2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #39461

Work in Progress: Investigating the Relationship between Active Learning Strategies in Engineering Courses and Students' Sustainability Behaviors

Trevion S. Henderson, Tufts University

Trevion Henderson is Assistant Professor of Mechanical Engineering at Tufts University. He earned his Ph.D. in Higher Education at the University of Michigan.

OnKee Min, Tufts University

Graduate student at Tufts University pursuing Masters of Science in Human Factors Engineering.

Jessica Ostrow Michel

(WIP) Investigating the Relationship between Active Learning Strategies in Engineering Courses and Students' Sustainability Behaviors

Abstract

This work-in-progress paper examines the relationship between active learning strategies in engineering education and engineering students' sustainability-related behaviors. Using survey data (N = 262) from students who reported that an engineering course taught them the most about sustainability at a large, public, Midwestern university, we examined the relationship between the degree to which students believed their sustainability-related engineering courses employed active learning pedagogies and their self-reported likelihood of engaging in sustainability-related activism behaviors. Our results indicated a positive relationship between active learning strategies and students' likelihood of engaging in organizing behaviors for sustainability. Furthermore, we found a positive relationship between futures thinking and sustainability-related activism behaviors, indicating that students who reported spending time thinking about climate change and its future impact also reported being more likely to engage in activism behaviors.

Keywords: active learning; sustainability

Introduction and Background

While educators and policymakers give much attention to issues such as workforce development, global competitiveness, and economic advancement as important long-term outcomes of higher education [1-3], colleges and universities should also be concerned with developing civically engaged leaders equipped with the knowledge and skills for addressing challenges of national and global concern, such as sustainability problems and climate change [4-5]. Scholars have consistently pointed to higher education as a critical catalyst for climate change activism since universities (a) are important sources of new knowledge related to sustainability, (b) educate millions of citizens around the country annually, and (c) can commit massive intellectual and financial resources to educating, organizing, and mobilizing sustainability leaders of the future [6-7]. Thus, there is a need to understand how higher education institutions can best to support sustainability leadership develop in the students they educate.

In engineering education, scholars have increasingly called for educators to center the critical role engineers will play in addressing sustainability problems [8], and many scholars argue that sustainability learning is particularly important for engineers. For example, noting that "engineers play a key role in the development of infrastructure, bringing products and services to market, developing information and communications technologies, and the development of new technologies in science and medicine," Kerr [9] argued that the application of sustainability principles and practices is particularly important for future engineers and is thus a critical need in engineering education.

The purpose of this research is to examine the types of instructional strategies that support students' sustainability learning and behaviors in higher education. Existing research has demonstrated the ways that students' (a) knowledge, (b) attitudes, and (c) behaviors about sustainability work in tandem to positively reinforce one another [10]. For example, Henderson and colleagues [5] studied the role of sustainability involvement in students' activism and leadership practices and found that involvement in sustainability organizations was positively related to sustainability leadership development. These findings raise the question about how best to foster students' sustainability knowledge, shape students' attitudes about sustainability problems, and catalyze students' positive sustainability-related behaviors.

Recent literature suggests active learning strategies in sustainability education can help promote students' sustainability behaviors. The term *active learning* has been used to describe a broad range of student- or learner-centered instructional methods. For example, Felder and Brent [11] argued that active learning is "a teaching approach that encompasses anything students might be called on to do in class besides watching and listening to an instructor and taking notes" (p. 111). While definitions of active learning vary, most scholars agree that active learning involves students' active engagement, continuous participation, action, and reflection [12-13].

For decades, scholars have called for college educators to incorporate more active learning in their teaching practices [12-13] and, as a result, several pedagogical strategies that constitute active learning appear in the literature. For example, instructional strategies such as flipped classrooms, class discussions, working in pairs or teams (e.g., think-pair-share, paired programming), are all listed as promising active learning pedagogical strategies for supporting students learning [11]. Still, existing research suggests the relationship between learning and behaviors in sustainability is tentative, with several studies finding that as students gain sustainability knowledge, they become less likely to engage in positive behaviors that support sustainability or mitigate climate change in their personal lives [5, 14].

Still, research documenting the benefits of active learning in engineering education are common in the empirical literature. Studies have focused attention on issues such as short- and long-term knowledge retention, test scores and grades, and major and college retention across diverse student bodies in higher education [11, 14-17]. While many scholars argue in favor of the benefits of active learning instructional strategies for facilitating students' knowledge retention, this research posits that the way students learn about sustainability issues might shape both their knowledge, as well as their practical sustainability behaviors. The purpose of this work-in-progress research paper is to explore the relationship between active learning instructional strategies and students' behavioral intentions related to sustainability. We sought to answer the following research question: (1) What is the relationship between students' participation in active learning instructional strategies and their intentions to engage in sustainability activism?

Methods

Data Collection

This work-in-progress paper uses data collected from a large, public university in the Midwestern United States. While this research was part of a larger pre- and post-test study examining students' sustainability-related learning in higher education, this work-in-progress paper examines post-test data collected at the end of the 2020-2021 academic school year. At the start and end of the 2020-2021 academic year, eligible graduate and undergraduate students were invited to participate in an online survey. In full, 2,361 students completed the post-test survey. The online survey asked students to identify specific courses in which they felt they learned the most about sustainability. For this analysis, our sample consists of students who reported that they learned the most about sustainability in an engineering course (N = 262).

Demographic characteristics of student respondents were collected from an institutional database. Race/ethnicity was coded dichotomously using the institutional database's indicators for underrepresented minority status (0 = non-URM, 1 = URM). Specifically, URM respondents included students who self-reported as Black/African American, Latino/a, Native Hawaiian, Native American/Native Alaskan, or two or more racial/ethnic identities with at least one of the above. Moreover, international students were grouped with underrepresented minority students (1 = URM). Sex was coded similarly (0 = Male, 1 = Female). Lastly, socio-economic status (i.e., income) was coded based on categories of income in the institutional database. For example, "low-income" students (coded 0) included respondents whose family's income was equal to or less than $74,999 annually whereas "high-income" students included respondents whose family's income was equal to or greater than $75,000 annually. This study sample included 18.7% URM and international students and 81.3% non-URMs. Students who identified as male made up 41.6% of the sample and 58.4% identified as female. Lastly, 53.4% of the sample were recognized as low-income.

The outcomes of interest in this study were sustainability activism. To measure sustainability activism, we used a survey developed by Shephard and colleagues [18] asking students how likely they were to engage in a set of sustainability behaviors such as contacting the local government or community organizing. We identified two factors in the sustainability activism scales: (a) Sustainability Action (e.g., contacting one's local government about climate change) (Cronbach's alpha = .82) and (b) Organizing for Sustainability (e.g., organizing a local group of individuals who want to increase awareness about climate change) (Cronbach's alpha = .92). Students responded to activism items on a five-point scale (i.e., 1 = Extremely unlikely, 2 = Somewhat unlikely, 3 = Neither likely nor unlikely, 4 = Somewhat likely, 5 = Extremely likely).

We examined two cognitive explanatory variables to examine factors that inform students' sustainability behaviors: sustainability literacy and futures thinking. To measure *sustainability literacy*, we used a survey developed by Braun and colleagues [19] asking students to assess their sustainability-related knowledge. We identified three factors in the sustainability literacy scale: (a) Understanding Context (e.g., "I understand how climate change impacts people, the planet, and our economy.") (Cronbach's alpha = .87), (b) Understanding Sustainability Principles (e.g., circularity, waste reduction, life cycle) (Cronbach's alpha = .78), and Explaining Sustainability Issues (e.g., "I can explain what climate change is to suit various audiences) (Cronbach's alpha = .93).

Similarly, to measure *futures thinking*, we used a survey developed by Tonn and MacGregor [20] pertaining to the degree to which students thought about how climate change and other sustainability concerns will impact the future. We identified two factors in the futures thinking scale: (a) Positive Futures Thinking (e.g., "I spend time thinking about how climate change will affect my personal future") (Cronbach's alpha = .79) and (b) Negative Futures Thinking (e.g., "I find it difficult to concentrate on how climate change will impact future generations.")

(Cronbach's alpha = .75). Items measuring sustainability literacy and futures thinking were each measured on a five-point Likert scale (i.e., 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, 5 = Strongly agree).

Finally, we measured the degree to which students believed their instructors employed specific pedagogical strategies in the class they listed as having taught them the most about sustainability. While our analysis identified three factors in the instructional strategy scale, this paper utilizes a single factor (Cronbach's alpha = .77) measuring active learning strategies, such as group discussions and class debates. Students reported the frequency with which their instructors used these strategies using a five-point scale (i.e., 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always).

Data Analysis

We conducted exploratory factor analyses using a common-factors method and promax oblique rotation for each construct (i.e., literacy, futures thinking, instructional strategy). Following the exploratory factor analyses, we computed factor scores for each subscale in the activism, literacy, futures thinking, and instructional strategy scales using regression scores, which DiStefano and colleagues [21] referred to as a refined method for computing factor scores. Finally, to develop a preliminary understanding of the relationships between students' likelihood of engaging in activism behaviors and the explanatory variables, we estimated two ordinary least squares (OLS) regression models for the two dependent variables.

Findings

The outcome of interest in the first model was Sustainability Action. Our results indicated the model was statistically significant ($F(9{,}252) = 21.1, p < .001$), and results indicated that the explanatory variables explained 33% of the variance ($r^2 = 33.28$). Low-income status ($b = 0.18, p = 0.05$) and positive futures thinking ($b = 0.54, p < 0.001$) were statistically significant predictors of Sustainability Action. However, results indicated that active learning strategies was not a statistically significant predictor ($b = 0.10, p = 0.092$) of Sustainability Action.

The outcome of interest in the second model was Organizing for Sustainability. Our results indicated this model was also statistically significant ($F(9{,}252) = 14.0, p < .001$) with explanatory variables explaining 26% of the variance ($r^2 = 26.30$). For this model, low-income status ($b = 0.23, p = 0.03$), positive futures thinking ($b = 0.45, p < 0.001$), and active learning strategies ($b = 0.19, p = 0.005$) were statistically significant predictors of Organizing for Sustainability. As such, results indicated that students who reported more frequently participating in active learning strategies also reported being more likely to participate in organizing behaviors.

Discussion and Future Work

This paper draws on the three-pronged competency approach, which demonstrates how students' (a) knowledge (e.g., sustainability literacy), (b) attitudes (e.g., futures thinking), and (c) behaviors (e.g., related to sustainability and climate work in tandem to positively reinforce one another [10]. Our overarching goal is to examine the relationship between the three prongs to understand how opportunities to learn about sustainability both in the classroom and in co-curricular settings shape leadership development and sustainability behaviors in practice.

Existing research has demonstrated the knowledge gains do not necessarily translate into positive sustainability related behaviors [5, 8]. For example, in prior research, Henderson and colleagues found that sustainability literacy was negatively related to engagement in sustainability-related behaviors [5]. Scholars have pointed to feelings of anxiety about the scale of sustainability challenges, guilt, helplessness, apathy, and melancholia resulting from increased knowledge as potential explanations for this surprising finding [5, 22-23]. If this is true, then engineering educators who teach about sustainability must be aware of and responsive to the ways their pedagogies might result in negative changes in students' attitudes and behaviors.

This research suggests that active learning strategies might support positive sustainability attitudes and behaviors in engineering education. While active learning was measured using student interpersonal engagement strategies, such as group discussions and class debates, other researchers have similarly pointed to active learning strategies, such as problem-based learning, when done effectively, can support positive learning outcomes [8]. Thus, future work should examine the short- and long-term outcomes associated with various active learning strategies.

Our future work will examine the types of learning experiences that support students' cognitive and behavioral learning outcomes, focusing particularly on engineering students' knowledge, attitudinal, and behavioral changes resulting from their sustainability-related learning experiences. We posit that focusing on engineering education is particularly important given the role engineers play in shaping how new technology does, or does not, address sustainability problems. As Kerr notes [9], engineers of the future will be responsible for the development of infrastructure, bringing products and services to market in an increasingly global economy, and developing new technologies, all of which will have specific sustainability problems and immense implications for future national and global sustainability goals.

As such, the ways engineering students come to understand and respond to sustainability knowledge (e.g., how their learning experiences shape their attitudes and behaviors), may hold particularly important implications for America's future efforts to address sustainability and climate change problems on larger scales than can be accomplished in changing individual behaviors. This research seeks to understand the types of opportunities to learn about sustainability that catalyze students' positive behaviors, as well as those that appear to undermine the development of positive attitudes and behaviors, to meet these ends.

References

[1] Chen, X. (2013). STEM attrition: College students' paths into and out of STEM fields (NCES 2014 – 001). National Center for Educational Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, D. C.

[2] Camili, G. & Hira, R. (2019). Introduction to special issue–STEM workforce: STEM education and the post-scientific society. *Journal of Science Education and Technology, 28*, 1 – 8.

[3] Alfred, M. V., Ray, S. M., Johnson, M. A. (2019). Advancing women of color in STEM: An imperative for U.S. global competitiveness. *Advances in Developing Human Resources, 21*(1), 114 – 132.

[4] Wodika, A. B. & Middleton, W. K., (2020). Climate change advocacy: Exploring links between student empowerment and civic engagement. *International Journal of Sustainability in Higher Education, 21*(6), 1209 – 1231.

[5] Henderson, T. S., Michel, J. O., Bryan, A., Canosa, E., Gamalski, C., Jones, K., & Moghtader, J. (2022). An exploration of the relationship between sustainability-related involvement and learning in higher education. *Sustainability, 14*(9), 1 – 21.

[6] McAdam, D. (2017). Social movement theory and the prospects for climate change activism in the United States. *Annual Review of Political Science*, *20*, 189-208.

[7] Hart, D. D., Buizer, J. L., Foley, J. A., Gilbert, L. E., Graumlich, L. J., Kapuscinski, A. R., Kramer, J. G., Palmer, M. A., Peart, D. R., & Silka, L. (2016). Mobilizing the power of higher education to tackle the grand challenge of sustainability: Lessons from novel initiatives. *Elementa: Science of the Anthropocene*, *4,* 1 – 5.

[8] Guerra, A. (2016). Integration of sustainability in engineering education. Why is PBL an answer? *International Journal of Sustainability in Higher Education, 18*(3), 436 – 454.

[9] Kerr, I. R. (2010). Futures thinking for engineering and engineers Australia's continuing professional development process. *Australasian Journal of Engineering Education, 16*(1), 13 – 20.

[10] Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science*, *6*, 203-218.

[11] Felder, R. M., & Brent, R. (2016). *Teaching and learning STEM: A practical guide*. John Wiley & Sons.

[12] Børte, K., Nesje, K., & Lillejord, S. (2020). Barriers to student active learning in higher education. *Teaching in Higher Education*, 1-19.

[13] Felder, R. M., Brent, R., & Prince, M. J. (2015). Engineering instructional development: Program, best practices, and recommendations. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 409 – 436). Cambridge University Press.

[14] Earl, A., VanWynsberghe, R., Walter, P., & Straka, T. (2018). Adaptive education applied to higher education for sustainability. *International Journal of Sustainability in Higher Education, 19*(6), 1111 – 1130.

[15] Cooper, K. M. & Brownell (2016). Coming out in class: Challenges and benefits of active learning in a biology classroom for LGBTQIA students. *CBE—Life Sciences Education, 15*(3), 1 – 19.

[16] Haak, D. C., HilleRisLambers, J., Pitre, E., & Freeman, S. (2011). Increased structure and active learning reduce the achievement gap in introductory biology. *Science*, *332*(6034), 1213-1216.
[17] Kressler, B. & Kressler, J. (2020). Diverse student perceptions of active learning in a large enrollment STEM course. *Journal of the Scholarship of Teaching and Learning, 20*(1), 40 – 64.
[18] Shephard, K., Harraway, J., Lovelock, B., Skeaff, S., Slooten, L., Strack, M., Furnari, M., & Jowett, T. (2014). Is the environmental literacy of university students measurable?. *Environmental Education Research*, *20*(4), 476-495.
[19] Braun, D., Evans, E. B., Knight, R., & Ruehr, T. (2007). Interdisciplinary team teaching: Lessons for engineering instructors from a capstone course in environmental studies. Research paper presented at the American Society for Engineering Education Annual Conference & Exposition: Honolulu, Hawaii.
[20] Tonn, B. & MacGregor, D. (2009). Individual approaches to futures thinking and decision making. *Futures, 41,* 117–125.
[21] DiStefano, C., Zhu, M., & Mîndrila (2009). Understanding and using factors scores: Considerations for the applied researcher. *Practical Assessment, Research, and Evaluation, 14*(20), 1 – 11.
[22] Haseley, D. Climate change: Clinical considerations. *International Journal of Applied Psychoanalytic Studies, 16*(2), 109 – 115.
[23] Lertzman, R. (2015). *Environmental melancholia: Psychoanalytic dimensions of engagement.* Routledge.