

Agency for Sustainability among Senior Engineering Students: Curriculum and Assessment Implications for Sustainability Education

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Abstract

Developing graduates capable of acting for sustainability remains a challenge in education, where students often express strong sustainability values yet struggle to translate these into action. This study examines how senior engineering students conceptualize and enact agency for sustainability, and identifies the internal and educational factors that enable or constrain such agency. Guided by Bandura's framework of human agency, a qualitative study was conducted using semi-structured interviews with ten senior engineering students across multiple disciplines at a research-intensive university. Data were analyzed using theory-informed thematic analysis. Findings indicate that students' sustainability agency is present but largely conditional and structurally mediated. Although participants articulated strong sustainability values and moral responsibility, sustainability-oriented action occurred primarily when curricular and assessment structures legitimized and enabled such action. These findings suggest that commonly described attitude-behavior gaps are better understood as agency activation gaps, where intentions remain latent without institutional support. The study highlights curriculum and assessment design as critical levers for activating agency for sustainability and offers practical implications for engineering educators.

Keywords: sustainability education; student agency; curriculum design; assessment.

1. Introduction

Sustainability has become a defining priority for higher education institutions worldwide as societies confront escalating environmental degradation, resource scarcity, and social inequality (Wiek et al., 2011). Universities are increasingly expected not only to raise awareness of sustainability issues, but also to prepare graduates who are capable of acting responsibly and

effectively within their professional and civic roles (Lozano et al., 2017; Barth & Rieckmann, 2016; Shephard, 2008). This expectation is particularly salient in engineering education, where graduates are positioned as designers and decision-makers whose technical choices have long-term societal and environmental consequences. In response, engineering programs have integrated sustainability into curricula through learning outcomes, course content, project-based learning, etc. (Mulder et al. 2012). However, there is growing concern that sustainability education often prioritizes conceptual understanding over students' capacity to act (attitude-behavior gap). Students may demonstrate awareness of sustainability principles yet feel constrained, uncertain, or dependent on institutional structures when attempting to apply sustainability in practice (Kollmuss & Agyeman, 2002; ElHaffar et al., 2020).

An agency-oriented perspective offers a productive lens for examining this gap. Agency foregrounds students' capacity to make intentional choices, influence outcomes, and navigate constraints within educational systems (Mameli et al., 2023). Despite its relevance, empirical research examining student agency for sustainability particularly from the perspective of assessment design in engineering education remains limited (King et al, 2024). The objective of this study is to examine how senior engineering students conceive their agency for sustainability and to identify the internal and educational factors that shape this agency. The study is guided by the following research questions: (1) How do senior engineering students conceptualize their agency for sustainability? (2) What internal factors, such as values, self-efficacy, and emotions, influence students' agency for sustainability? (3) What curricular and assessment-related factors enable or constrain students' ability to act for sustainability? Addressing these questions advances understanding of how sustainability agency is constructed within engineering education and how educational practice can be designed to support it.

2. Human Agency as a Lens for Sustainability Education

This study is grounded in Bandura's theory of human agency, which conceptualizes individuals as proactive agents capable of influencing their own actions and the conditions of their lives (Bandura, 2001; Guerra et al, 2025; Guerra et al, 2022). Bandura conceptualizes agency as comprising three interrelated forms: personal agency, proxy agency, and collective agency. Personal agency involves intentionality, forethought, self-efficacy, and self-regulation. Proxy agency refers to situations in which individuals rely on others or systems with greater authority or resources to act on their behalf. Collective agency emphasizes coordinated action through teamwork and shared belief in collective capability. Within higher education, student agency is inherently situated within institutional structures such as curricula, assessment regimes, disciplinary norms, and professional expectations. These structures do not merely constrain agency; they also shape how agency is expressed and recognized. Applying Bandura's framework to sustainability education enables a nuanced understanding of how students act not

only through individual initiative, but also through engagement with design requirements, grading criteria, teamwork arrangements, and professional standards.

3. Methodology

A qualitative interpretive research design was adopted to explore senior engineering students' experiences of agency for sustainability. This approach was chosen to capture students' meanings, interpretations, and lived experiences rather than to measure predefined variables. Qualitative inquiry is particularly appropriate for examining agency, as agency is context-dependent and constructed through interaction with educational environments. Participants consisted of ten senior engineering students enrolled in mechanical, chemical, electrical, mechatronics, and architecture-related programs at a research-intensive university. All participants were in their final year of study and had engaged with sustainability through coursework, capstone projects, or design experiences. Purposeful sampling was used to capture disciplinary variation while maintaining a focus on students approaching professional practice.

Data were collected through semi-structured interviews lasting between 45 and 60 minutes. Interview questions were designed to align explicitly with the research objectives and Bandura's agency framework. Students were invited to reflect on their understanding of sustainability, their perceived ability to act, emotional and motivational influences, and the role of curriculum, assessment, leadership, teamwork, and resources in shaping their experiences. All interviews were audio-recorded, transcribed verbatim, and anonymized (Jamshed, 2014). All research procedures were accordance to approval from the university's ethical committee.

Data analysis followed a theory-informed thematic analysis process. The analysis began with familiarization, during which transcripts were read multiple times to develop a holistic understanding of each participant's narrative. Analytic memos were written for each transcript to capture early interpretations related to sustainability understanding, expressions of agency, and perceived constraints. First-cycle coding involved open and descriptive coding, with attention to participants' language and meaning-making. Codes captured references to sustainability conceptions, confidence, emotions, values, educational experiences, assessment practices, teamwork, professional standards, and resource constraints.

In the second cycle, codes were refined and grouped into broader categories reflecting internal and external dimensions of agency. At this stage, Bandura's framework was used as a sensitizing lens rather than a prescriptive structure, allowing design-mediated and proxy forms of agency to emerge from the data. Constant comparison across cases was employed to identify patterns, similarities, and divergences among participants. Themes were developed through iterative refinement and mapped onto Bandura's components of personal, proxy, and collective agency. Cross-case analysis was then conducted to examine how different combinations of internal dispositions and educational structures shaped students' agency for sustainability.

4. Results

The analysis revealed that students' agency for sustainability is best understood as conditional and structurally mediated. While all participants expressed awareness of sustainability and articulated moral responsibility toward future generations, their ability to act was shaped by curricular design, assessment requirements, access to resources, teamwork structures, and exposure to professional contexts. Table 1 presents the coding framework developed through the analysis. The framework was derived inductively from participants' accounts and subsequently organized using Bandura's agency constructs. It distinguishes between personal agency, proxy agency, collective agency, and contextual factors, providing a structured representation of how sustainability agency is expressed and constrained within engineering education.

Table 2 maps the identified themes onto Bandura's components of agency and contextual factors. This mapping demonstrates how themes such as conditional agency and design-mediated agency emerge from the interaction of personal intentions, proxy structures, collective arrangements, and contextual factors. Together, these tables strengthen the analytic coherence of the findings and clarify the theoretical contribution of the study.

Table 1. Coding framework for sustainability agency.

Agency Dimension	Code	Description
Personal Agency	Self-efficacy	Confidence in ability to address sustainability challenges
	Values and responsibility	Moral and ethical commitment to sustainability
Proxy Agency	Assessment structures	Reliance on grading criteria and rubrics
	Professional standards	Use of industry frameworks and sustainability standards
Collective Agency	Teamwork	Shared effort and distributed responsibility
Contextual Factors	Resources	Time, budget, tools, and infrastructure constraints

Table 2. Themes mapped to Bandura's components of agency and contextual factors.

Theme	Personal Agency	Proxy Agency	Collective Agency	Contextual factors
Conditional sustainability agency	Students showed strong sustainability values and motivation but lacked confidence and authority to act independently.	Sustainability action depended on instructors, assessments, and institutional expectations to legitimize and enable student action.	Group work occasionally supported sustainability engagement, but collective responsibility was not assumed unless explicitly structured within the task.	Sustainability agency was contingent on assessment weighting, time availability, budget constraints, and access to institutional resources, indicating that action depended on enabling educational conditions rather than personal willingness alone.
Design- and assessment-mediated agency	Students enacted agency through technical design choices, reflecting intentional sustainability action within professional engineering roles	Professional standards, sustainability frameworks, and rubrics legitimized sustainability decisions, shaping how students exercised agency.	Design projects enabled collective sustainability problem-solving but sometimes diffused individual responsibility.	Curriculum and assessment design positioned sustainability as a design constraint within specific courses and capstone projects, shaping agency as a professional obligation rather than a stand-alone ethical choice.

5. Discussion

Addressing the first research question, the findings show that students conceptualize their agency for sustainability as bounded and context-dependent, rather than autonomous or activist in nature. Students did not frame their agency as individual moral action detached from institutional structures; instead, they understood their capacity to act as something that must be legitimized by curricular expectations, assessment requirements, and professional norms. This conceptualization reflects an implicit recognition of their position as students operating within constrained decision-making spaces. Agency, in this sense, was understood not as freedom to act independently, but as the ability to make sustainability-informed decisions within the limits of assigned tasks, design briefs, and evaluation criteria (Guerra et al, 2025; Guerra et al, 2022). This challenges the individualistic interpretations of agency and aligns with perspectives that view agency as an achievement emerging through interaction with educational structures.

In relation to the second research question, the findings clearly demonstrate that internal factors such as values, motivation, and moral responsibility were strongly present across participants (Sahin et al, 2012). Students articulated concern for environmental and social impacts and expressed a desire to contribute to sustainability. However, these internal dispositions alone were insufficient to produce sustained action. Students frequently reported uncertainty regarding their authority to prioritize sustainability when faced with competing constraints such as cost, feasibility, and grading priorities. This indicates that limited sustainability action cannot be attributed to weak attitudes or lack of concern. Instead, students' self-efficacy was situational and conditional, shaped by their perceptions of legitimacy and support. From an agency perspective, this suggests that internal dispositions function as potential for agency, which requires activation through enabling conditions rather than operating as a direct driver of behavior.

The third research question concerned the curricular and assessment-related factors that enable or constrain sustainability agency. Here, the findings are particularly strong and consistent. Sustainability agency was enacted primarily through design- and assessment-mediated pathways, with students engaging deeply with sustainability when it was embedded in design tasks, professional standards, or explicitly assessed criteria. Assessment structures, including rubrics and marking schemes, functioned as powerful proxy mechanisms that clarified expectations and authorized sustainability-oriented decision-making. Rather than constraining agency, assessment in this context served as a legitimizing structure, reducing ambiguity about whether sustainability "counted" and justifying the allocation of time and effort toward sustainability considerations. This finding underscores the central role of assessment in shaping not only what students learn, but how and whether they act.

6. Implications for Sustainability Education Practice

The findings of this study have important implications for sustainability education practice in engineering, where sustainability is increasingly framed as a core professional responsibility. By showing that student agency for sustainability is conditional and largely mediated through curriculum and assessment, the study underscores the need to move beyond awareness-raising toward designing educational conditions that actively enable agency. First, sustainability education should recognize that agency is enabled rather than assumed. Although students expressed strong sustainability values, interventions focused solely on attitude change are insufficient. Instead, curricula should intentionally provide legitimate opportunities for students to act on these values by embedding sustainability as a recurring and consequential design constraint across programs, rather than isolating it within standalone modules or electives. When sustainability is consistently positioned as integral to engineering decision-making, students are more likely to view it as a normal and expected aspect of professional practice.

Second, assessment design emerges as a key lever for activating sustainability agency. Students engaged most strongly with sustainability when it was explicitly assessed and clearly articulated through rubrics and criteria. Assessment should therefore be understood not only as a measure of learning, but as a formative structure that legitimizes action. Assessments that require justification of sustainability trade-offs and engagement with real-world constraints can reduce ambiguity and signal institutional commitment. Third, aligning sustainability education with professional standards and authentic engineering contexts strengthens agency. The use of industry frameworks, real-world case studies, and professional norms helps students see themselves as capable sustainability actors within bounded professional roles. Finally, addressing structural constraints such as time pressures, limited resources, and access to expertise requires institutional support. Without such commitment, sustainability initiatives risk reinforcing conditional rather than sustained agency.

7. Limitations and Future Research

This study has limitations that should be considered when interpreting the findings. The sample size was small and drawn from a single institution, which limits transferability. The focus on senior students provides insight into agency at the point of graduation, but agency development may differ at earlier stages of the curriculum. Additionally, the reliance on self-reported data may not fully capture enacted behavior. Future research could examine sustainability agency longitudinally across engineering programs, compare institutional contexts, or integrate observational and artifact-based data. Further studies could also investigate how specific assessment designs or industry partnerships influence agency development over time.

8. Conclusion

This study examined how senior engineering students conceptualize and enact agency for sustainability, with particular attention to the internal and educational factors that enable or constrain such agency. Drawing on Bandura's framework of human agency, the findings demonstrate that students' agency is present but fundamentally conditional and structurally mediated, rather than absent or underdeveloped. While participants articulated strong sustainability values and moral responsibility, their capacity to act was shaped by curricular expectations, assessment structures, and perceived legitimacy within educational contexts. The study underscores the central role of curriculum and assessment design in shaping student agency, positioning these elements as critical levers for enabling sustainability action. By shifting attention from individual attitudes to educational conditions, this work offers actionable insights for engineering educators seeking to foster graduates who are not only sustainability-aware, but also empowered to act. Future research can build on these findings by examining

how specific curricular and assessment interventions influence the development of sustainability agency across diverse institutional and disciplinary contexts.

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