Transcending Disciplinary Boundaries to Improve Life on the River: Expanding students' conceptual understanding through interdisciplinary engineering service learning approaches

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Tristan Cunanan is a second-year B.Arch student in the Albert Dorman Honors College at NJIT, where he is also pursuing an accelerated dual-degree with a Master of Urban Design. Minoring in Psychology and Business, he is particularly interested in how design can respond to the human experience from the pedestrian level. Since May 2025, he has been a researcher for the Honors College's 'Life on the River' Initiative under Drs. Emily Tancredi-Brice Agbenyega and Ashish Borgaonkar as part of an interdisciplinary team of students. His research work has centered on assessing urban riverfronts on the Lower Passaic River Superfund site and investigating potential ways to reactivate these degraded, underutilized spaces in a manner that both reflects the local communities' perspectives, and responds to environmental issues such as site flood risks and industrial water/soil contamination. He has presented at the 2025 NJIT Undergraduate Summer Research and Innovation Symposium, December 2025 NJIT Honors Interdisciplinary Research Forum, Spring 2026 American Society of Engineering Education Middle-Atlantic Section Conference at the University of Delaware, and was a finalist at the 2026 NJIT Dana Knox Student Research Showcase.

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Abstract

Given the multifaceted nature of sustainability challenges, courses on environmental topics must be correspondingly interdisciplinary. This proposal outlines the design of a Scholarship of Teaching and Learning (SoTL) study of an engineering service learning course: "Service-Learning Experience for Engineers - Life on the River," a team-taught, interdisciplinary course focused on the human ecology of the Lower Passaic River (LPR) watershed. The course was developed through a collaboration between instructors from three different departments at a mid-size polytechnic university on the East Coast. The course structure, which requires students to tackle complex, interconnected systems, is organized around four concurrent lines of action: (1) The development of an eco-cultural mapping tool to visualize the sociocultural, economic, and environmental conditions of the LPR and surrounding communities, (2) educational and service programming that will engage the local community in the process of learning about and addressing the environmental and social impacts of the River on their communities, (3) the measurement of pollutants in and along the River, and (4) the creation of preliminary designs for water and sediment remediation. The pedagogy is designed to advance conceptual understanding by applying engineering design principles to improve the human ecology of the Lower Passaic River watershed through service learning.

Considering the course's interdisciplinary approach to analyzing possibilities for remediating the Lower Passaic, we hypothesize that course participation will transform students' conceptual models of the River and possibilities for its restoration as well as their worldviews on sustainability in urban areas. The proposed SoTL study will examine student learning outcomes (SLOs) by tracking conceptual advancements across the three phases of engagement before and during the course: summer research, fall research, and coursework. The primary methodology will be the identification of students' entrepreneurial mindset (EM) as measured through their demonstration of the "3 Cs" as identified by the KEEN framework: Curiosity, connections, and creating value [1]. Reflection questions will focus on students' evolving understanding of: the scope and feasibility of their deliverables, the relationship between their teams' work and that of other teams, and the expanding potential for their deliverables to have a greater impact. This paper serves as a Works in Progress submission to gather crucial feedback on the project's pedagogical model, the viability of the entrepreneurial mindset as an analytical lens , and best practices for coordinating student learning across multiple engagement pathways. We aim to present a working model that other institutions can replicate. We anticipate that this work will be highly relevant to the overall ASEE community, but in particular to the members of the Environmental Engineering and Sustainability Division (ENVIRON).

Introduction

Sustainability is a chief concern for all engineers; therefore, there is a need for engineering courses that effectively prepare engineering students to develop the competencies required to address complex sustainability issues [3]. As these issues are interdisciplinary, coursework is needed that develops knowledge and skills beyond the silo of any given engineering discipline. Specifically, both curriculum and pedagogy must transcend disciplinary boundaries to effectively address the range of environmental and social factors that contribute to sustainable development, particularly in urban areas. As one of National Academy of Engineering's (NAE) fourteen "Grand Challenges," restoring and improving urban infrastructure represents a critical area of focus for engineers and their collaborators [4]. Improving urban infrastructure, in turn, intersects with two of the UN's Sustainable Development Goals (SDGs): improving infrastructure and fostering sustainable cities [4]. Courses that explore urban infrastructure thus need to be correspondingly complex to equip students with the necessary knowledge and skills to develop sustainable solutions.

Life on the River (LotR) is designed to explore the environmental and social challenges facing the Lower Passaic River (LPR) watershed which stretches 17.4 miles from Dundee Dam in Garfield, NJ to Newark Bay in Newark, NJ. The LPR is one of the most polluted waterways in the United States [4], [5]. Like rivers adjacent to many northeastern cities, the Lower Passaic River has a history of industrial and municipal wastewater flowing into it, untreated, in combined sewer overflows (CSOs) [6]. Additionally, non-point source pollution, along with dense urban development, including land reclamation of former wetlands, impairs the waterway, and it is characterized by low ecological diversity [5]. In addition to the many challenges the river has faced, the LPR is the location of several U.S. Environmental Protection Agency (EPA) Superfund sites, including one of the most expensive cleanups to date, because of the legacy of Agent Orange, the chemical defoliant used heavily in the Vietnam War. In Newark, NJ, an ingredient of this phenoxy herbicide was manufactured by a company then known as Diamond Alkali between 1948 and 1969 [7]. A byproduct of the production of one ingredient, 2,4,5-trichlorophenol, is a dioxin called 2,3,7,8-tetracholorodibenzo-p-dioxin (TCDD), considered the most toxic of its kind. As it has the tendency to accumulate in sediments and to bioaccumulate, it remains a persistent environmental problem, with fish and crabs from the Lower Passaic River being too contaminated for human consumption [4], [8]. Billions of dollars have been spent remediating the Diamond Alkali site, and extensive sediment removal work is planned [4].

Course Design and Pedagogy

Life on the River is a multi-phase project organized as follows:

Phase 1 - Summer 2025: This was a summer research experience that engaged a team of seven students, each of whom was working on independent research projects related to a range of fields, including policy development, public health, water remediation, and Urban Design. Students spent approximately 8 weeks designing and implementing research projects with the aim of producing brief presentations on their initial findings and conclusions. During the course of the eight weeks, students were responsible for doing background research, designing brief research studies, and implementing their methodologies. Additionally, the research team met during six out of the eight weeks for students to share research updates and provide feedback on each other's projects and to consult with industry experts at various stages of their research. The combination of students' independent work and the collaborative project development that took place during the team meetings provided an environment in which students were able to develop their research projects in an iterative manner.

Phase 2 - Fall 2025: During the fall semester, five of the research team members continued their work on an independent basis, collaborating as needed. Additionally, research team meetings proceeded. The focus of the Fall was for each student to build off of their summer's work and to continue to build a foundation for class projects for the spring course. Additional industry experts met with the team to share insights from the field and to offer guiding questions for students to consider in their work.

Phase 3 - Spring 2026: The spring 2026 course is in its concluding week. Like Phase 1 and Phase 2, the course has drawn from local community engagement and continued industry advisor contact to support project teams in executing the deliverables. Additionally, elements of socially engaged engineering design were employed in full as project teams work through the development and prototyping of their deliverables.

For instructors, an advantage of this course design is its interconnectedness. The population of students attracted from disparate departments and colleges provides a larger talent pool of motivated students to work on research. Students are able to draw from each other's subject matter expertise in an effort to strengthen their respective projects, thus fostering the progress of the service-learning initiative as a whole. Likewise, the course provides a more seamless connection between research and pedagogy, unifying the research efforts of an individual instructor with the teaching and research efforts of other faculty.

The LoTR pedagogical model has been twofold, involving both lateral and vertical modes of learning (and subsequent project development). This novel methodology provided students with the unique opportunity to engage with sustainability studies through an interdisciplinary, hands-on approach that many other sustainability courses do not offer.

On the front of lateral development, students were introduced to multidisciplinary methods of thinking and approaching subject matters within the research team, and were additionally given the opportunity to interface with varying expert and community perspectives that were brought in as part of the research project, one that traditional modes of pedagogy do not provide, at least to as much of a degree as interdisciplinary experiential learning. Students were able to engage thoroughly with both the internal discourse of the interdisciplinary team members, as well the external discourse of the community & expert partners and resources students brought into their, and, by extension, the team's, work. Simultaneously, students' vertical development occurred through the active hands-on application of students' fields/backgrounds to real-life, real-time, real-stakes problems that forced them to resolve confounding variables that might not otherwise arise in an example problem or educational scenario. Both the lateral and vertical learning development components of this initiative have introduced students to vital skills and manners of thinking necessary to address multi-faceted, complex challenges in the real world through the collaborative intersection of various disciplines working simultaneously from the ground up and top down.

The Life on the River (LotR) service-learning initiative offers a useful model for such courses because it has been designed and implemented by a team of faculty from two different colleges at the New Jersey Institute of Technology, an R1 polytechnic university in Newark, NJ. The course has engaged students from over ten majors, ranging from chemical engineering and biology to architecture and human-computer interaction, across four colleges. Life on the River focuses on the remediation of the Second River, a tributary of the LPR. Socially engaged engineering design, the primary methodological approach employed in the Life on the River initiative, enables students from multiple disciplines to tackle urban infrastructure issues facing the Second River within a framework that allows for expansive definitions of the problem(s) at hand and iterative development of solutions based on input from the surrounding community. The course structure is organized around four concurrent lines of action: (1) The development of an eco-cultural mapping tool to visualize the sociocultural, economic, and environmental conditions of the Lower Passaic and surrounding communities, (2) educational and service programming that will engage the local community in the process of learning about and addressing the environmental and social impacts of the River on their communities, (3) the measurement of pollutants in and along the River, and (4) the creation of preliminary designs for water and sediment remediation.

III. STUDENT LEARNING OUTCOMES

Table I below outlines the team's hypotheses regarding the SLOs as defined by the Engineering Accreditation Commission (EAC) and the corresponding course mechanisms that could aid in students' achieving those outcomes. It was expected that in the context of the summer research program, continued research engagement during the fall semester, as well as during the course itself, students would advance along the spectrum of one or more of these outcomes. Pending IRB approval, the research team will analyze student artifacts (e.g. log books and reflection assignments) from the Summer 2025, Fall 2025, and Spring 2026 to identify evidence of student learning in each of the SLO areas, with an emphasis on SLOs that align most closely with sustainability competencies. This analysis will establish a baseline for types of evidence to measure in future iterations of the course.

SLO	Description	Summer 2025	Fall 2025	Spring 2026
SLO 1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, technology, and mathematics.	Students identified problems related to the Lower Passaic that were either engineering-focused or, if rooted in another field, related to the engineering problem at hand.	Students began to apply engineering principles to their prior research, now with a focus on the Second River and a specific neighboring community.	Both new and continuing students move through the next iteration of identifying complex engineering problems related to the potential environmental impacts of illegal dumping along the Second River.
SLO 2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare,	Students initiated an iterative research design that invited input from industry and local community organizations.	Students continued an iterative research design that invited input from additional industry and	New and continuing students continue to invite input from the local neighborhood as well as additional stakeholders.

SLO	Description	Summer 2025	Fall 2025	Spring 2026
	as well as global, cultural, social, environmental, and economic factors.		local community members/organizations.	
SLO 3	An ability to communicate effectively with a range of audiences.	Students presented their research to an audience of their peers as well as a panel of industry experts.	Students presented their research to prospective Spring course enrollees as well as a restoration ecology expert.	Students will share their work with community members as part of the course's community engagement strategy.
SLO 4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments.	Students consulted with an industry expert in water remediation on ethical considerations in community-based projects.	Students learned about specific restoration projects on the Lower Passaic from an expert restoration ecologist.	Students will continue to engage with industry experts as well as community-based stakeholders.
SLO 5	An ability to function effectively on a team whose members together provide leadership.	Students collaborated on data collection and analysis and small group presentations.	Students worked in small groups to collect and analyze additional data.	Students will work in project teams to complete all research tasks and share updates with the full class.
SLO 6	An ability to develop and conduct appropriate experimentation, analyze and interpret data.	Students designed and implemented a methodology within an engineering design framework.	Students continued to implement their proposed methods or revised their methods.	Students will work in teams to carry out experiments, analyze data, and draw conclusions.
SLO 7	An ability to acquire and apply new knowledge as needed.	Students did secondary research and began to collect primary research on water quality and	Students continued to do secondary research as well as primary	Students will work in teams to continue to collect and analyze data, inviting community

SLO	Description	Summer 2025	Fall 2025	Spring 2026
		design.	research primarily through site visits.	stakeholder input.

IV. ASSESSMENT METHODOLOGY

Assessing students' attainment of the SLOs outlined above will occur primarily through reflection assignments that can reveal the development of students' conceptual understanding of course topics over the course of the semester. Specifically, demonstrations of the 3C's will be explored in order to generate a list of common associated concepts to measure in future iterations of the course. Concept mapping has been shown to be an effective learning and assessment tool in engineering education among other disciplines [9]. The interdisciplinary structure of the Life on the River course will require instructional tools that can be effectively used in a range of disciplines. Concept mapping is thus an ideal tool as its efficacy has been confirmed in interdisciplinary STEM courses [10]. Key concepts of ecological restoration and community engagement have been central to the research team's work during the summer and fall terms. These same concepts will remain central to the spring course as materials explore the former directly, and each project team will be required to engage with local community partners as part of their methodology.

Concept maps may thus be a useful tool both to teach key concepts [11] of the course and to assess students' understanding of these concepts at critical junctures in the course. Concept maps can be integrated into the students' reflection assignments, and students can revisit guiding questions related to both concepts and the connections among them and their associated propositions and cross-links [9]. Especially in the context of Life on the River, in which students come from a variety of majors both within and outside engineering, concept maps will be an accessible means of assessing students' ability to learn new concepts they may not have been familiar with prior to the class.

Having students construct their own concept map allows more freedom to explore the topic and to go even beyond the individual instructors' knowledge of the topic [12]. Although traditional scoring will be used for ease and its relatability to other scoring techniques and literature studies [13], categorical scoring is particularly valuable since it was originally developed for teaching sustainability, a core topic of this course, and allows for generation of a complexity score, which reflects the interdisciplinary learning of students [14]. Watson et al. [15] showed the value of applying multiple scoring techniques to assess student learning.
Of particular interest for this study is the interdisciplinary backgrounds of the students. While previous exposure to sustainability concepts and the course will contribute to similarities in student concept maps [15], there will likely be topics with which students will be more familiar which will create biases in the maps of, for example, science versus engineering

students. Mladenovic [16] created a methodology to assess the impact of student background using a combination of concept maps and surveys to detect differences in student perspective acquired prior to the course. DeFranco and Neill [17] assessed the impact of a critical thinking framework on team consensus using concept maps as a tool. Taken together, the methods of [16], [17] provide an opportunity to see the differences disciplinary background make in approaching sustainability problems and potentially how the interdisciplinary course creates cross-pollination of these concepts.

V. REFLECTIONS AND FUTURE PLANS

In terms of specifics of how developments have been observed throughout the initiative, we can identify impacts across three distinct phases of the LoTR project: (1) preliminary background research in an 8-week summer research program, (2) continued research through the Fall 2025 term, and (3) deployment of experimental designs in Spring 2026.
Prior to their participation in the summer research program, students' knowledge of the Passaic River was limited. Some were only aware of general environmental concerns surrounding the river. In the first two weeks of the summer program, students engaged in preliminary background research. Overall, they found that the river was one of the most polluted in the country, and more importantly, became informed of the specific causes and subsequent cleanup efforts. This allowed students to develop targeted research projects that intersected their newfound knowledge with their own interests and fields of study.
On the front of cleanup, restoration, and remediation efforts, students' understanding advanced from the simple knowledge of the existence of major federal environmental organizations, such as the EPA and NOAA, to active, direct engagement with field experts and community partners working on the ground. Familiarizing themselves with the existing discourse, students were able to either isolate or qualify research objectives in a manner informed by their respective positionalities. Diverging from the traditional method of classroom content-theory learning in favor of direct site engagement allowed students' personal and academic backgrounds to drive individually-curated learning experiences. Through the summer program, students collaborated with many community partners like the Passaic River Coalition and Branch Brook Park Alliance. Engaging with these organizations expanded students' cognizance of the ongoing environmental efforts.

When students were asked to reflect on their own positionalities, it highlighted the way these diverse backgrounds each contributed to distinct, yet overlapping projects. Frequent collaboration created a push for more expansive research goals, creating 'internal partners' amongst the students themselves. Students were also able to vertically develop an in-depth understanding of the Passaic River as it related to their specific research, spanning testing methodologies, qualitative interview themes, and GIS tools. Throughout this process, students continued to contribute these findings to the internal discourse of the team and to the greater external discourse through presentations and continuous engagement.

By the Fall 2025 semester, students were able to gather what they had learned and either continue their research or branch off into more focused efforts. Interface with both experienced community members and field experts refined their research approaches. University faculty resources in particular were engaged to great effect. Tracking ongoing projects from various perspectives gave students a real-time glimpse at how such endeavors are handled by different stakeholders. Moving into the spring course phase, students have assumed a strong foundation, built upon their own initial positionalities, and driven their own initiatives. Currently, it is evident that students' conceptual models have transformed into a nuanced multidisciplinary grasp of the reality at hand.

Questions to Consider

Just as reflection to students' growth throughout the LotR service-learning initiative, so too do the instructors strive to reflect on their learning throughout the course. In particular, the instructors want to reflect on the efficacy of the interdisciplinary, team-led pedagogy that the LotR initiative employs, including the integration of concept mapping as a learning and assessment tool. The authors of this paper thus invite questions from ENVIRON colleagues to identify elements of the initiative that could be adapted and applied at other institutions as well as areas in need of improvement. The authors seek input on the following:

- Effective ways of measuring both lateral and vertical learning for students
- Ways in which interdisciplinary courses expand instructional capacity for instructors

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