

From Exposure to Mastery: A Sustainability and Climate Resilience Roadmap for Civil, Architectural, and Environmental Engineering

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Introduction

Engineering programs increasingly recognize sustainability and climate resilience as essential competencies, yet these topics are often introduced unevenly, limiting students' opportunities to practice applied, systems-based decision-making. To address this gap, we developed a curricular roadmap that integrates sustainability and climate resilience across Civil, Architectural, and Environmental Engineering programs and course levels, spanning early exposure, competency building, and mastery (Figure 1). In Fall 2025, we piloted sustainability-focused interventions in five courses, aligned with existing course structures and Engineering for One Planet (EOP) learning outcomes. Additional interventions will be developed across remaining courses through Spring 2026. This poster describes the roadmap development process, evaluation methods, and preliminary results from three courses (AE 390, AE 444, and CIVE 430), illustrating progression from conceptual exposure to applied sustainability decision-making.

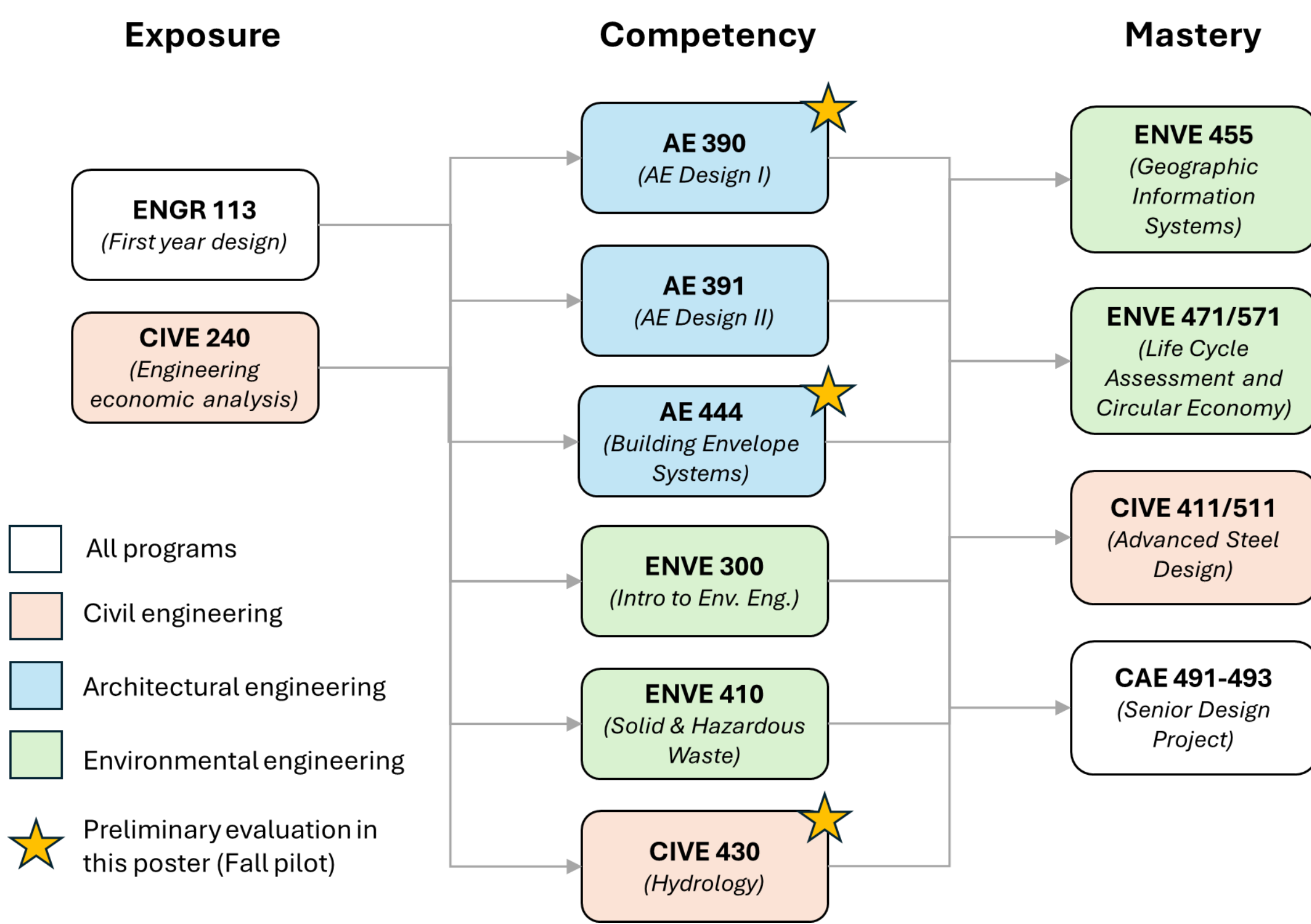


Figure 1. Sustainability and Climate Resilience Roadmap for Civil, Architectural, and Environmental Engineering.

Methods

To operationalize the roadmap, the team lead developed modular sustainability and climate resilience "teaching cards" aligned with Engineering for One Planet (EOP) learning outcomes (Figure 2). Created as a Microsoft Teams List, the cards function as a shared teaching library. Each card specifies the activity, course level and program, targeted competencies, and supporting resources, and is designed to integrate into existing course structures rather than replace technical content. Course instructors reviewed and selected cards based on relevance and instructional goals. Selected activities were implemented within existing projects, assignments, or discussions during Fall 2025. All materials and implementation details were stored in a shared Teams workspace to support coordination and future scaling.

Figure 2. Examples of Sustainability and Climate Resilience "Teaching Cards" in Microsoft Teams.

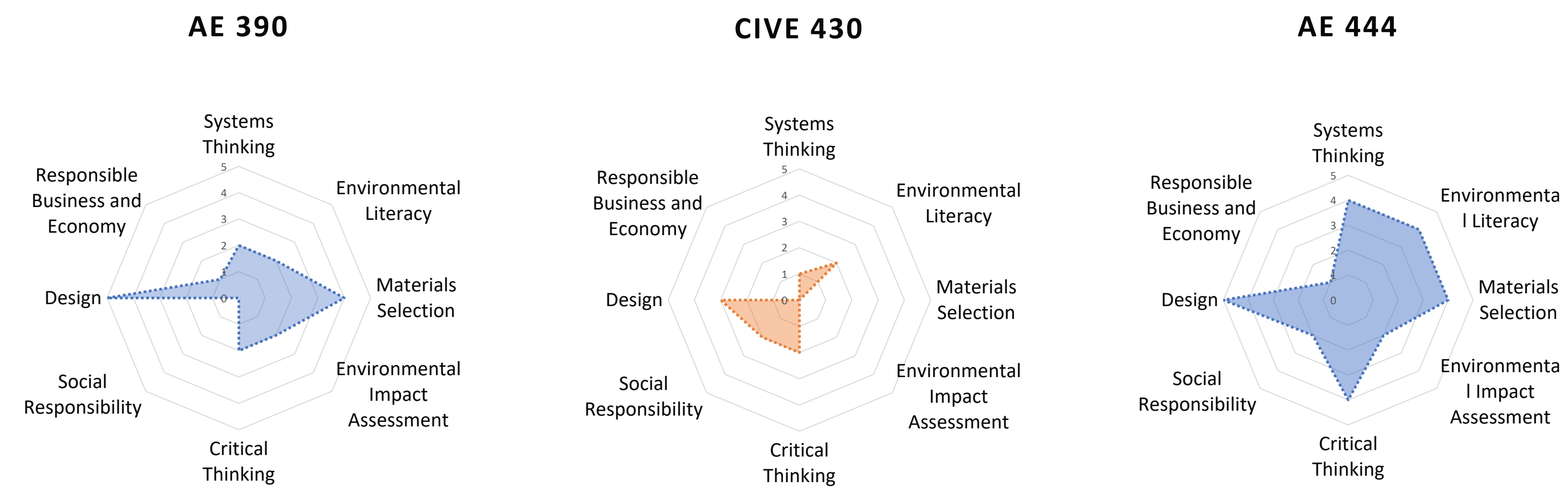


Figure 3. Mapping EOP outcomes across three courses.

Sustainability and climate resilience interventions were mapped to Engineering for One Planet (EOP) learning outcomes to maintain consistency across courses while allowing flexible implementation. Instructors identified which outcomes were addressed in each course, with the distribution shown in the radar plots in Figure 3. To support evaluation, the team developed outcome-specific rubrics aligned with EOP competencies (Figure 4). The rubrics defined performance criteria for applied skills, including systems thinking, life-cycle reasoning, data interpretation, and trade-off analysis, and were used to assess student work and compare instructional intent with student self-reported learning.

EOP Categories and Outcomes	Evaluation Rubrics				
	0- Fails to Meet	1- Partially Meets	2- Meets	3- Exceeds	
Design 3 Create long-term approaches for tackling environmental problems (e.g. climate mitigation and adaptation) or preventing negative environmental and/or social impacts including creative solutions within supply chains.	Does not propose meaningful long-term approaches to environmental problems or prevention of negative environmental or social impacts and does not consider supply chain impacts or to create supply chain solutions.	Proposes some long-term approaches but with limited depth, feasibility, or clarity, and gives only basic or uneven attention to preventing negative impacts or to create supply chain solutions.	Proposes clear and appropriate long-term approaches for tackling environmental problems or preventing negative environmental and social impacts, including viable ideas that may involve supply chain improvements.	Develops well-reasoned, forward-looking approaches that address environmental problems and prevent negative environmental and social impacts, offering creative and feasible strategies that can be implemented within or across supply chains.	
Environmental Literacy 5 Examine data about environmental issues (e.g., climate change, energy and water use, scarcity and pollution, air quality, waste management, toxicity, etc.) including consideration for past/current/future and local/regional/global impacts.	Examines data inaccurately or superficially, misinterprets key trends, and does not consider temporal or spatial impacts when discussing environmental issues.	Interprets some data correctly but with gaps in accuracy, scope, or clarity, and considers past, current, future, or local-global impacts only in a limited or uneven way.	Accurately interprets data related to environmental issues and considers past, current, and future trends as well as local, regional, or global impacts in a clear and appropriate manner.	Interprets data with strong accuracy and reasoning, integrates past, current, and future trends, and offers thoughtful analysis of local, regional, and global impacts that strengthens understanding of environmental issues.	
Critical Thinking Adv. 2 Identify issues and actions of environmental and social priority.	Does not identify meaningful environmental or social priority issues and does not propose relevant actions to address them.	Identifies a few environmental or social priority issues but with limited accuracy or scope, and suggests actions that are only loosely connected or insufficiently justified.	Accurately identifies key environmental and social priority issues and proposes appropriate actions that are clearly connected to those priorities.	Identifies environmental and social priority issues with strong clarity and reasoning and proposes well-supported actions that meaningfully address those priorities and reflect thoughtful consideration of context.	

Figure 4. Example of rubrics for each EOP learning outcome.

Assessment and Evaluation: Students Attitudes and Self-Assessed Learning

Student attitudes, motivation, and self-assessed knowledge were evaluated using a post-course survey across three courses (n = 45). Items measured views on the importance of sustainability and climate resilience, motivation to pursue related careers, and confidence in applying sustainability concepts and tools. Students also provided written definitions of sustainability and climate resilience and reflected on changes in their understanding.

Across courses, students strongly agreed that sustainability and climate resilience should be core engineering priorities. Qualitative responses show a shift from broad or abstract definitions toward more applied, systems-oriented understandings, with many students describing sustainability as embedded in engineering decisions, trade-offs, and long-term planning, including social and economic dimensions.

"I thought sustainability was mostly about being "eco-friendly," but now I see it involves economic and social factors too like cost, community needs, and long term durability." (CIVE 430 student)

"After taking this course, my understanding became more grounded in actual design decisions." (AE 390 student)

"Before this course, I thought sustainability was mainly about reducing pollution and saving resources, and climate resilience was about making structures stronger. After taking this course, I understand sustainability as an approach that includes social and economic dimensions, and climate resilience as proactive planning and adaptability to future climate conditions." (AE 444 student)

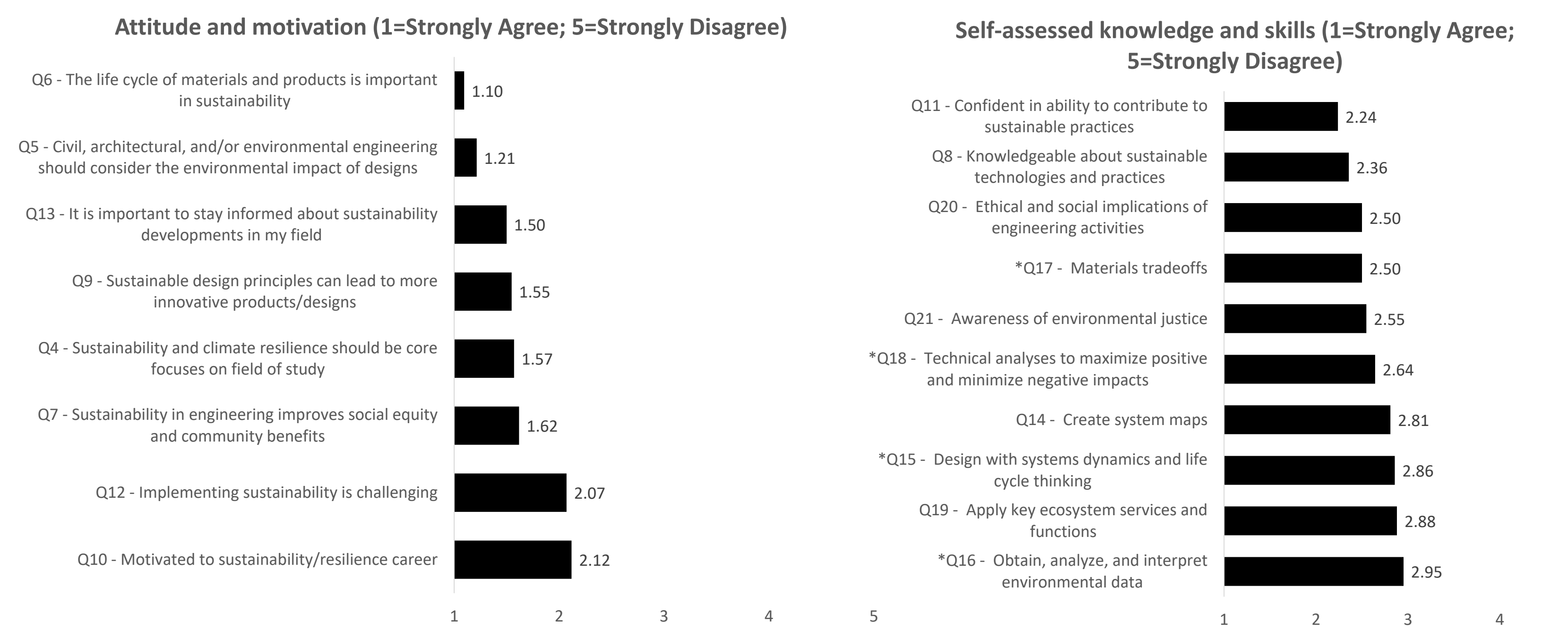


Figure 5. Preliminary results for students' attitude, motivation, and self-assessed knowledge and skills (n=45).

Assessment and Evaluation: Applied Skills

The survey also assessed students' confidence in applying sustainability and climate resilience skills, including systems thinking, life-cycle reasoning, data interpretation, trade-off analysis, and technical evaluation. Statistically significant differences across courses were observed for items related to material trade-offs, technical analyses, and systems- and life-cycle-based design (Figure 6). To contextualize these differences, the poster highlights AE 444 (Building Envelope Systems) as a design-intensive example. Students completed a quarter-long envelope redesign project that required identifying design shortcomings, justifying redesign goals, and evaluating alternatives using multiple analytical lenses, including systems mapping, climate risk analysis, embodied carbon comparisons, and multi-benefit evaluation (Figure 7).

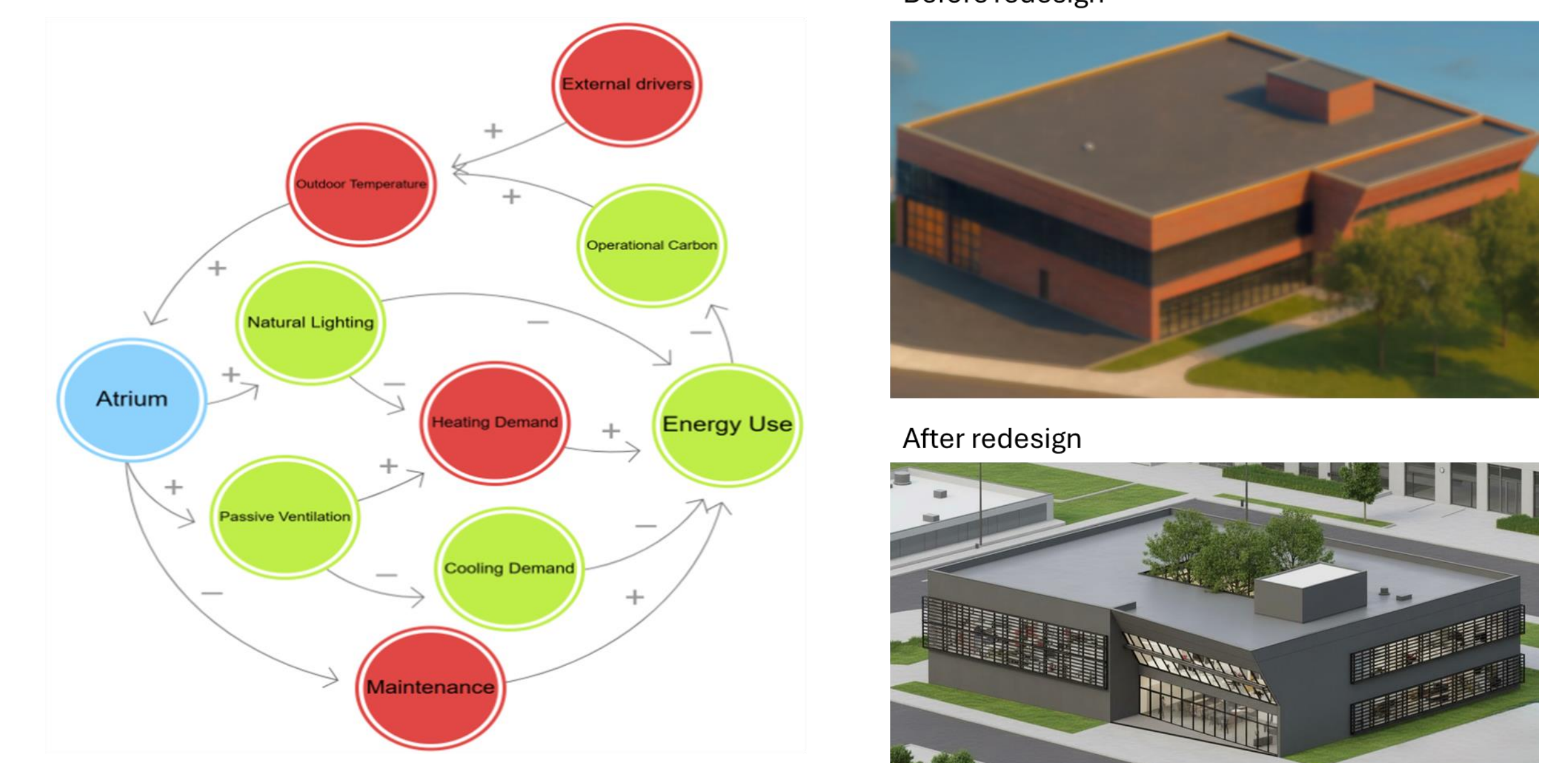
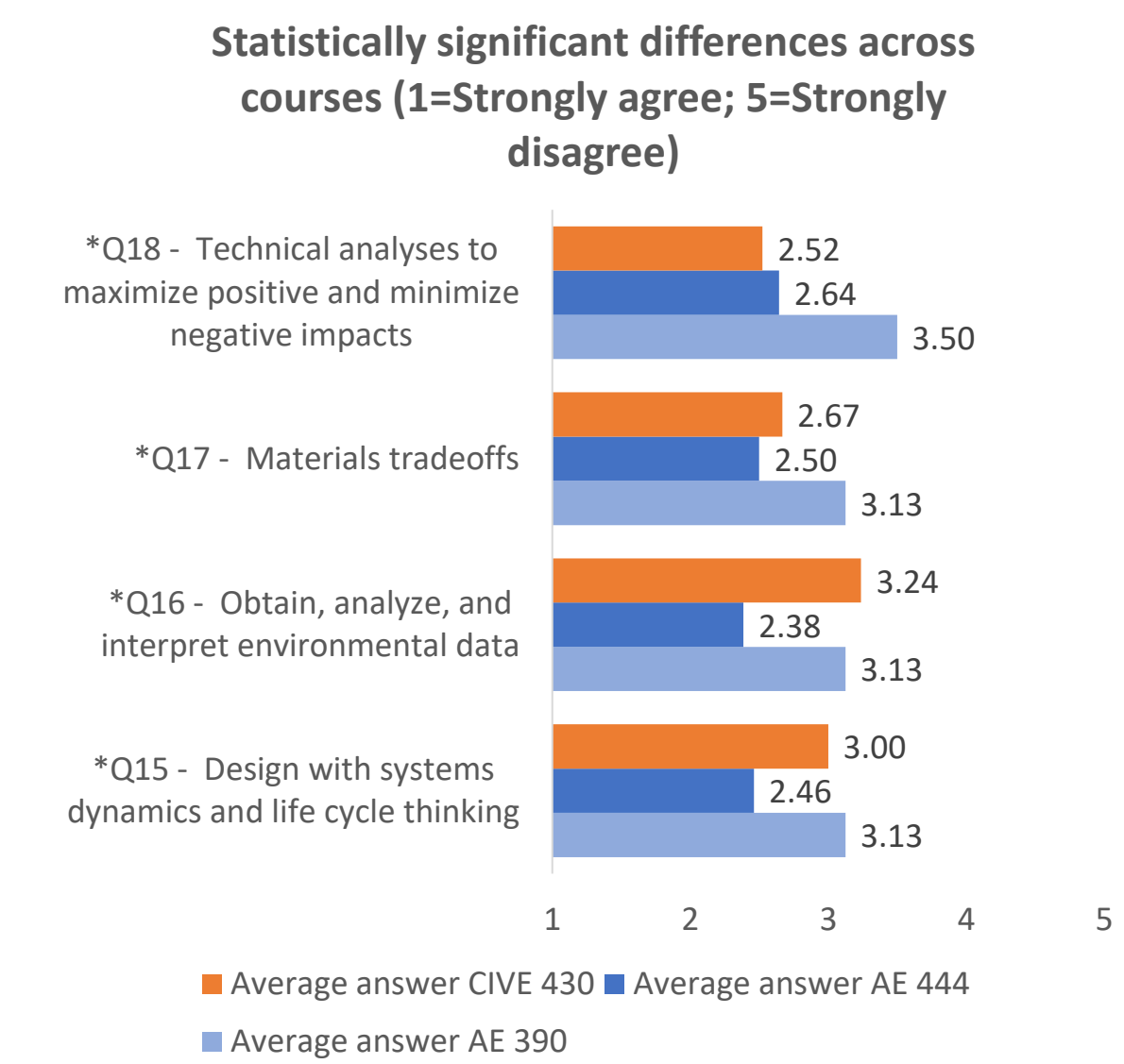


Figure 7. Examples of student work (causal loop diagram and building design before and after redesign).

Students justified design decisions using quantitative evidence and explicitly addressed trade-offs among performance, cost, environmental impact, and resilience. Instructor evaluations placed performance near the satisfactory threshold across most competencies, with stronger results for material trade-off analysis and weaker performance for interpreting environmental data (Figure 8).

Self-assessed knowledge and skills (AE 444)

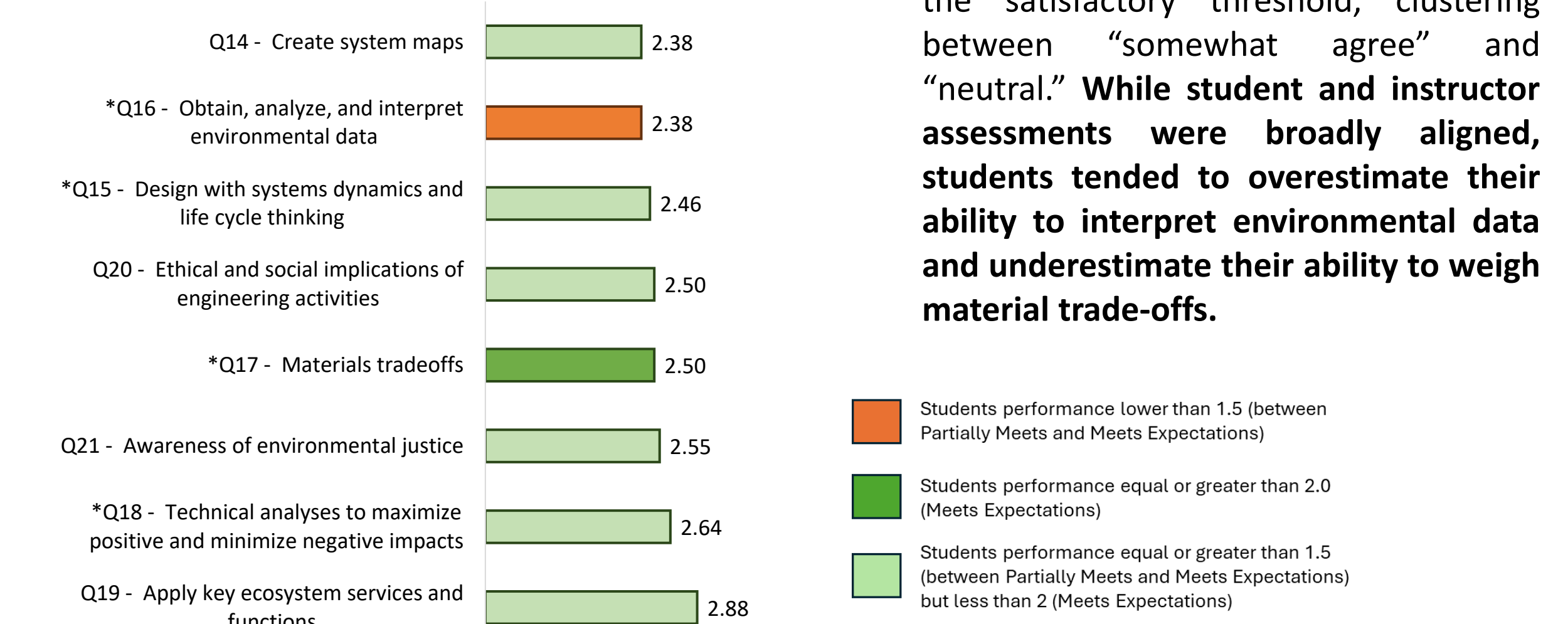


Figure 8. Differences in self-assessed knowledge (1=Strongly Agree, 5=Strongly Disagree) and Instructor's assessment of student outcomes

Conclusion: Why a Curricular Roadmap Matters

Differences between student self-assessments and instructor evaluations reflect the types of knowledge emphasized across courses. In AE 390, learning centers on foundational and procedural skills; in AE 444, students describe shifts toward systems thinking and life-cycle reasoning; and in CIVE 430, learning is strongly data-driven, with emphasis on environmental datasets and modeling. These patterns highlight an opportunity to leverage complementary strengths through a coordinated curricular roadmap. Making the progression from foundational tools, to systems thinking, to data-informed climate resilience analysis explicit can strengthen curricular coherence, student confidence, and transfer of learning.

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