The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
Paper ID #42553

Identifying Shared Meaning to Enhance a Collaborative Teaching Culture

Brooke Lahneman, Montana State University

Brooke Lahneman is an Assistant Professor of Management at the Jake Jabs College of Business & Entrepreneurship at Montana State Univer¬sity. Her research contributes to a deeper understanding of the changes organiza¬tions and industries can make toward more sustainable operations and systems.

Susan Gallagher, Montana State University

Susan Gallagher is the Education and Workforce Program Manager at the Western Transportation Institute (WTI), a transportation research center within Montana State University's College of Engineering.

Dr. Catherine M. Kirkland, Montana State University

Dr. Catherine Kirkland is an assistant professor of Environmental Engineering in the Civil Engineering Department at Montana State University. In addition to her background in environmental engineering, Catherine also holds a BA in Anthropology and Sociology from Rhodes College. Her research areas include beneficial biofilms, nuclear magnetic resonance, and engineering education.

Dr. Kathryn Plymesser, Montana State University

Dr. Plymesser hold a B.S. (Case Western Reserve University '01) and Ph.D. (MSU '14) degrees in Civil Engineering. She began her academic career at Montana State University – Billings with a teaching and research tenure-track appointment. Dr. Plymesser joined the Civil Engineering Department at Montana State University in 2016. Her research is focused in ecohydraulics and fish passage with a particular fondness for the application of hydraulic and fluid dynamic models to answer research questions in natural settings. Dr. Plymesser currently teaches Introduction to Environmental Engineering Design and Sustainability, Open Channel Hydrualics, and River Modeling.

Ellen Lauchnor, Montana State University

Ellen Lauchnor is an Associate Professor of Environmental Engineering in the Civil Engineering Department at Montana State University.

Amanda Hohner, Montana State University

Dr. Amanda Hohner is an Assistant Professor in Civil Engineering at Montana State University. She teaches courses in Environmental Engineering and conducts research on drinking water.

Adrienne Phillips, Montana State University

Dr. Adie Phillips is an associate professor in the Civil Engineering department at Montana State University. She teaches environmental engineering courses and does research in biofilms and engineering education.

Dr. Craig R. Woolard, Montana State University
Dr. Otto R. Stein, Montana State University

Identifying Shared Meaning to Enhance a Collaborative Teaching Culture

Introduction

The Civil Engineering Department at Montana State University (MSU) is entering its fourth year of a five-year project to transform its environmental engineering undergraduate program with support from a National Science Foundation *Revolutionizing Engineering and Computer Science Departments (RED)* grant. The project team's intent is to move away from a topic-focused undergraduate engineering curriculum model, in which technical content is siloed into individual courses, and few connections are made to broader social and environmental contexts or to professional practice. In its place, faculty are developing an integrated project-based curriculum that intentionally builds students' competencies in engineering and sustainability in a connected manner throughout their program of study.

The project team comprises all faculty members in Environmental Engineering as well as faculty from Civil Engineering, Chemical and Biological Engineering, History and Philosophy, Business Management, Political Science, and English. From the outset, the team adopted an outcomes-based approach to curricular redesign. In the first phase of the project, the multidisciplinary team developed a comprehensive list of knowledge, skills, values, and attitudes desired in successful environmental engineering graduates. Targeted competencies encompass discipline-specific technical knowledge, as well as cross-disciplinary skillsets related to ethics, communication, teamwork, social justice, economics, sustainability, and public policy. The list of desired student learning outcomes was produced without consideration of existing course content [1].

In the second phase of the project, the team reviewed existing courses. The goal of this undertaking was to review how and when specific knowledge, skills, and abilities are developed and delivered as students currently progress through the program, and to identify gaps between existing and desired program outcomes [1]. A key take-away from the review process is highlighted below (emphasis added):

> "The exercise of intentionally reviewing course and program outcomes provided us insight into the program that did not previously exist. *We learned, perhaps for the first time, what topics our colleagues are covering in their courses, what approaches and techniques they use in the classroom, and how they develop course- and lecture-level outcomes*. It may be beneficial for faculty in the other programs in our department to undertake a similar exercise, if only *to increase understanding of how content is distributed, delivered, and assessed* [1]."

This finding illuminates an ancillary goal for the MSU RED project. The team envisions that the integrated project-based curriculum will establish a culture that supports faculty collaboration and continuous learning, and one in which—rather than being responsible for siloed content delivery based solely on individual course teaching assignments—faculty collectively participate in constructing and delivering integrated program learning outcomes. To facilitate this shift, the team identified four high-level thematic knowledge threads that broadly connect and link all the desired competencies across the curriculum:

1. Systems Thinking
2. Sustainability

3. Professionalism
4. Environmental Engineering Competencies

Faculty consensus and collective ownership of desired student learning outcomes is a critical step to implementing an integrated curriculum [2]. In the transformed curriculum, faculty mutually agree to integrate systems thinking, sustainability, and professionalism competencies and to cultivate students' identity formation as environmental engineers throughout the degree. However, beyond identification of core program pillars, it is also essential to establish a shared understanding around the core concepts. Individual faculty members, for instance, may differ in their perceptions of which traits "professionalism" embodies or what defines sustainable practice. Shared understanding around central organizing principles ensures a common foundation for collective action and pedagogical decision-making [3].

The faculty team conceptualizes the redesign of the environmental engineering program as the collaborative implementation of mutually agreed upon learning outcomes interwoven into the fabric of various topical courses across the curriculum. The outcomes are thematically grouped around the four conceptual threads: systems thinking, sustainability, professionalism, and technical competencies related to the practice of environmental engineering. Faculty consensus around what meanings and value are applied to the four concepts is essential for achieving collective action and systems change within the Environmental Engineering program [2].

Background

Culture is defined as shared values, assumptions, beliefs, or ideologies, which in tandem, are manifested as group agreement around appropriate behaviors or approaches [4]. As such, organizational culture acts as a framework to guide and motivate individuals to act in certain ways [5]. Because organizational culture influences and motivates group actions, it can either hinder or enhance innovation [5], [6]. However, the underlying assumptions that underpin cultural norms are rarely explicitly identified and discussed, leaving open the possibility for multiple interpretations and individual actions that do not conform with stated group goals [4], [7]. The concept of 'sustainability,' in particular, causes conceptual difficulties for organizations due to the various meanings applied, which inhibits developing coherent organizational strategies that foster sustainable practices [7].

A qualitative cultural assessment was conducted to investigate, analyze, and describe the shared meanings faculty hold around the four program pillars: systems thinking, sustainability, professionalism, and environmental engineering practice. The goal of the assessment was to uncover areas of shared meaning with the strongest consensus within and across constructs. By eliciting and describing "definitions by consensus," faculty will be able to generate consistency in teaching and assessment practices throughout the curriculum.

The methodology used to conduct the faculty culture assessment draws from Cultural Consensus Modeling (CCM), which asks open-ended questions of group members to capture shared beliefs or meanings and to assess the degree of agreement present [8]. CCM draws on qualitative interview data eliciting cultural beliefs surrounding a specific construct or constructs [7]. Strong consensus within a group helps create consistent actions and ensures that there is alignment among individual group members and stated organizational goals [6].

Methodology
The Environmental Engineering faculty culture assessment was conducted using semi-structured interviews with seven tenure-track faculty members, encompassing Assistant, Associate, and Full Professor ranks. Each interview was led by a non-engineering faculty experienced in this methodology, conducted one-on-one with the engineering faculty, and lasted approximately an hour. The interview protocol centered on eliciting the meanings individual faculty members attach to ‘environmental engineering’ as a field or profession, and the three primary constructs of interest for the RED project – ‘sustainability,’ ‘systems thinking,’ and ‘professionalism’. Interviews were recorded and transcribed using the online platform Otter.ai and edited for accurateness [9].

Transcriptions were uploaded into NVivo, a qualitative analysis software, and a multi-step analysis process implemented.

1. All faculty interviews were coded for ‘emergent codes,’ keeping the codes similar to actual descriptions provided by the participants [9]. This step resulted in 190 emergent codes.
2. Emergent codes were compared and grouped into secondary codes with closely related or substantially overlapping meanings.
3. Secondary codes were sorted into ‘themes’ by the construct of interest (i.e., environmental engineering, sustainability, systems thinking, and professionalism). These themes indicate a set of codes that share meanings among participants.
4. Themes were sorted into ‘categories’, which indicate overarching sets of shared meanings among participants.

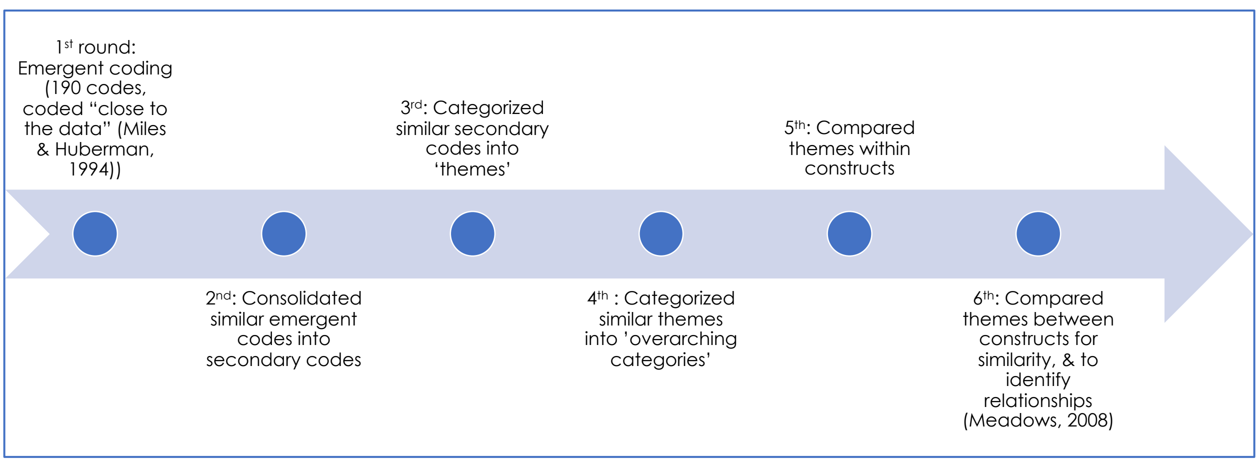

Figure 1: Qualitative Analysis Methodology

The investigator then compared the themes and codes from each construct of interest (i.e., environmental engineering, sustainability, systems thinking, and professionalism) to determine similarity between constructs [10]. The identified themes with consensus around shared meanings are described in this section along a gradient (i.e., themes with strong, moderate or minimal consensus among participating faculty). The faculty’s “definitions by consensus” are derived from the shared meanings with the strongest consensus for each construct.

Findings

Environmental Engineering

To elicit shared meanings, the investigator asked interview participants “What comes to mind when I mention ‘environmental engineering’ as a field of study and/or profession?” This first question highlighted general agreement around the purpose of environmental engineering as a field, and the principal activities of environmental engineering professionals to achieve that purpose.

Table 1: Shared Meaning: Environmental Engineering as a Professional Field

Purpose	To protect the public welfare
Mechanisms	Conserve the natural environment
	Mitigate natural and anthropogenic disasters (e.g., toxic waste exposure, air pollution, water pollution).

Faculty were then asked to provide some traits of a ‘good’ environmental engineer and of a ‘bad’ environmental engineer. These responses elicited perspectives about desirable and undesirable attributes of environmental engineering professionals. Responses to this question were more diverse and levels of consensus varied along a gradient from “strongest consensus” to “least consensus” as highlighted in Table 2. Shared meanings that held the strongest consensus in describing the “ideal” environmental engineer centered around desired skillsets and knowledge. Effective communication skills, which integrate both technical communication as well as interpersonal skills, were identified as critical. Respondents defined technical communication skills as encompassing the ability to write and present professional reports, while interpersonal skills comprised abilities to: a) consider stakeholder input and feedback as valuable and necessary to the project’s success; b) adapt written and oral communication to diverse stakeholder audiences; and c) practice empathy when communicating project updates and impacts to stakeholders.

Strong consensus also emerged around the shared perspective that the ideal environmental engineer should have a combination of strong technical expertise in multi-disciplinary areas, as well as an appreciation for others’ perspectives.

Responses revealed “moderate consensus” about desired attitudes and mindsets for the ideal environmental engineer. Shared meanings that held moderate consensus, included: having a compassion for the natural environment and social issues; holding diverse stakeholder perspectives as important and valuable; holding multidisciplinary knowledge as vital and collaboration as important; and knowing the limits of one’s own technical expertise.

Other themes with less consensus focused on the importance of creativity. Respondents indicated the ideal environmental engineer should understand traditional models and systems, but approach problems with curiosity and creativity. Underpinning the need for a creative focus is comfort with ambiguity and uncertainty. Because each problem is unique, and there are many unknowns, a creative focus was identified as necessary to understand which solutions will be a win-win for all involved (i.e., solutions that consider and balance impacts along environmental, social, economic, and long-term dimensions). Similarly, some consensus emerged around ethical decision-making as exhibiting curiosity about multidisciplinary solutions to generate win-win solutions and balancing the needs of clients with those of the natural environment, society, and costs. Responses highlighted consensus among faculty that the environmental engineer acts as a 'broker' between the needs of the client (which may include costs), and what is best for the environment, society, and local communities. Desirable attributes mentioned for "ideal" environmental engineers that held the least consensus related to influencing public policy to support the best solutions.

Table 2: Shared Meaning: Attributes of the Ideal Environmental Engineer

Theme	Code	Total References
Communication/ Interpersonal	Can work effectively with interdisciplinary team	23
	2-way communication necessary (listening, providing)	
	Effective at communication, broadly	
	Deliver updates on project with empathy & concern for others	
	Professional written communication (reports, emails)	
	Interact with diverse stakeholders	
	Adapting communication style to audience at hand	
	Effective interpersonal skills, broadly	
Technical Expertise	Combination of sufficient breadth/depth on multi-disciplinary topics & appreciation for other's perspective	17
	Sufficient breadth/depth on multi-disciplinary topics	
Attitude	Compassion for environmental and social issues	10
	Frame stakeholder feedback & input as constructive & valuable	
Scope/Mindset	Takes problem solving approach to issue (doesn't assume knows answer)	10
	Appreciation of the value of diverse stakeholders' perspectives	
	Combination of sufficient breadth/depth on multi-disciplinary topics & appreciation for collaboration	
	Gathering information to ensure generating win-win solutions for all	
	Knowing bounds of technical expertise, and not 'overstepping'	
	Knowledge multi-disciplinary topics & appreciation for systems thinking (how they fit together)	
Creative focus	Comfortable with ambiguity (varied issues arise)	8
	Thinking in a circular way - requires creativity & innovation - instead of relying on traditional systems	
	Thinking in sustainable way - requires creativity & innovation - instead of relying on traditional systems	
Ethical	Being curious about multi-discipline solutions helps being ethical (relates to not following policy blindly/Influencer)	6

Theme	Code	Total References
	Balance client demands with natural systems needs	
	Balance social, environmental, and economic costs	
Critical thinker / Influencer	Critically thinking about policy, not blindly following	5
	Elevate issues of concern for public health	

The strongest consensus around what negative attributes environmental engineers should avoid emphasized: assuming they know everything, not acknowledging the bounds of their own technical expertise, and not considering stakeholder or multidisciplinary collaboration as important. Other shared "avoid" themes included judgmental attitudes against non-engineers, arrogance; apathy toward issues affecting the natural environment or society; poor communication and interpersonal skills; and technical incompetence.

Sustainability

Respondents were next asked for their definition of the word 'sustainability' as well as their interpretation about how sustainability relates to the Environmental Engineering degree at MSU. The investigator asked faculty "What comes to mind when I mention the word 'sustainability'?" They were also prompted to provide examples of how the current Environmental Engineering program might promote or inhibit sustainability as defined by the informant. Analysis of responses produced themes with consensus around what aspects of sustainability faculty could prioritize, encourage, and reinforce in course teaching and activities.

Shared meaning with strong consensus among faculty linked sustainability with a holistic approach to problem solving. A general definition for a 'holistic approach' to engineering design is one which considers economic, social, and environmental dimensions, avoids unanticipated consequences and costs, and adopts a long-term perspective. Respondents emphasized a holistic approach as using a systems perspective to integrate multiple dimensions. The holistic approach emphasizes a mindset that values generating win-win solutions for clients, the natural environment, society, and local communities over the long-term.

There was moderate consensus around the idea of sustainability as an approach that applies analytical tools that incorporate multiple dimensions. Specific tools mentioned included lifecycle analysis (LCA), alternatives analysis, and systems thinking frameworks. To generate sustainable solutions with such tools, the respondents observed the need to define the scope of the system being examined in a particular problem. This relates to a second theme with moderate consensus. Interview participants discussed sustainability as being a complex construct, and thus environmental engineers need to have a mindset that expects and accounts for complexity. An additional dimension to this mindset is that—because problems are complex—to generate sustainable solutions environmental engineers need to possess multidisciplinary skillsets and to engage others in solution designs that address that complexity. Common themes identified by faculty on the topic of sustainability are presented in Table 3.

Table 3: Shared Meaning: Sustainability

Theme	Code	Total References
Holistic approach / Systems perspective	Appreciate system components & their interconnections	11
	Approach to design that considers economic & social & environmental dimensions - and long-term view - to avoid unanticipated consequences & costs	
Holistic approach / Systems perspective (LCA)	Approach to design that considers economic & social & environmental dimensions - and long-term view - to avoid unanticipated consequences & costs (by using LCA)	11
Holistic approach / Win-wins	Approach to design that considers economic & social and environmental dimensions - and long-term view - will generate win-win solutions for all	11
Long-term perspective	Best solutions involve considering impacts over long-term	11
Mindset – Complexity	Expect complexity, so approach problems ready to analyze and account for it	8
	Expect complexity, so approach problems ready to influence people to create and adopt complex solutions	
Technical Expertise	Strong technical expertise – multi-disciplinary – aids in finding win-win solutions	7
	Strong technical expertise aids in finding solutions that fit into bigger context (related to Systems Thinking)	
Analytical dimension	Alternatives analyses need to incorporate economic and social and environmental dimensions	7
	Defining systems boundaries at particular scales is crucial for sustainable solutions	
	Lifecycle analysis is framework for holistic design and measuring sustainability	
Creative focus	Thinking in circular way – requires creativity and innovation – instead of relying on traditional systems	6
Balancing	Need to consider how environmental, social, and economic dimensions balance (cannot trade one for another) – e.g., cost of project, lifespan of materials	5
	Passion for environmental side, but also need to consider how social and economic dimensions balance (cannot trade one for another)	
Inherent to EE	Environmental Engineering mission is to protect public health (through sustainable design)	4
Circularity/ Nature-based	The most circular (i.e., sustainable) designs are nature-based	3
Scale & Scope	Must match solution to scale of issue	1

Shared meanings elicited in interviews around “unsustainable” practices highlight teaching approaches faculty should avoid. These included:

- Providing a narrow scope of focus or criteria for solutions design.
- Emphasizing “trade-offs” between multiple dimensions rather than achieving balance and win-win solutions.
- Using tools that do not incorporate sustainability dimensions into measurements and scope.

There was strong consensus among faculty that approaches to the design process should not be limited to the technical dimensions of design only, but should include the natural environment, society, economics, and other contextual dimensions.

Systems Thinking

Faculty were asked to interpret what “systems thinking” means to them and how it relates to the Environmental Engineering program. Shared meanings about systems thinking identified in the interviews highlight themes that faculty can reinforce in course content and activities. The themes with the strongest consensus closely align with sustainability themes. Faculty interpret systems thinking as integrating a holistic approach to design and adopting a holistic mindset. The two concepts are clearly related but distinct from one another. A holistic approach to design is one that considers economic and environmental dimensions and adopts a long-term view. A holistic mindset is an adopted outlook or lens through which engineers view interactions as complex and nonlinear. A person with this mindset would view systems and system dimensions as interconnected and would approach problems ready to embrace complexity.

Shared meanings around systems thinking with moderate consensus also closely align with sustainability themes already identified. Systems thinking is envisioned as requiring strong multidisciplinary expertise and the application of analytical tools that incorporate and account for complexity. Systems thinking requires environmental engineers to have technical expertise from multiple disciplines so that they understand different parts of systems, the interconnections between system dimensions, and the interconnections between entire systems. Systems thinking is also interpreted as the application of analytical tools or methodologies that incorporate multiple dimensions. Examples provided are the same as those discussed to incorporate sustainability, to include lifecycle analysis or alternatives analysis.

Table 4: Shared Meaning: Systems Thinking

Theme	**Code**	**Total References**
Holistic approach / Design	Approach to design that considers economic & social & environmental dimensions - and long-term view - to avoid unanticipated consequences	22
	Best designs consider economic & social & environmental impacts	
	Approach to design that considers economic & social & environmental impacts	
Holistic Scope / Mindset	Appreciate system components & their interconnections	18
	Appreciate that components together are not additive; interconnections are complex & non-linear	

Theme	Code	Total References
Technical Expertise	Strong technical expertise allows EEs to see parts & their interconnections	11
	Strong technical expertise allows EEs to diagnose issue & design solutions through systems thinking approach	
Analytical tool	Alternatives analyses need to incorporate economic & social and environmental dimensions - and long-term view	8
	Lifecycle analysis is framework for holistic design	
Applied sustainability	Way of thinking that incorporates sustainability	7
	Analysis that incorporates sustainability - accounting for all inputs and outputs	
	Best designs work within rules of natural systems	
Nested view	Being able to see interconnections between systems	6
	Must understand where to set boundaries of system to know how to analyze it	
Holistic approach / Communication	Need to frame all projects through systems thinking lens, and communicate systems aspects back to clients too	1
Holistic approach / Interpersonal	Strong interpersonal skills allow EEs to see value of teamwork for complex issues	1

There was strong faculty consensus on what pedagogical approaches should be avoided to foster systems thinking competencies throughout the Environmental Engineering curriculum. Faculty agreed that compartmentalization was antithetical to systems thinking. Compartmentalization was interpreted as taking multiple forms:

- Focusing on a single part without interest in the role of other system components or their interconnections.
- Focusing narrowly on engineering design without consideration of broader environmental, social, or economic contexts.
- Ignoring hidden costs or benefits.
- Focusing only on one's own work without valuing team contributions.

Professionalism

Faculty were lastly asked to describe their interpretation of "professionalism" as it relates to the Environmental Engineering degree program and to provide examples of both professionalism and unprofessionalism. Themes with the strongest consensus about what professionalism in environmental engineering means related to effective communication skills to encompass both technical communication and interpersonal skills. Shared meanings around how interpersonal communication skills are demonstrated differed somewhat. There was strong consensus that interpersonal communication skills require emotional intelligence (e.g., listening with empathy and adapting communication style to the specific audience). There was moderate consensus that strong interpersonal communication skills are demonstrated through effective interactions with interdisciplinary teams or diverse stakeholders. Related to interpersonal skills, participant responses highlighted attitudes and mindsets needed for professional environmental engineering professionals, such as framing diverse stakeholder perspectives as important and valuable, possessing compassion about social issues, and valuing input from stakeholders or other disciplines.

Table 5: Shared Meaning: Professionalism

Theme	Code	Total References
Communication/ Interpersonal	Good communication requires Emotional Intelligence (self-management, interpersonal skills)	19
	Adapting communication style to audience at hand	
	Listening with empathy & concern to stakeholders' issues	
	Professional written communication (reports, emails)	
Interpersonal	Can work effectively with interdisciplinary team	10
	Effective at interacting with diverse stakeholders	
	Having strong leadership skills to be self-motivated & motivate team	
	Facilitates cohesive teamwork (with diverse team)	
Attitude	Frame stakeholder feedback & input as constructive & valuable (even if negative)	10
	Frame stakeholder feedback & input as constructive & valuable (not judging)	
	Compassion for impact solutions may have on stakeholders	
	Seeing value in lifelong learning (technical expertise, issues, etc.)	
Scope/Mindset	Knowing bounds of technical expertise, and not 'overstepping'	6
	Appreciation of the value of diverse stakeholders' perspectives	
	Using systems thinking to generate win-win solutions for all involved	
Technical Expertise	Sufficient breadth/depth on multi-disciplinary topics	2
Ethics	Represent EE profession, need to act ethically	2
Identity/purpose	Protecting public health (through natural systems)	2
Influencer	Critically thinking about policy, not blindly following	1

Strong consensus around faculty definitions of "unprofessional" attributes related to narrow mindsets about project scopes and roles. An unprofessional engineer might assume they know everything, disregard the bounds of their own technical expertise, not value stakeholder feedback or multi-disciplinary collaboration, and not consider interconnections between technical and social contexts as important factors to consider. There was moderate consensus that an unprofessional engineer would be a poor communicator with poor interpersonal skills. Being mean or rude was specifically mentioned by multiple participants as behaviors to avoid. The least consensus centered on unethical behaviors, lack of a creative focus, or displaying poor attitudes (e.g., acting defensively or arrogantly when presented with differing opinions).

Discussion and Applications

The purpose of the qualitative analysis was to support the Environmental Engineering faculty in redesigning their undergraduate curriculum. The faculty team conceptualizes the redesign of the Environmental Engineering program as the collaborative implementation of mutually agreed upon learning outcomes interwoven into the fabric of various topical courses across the curriculum. The outcomes are thematically grouped around four conceptual threads: systems thinking, sustainability, professionalism, and environmental engineering practice. Faculty consensus around what meanings and value are applied to the four concepts is essential for achieving collective action and systems change within the Environmental Engineering program [2].

The cultural assessment was aimed at investigating, analyzing, and describing the shared meanings faculty hold around the four constructs of interest. The shared meanings with strongest consensus for each construct indicate the faculty's "definitions by consensus" for use in developing teaching materials and assessment strategies. Uncovering areas of shared meanings within and across these constructs enables faculty to design course content and activities that underscore collectively desirable learning outcomes and behaviors.

Beyond uncovering patterns of shared meanings within each construct, the investigation revealed relationships and interconnections between sets of constructs. For example, responses for sustainability and systems thinking were closely linked. However, a pattern was observed that faculty generally describe sustainability as the outcomes or criteria for measurement (which are embedded in decision-making and design tools), whereas they describe systems thinking as a methodology or analytical approach to ensure sustainability criteria are considered and valued in engineering design. To integrate these two constructs in coursework, faculty could develop a decision-making framework that utilizes a systems thinking methodology to define sustainability criteria and then introduces analytical tools to incorporate and measure sustainability criteria in design. This framework could be applied throughout the curriculum as "the way things are done" in environmental engineering with the intention of achieving win-win outcomes. Examples of "what goes wrong" when the framework is not utilized can reinforce this message for students.

Faculty generally equated the 'ideal environmental engineer' as one who meets the criteria ascribed to professionalism. Many of the attributes for professionalism relate to interpersonal skills, attitudes, or mindsets. These may be more difficult to teach but can be integrated into the same systems thinking decision-making framework described above and modeled for students as a critical first step in the design process. For instance, adoption of a holistic mindset can be taught as a "must do" action before initiating problem-solving. Faculty might consider the development of case studies, interactive simulations, or other class-based activities that engage students in creating "habits" or approaches to problem-solving that involve adopting appropriate attitudes and mindsets.

The cultural assessment also provides feedback to the faculty team about concepts that still lack a definition by consensus. As envisioned by the faculty, "professionalism" competencies are categorized into four domains: communication, teamwork, social justice, and ethics. Ethics was only minimally mentioned in respondents' description of the "ideal" environmental engineer or behaviors ascribed to professionalism. If ethics is meant to be a major component of programmatic learning outcomes, the faculty team may need to spend some time clarifying how they define “ethical” practice so that the design of course content, activities, and assessment around ethics is consistently executed and reinforced across the curriculum.

Lessons Learned and Next Steps

The redesigned environmental engineering curriculum involves the addition of team-taught project-based courses in the first and second years of the degree program. The first two project-based courses developed under this RED project were implemented in the 2023-2024 academic year. Both courses have a strong emphasis on sustainability. The first-year course, *EENV 102: Introduction to Environmental Engineering Design and Sustainability*, also addresses professionalism competencies with its focus on introducing career paths in environmental engineering, use of basic engineering tools, and building communication skills. The second-year course, *EENV 202: Sustainable Waste Management*, includes formal content introducing systems thinking, social justice, and ethics. Both courses utilize student teams to complete the assigned projects. EENV 202 additionally includes assessment of team function using the CATME platform, developed by Purdue University [11]. The findings from the faculty interviews were one driver for the development of content for the first project-based learning courses. Collaborative development of the new team-taught courses surfaced additional insights.

The faculty culture assessment in conjunction with the implementation of the first team-taught project-based courses helped to identify areas where shared understanding among faculty of key programmatic concepts lacked clarity, making them difficult to convey to students and to translate into specific learning outcomes for assessment purposes. As an example, the overlap between sustainability and systems thinking in faculty responses suggests that faculty may need to consciously work to differentiate the two concepts for students and for themselves. In the process of introducing systems thinking to students in EENV 202, for instance, the co-instructors had to re-assess their understanding of systems thinking. While systems thinking can be described as a pre-requisite for sustainability, it can also be applied to very unsustainable and dysfunctional systems. The team found that having students investigate unsustainable or dysfunctional systems through a systems thinking lens can provide meaningful insights about system behaviors that may be less apparent in sustainable systems. This broader definition for systems thinking, de-coupled from sustainability, also helped instructors introduce social and environmental justice topics, and to highlight to students how not all systems are just.

The faculty will continue to collaboratively implement and adapt new and existing course content to achieve desired student learning outcomes as identified and refined through a continuous faculty consensus process. Furthermore, faculty will use student and faculty feedback from each course to refine and improve course content and delivery in future years. The two project-based courses, as currently implemented, introduce the competencies and constructs explored in this paper. Qualitative assessments related to the formation of engineering identity are being conducted over several years to compare students enrolled in the new project-based classes with similar cohorts not enrolled in the courses. Outcomes will be shared with other programs in the department (Civil Engineering and Construction Engineering Technology) as well as with other departments considering new approaches to fostering faculty collaboration in engineering education reform.

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