NSF RFE: Students' Professional Identity Formation through Sustainability-Focused Course Interventions

Dr. Ashish Agrawal, Rochester Institute of Technology (CET)

Ashish Agrawal is an Assistant Professor in the College of Engineering Technology at Rochester Institute of Technology. His research interests include exploring the intricacies of STEM curricula, studying the influence of curricular features on students' experiences, and designing equitable interventions and assessing their influence on student learning. He has taught several introductory engineering courses using student-centric approaches such as project-based learning and flipped classroom.

Lucio Salles de Salles, Rochester Institute of Technology (CET)
Dr. Yewande S Abraham, Texas A&M University

Yewande Abraham Ph.D., LEED AP O+M, is an Associate Professor in the Department of Construction Science at Texas A&M University. She received her Bachelor's and Master's in Civil Engineering from Cardiff University, Wales, United Kingdom. She has construction industry experience in the US and internationally. Her research focuses on sustainable built environments, construction education, and the integration of emerging technologies into civil engineering and construction curricula. Dr. Abraham brings a global perspective to engineering education through her professional experiences in curriculum innovation, workforce development, and industry-academic partnerships. She is passionate about advancing future-ready construction education that aligns with real-world challenges and opportunities.

Dr. Lisa L Greenwood, Rochester Institute of Technology (CET)

Dr. Lisa Greenwood is an assistant professor in the Department of Civil Engineering Technology, Environmental Management and Safety at the Rochester Institute of Technology. Dr. Greenwood has been involved in national and international environmental stan

Dr. Amanda Y Bao P.E., Rochester Institute of Technology (CET)

Amanda Bao is a Professor and Program Director in Civil Engineering Technology at Rochester Institute of Technology. She got her Ph.D. degree in Civil Engineering from the University of Colorado at Boulder, USA, in 2006. Dr. Bao started teaching at Rochester Institute of Technology in 2010 and she regularly teaches structural engineering courses. Prior to RIT, she worked as a bridge structural engineer at Jacobs Engineering Group, Inc. and Michael Baker International, Inc. in Denver, Colorado, and she is a licensed professional engineer in Colorado and New York, USA. Dr. Amanda Bao won the 2021 Eisenhart Award for Outstanding Teaching at RIT. Dr. Bao has been actively involved in engineering education research since 2011, including digital learning, active learning and intensive collaboration with industry. Dr. Bao develops a teaching website: http://baoteachingcet.com/ and opens a YouTube Structural Design Teaching channel to post screencasts to supplement traditional lecture-type classes, and she also created hands-on active learning modules to improve teaching and learning effectiveness. In addition to education research, Dr. Bao conducts research in the areas of bridge resiliency and sustainability, innovative construction materials and evaluation of aging infrastructure. She has extensive research experience in finite element modeling and lab testing of structures and published more than 25 research papers. She is an active member in ASEE, ASCE and AISC

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1. Introduction

Sustainability is a crucial issue in modern times, as we face a changing climate, finite resources, and related threats to human well-being. The United Nations (UN) defines sustainable development as development that leads to economic growth, addresses social needs, and tackles environmental challenges [1]. Global sustainable development goals have been emphasized by the UN, and are further reinforced by the National Academy of Engineering in the form of the Grand Challenges [2]. As such, the role of engineers is evolving beyond technical problem-solving to addressing complex challenges with a sustainability-focused approach. This necessitates preparing tomorrow's engineers with both an understanding of how technical solutions interact with environmental, social, and economic systems, and the ability to address sustainability risks and constraints [3]. To this end, this project aims to integrate sustainability-focused course interventions into ten engineering technology and applied science courses at a private R2 university and to analyze the influence of these interventions on students' professional identity formation.

Professional identity is a construct representing how one envisions who they are (i.e., their "sense of self") and assigns meaning to themselves as a member of a specific professional discipline [4]. Institutions of higher education significantly influence the formation of students' professional identities through curricular and extra-curricular engagements. These engagements influence students' knowledge and understanding of their professional roles, their attitudes and beliefs toward their professional responsibilities, and the decisions they make or actions they take in their professional roles [5]. As graduates take up positions in engineering and related professions and advance into leadership roles, they shape professional practices and priorities [6]. This project aims to help students cultivate a professional identity grounded in sustainability principles by implementing sustainability-focused course interventions and measuring their influence on students' identity formation.

2. Course Interventions

Guided by the Engineering for One Planet (EOP) [7] and Sustainability Consciousness [8] frameworks, the project team developed interventions for ten courses in engineering technology and applied science as listed in Table 1. The research team used the EOP framework developed by the Lemelson Foundation as a guide to map existing course learning outcomes to sustainability-focused outcomes. These outcomes were then used to develop course interventions including sustainability-focused case studies, assignments, and course projects [9], [10], which are currently being implemented.

Table 1: Courses with Sustainability Interventions

Course Title	**Academic Discipline**	**Academic Level**
Introduction to Civil Engineering	Civil Engineering Technology	1st year
Circuits I	Electrical Engineering Technology	1st year
Principles of Environmental Sustainability, Health and Safety	Environmental Sustainability, Health and Safety	1st year
Strength of Materials	Civil Engineering Technology	2nd year
Structural Steel Design	Civil Engineering Technology	4th year
Design of Highway Bridges	Civil Engineering Technology	5th year*
Capstone	Civil Engineering Technology	5th year
Sustainable Building Design and Construction	Construction Management	Graduate/5th year
Environmental, Health and Safety Management	Environmental Sustainability, Health and Safety	5th year
Environmental, Health and Safety Management	Environmental, Health and Safety Management	Graduate

**The undergraduate degrees in engineering technology at the research site are five-year programs.*

3. Research Design

To explore the influence of these interventions on students' sustainability-focused identity construction, the project uses a multiple-case study research design, with each course serving as a case. The study was approved by the Institutional Review Board (IRB) at the research site.

Data collection started in Spring 2025. Data for this study include written reflections and semi-structured individual interviews, which capture students' understanding of sustainability and the influence of the course interventions on their professional identity development. These data are collected from students enrolled in the courses in which the interventions are being implemented. Students first complete a written reflection as part of the course requirement. Students who consent are then interviewed to explore their thoughts in-depth. The interview builds on the reflection completed by the student. Students are given the option to participate in the study by allowing the research team to analyze their written reflections without completing the interview. We plan to collect data for 2-3 offerings of each course listed in Table 1, with a goal to conduct 6-10 student interviews during each offering.

These data will be analyzed using the Sustainability Consciousness framework [8], which characterizes sustainability along three dimensions - social, environmental, and economic - and three identity constructs - knowledge, attitude, and behavior. This characterization of sustainability aligns with and is based on the UN's definition of sustainable development [1].

4. Preliminary Findings

We are currently in the process of systematically analyzing the written reflections and interviews to understand students' conceptualization of sustainability and their professional identity along sustainability-related knowledge, behavior, and attitude. Here we present our

preliminary findings along with example quotes from reflections or interviews. Note that participants are referred to by pseudonyms and pronouns aligned with their self-identified gender.

The preliminary findings suggest that students had a varied understanding of sustainability based on their prior experiences. For some students, the interventions reinforced what they already knew; for others, the interventions provided new insights. For example, Avery noted not having a deeper understanding of sustainability before starting their undergraduate degree.

> *I didn't really have much of an understanding in sustainability before coming to college. I definitely knew that going into mechatronics, I wanted to do something in prosthetics, and I, myself have always been kind of conscious about how much I recycle or anything like that… I knew that I would probably want to do research or get into something like that. (Interview)*

Later during the interview, Avery highlighted that they learned about sustainability through their different undergraduate courses. On the other hand, Andrew noted that he already had a deeper understanding of sustainability-related issues prior to coming to college. Talking about how he learned about sustainability from the practices adopted in his family, Andrew noted:

> *I wasn't really directly taught it, just obviously by doing. My family… we go out and get things, whatever we can we reuse. We try to create new things out of things that are old, whether it requires welding techniques or whatever. My family's goal is always to save money and so we had to be pretty creative and make new designs and either, if it's broke, got to fix it. And then I learned as I got older, as I got more into reading and whatnot, that, "Oh, okay, that's really part of sustainability." (Interview)*

While Avery's and Andrew's prior experiences with sustainability lie on two relative ends of the spectrum, Barbara's experiences can be described as a combination of the two. She noted already having some prior understanding of sustainability. However, the different courses and extra-curricular experiences during her undergraduate degree helped her gain a nuanced understanding of the topic.

> *I think at more of the surface level, sustainability is usually just presented in daily conversation in terms of just like the environment, but not as much in terms of the other aspects of it. But definitely in this class, we talked about a lot of the different aspects of sustainability, and I think I also have learned more about sustainability just kind of through my own conversations with people and like my own research with it… I guess work a little bit too, like with co-ops. (Interview)*

Barabara elaborated during the interview how she learned that the scope of sustainability extends beyond just the environment to the economy and the community.

Like differences in participants' prior awareness of sustainability, we found variations in their attitude or behavior toward sustainability based on their learning from the course modules

and other experiences. For example, Brian noted how learning from the sustainability module in his capstone course helped him broaden his understanding of the role of professional engineers.

> *I feel that along with discussions of environmental and economic sustainability we should also be talking about the social aspects of a project. I feel that often we get so wrapped up with designing for a single use case on a project that we lose sight of the total scope and impact. I think pushing for all aspects to be considered benefits the future massively. (Written Reflection)*

Similarly, Amit noted that the insights he gained into electronic waste in his Circuits course encouraged him to adopt new sustainability-related practices.

> *Yes, these insights influenced my everyday actions because, before I want to buy a new electronic [product], I'll think to myself if I do really need a new device, and since I'm [studying to be] a computer engineer I can ask myself if I can reuse or salvage the parts in the electronic. (Written Reflection)*

For some others, the sustainability module in their course did not significantly shift their attitude or behavior, as they were already inclined to incorporate sustainable practices in their professional work. For example, Bob noted that he "already wanted to be a designer who considered the environmental and social impacts of their projects" (Written Reflection). However, the insights he gained from the sustainability module in the capstone course strengthened this desire.

5. Conclusion

Preliminary findings suggest that while students enter engineering and related academic programs with disparate degrees of exposure to sustainability, course interventions can enhance student knowledge of sustainability at an introductory level, and reinforce its importance for those with prior knowledge. As we continue to collect and analyze data for this project, we expect the findings to provide deeper insights into how students develop a sustainability-focused professional identity. This knowledge can further inform the design and development of curricula in engineering and applied sciences, leading to the development of a workforce more aware of and equipped to address the current sustainability-related challenges.

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