide range of backgrounds, experiences and perspectives within the efforts and initiatives aimed at promoting environmental conservation, social responsibility, and economic viability[2]. There was generally strong agreement that sustainability was a key component of environmental engineering, but this belief was less widely supported across all engineering disciplines[3]. First-year engineering courses have been offered under Civil and Environmental Engineering at many colleges, and research has been conducted to evaluate the effectiveness of teaching topics such as sustainability, LCA, and renewable energy[4,5]. A five-year research project was conducted to analyze how sustainable development (SD) was introduced into technological universities[6].The research found a lack of teaching in the areas of social and attitudinal aspects of sustainability. Furthermore, the findings showed that courses applying a more community-oriented and constructive, active learning pedagogical approach increased students' knowledge of SD.

The literature survey findings and emerging engineering ethics criteria of ABET and other professional organizations paved the way to reevaluate the curriculum to respond and act. This paper highlights preliminary research conducted and the initiation of action to address the findings of an ongoing project on the incorporation of sustainability.

The research survey findings can be categorized under key areas of relevance to engineering curricular revisions.

1. **Foundation**: Early exposure ensures that sustainability becomes a core part of their engineering mindset and approach to problem-solving throughout their education and career.

2. **Interdisciplinary Thinking**: MET-1100 is the gateway course for all engineering disciplines at Tri-C. Sustainability is inherently interdisciplinary, blending environmental, economic, and social considerations. Learning about it early-on encourages students to think across traditional boundaries.
3. **Responsibility**: Engineers play a crucial role in creating sustainable solutions for global challenges like climate change, resource depletion, and pollution. Starting this conversation early prepares them to take on this responsibility.
4. **Innovation**: By understanding sustainability from the start, students are more likely to innovate and design with a sustainable future in mind, leading to more environmentally-friendly and socially-conscious engineering practices.
5. **Career Readiness**: As industries increasingly prioritize sustainability, having a strong grounding in these principles can make graduates more attractive to employers and better prepared for the demands of the modern workforce.

Method

1. Participation in formal enrichment programs, seminars, and training.

   Faculty were instructed to participate in seminars and professional development activities related to sustainability to become resourceful in teaching the topics. Monthly brainstorming meetings have been conducted to share the knowledge gained and revisit the curriculum to identify the courses for including these topics or to evaluate the necessity of creating a new course to address above-mentioned key areas.

2. Systematic review of course outlines and materials.

   Last year, ABET evaluations and advisory meetings across all engineering disciplines enabled us to review the curriculum in the areas of ethics, sustainability, and climate change [1,7].

3. Monthly series of conversations that examined sustainability in the context of engineering education from academic, social, and personal perspectives.

   This process enables the decision on the pedagogy to teach identified topics, the use of technology in teaching and evaluation, and the conduct of student surveys to evaluate sustainability awareness.

   It was decided to identify key courses to include the topics and revise the courses rather designing new courses, due to limited course credit requirements of programs. MET-1100 was identified to include sustainability along with Life Cycle Analysis (LCA) and renewable energy. The literature review was conducted to find teaching resources for these topics and suggested the use of OpenLCA[8,9], Carbon Footprint Calculator [10].

4. Conduct a student survey to evaluate sustainability awareness.

   Students are the most important constituents in the education system, and their feedback is utmost importance to faculty, advisory committee, and accreditation bodies. The student survey consisting of 18 questions was designed to focus on the five areas listed below and targeting the topics of sustainability, LCA, and renewable energy. A literature review was conducted to implement the survey questioner, and the questions were adapted from previous surveys conducted by other institutions[11,12,13].

   - General Understanding
   - Knowledge and Education
   - Attitudes and Perceptions
   - Practical Application
   - Engineering Courses Offered at Tri-C

   The purpose of the survey was to briefly evaluate students' self-assessed background, knowledge, and education level regarding sustainability along with their attitudes toward learning about sustainability, LCA, and renewable energy.

Results and Discussion

There were 50 students from courses taken under MET, MIET, EET and BMET included in this survey. The responses were compiled in an Excel document, and the number of instances of each word/phrases was counted. A free web program called Wordle was used to better visualize the most frequently used words. Figure 1 shows the Wordle word cloud illustration of students' response to question 1 of the survey conducted at the beginning of the Spring 2025: "How would you define sustainability in your own words (use a short phrase or word to describe)?". As shown, the students had many diverse ideas to define sustainability, and it can be concluded that most students have a general understanding of the term "Sustainability". Public interest in sustainability appears to be growing, which may drive this general understanding. Furthermore, the word "Unsure" is also highlighted as high-frequency term, indicating a lack of general awareness that we need to address.

Figure 1. Word cloud representation of student response to the question "How would you define sustainability in your own words (use a short phrase or word to describe)? "

Another question asked students to evaluate their self-assessed knowledge of sustainability by rating their knowledge regarding sustainability. As shown in Figure 2, none of the students rate their knowledge as 9 or 10 on the rating scale, while 20% rated themselves at the lowest rating of 1.

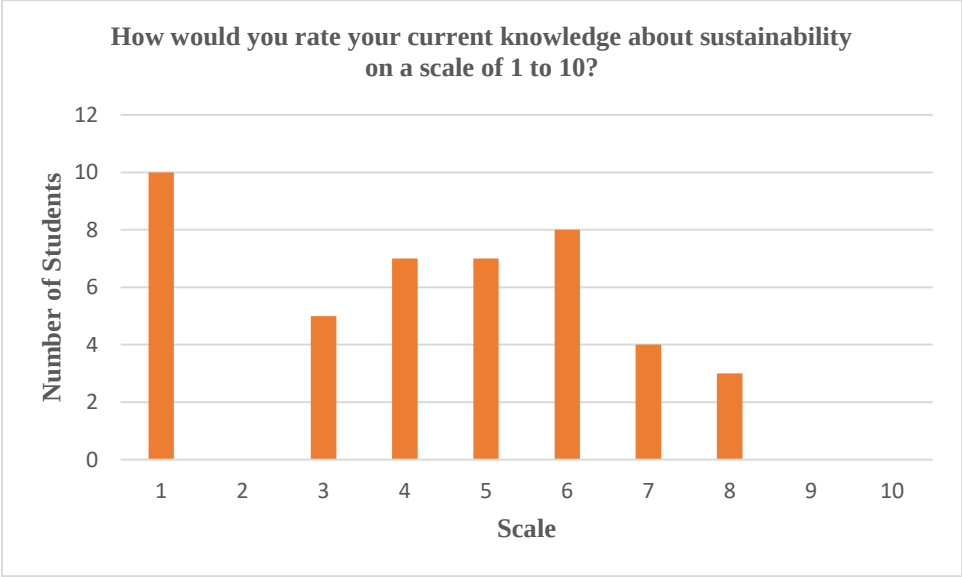

Figure 2- Students self-rating regarding their knowledge of sustainability

Figure 3 summarizes the survey poll results for the question asking whether to include sustainability in the MET-1100 Technology Orientation first-year engineering course. Overwhelmingly, 98% of the students voted to introduce sustainability in MET-1100, which

aligns with the faculty's conclusions/recommendations of curricular revisions and brainstorming sessions carried out before the student survey.

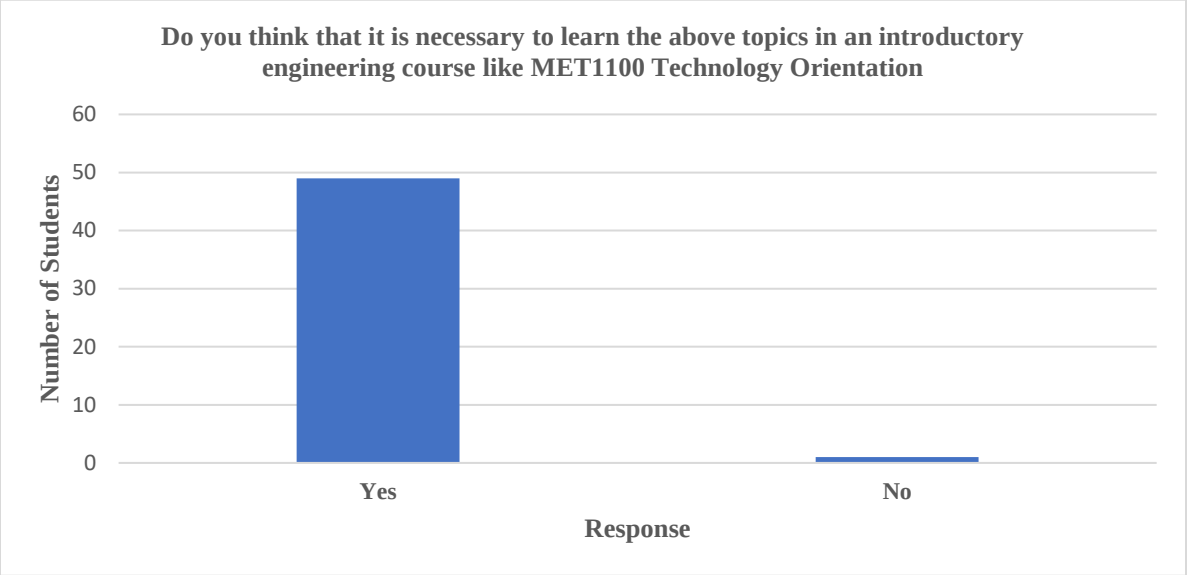

Figure 3- Students response summary for sustainability inclusion in MET-1100

Figure 4 shows the feedback related to knowledge and education of the topics of sustainability, LCA, and renewable energy. The data summary reflects that more than 80% of students have not taken any formal education or courses in these topics. The word cloud concludes that the students have a general understanding of the topics rather than in-depth knowledge or education. Based on the results, it is recommended to include: (1) lectures related to sustainability and LCA that cover general understanding and social ethical responsibility, (2) a group project, where students conduct LCA on a product of their choice and introduce interactive software tools like OpenLCA[8,9], and (3) an individual project for calculating individual carbon foot print using the free carbon footprint calculator from the United States Environmental Protection Agency (US EPA). Additionally, include a discussion on how to change own personal choices to reduce carbon footprint[10].

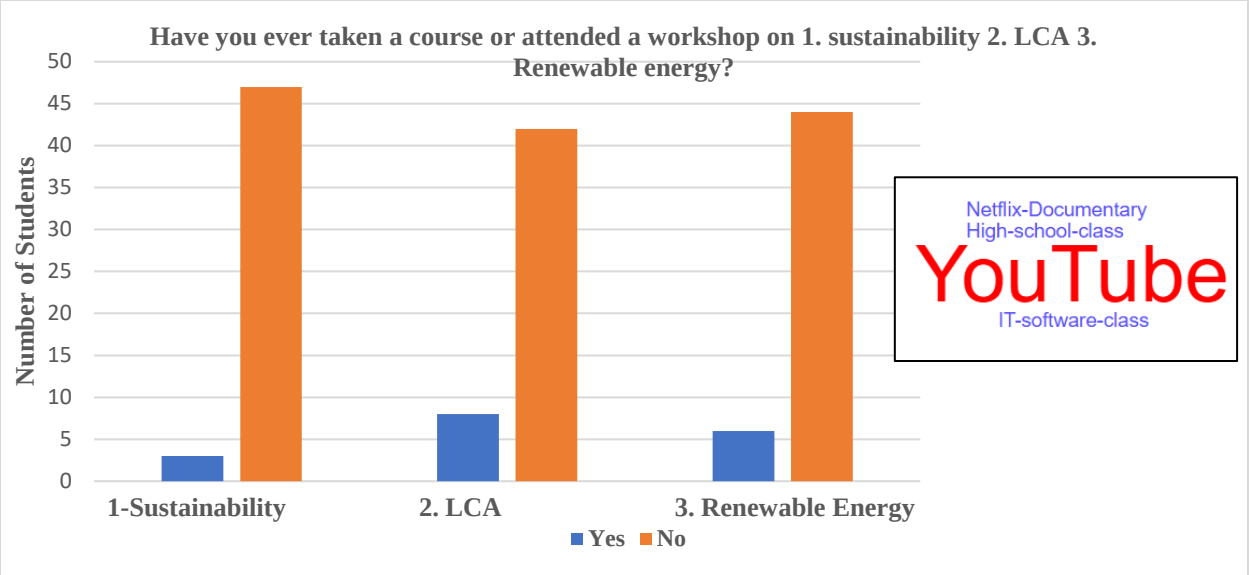

Figure 4- Students response related to sustainability, LAC and renewable energy courses

As shown in Figure 5, students strongly agree that engineers play a major role in promoting sustainability confirming that the curriculum should include practical applications with case studies. This question aimed to gauge students' perceptions related to social responsibility regarding sustainability. As can be seen, 8% of surveyed students responded neutrally. This result indicates that the lecture or case study should highlight the importance of ethical and social responsibility in engineering, particularly concerning sustainability and sustainable product design. Capstone project/machine design course is another excellent course to reinforce what students learn at the entry level to solve real-world problems, enabling them to think holistically and consider the broader implications of their work.

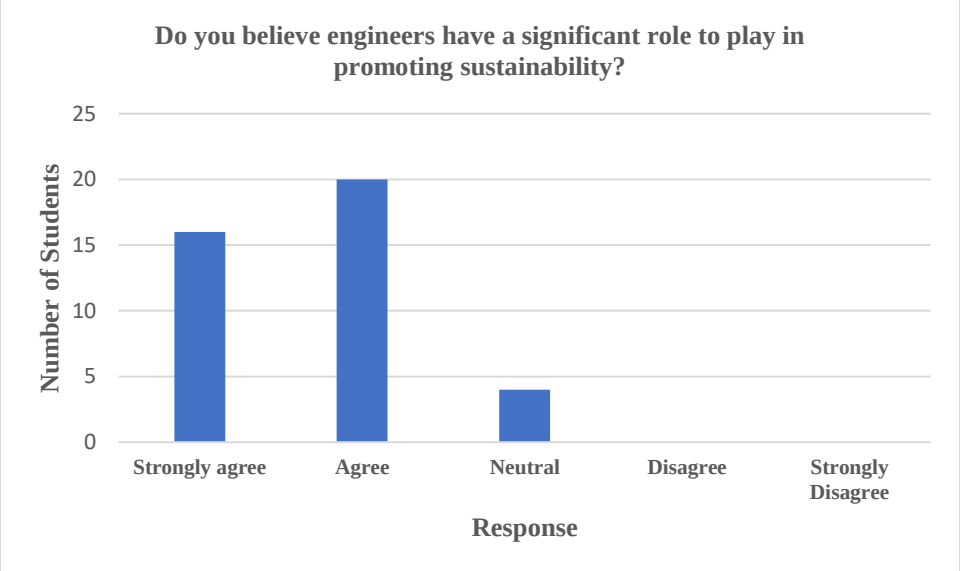

Figure 5- Students response related to the question, "Do you believe engineers have a significant role to play in promoting sustainability?

Conclusion and Future Work

MET-1100 Technology Orientation was identified as the course to introduce sustainability and relevant topics based on survey results and faculty recommendation. Monthly brainstorming sessions and attending faculty development activities have helped identify key areas in implementing sustainably, such as environmental protection, resource management, economic benefit, social responsibility, and innovation/competitiveness. Measurable outcomes of the course, the outline of activities, and the course assessment methods related to the topics of sustainability, LCA, and renewable energy have been successfully implemented in the MET-1100 Technology Orientation course. Pre- and post- course assessments are proposed as future work to evaluate the effectiveness of teaching these topics. Additionally, the capstone projects should be evaluated for necessary revisions to incorporate sustainable product design.

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