# Board 345: Perceptions of Sustainability Among Participants at the NSF REU Site on Sustainable Resilient Transportation Systems

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## Background

Concepts of sustainability, climate change, and resilience have become increasingly important in undergraduate education across all engineering disciplines. Organizations like the United Nations [1] and the National Academy of Engineers [2] have articulated goals and challenges related to sustainability for the 21st century. Solutions to climate change require interdisciplinary efforts and it is important to engage undergraduate students in these topics to develop a workforce that is capable of tackling these challenges. There has been a concerted effort to incorporate sustainability topics into the undergraduate engineering curriculum [3]–[8]. In addition to these curricular experiences, it is important to provide opportunities to engage in sustainability topics outside of the curriculum. Many studies report on the positive learning outcomes that result from engaging in undergraduate research experiences [9]–[11].

In 2021, a Research Experience for Undergraduates site in Sustainable Resilient Transportation Systems (SRTS-REU) was established at the University of Delaware with support from the National Science Foundation (NSF) Division of Engineering Education and Centers. This 10-week summer program aims to provide participants with interdisciplinary research experiences in engineering, improve their professional and communication skills, and develop their quantitative analysis capabilities. Over the past two years, this site has hosted a diverse cohort of undergraduate researchers. They worked on interdisciplinary research projects in electric and autonomous vehicles, green construction materials and structures, and resilient infrastructure. In addition to the individual research experiences, all SRTS-REU participants engaged in cohort experiences including workshops and seminars that addressed sustainability topics and supported the development of students' research, communication, and collaboration skills. In this short paper, we summarize findings on perceptions of sustainability among participants of the latest cohort of the SRTS-REU program, which can be used to inform similar future programs that aim to engage undergraduate students in sustainability topics.

## Study Setting

In the summer of 2023, ten undergraduate students from eight different states in the USA and Puerto Rico participated in the program. Participants included second-, third-, and fourth-year students from five STEM disciplines: Chemistry, Chemical Engineering, Civil Engineering, Computer Science, and Mechanical Engineering. As part of the overall program evaluation, all participants were asked to complete a pre- and post-program survey that included sustainability-related questions. They were also invited to participate in an interview after the summer program, which included a question about the impact of the SRTS-REU program on their knowledge of sustainability issues in transportation. The program evaluation was submitted to and granted exempt status by the University of Delaware's Institutional Review Board.

The pre- and post-program online surveys were primarily based on the Undergraduate Research Student Self-Assessment (URSSA) [12]. NSF has supported the development and testing of the URSSA through its Divisions of Chemistry and Undergraduate Education, the Biological

Sciences Directorate, and the Office of Multidisciplinary Affairs. In addition to questions from URSSA, both surveys included the same open-ended and Likert-scale questions to measure the knowledge of sustainability among the SRTS-REU participants. Table 1 shows the sustainability-related questions used in these surveys. For both the pre- and post-program surveys, nine of the ten student participants completed the survey (90% participation rate).

**Table 1. Sustainability-related Questionnaire for Pre-program and Post-program Surveys**

| **Question** | **Answer Choice** |
|---|---|
| In your words, briefly describe the term, "sustainability". | Open-ended |
| In your words, how would you describe a resilient system? | |
| I can name the three fundamental aspects that should be addressed in sustainable development. | Four-level Likert scale:<br>Strongly agree<br>Agree<br>Disagree<br>Strongly disagree |
| I can describe the cause of climate change. | |
| Sustainability is an important concern in engineering. | |
| My field of study is contributing toward sustainable development. | |
| I can rank various sectors (e.g. transportation, industry, electricity) by the amount of greenhouse gas emissions. | |
| Sustainability is an important factor in the design of engineered products and systems. | |
| Technological solutions and innovations are important to address climate change and improve sustainability. | |
| Politics and policy are important to address climate change and improve sustainability. | |
| I believe that we will be able to overcome the challenges of climate change. | |

Eight of the ten students completed the end-of-program interview (80% participation rate), which included several questions to ascertain any changes in attitudes or perceptions from the beginning to the end of the program. Pertinent to this study, during the interview, students were asked, *"Describe how your knowledge of issues of sustainability relevant to transportation has been impacted by your experience in the REU program?"* Interviews averaged 30 minutes in length in total for all questions in the interview protocol. Student interviews were audio-recorded with the participant's permission and later transcribed by a professional transcription service; transcripts were examined for broad themes.

**Results**

Responses to the open-ended questions from the pre- and post-program surveys indicated that students came into the SRTS-REU program with some general awareness of sustainability and resilience. Likert scale responses in the pre-program survey and the post-program survey are shown in Figures 1 and 2, respectively. Levels of agreement to these questions generally increased in the post-program survey. All respondents agreed or strongly agreed that sustainability is an important concern in engineering, sustainability is an important factor in engineering design, and that technology, politics, and policy are all important in addressing climate change and sustainability in both the pre- and post-program surveys.

Comparison of responses to the other sustainability questions indicates a gain in knowledge of sustainability and climate change among the SRTS-REU participants. A higher percentage of respondents agreed or strongly agreed that they could name the three fundamental aspects of sustainable development, describe the cause of climate change, rank various sectors by the amount of greenhouse gas emissions, and believe that their field of study is contributing to sustainable development.

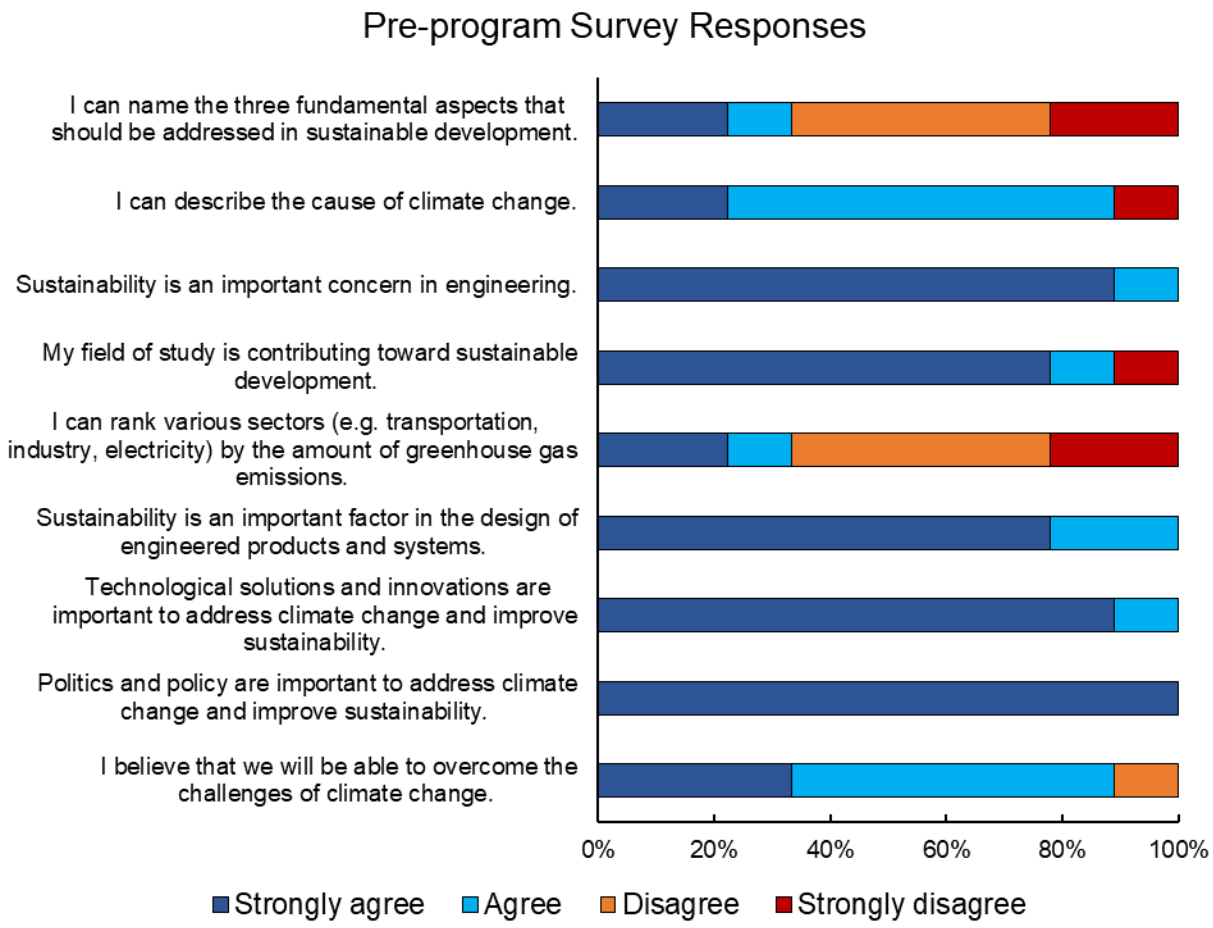


**Figure 1. SRTS-REU participant responses to sustainability-related questions in the pre-program survey (90% response rate).**

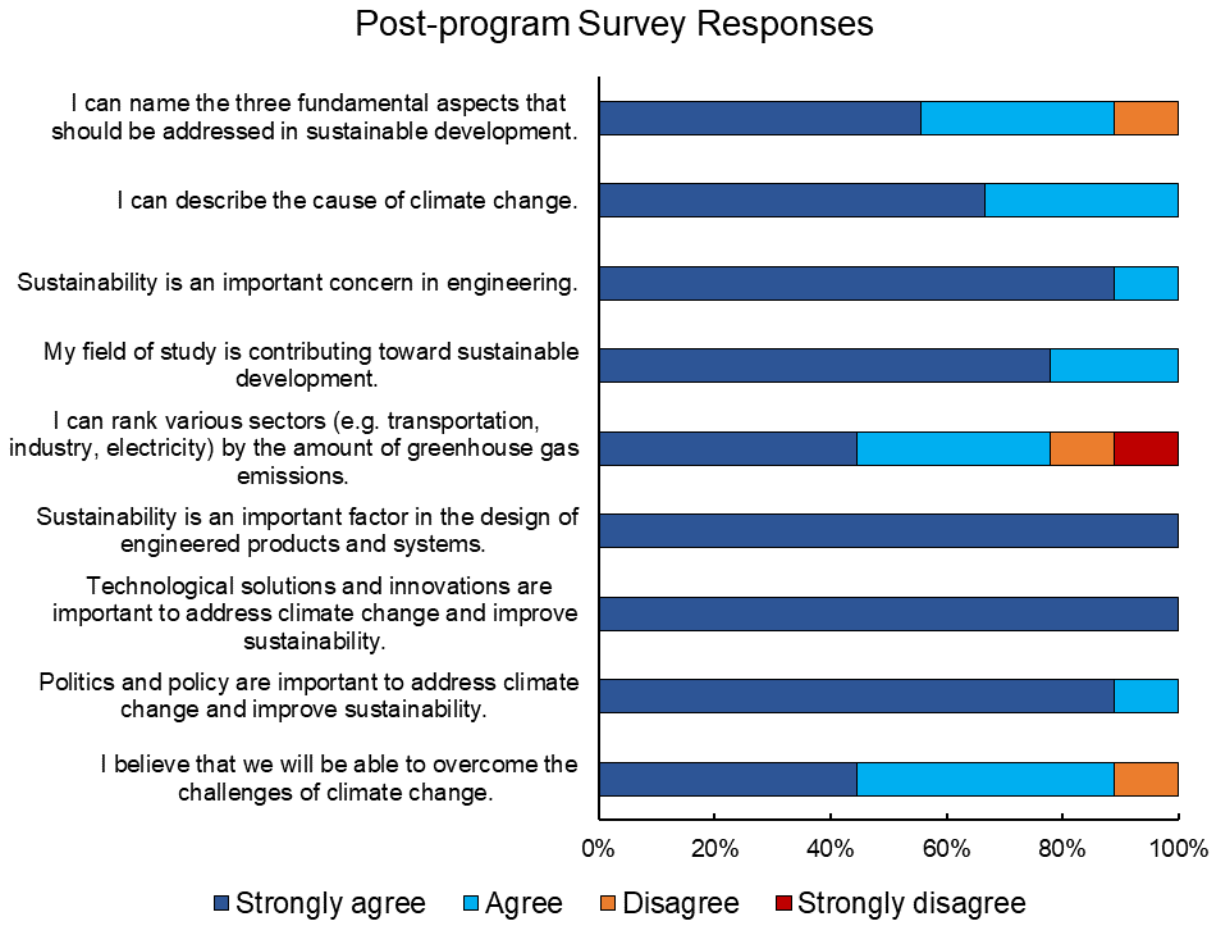


**Figure 2. SRTS-REU participant responses to sustainability-related questions in the post-program survey (90% response rate).**

SRTS-REU participants were asked during the end-of-program interview to describe how (if at all) their knowledge of issues of sustainability relevant to transportation was impacted by their experience in the REU program. Most of the students acknowledged they came into the program with a general knowledge of issues of sustainability as it related to transportation. Still, all expressed that the program increased their knowledge of sustainability. Some example excerpts are below:

*"Definitely, I've gained way more knowledge. Since there were different majors, I learned how each of them could contribute to it. We could work together. And certainly, I was made more aware of issues that we have that I wasn't aware of, and the importance of acting towards changing those things."*

*"So I kind of have some knowledge about sustainability since I'm <major removed> and also about transportation. But I feel like, as I said in the beginning, it's more about seeing other fields that sustainability can impact; as for example, there's science, computer working on*

*sustainability, electrical engineering students, and chemical engineering. So yeah, this is the way that I feel like I learn about how sustainability can apply to this field."*

*"So before I came to the program, I was personally interested in sustainability ecosystem and climate change. So I even took a climate change class, and they deal a lot with how we can improve gas emissions and things like that. So I knew overall, but I didn't really know how we could fix it… Yeah, I think it was a very good chance for me to realize that there are so many applications and so many things we can do. Yeah, I think it was... How do I say? My view on sustainability has more details from before because yeah, I think I knew overall, but yeah."*

*"I would say that coming into the program, I guess I had a general idea of sustainability in transportation. I think through this program, I was able to get a much more specific view. I would say that through my program, at least, if that had to do with batteries and specifically, I guess, it could be applied to the battery science in electric vehicles, and so that was interesting to learn about all of the different sustainability issues that had to do with the battery manufacturing process. But I guess I was also able to learn more about... I feel like the main focus on sustainability had to do with electric vehicles throughout the program and I was able to learn much more about how they work and both their benefits and issues and the scheme of modern technology."*

*"I think a lot of the topics I had already learned in classes I've taken, but it definitely reinforced a lot of the things that I learned before. They also showed me how we, as engineers, can work to solve these problems. Because in the classes we've had before, they just tell you the problem, but they don't tell you what we can do to fix it. And in this program, we were actively making solutions to these problems. So, it definitely showed me how there are a lot of different ways to go about finding a solution to these problems. So I definitely enjoyed learning more about both the problems and the solutions."*

One student remarked that they entered the program with no knowledge of sustainability concepts in transportation. They expressed that they gained a great deal of knowledge in this area as a result of their experience. As the student explained:

*"I had no idea what sustainable transportation was before I came here. So, I feel like I gained a good amount of knowledge on what it does, what sustainable transportation is."*

**Conclusions**

Results from this study indicate that the SRTS-REU 10-week summer program was successful in increasing the knowledge of sustainable transportation among the participants. The program was structured with individual research projects, group seminars, and workshops related to sustainability topics. Participants in the program were diverse in their year of undergraduate study, discipline of study in STEM, and location in the USA. Participants came into the program with some awareness of sustainability and climate-change basics and challenges. Still, pre- and post-program surveys and end-of-program interviews showed a short-term gain in knowledge of sustainability and climate change among the SRTS-REU participants. These results can be used to inform similar future programs that aim to engage undergraduate students in sustainability topics. We plan to build upon this study with future cohorts of program participants.

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