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Integrating the Envision Framework into Sustainability Education in Civil Engineering

Dr. Jeong Eun Ahn, The Cooper Union

Jeong Eun Ahn is an Assistant Professor of Civil Engineering at The Cooper Union. She received her Ph.D. in Civil Engineering from New York University. Dr. Ahn's research focuses on developing predictive models of fluid movement and its environmental impacts, with the overarching goal of building sustainable and resilient coastal systems that protect urban environments and preserve water quality. Her work integrates numerical modeling, data-driven analysis, and interdisciplinary collaboration to address challenges in coastal resilience and infrastructure design. She is deeply committed to engaging undergraduate students in research and advancing innovation in engineering education. Dr. Ahn also contributes to professional and community initiatives promoting sustainability and STEM learning.

Prof. Cosmas Tzavelis, The Cooper Union

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Abstract

One of the required senior-level courses in Civil Engineering was redesigned to integrate the Envision Framework into existing project-based learning experiences. These project-based activities were developed to strengthen students' ability to apply engineering design principles to complex, real-world problems. Each student team selected a project related to either enhancing coastal resilience or improving stormwater management practices. As sustainability continues to emerge as a defining professional competency for civil engineers, there is a growing demand for educational approaches that embed measurable sustainability practices. This study responds to that need by incorporating the Envision Framework, a sustainability rating system for civil infrastructure projects developed by the Institute for Sustainable Infrastructure [1], as a pedagogical tool.

The Envision Framework was used to guide students in identifying, integrating, and evaluating sustainability considerations throughout the design process. This integration was intended to help students connect theoretical concepts of sustainability with professional practice and prepare them for careers in sustainable infrastructure design.

This integration targeted three major learning objectives to enhance our students' capabilities not only to meet technical performance standards but also to address broader societal needs by considering the social, environmental, and economic impacts on public health, safety, and welfare [3]: (1) redefining sustainability as measurable and actionable goals through quantifiable indicators and evidence-based metrics; (2) developing systems thinking by recognizing the interconnections among environmental, social, and economic factors and by assessing life-cycle impacts; and (3) strengthening sustainable design skills by incorporating sustainability criteria into project planning, evaluating design alternatives, and addressing resilience, equity, and community well-being.

To assess student learning, pre- and post-course surveys were administered to senior civil engineering students (n = 26) over one semester. The surveys included rating-scale items aligned with the three learning objectives, measured on a five-point agreement scale ranging from strongly disagree to strongly agree. Quantitative data were analyzed to examine changes in students' self-assessed knowledge, attitudes, and confidence regarding sustainability concepts and applications. Results suggest that integrating the Envision Framework can improve students' confidence in applying measurable sustainability criteria in design.

Introduction

The American Society of Civil Engineers (ASCE) defines sustainability as the integration of environmental, social, and economic considerations to support long-term quality of life without degrading essential resources. Civil infrastructure is expected to account for both quantifiable and non-quantifiable impacts across the full project life cycle, reflecting sustainability as a core responsibility of professional civil engineering practice [4]. These expectations are further

reinforced by the ASCE Code of Ethics, which emphasizes the responsibility of civil engineers to create safe, resilient, and sustainable infrastructure; to treat all individuals with respect, dignity, and fairness; to consider both current and anticipated societal needs; and to apply professional knowledge and skills to enhance human well-being [5].

As the profession continues to evolve in response to climate change, aging infrastructure, and increasing social and environmental complexity, civil engineering education must likewise adapt to prepare graduates for these challenges. While sustainability is frequently included in engineering curricula, it is often introduced in abstract or qualitative terms. This creates a need for pedagogical approaches that incorporate structured, measurable, and evidence-based sustainability frameworks into design-focused coursework. This study addresses that need by integrating the Envision Framework into a required senior-level civil engineering course. The Envision Framework is a comprehensive sustainability rating system for civil infrastructure projects developed by the Institute for Sustainable Infrastructure (ISI) [1] and widely used in professional practice. Since 2013, a total of 230 projects worldwide including projects in the USA, Spain, Italy, Canada, and Guatemala have been verified by Envision as of April 2026 [6]. The framework provides defined categories, credits, and performance levels that enable sustainability to be evaluated using transparent and measurable criteria.

The course redesign employed the Envision Framework as a pedagogical tool to support students in identifying, integrating, and evaluating sustainability considerations throughout the engineering design process. Several studies have explored the educational applications of the Envision Framework in civil engineering curricula. For instance, McWhirter and Shealy [7] incorporated Envision with case studies to develop students' decision-making skills for sustainability. Brunell [8] demonstrated that combining the United Nations Sustainable Development Goals with the Envision rating system enhanced undergraduates' awareness of sustainability throughout their capstone design projects. Mueller, Marincel Payne, and Shrestha [9] further established that Envision serves not only as a retroactive project evaluation tool, but as a proactive framework through which students can learn to integrate sustainability considerations directly into the design process. In a similar vein, this course redesign applies the Envision Framework not only as an assessment tool, but also as a mechanism for developing systems thinking, measurable sustainability evaluation, and socially responsive design practices.

By embedding the Envision Framework within existing project-based learning activities focused on either enhancing coastal resilience or improving stormwater management practices, the course redesign emphasized the intentional integration of sustainability considerations throughout the engineering design process. This integration targeted three major learning objectives aimed at enhancing students’ ability not only to meet technical performance standards but also to address broader societal needs by considering the social, environmental, and economic impacts on public health, safety, and welfare [2]. Specifically, the learning objectives included: (1) redefining sustainability as measurable and actionable goals through the use of quantifiable indicators and evidence-based metrics; (2) developing systems thinking by recognizing interconnections among environmental, social, and economic factors and by evaluating life-cycle impacts; and (3) strengthening sustainable design skills by incorporating sustainability criteria into project

planning, evaluating design alternatives, and addressing issues related to resilience, equity, and community well-being.

This paper presents the course redesign, assessment methods, and outcomes related to student learning, with particular attention to how structured sustainability frameworks can enhance systems thinking and sustainable design skills in undergraduate civil engineering education.

Methods

Course Context and Redesign

The study was conducted in one required senior-level civil engineering course which focuses on water resources engineering. The course traditionally has two modules; the first module is lecture-based, and the second module is project-based learning, with student teams completing open-ended design projects addressing either enhancing coastal resilience or improving stormwater management practices. For this redesign, the overall course format remained the same, but the Envision Framework was integrated into the existing project-based module.

Integration of the Envision Framework

At the initial introduction of the Envision Framework, students developed an awareness of its categories, credits, and performance levels as they relate to sustainable infrastructure design. Students then engaged with the framework throughout the project-based module, exploring how each category applies to real-world professional practice through concrete examples. Finally, students applied the entire framework to their own designs, identifying and justifying relevant credits in the context of their project outcomes.

Because the course projects primarily addressed water-related infrastructure challenges and represented students' first formal exposure to the Envision Framework, students were guided to focus on a selected set of Envision credits (Figure 1) that were most directly applicable to the project scope and learning objectives. Specifically, emphasis was placed on credits related to Quality of Life (QL3: Community), Natural World (NW), and Climate and Resilience (CR) as these credits align closely with the context of students' projects.

For this study, the class consisted of five project teams. Each team was required to apply the Envision Framework to evaluate the sustainability considerations of their design, engaging with the selected credits and providing evidence-based justification for their decisions through a final presentation and written report.

Figure 1 Envision Credits List [5]

Assessment and Data Collection

To assess student learning outcomes, pre- and post-implementation surveys were administered to senior civil engineering students enrolled in the course (n = 26). Survey data were collected as part of normal course activities and analyzed in de-identified, aggregate form for the purposes of this study. The surveys consisted of rating-scale items aligned with the three targeted learning objectives. Students rated their level of agreement with statements related to sustainability knowledge, confidence, and application using a five-point Likert scale ranging from strongly disagree to strongly agree.

The survey instrument was designed to evaluate how the integration of the Envision Framework influenced students' understanding of sustainability and their attitudes toward designing sustainable infrastructure. Eleven questions were included in both the pre- and post-implementation surveys. Three additional questions were included in the pre-survey to further explore baseline student perceptions and prior exposure to sustainability concepts. The eleven core survey questions are presented in Table 1. Although one survey item (i.e., Q9) references

evaluating multiple design alternatives, students were not required to submit formal alternative comparison reports; responses reflect students' perceived ability to apply sustainability criteria within their design projects.

Table 1 Survey Questions Aligned with Learning Objectives and Assessment Rationale

Learning Objectives (LO)	**Survey Question**	**Assessment Rationale**
LO1: Redefining sustainability as measurable and actionable goals	Q 1: I can define sustainability using specific, measurable indicators rather than general concepts.	Assesses ability to operationalize sustainability using quantifiable criteria.
	Q2: I feel confident using metrics to evaluate sustainability performance.	Evaluates confidence in applying evidence-based sustainability metrics.
	Q3: I can communicate sustainability outcomes using measurable evidence.	Measures ability to justify sustainability decisions using data.
LO2: Developing systems thinking	Q4: I understand how design decisions affect long-term sustainability outcomes.	Assesses awareness of life cycle and long-term system impacts.
	Q5: I recognize trade-offs and synergies among sustainability goals (e.g., cost vs. ecological benefit).	Evaluates understanding of interactions among sustainability dimensions.
	Q6: I understand how infrastructure can affect different social groups and communities in different ways.	Measures recognition of differential social impacts of infrastructure systems.
	Q7: I am aware that infrastructure projects can create or exacerbate different challenges for different communities (e.g., language, access, technology, mobility).	Assesses systems-level understanding of equity-related impacts.
LO3: Strengthening sustainable design skills	Q8: I understand how equity, inclusion, and resilience are interlinked in sustainability design.	Evaluates conceptual integration of social sustainability principles in design.
	Q9: I can evaluate multiple design alternatives based on sustainability performance.	Measures ability to apply sustainability criteria in design evaluation.
	Q10: I understand how social justice, inclusion, and resilience are interlinked in sustainability design.	Assesses deeper integration of equity and resilience considerations.
	Q11: I can incorporate design strategies that improve community well-being and equity.	Evaluates applied ability to integrate social sustainability into design solutions.

Quantitative data were analyzed to examine changes in students' self-assessed understanding and confidence before and after the implementation of Envision. While the study focused primarily on self-reported learning outcomes, the survey results were supplemented by observations of student project work and reflections collected during the course.

Results

Analysis of the pre- and post-implementation survey data indicated positive shifts in students' self-assessed learning across all three targeted learning objectives (Table 2). Mean post-implementation scores exceeded pre-implementation scores for all eleven survey items, with mean changes ranging from 0.20 to 0.73 on a five-point scale.

Table 2 Survey Results

Survey Question	Pre Mean	Post Mean	Mean Change
Q1: I can define sustainability using specific, measurable indicators rather than general concepts.	3.69	4.42	0.73
Q2: I feel confident using metrics to evaluate sustainability performance.	3.62	4.19	0.57
Q3: I can communicate sustainability outcomes using measurable evidence.	3.81	4.46	0.65
Q4: I understand how design decisions affect long-term sustainability outcomes.	4.19	4.85	0.66
Q5: I recognize trade-offs and synergies among sustainability goals (e.g., cost vs. ecological benefit).	4.04	4.50	0.46
Q6: I understand how infrastructure can affect different social groups and communities in different ways.	4.42	4.69	0.27
Q7: I am aware that infrastructure projects can create or exacerbate different challenges for different communities (e.g., language, access, technology, mobility).	4.38	4.58	0.2
Q8: I understand how equity, inclusion, and resilience are interlinked in sustainability design.	4.12	4.58	0.46
Q9: I can evaluate multiple design alternatives based on sustainability performance.	3.96	4.54	0.58
Q10: I understand how social justice, inclusion, and resilience are interlinked in sustainability design.	4.27	4.62	0.35
Q11: I can incorporate design strategies that improve community well-being and equity.	4.15	4.58	0.43

For the first learning objective related to redefining sustainability as measurable and actionable goals (Q1–Q3), the largest mean gains were observed. Students reported increased confidence in defining sustainability using measurable indicators, evaluating sustainability performance using metrics, and communicating sustainability outcomes using evidence. These results align with the course emphasis on applying the Envision Framework as a structured, metrics-based sustainability evaluation tool.

Results associated with the second learning objective focused on systems thinking (Q4–Q7) showed consistent but smaller mean increases. Pre-implementation scores for these items were relatively high, suggesting that students entered the course with some prior exposure to concepts related to long-term impacts, trade-offs, and differential community effects. The smaller observed changes likely reflect this higher baseline familiarity rather than limited instructional impact.

For the third learning objective related to strengthening sustainable design skills (Q8–Q11), results showed meaningful gains in students' perceived ability to apply sustainability criteria within their design projects and incorporate equity, resilience, and community well-being considerations into engineering design. Notably, the item related to evaluating design alternatives based on sustainability performance demonstrated one of the larger mean increases, suggesting that Envision supported students' application of sustainability criteria in design decision-making.

To further support interpretation of these findings, three additional post-implementation questions were included to examine students' perceptions of how the Envision Framework supported each learning objective. Students reported strong agreement that Envision supported redefining sustainability as measurable and actionable goals (mean = 4.65), developing systems thinking (mean = 4.58), and strengthening sustainable design skills (mean = 4.58).

Because results are based on self-reported survey data and descriptive analysis, findings are interpreted as indicative of trends in student learning rather than definitive measures of learning outcomes.

Discussion

Overall, the results suggest that integrating the Envision Framework into the curriculum supports students' ability to operationalize sustainability in infrastructure design. Patterns observed across the survey data indicate that Envision is effective in supporting students in translating sustainability concepts into measurable criteria and evidence-based design decisions, consistent with its role as a structured, metrics-based evaluation tool. Given that the analysis is based on self-reported survey data, the findings are interpreted as indicative of patterns in student learning rather than as direct measures of learning outcomes.

Within this scope, the approach supports ABET Student Outcome 2, which requires students to consider public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors in their designs. The observed gains in students' ability to apply sustainability criteria in design decisions and address issues of social equity suggest that the Envision Framework provides a practical methodology for systematically integrating these considerations into engineering design.

This study relies primarily on self-reported survey data from a single course offering, which limits generalizability. While qualitative observations of student work were positive, this study did not use standardized rubric to quantitatively assess improvements in the final design deliverables. In addition, the small sample size and single instructional context limit the ability to attribute observed changes solely to the integration of the Envision Framework, as other course components may also have influenced student learning. Finally, high baseline scores on several systems-thinking items may have limited measurable change over the semester.

Although this study was conducted within a single program and course offering, the findings carry implications for other civil engineering programs seeking to embed sustainability into their

curricula. The Envision Framework is adaptable across subdisciplines including transportation, geotechnical, structural, environmental, and water resources engineering, where infrastructure design decisions carry significant public, environmental, and economic consequences. Its structure makes it well suited as a scaffolding tool within existing project-based design courses, without requiring substantial curriculum restructuring. This integration also has the potential to strengthen students' capacity to engage with the professional responsibilities inherent in infrastructure design, including social equity, community impact, and ethical decision-making.

Future work will expand the integration of the Envision Framework to additional civil engineering courses with varied technical emphases and levels of design complexity. This broader implementation will enable examination of the framework’s transferability, its alignment with varied learning objectives, and its potential to support longitudinal development of sustainability competencies across the curriculum.

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