

Shared Responsibility for Positive Societal Impact: An Interdisciplinary Course

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Abstract

A new technical interdisciplinary course entitled “The Intersection of Society and Design” was developed collaboratively and implemented by three departments at three separate universities. It is a team-based, project-based course that is team-taught by a faculty member from engineering, from health science, and from psychology. The overarching goal of the course was to develop an interdisciplinary understanding of the necessary balance between the needs of society and engineering design. It explicitly addresses four societal impact outcomes in ABET Criterion 3: public health and safety impacts of design, ethical decision-making, collaborative productivity, and effective communication with diverse audiences [1]. This course is supportive of the Engineering One Planet (EOP) program of the American Society for Engineering Education (ASEE) [2]. In addition, the importance of making design decisions in economic, environmental, and societal contexts is emphasized from the perspectives of engineering and physical and mental health.

Introduction

A new technical interdisciplinary course entitled “The Intersection of Society and Design” was developed collaboratively and implemented by three departments at three separate universities. It is a team-based, project-based course that is team-taught by a faculty member from engineering, from health science, and from psychology. Although this course was developed and offered on the Texas A&M University System RELIS Campus, a campus where multiple institutions in the System offer non-competing degree programs, the same model could be employed at a single university among multiple departments and colleges, or at a Multi-Institution Teaching Center (MTIC) among multiple institutions. It could also work with universities that are in close proximity to each other. The key factor is faculty from multiple departments and colleges willing to collaborate outside of their immediate area of expertise, which can be uncomfortable. The important consideration, in the opinion of the authors at present, is that the faculty and students sit together in a face-to-face environment.

The overarching goal of the course was to develop an interdisciplinary understanding of the necessary balance between the needs of society, and engineering design. Archonita Manolakelli [3] probably addresses the need for such a course when she said:

From a practical perspective, the problems our world is facing at the moment are not organised according to academic disciplines and continue to be increasingly complex, messy and interconnected. As a result, there is a general move towards the requirement of a more holistic and integrated understanding of various challenges that can only be achieved by crossing disciplinary boundaries. [3]

She further said:

An approach towards integrating knowledge and experience both within and between disciplines, and across academia and practice, is becoming increasingly more crucial in our efforts to adequately respond to these large-scale challenges. [3]

As prelude to this discussion, the terms multi-disciplinary, interdisciplinary, and transdisciplinary need to be compared and contrasted. The working definitions of these terms considered by the authors when developing this course are:

- **Multidisciplinary:** Disciplines work independently of each other but contribute to achieving the design objective
- **Interdisciplinary:** Discipline contributions are integrated holistically when solving problems with complex interrelationships
- **Transdisciplinary:** Different disciplines draw from each other effectively forming a new discipline that achieves the design objective.

These working definitions used by the authors were influenced by the definitions presented by Manolakelli and are shown graphically in Figure 1. As previously stated, this course was intended to be an interdisciplinary course and is likely to continue this modality in near term. Over time, however, it could naturally become a transdisciplinary emphasis area.

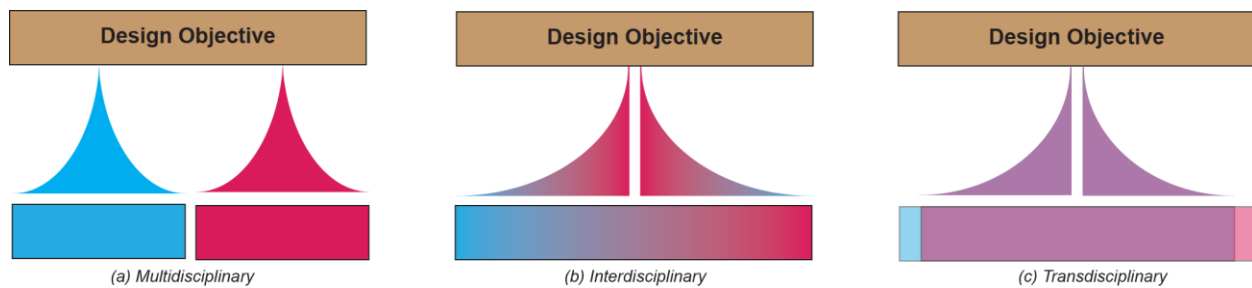


Figure 1: Collaboration among disciplines

Supporting Literature

Within colleges of engineering, a fair amount has been written over the past several decades about designing and incorporating interdisciplinary elements [4]. The importance and relevance of interdisciplinary education and perspectives is gaining traction; the evidence is seen through ample studies in engineering journals and conference proceedings. New courses and programs discussed in the conference proceedings arena alone include Waidley and Bittner [5], Cone, et al. [6], Kurtanich, et al. [7], Backer and Bates [8], and Cho, et al. [9]. The peer-reviewed literature and other conference proceedings offer more and innovative examples of how to include perspectives, knowledge and skills across engineering curriculum.

However, among departments outside colleges of engineering in collaboration with colleges of engineering, the importance and role of interdisciplinary education has not been studied as much over the decades; the body of knowledge is small but is growing. Findings indicate interdisciplinary education helps form connections to solve large-scale problems requiring sustainable solutions. In the early 20th century, John Dewey served as major proponent of integrated education [10]. One hundred years later major organizations in multiple sectors, such as the National Academy of Engineering (NAE) and Institute of Medicine (IOM) (now National Academies of Medicine), have called for interdisciplinary opportunities [11]. The World Health Organization (WHO) through its Interprofessional Education and Collaborative Practice [12] and

National Institutes of Health (NIH) fund work about the importance of interdisciplinary education and research [13].

Interdisciplinary education aids in teaching students skills around critical thinking and problem solving, and supports understanding of complex issues [4], the ability to appreciate the perspective of others, increased acceptance of vagueness, increased skill in synthesis and information integration, creative and even unconventional thinking, and heightened listening skills [14].

Challenges to creating and delivering interdisciplinary courses exist for both faculty and students; faculty face complexities in assessing interdisciplinary learning outcomes, logistics coordination around course calendars, creation of a cohesive course curriculum from multiple disciplines' perspectives, institutional buy-in on the merits of interdisciplinary efforts, administrative complexities (scheduling, faculty workload distributions, academic advising) [15], and university culture can create barriers to new pedagogical approaches [16]. Students and faculty without a willingness to communicate and learn about other subject areas may not get as much from the interdisciplinary experience as others who are willing and able to interact and communicate with those from other disciplines [17]. Further, students may perceive a fragmented and less ideal learning experience in team-taught interdisciplinary classes if learning goals are not strategically synthesized among participating disciplines [18].

Despite the challenges, faculty engaged in this work espouse common views that: 1) interdisciplinary efforts lead to transformational experiences as noted in student evaluations [17], 2) interdisciplinary education can broaden perspectives around large-scale problems, 3) complex problems require multiple disciplines working together to develop a sustainable solution, and 4) students can hope that the faculty, universities and other significant stakeholders are concerned about large problems and want to make change [4]. Preparing students to influence solutions to society's struggles is a significant goal of higher education. The complexity of these problems spans a world with an increasing number of specializations, which creates the need to coordinate efforts across subject areas [15] [19]. As Einstein said, "We cannot solve our problems with the same thinking we used when we created them." [11].

Previous authors have offered typologies for interdisciplinary learning. Suggested categories are organized by goals of inquiry [20], or more recently, how close versus distant disciplines are in terms of knowledge paradigms (interdisciplinarity), and how student teams are structured [21]. Typological models within interdisciplinary curriculum facilitates discussion of appropriate scaffolding for students, requisite faculty skills when leading such learning experiences, and measuring relevant learning outcomes.

Course Structure

This course seeks to prepare undergraduate engineering and non-engineering students to function as skilled interdisciplinary team members, ready to recognize and communicate about their disciplinary interdependencies in solving large-scale design problems. The learning objectives, course structure, and scaffolding enter an evolving conversation in the global engineering education community about equipping students with skills needed to view design questions with a more holistic lens, inclusive of cultural, ethical, health, and psychological variables [4] [22].

The course was structured with three societal/design considerations. These considerations are:

- Individuals have intrapersonal wellness needs within the society in which they live.
- Communities have collective interpersonal wellness needs within the society in which they live.
- Engineers must provide safe and usable systems that are supportive of individual and collective societal needs.

The intersection of these needs and the space in which design occurs is depicted in Figure 2.

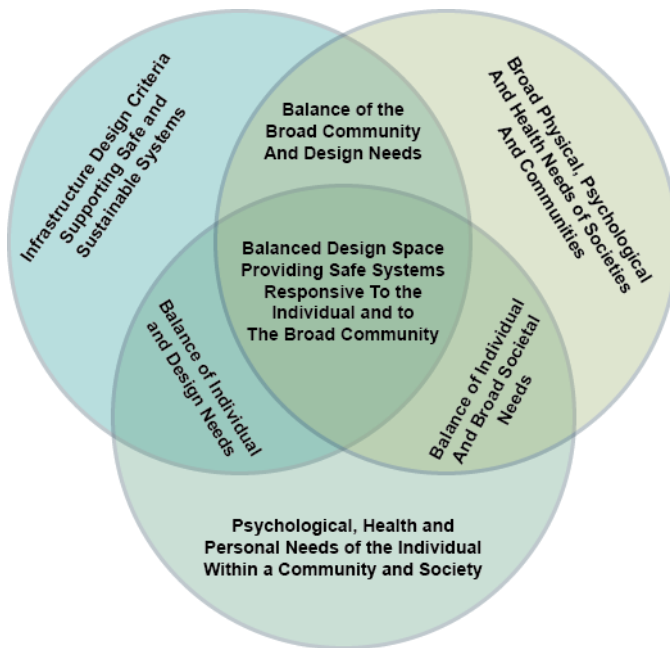


Figure 2: Development of balanced design space.

In this context, the Course Objectives and Student Learning Outcomes are:

Course Objectives

1. Evaluate and discuss individual and social wellness factors that support restorative environments
2. Describe the interrelationships between engineering design factors and psychological health and community resilience.
3. Develop critical questioning skills, not just critical thinking skills regarding societal impact of design and public health decisions.
4. Contribute to problem-solving within an interdisciplinary team.
5. Address environmental sustainability concerns while considering the balance of infrastructure needs with wellness impacts.
6. Develop ability to effectively communicate with constituencies having different backgrounds.

Student Learning Outcomes

Upon completion of this course, students will be able to:

1. Communicate effectively with diverse audiences.
2. Describe environmental and infrastructure influences in built and natural settings on psychological and physical health.
3. Prioritize psychological and social factors influencing environmental and infrastructure design decisions.
4. Analyze connections among human motivation, behavior change, and environmental factors with an evidence-based perspective.
5. Apply research on psychological adaptation and resilience regarding environmental and community sustainability.
6. Describe design influences on community services and programs.
7. Recognize cross-disciplinary questions that need to be asked regarding community health, community resiliency, and community development.
8. Describe means to affect communication across multiple constituencies for effective community-based infrastructure and environmental projects.
9. Develop and evaluate the workflow of an interdisciplinary team.

Twelve undergraduate students enrolled in this first offering of the course: 2 mechanical engineering technology students, 4 health science students, and 6 psychology students. The original plan for dividing the students into groups was to have students from all disciplines on each team. With only two engineering students, this was not possible without having teams that were believed to be too large to necessitate active participation of all members. As such, the engineering students formed a consulting team and the remaining students were divided into three project teams, each of which was composed of health science and psychology students. The composition and interaction of the teams is shown in Figure 3.

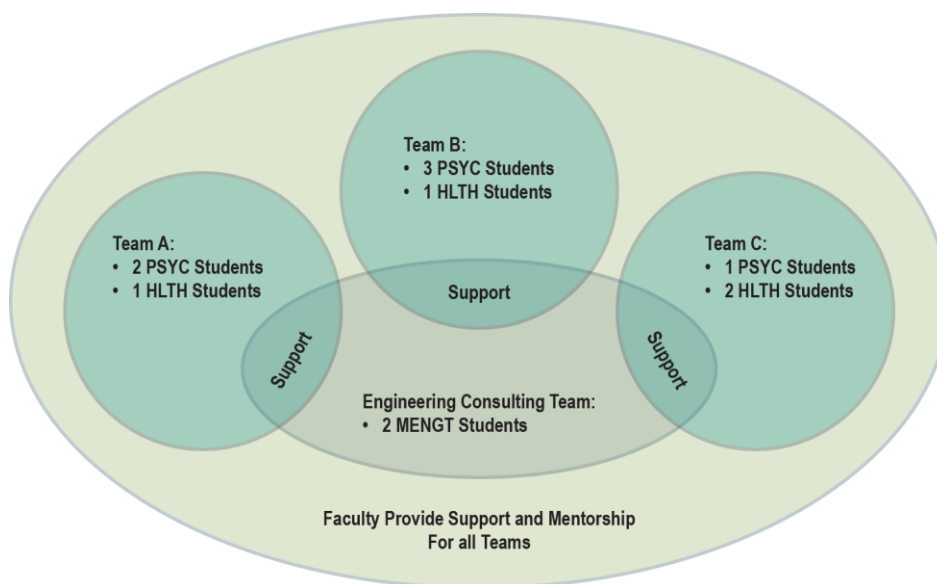


Figure 3: Team composition and interaction

From the vantage of engineering students enrolled in this course, their learning modality most closely resembled a hybrid, networked learning typology due to their need to both work within their own discipline-specific team and across multiple interdisciplinary teams. The latter groups were comprised of social science (health science and psychology) students, a tighter disciplinary clustering on an interdisciplinarity scale [21]. The engineering students provided technical consultation for each of these teams during the semester-long project. As the project required students to address sustainability in the form of large-scale transportation and health access solution, it fell within Nikitina’s “problem-centering” typology [20].

The overall flow for the course is presented in Figure 4. Initial weeks were spent introducing students to the other disciplines and the Restorative Cities model established by Roe and McCay, with the text adopted as required reading [23]. This model provides an overview of urban design elements that research connects with mental health and wellness gains. The seven design constructs introduced include green, blue, sensory, neighborly, active, playable, and inclusive cities. Each element is described, supported with available mental health research and proposed etiologies, and exemplified with urban design ideas. This model bridges the wellness and design domains, complementing the systemic thinking students were expected to apply in their project designs. Before introducing the project, a brief concept check paper shown in Appendix 3 was assigned to ensure students understood and were able to apply the restorative concepts. Additional course elements which prepared students for team-based problem-solving included class activities, guest speakers, formative assessment, and discussion to support foundational concepts, e.g. participatory design, sustainability, and safety.

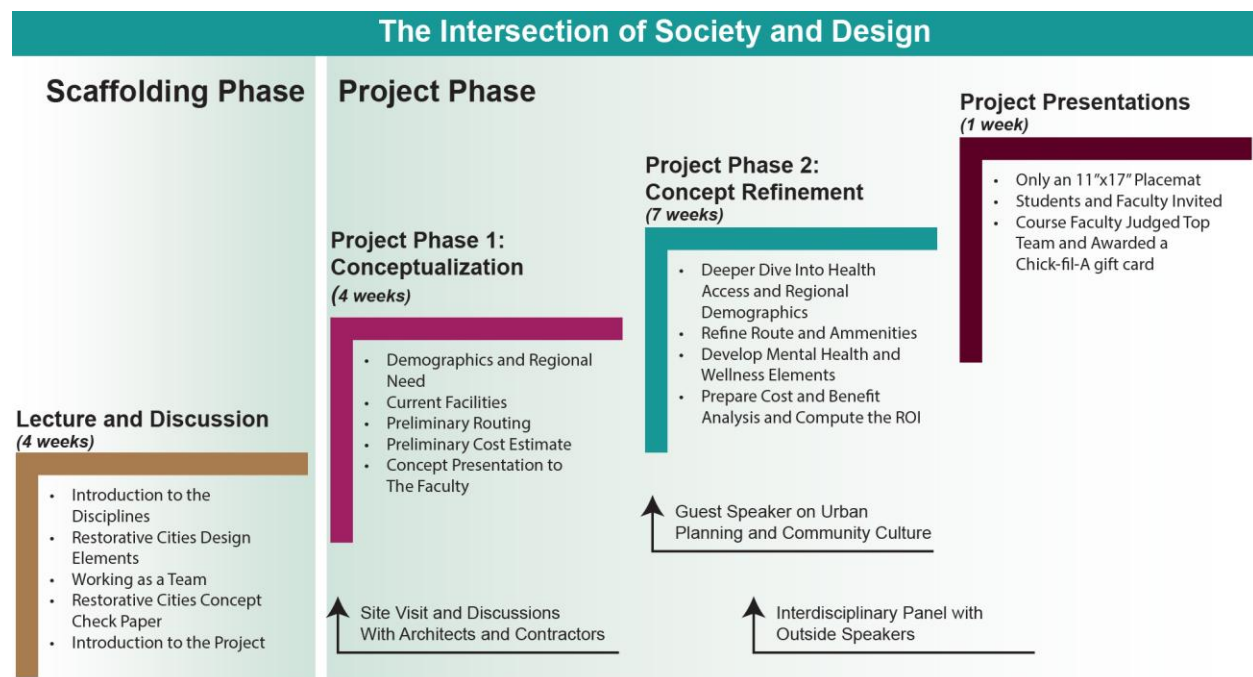


Figure 4: Overall course progression

After the first four weeks, the faculty transitioned students to team projects, which entailed designing a new rapid rail route connecting three urban areas, each with unique cultures, public health needs, and established infrastructure to consider. Students needed to determine

appropriate locations for a mental health hospital and for a children's hospital along the rail route. Directions specified the need to improve access to health facilities and overall community health and wellness by incorporating blue and green spaces. As such, regional demographics and culture needed to be considered. The project was cast in the form of a Request for Proposal as presented in Appendix 1. In hindsight, more time should have been included in Phase 1 (about one week), as this is the time when the students first got their "feet wet" and aligned their thinking related to expectations. The additional time for Phase 1 can be taken from Phase 2 without negatively affecting that part of the team project.

A part of the course included discussions with practicing architects and contractors about design considerations, public safety, and construction practices. At two points during the course, the students presented their design concepts and justification. For the presentations all that could be used was an 11x17 placemat, which required the students to be succinct and focused. The interim presentations were made to the faculty and critiqued. The final presentations were to an "open" group of faculty and administrators. In this first iteration of the course, individuals in the outside community were not invited, but this is being considered for the next iteration of the course.



a) Discussion with architects



b) Construction site visit



c) Presentation of design concept

Figure 5: Students engaging with professionals and making concept presentations

This course model is supportive of the Engineering One Planet (EOP) program of the American Society for Engineering Education (ASEE) [2]. Presented in Figure 6 is a mapping of the course objectives (CO) onto the eight EOP core outcomes.



Figure 6: Mapping EOP outcomes to course objectives.

Engineering Technical Elective

“The Intersection of Society and Design” can be used as a technical elective for participating engineering students. It explicitly addresses four societal impact outcomes in ABET/EAC Criterion 3: Student Outcomes. They are outcomes 2, 3, 4, 5, which emphasize the public health and safety impacts of design, ethical decision-making, collaborative productivity as a team member, and effective communication with diverse audiences [1]. The importance of making design decisions in economic, environmental, and societal contexts is emphasized from the perspectives of engineering and physical and mental health.

The course also can be considered as a design elective as it addresses an open-ended problem with multiple constraints and no immediately obvious solution. Working with the rest of the team, a solution must be developed that addresses the constraints in an effective manner. As stated, societal impacts are part of the design constraints, as are cost and schedule.

Course Assessment

Course learning objectives and value to students were assessed utilizing the ASEE-EOP evaluation tool, a retrospective pre-post student survey, and qualitative student answers to short answer questions.

Assessment of EOP Core Outcomes

As “The Intersection of Design and Society” was developed with the EOP framework in mind, the EOP Evaluation Tool [2] was used to retrospectively compare actual course experiences and student learning opportunities with this outcome measure. Each interdisciplinary group had some degree of latitude in applying sustainability in ways that supported their rapid rail and supporting structures designs. However, the intention was for all groups to expand communication and teamwork skills, develop capacity for critical questioning and systemic thinking, and balance the health-related impacts of design considerations and cost.

The faculty involved independently completed the Evaluation Tool. Interestingly, even though the instructors represented different disciplines, there was very close alignment in their assessment of achievement of the outcomes. Presented in Table 1 are the analysis results obtained utilizing the evaluation tool. A visual representation of these scores is presented in Figure 7.

Table 1: Faculty Analysis of Course Outcome Achievement

EOP Core Outcome	Evaluation Tool Score	Number of Course Outcomes (COs) Initially Mapped to EOP Core Outcome
Communication and Teamwork	91%	2: CO 1 and CO 6
Social Responsibility	70%	2: CO 1 and CO 5
Critical Thinking	69%	2: CO 3 and CO 4
Systems Thinking	67%	6: CO 1, 2, 3, 4, 5, and 6
Design	50%	2: CO 2 and CO 5
Environmental Literacy	50%	5: CO 1, 2, 3, 4, and 5
Environmental Impact Assessment	17%	Indirectly Mapped
Materials Selection	7%	Indirectly Mapped

That the core outcome of Communication and Teamwork was a relative strength (91%) was affirming, but not unexpected as this anticipated outcome was a primary driver of course creation. The nature of the project and interdisciplinary/consulting class structure required students to adjust communication strategies if they were not immediately effective. Even so, additional didactic elements have been identified, such as brief videos on communication topics such as leadership, effective group membership, and use of decision-making tools for the next offering of this course. The process of team check-ins with faculty will be formalized, as well as meetings with team leadership to better model proactive communication planning.

Critical Thinking, Social Responsibility, and Systems Thinking all earned similar respectable scores (~70%), while leaving room for future growth. Critical Thinking may be expanded by inclusion of more objectives from the Advanced category. For example, the Health Science students could be directed to contribute research regarding potential health outcomes associated with design and quality of this data, supporting application of the precautionary principle. Psychology students, who have Cross Cultural Psychology included in their curriculum, are well poised to contribute understanding of diverse populations when considering design needs or motivating behavior change that supports sustainability. Attention to Social Responsibility will expand to include Public Policy faculty in the next iteration of this course. Systems Thinking was

well covered in the Core section but could be expanded with engineering student requirements related to system maps and/or life cycle analysis.

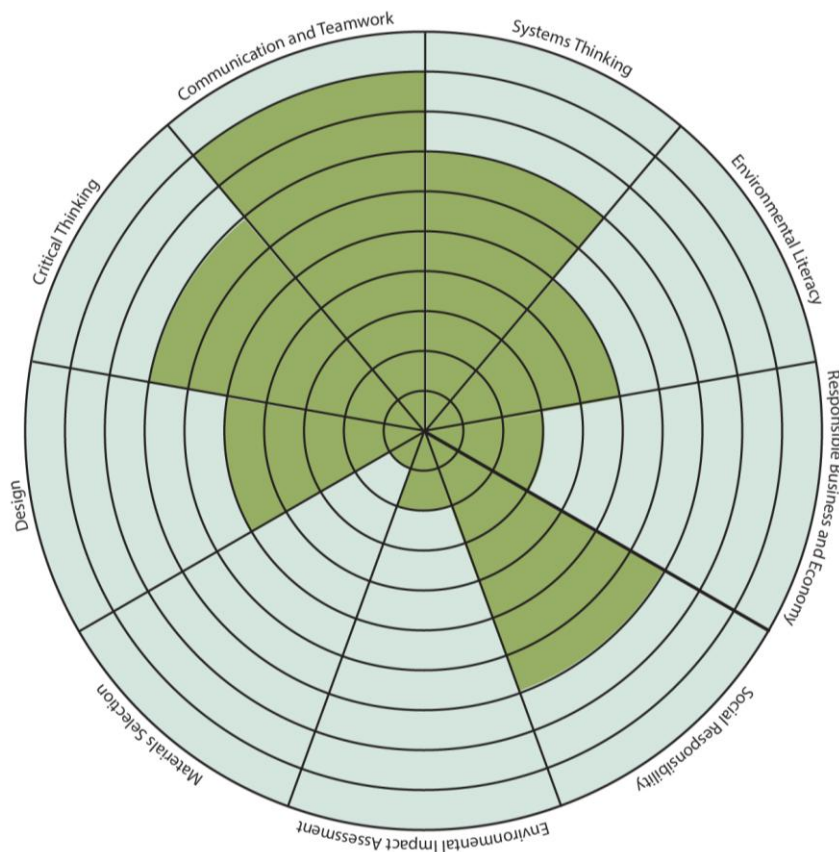


Figure 7: Graphical representation of analysis results

Materials Selection being a relative weakness (7%) is not surprising given that there was not an explicit course outcome for this EOP component. In future offerings, this could be developed by prompting engineering students to recommend materials for specific elements of the rail stations. For example, they could focus on roofing materials and/or hardscaping that minimize water runoff. More attention can be given to materials selection in the next offering of the course without overburdening the students, especially as they are preparing and justifying conceptual design rather than final design.

Compared to other explicit course outcomes, Environmental Literacy was a low performer. Environmental Impact Assessment, which was not a dedicated outcome, was also a low performer. Faculty perception of achievement of Environmental Literacy could have been negatively skewed unconsciously by the lack of discussion about environmental impact. Although these two items are related to each other, they are distinct items.

By including Public Policy students and faculty, improvements can be made by applying environmental laws and policies at various governmental levels. The instructors opted to utilize the Restorative Cities model to expand environmental literacy around design-health-mental health connections, as this provided benefit to all students within the interdisciplinary course.

While this text did not discuss engineering-specific concepts, it does summarize research regarding human benefits from connection with outdoor spaces and biophilic design.

Student Retrospective Pre-Post Survey

Students voluntarily completed a retrospective 20-question pre-post survey at the end of the semester regarding their perception of their abilities in multiple areas related to the course goals at the end of course. The survey was marked on a Likert Scale with 5 being strongly agree and 1 being strongly disagree. The weighted average results of the surveys are presented in Table 2.

A retrospective pre-post survey was constructed based upon course and student learning objectives and also Eagen et al [4]. A retrospective pre-post design was used because it controls for "response shift bias," when a question may assume a different meaning following new learning. [24] For example, a student may endorse feeling confident about knowing something before taking a course but afterward realize that they did not understand the question or know as much as they thought. A retrospective pre-post survey controls for this via one administration that follows learning, wherein participants are asked to remember what they knew prior to the learning condition (in this case, the course). In other words, students will be asked what they knew before and after the course in one survey administration.

Table 2: Results of student retrospective pre-post survey

Question	Question Topic Area	Weighted Average		
		Pre-Test	Post-Test	Change
Q13/33	Effective Communication	3.71	4.14	11.5%
Q14/34	Effective Communication With Diverse Audiences	3.00	3.86	28.6%
Q15/35	Working On Interdisciplinary Teams	2.00	3.86	92.9%
Q16/36	Listening	4.00	4.00	0.0%
Q17/37	Communicate Understanding	3.86	4.14	7.4%
Q18/38	Critically Think About Your Discipline	4.29	4.29	0.0%
Q19/39	Critically Think About Other Disciplines	2.43	3.57	47.1%
Q20/40	Critically Think And Ask Thoughtful Questions	3.29	4.14	26.1%
Q21/41	Natural Settings: Env. Influences	2.57	3.57	38.9%
Q22/42	Recognize Environmental Influences On The Built Environment	2.86	3.71	30.0%
Q23/43	Recognize Influences Of Psychological Factors On Design	2.43	3.71	52.9%
Q24/44	Recognize Influences Of Social Factors On Design	2.43	3.86	58.8%
Q25/45	Recognize Behavioral And Environmental Connections	2.00	3.86	92.9%
Q26/46	Apply Research	3.14	4.00	27.3%
Q27/47	Recognize Connections Between Design And Community Services	2.43	4.00	64.7%
Q28/48	Ask Question About Resilience, Health & Community Development	2.43	3.86	58.8%
Q29/49	Communication Across Constituencies For Projects	2.00	3.86	92.9%
Q30/50	Develop Team Workflow	3.57	4.14	16.0%
Q31/51	Develop Interdisciplinary Team Workflow	2.57	4.00	55.6%
Q32/52	Evaluate Interdisciplinary Team	2.57	3.71	44.4%

At the beginning of the course, weighted averages ranged from 2.0 to 4.29. Recognizing behavioral and environmental connections, communication across constituencies, and working

on interdisciplinary teams received the lowest scores. They rated themselves highly in listening and critically thinking about your discipline, 4.0 and 4.29, respectively.

By the end of the course, all questions received a weighted score of 3.57 or above. The two highest scores at the beginning of the course remained the same at the end of the course. The two lowest scores at the beginning of the course both showed more than a 90 percent increase in perception. A very favorable outcome in relation to societal impact was the nearly 65 percent increase in the recognition of connections between design and community services and the nearly 59 percent improvement in the recognition of social factors on design. Overall, the changes in perceptions and understanding by the end of the course was very satisfying and encouraging.

Table 3: Student overall perception of the course

Student Observation	Weighted Average
In this course, I was exposed to ideas and methods that I would not have otherwise been exposed to in my discipline	4.75
This course brought together disciplinary perspectives in a useful way	4.38
This course caused me to think in ways different from conventional theories of my discipline	4.50
The format of this course helped me to improve my ability to communicate directly with other outside of my discipline	4.25
The format of this course was useful for learning skills to communicate directly with outside my discipline	3.55
Participate in this course helped me to develop skills to communicate better with people in other disciplines about issues affecting diverse groups of people.	3.63
How useful for the course requirements (Project Phase 1 and Phase 2) for increasing your understanding of the need to work with other disciplines to incorporate sustainable elements into design?	3.63
How useful for the course requirements (Project Phase 1 and Phase 2) for increasing your understanding of the need to work with other disciplines to incorporate health-promoting elements into design?	4.00

Student Overall Perception of the Course

In addition to the surveys at the end of the course, the students were asked to complete a survey related to their overall perceptions of the course. The results of this survey are presented in Table 3. These results are quite satisfying and demonstrate achievement of the course objectives. Two

responses are particularly pleasing: student perspectives were broadened as a result of this course. Those responses relate to being exposed to ideas and methods outside their discipline, scored at 4.75, and being caused to think in ways different from conventional theories of their discipline, scored at 4.50.

Table 4: Qualitative student comments regarding the course

Favorite part of the course	
How personable it was. With three professors going through or have experienced interdisciplinary work relationships, it set the tone for the semester.	
Learn about other disciplines	
Skill development	
Restorative design	
Calculating budget. I guess I like numbers more than I thought I would.	
Least favorite part of course	
Creating team workflow. Had we outlines/planned better utiliz(ation) of (the) assignment, we would have spent our time must more efficiently and effectively.	
Making presentations	
Group work	
Not enough engineers to have an engineer in each group	
Phase 1 - felt like I had no idea what I was doing	
Tools, strategies and/or practices most important for those entering the workforce upon graduation	
Planning, how well your articulate your plan, listening. Your plan is only as good as you articulate it.	
Articulate your plan in their (those from other disciplines) language. You learn their language by listening.	
Communicate, critical thinking, skills, learning different discipline, not being afraid to learn something new regardless of your degree	
Networking, interviewing skills, professional development, strong communication skills, open-mindedness	
An open mind, self-assessment, teamwork/collaboration, skill diversification, boundaries	
Taking initiative, interdisciplinary work, remaining resilient, network, serve community	
Knowing what you know now, what advice would you give to future students in this course	
Listen. A good question answer offers more questions so listen, listen, listen. I often thought of success as pen to paper and if I understood that planing is 80% of a project, I would have spent more time asking and listening.	
Work hard together	
Not to be scared of (not) knowing (anything) and asking will lead to bigger outvcomes and ealrning something new can take your ability to gain new skills for your future.	
Foster collaboration	
Knowing what you know now, what advice can you offer to your boss (next instructor teaching this course) to better promote and encourage employee(e.g. student) sucess	
The classroom should never be quiet. The teachers did a great job of fostering that environment.	
Definitely try to go over in a more interactive way the different disciplines. We learned a little bit about them but it didn't really seem all that helpful to the class/project. ...Maybe dive more in depth into the restorative model. Also the Gantt chart seemed very random to me and genuinely had no purpose other than an extra stressor to get done.	
Provide an example or outline of the project to students in the course, so they have a vague idea of what the project looks like. I think that was the hardest part of this class because we set the tone for what this assignment looks like going forward.	

In addition to the surveys, the students were asked for comments regarding the course. These comments are presented in Table 4.

As with the other assessment data, these comments are encouraging, and at times, humorous. A couple of the more notable comments include “I guess I like numbers more than I thought I would,” and “Don’t be afraid of not knowing and having to ask, and listen, listen, listen.”

The final comments about what advice the students would like to give to the instructors are not surprising. The instructors recognized that the students struggled at times but always pulled through those struggles. The message was also very clear that more information needs to be provided about the different disciplines. Project scheduling also needs to be discussed in greater detail. These suggestions will be incorporated into the next offering of the course.

Additional observations and reflections of the students and faculty can be found in a paper entitled “Intersection of Design and Society: Student and Faculty Reflection on an Interdisciplinary Course.” [25]

Concluding Discussion and Final Thoughts

The Intersection of Design and Society provides another option for structuring interdisciplinary groups within existing typologies. The engineering students, as a dyad, functioned as consultants with three interdisciplinary groups. This approach solved the practical problem of low engineering enrollment, but provided a real-world consulting scenario for the engineering students. There were gains in terms of workflow management and proactive communication that may not have occurred had the engineers been truly integrated into the interdisciplinary groups.

Use of the EOP Evaluation Tool provides guidance for refining learning objectives and student outcomes. For example, including objectives relevant to materials selection would provide engineering students a greater depth of experience with identifying sustainable materials. However, this same objective may benefit non-engineering students as well, as they consider material selection evidence-based impact on human factors, such as noise pollution, visual complexity, etc. Each alteration of a learning objectives requires taking the perspective of each participating discipline/major.

As a result of working with students throughout the course, the need to incorporate a fourth discipline, Public Policy, into the next iteration of the course became apparent. Greater emphasis on materials selection within the project rubric may provide an opportunity for public policy research, especially at local levels. In the same context, the compensation piece referenced in the RFP was dropped as an expectation during the current offering and will be eliminated in future offerings. It was perceived as an innovative idea, but it became too time-consuming and students needed additional scaffolding to incorporate a payment structure into their Gantt charts. In hindsight, it provides little tangible benefit.

Due to the small sample size, student survey results are interpreted cautiously. However, present results point toward alignment between student perception of their own gains and the EOP Assessment tool. Survey questions pertaining to communication and management of interdisciplinary team workflow yielded pre-post shifts toward higher perceived competency. Critical thinking/questioning was another area of competency gain from the vantage of students. While questions pertaining to design influence/impact on health and mental health were posed, there were not have enough participants to analyze results by major; the results were evaluated holistically.

Interestingly, in retrospect, at the beginning the faculty had the same “deer in the headlights” feeling as the students. Coming from different professional backgrounds, the faculty had to learn each other’s language, and the concerns of the other’s disciplines had to be put into the context of their own. As all were experienced educators, each had their own pedagogical style, all of which had to be melded into a composite style without sacrificing individuality. Was this a challenge: Yes. But also interestingly, the faculty did not recognize the challenge; there was a natural evolution as they strived to reach a common goal. Student responses, as previously discussed, reflect these same feelings.

Overall, while the challenges unique to interdisciplinary education, especially the administrative challenges, had various ranges of difficulty, the faculty and the students alike believe that the overall experience was quite positive and would undergo this same experience again (while making improvements for students) with no question or hesitation.

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Appendix 1: The Team-Based Course Project

To provide more realism, the team project was cast in the form of a Request for Proposal (RFP). The text that was given to the students is provided following for information. The elements of the RFP were developed by the faculty to achieve explicit involvement of all participating disciplines. The full scope of the RFP evolved over a period of about four months; it is not based on a real project. The project was intended to be as open-ended as possible, with the design constraints evolving as the students worked together. The only explicit constraints were the major terminus points, rapid rail, children's hospital, mental health hospital, and improvement of community health and wellness. As a side note, the team project is expected to change with each offering of the course.

The cost data provided were estimated and were included in the project so the students could begin to develop an understanding of the magnitude of cost in a community development project and the economic benefit to the community.

Request for Proposals

Proposals are requested for conceptual routing of a rapid rail system with major stations located at Houston, San Antonio, and McAllen Texas. The system can be electric or diesel electric, or a combination of both. Additional station stops should be located along the route to serve communities by providing greater access to facilities and amenities along the way. Included in consideration should be locating a psychiatric hospital and a children's hospital in one of the communities served by the rapid rail system to enable greater access to services in regions where access is limited. In regard to the two hospitals, an estimate of the number of beds needed and estimated cost is all that is required; design of the hospitals is beyond the scope of this RFP. All questions regarding this RFP and expectations must be submitted in writing; answers will be provided to all potential responders.

This solicitation contains two phases:

1. Phase 1: System level perspective of the project with preliminary cost and health, wellness, and economic impact to the community.

This phase should include estimates of needed right-of-way, cost of construction, the number of individuals potentially served by the additional stops, and the health, wellness, and economic impact to the region (greater access to goods and services on the positive side and displaced families and individuals on the negative side, for instance) and estimated return on investment (ROI). Recommendations should be made as to the potential communities in which the two hospital facilities can be located. The Restorative Cities Model, and sustainability considerations must be used as a basis for the proposed route and related facilities and features. Design or selection of the rolling stock is not a part of this RFP; responders to this RFP are only expected to recommend the type of rail system (electric, diesel-electric, or . . .) and what are considered to be the necessary amenities onboard.

Each responder will submit a 5-page written response and will present their design concept. Each written proposal should begin with, a summary of the route and facility

locations, the population served and estimated costs of construction and economic benefit to the communities served. Each proposal must include a development timeline with milestones for the Phase 2 development and the estimated costs associated with each milestone. To fully evaluate the strength of your proposal, references for all assumptions must be included.

Phase 1 concept proposals are due by 1:00 PM on 10 October 2024. Proposals should be submitted electronically as a single pdf file to ASEE-EOP@rellis.tamus.edu.

Each design team will present their schematic design concept in a 10-minute presentation on 10 October 2024. During that presentation only a single 11x17 placemat can be used. The front side of the placemat should show the conceptual route with station stops indicated. The back side of the placemat should summarize the rationale for the conceptual route, the type of rail system recommended, the populations served, and the estimated costs and economic impact. PowerPoint presentations will not be permitted.

One or more Phase 1 responders will be requested to submit a Phase 2 compensated response.

2. Phase 2: Conceptual schematic design for the proposed route, as selected from Phase 1 including access to services, the communities served, environmental and economic impacts, health and wellness impacts, and cost.

As in Phase 1, the Restorative Cities Model and sustainability should be used as the basis for the proposed route and related facilities and features.

At the conclusion of Phase 2, each responder will submit a 10-page written response. Each written report should begin with a summary of the route and facility locations, the population served and estimated costs of construction and the health, wellness, and economic benefit to the communities served. This estimate should be more refined than that which was submitted in Phase 1 and can contain additional elements to improve ridership and service to the community. In addition, a plan to engage stakeholders in final design must be developed and presented. As in Phase 1, design or selection of the rolling stock is not a part of this RFP; each responder to this RFP is only expected to recommend the type of rail system (electric, diesel-electric, or . . .) and what are considered to be the necessary amenities onboard. Concept drawings for the stations, retail spaces and green spaces indicating the restorative cities elements for each should be included.

To fully evaluate the strength of the proposal when selecting the final contractor, references for all assumptions must be included. These should be listed at the end as well as included as in-text citations.

Phase 2 schematic designs and written responses are due by 11:59 PM CST on 2 December 2024. Schematic designs and final responses should be submitted electronically as a single pdf file to ASEE-EOP@rellis.tamus.edu.

Each design team will present their schematic design concept in a 15 to 20 minute presentation on TBD 2024. During that presentation only a single 11x17 placemat can be used. The front side of the placemat should show the proposed route with station stops and added facilities and amenities indicated. The back side of the placemat should summarize the rationale for the conceptual route, the type of rail system recommended, the populations served, and the estimated costs and economic impact. The responding team should be ready to justify their conceptual plans and the economic costs. PowerPoint presentations will not be permitted.

Initial compensation for Phase 2 will be based on ten percent (10%) of estimated Phase 1 construction cost. Milestone progress payments will be made to Phase 2 teams based on estimated construction costs and economic and societal impact at the respective milestones. Milestone payments will be decreased by ten percent (10%) of costs more than that proposed in Phase 1 and will be increased (or decreased) by ten percent (10%) of the economic benefit for the communities served proposed in Phase 1. Milestone progress payments will be made based on estimated costs for that milestone compared to the total budget provided in the Phase 1 proposal.

Phase 1 and Phase 2 submittals must include consideration of the environment, social responsibility, materials selection and sustainability, and mental and physical wellness outcomes. Use of the Restorative Cities model is essential.

After Phase 2 evaluations are complete, the successful responder will be selected for final design. The selection of the winning team will be based on Return on Investment (ROI) as computed by the estimated economic benefit to the community versus the estimated cost of construction. Please note that cost information will be reviewed by an outside group for reasonableness.

Appendix 2: Assumptions and Suggested Construction and Impact Costs

Basic Assumptions

• Mental Health Facility (GSF per patient served)	250
• Children's Hospital (GSF per patient served)	200
• Single-Track Right-of-Way (feet)	60
• Dual-Track Right-of-Way (feet)	100
• Rail Stations (GSF per person served, including retail at station stops)	85
• Retail Space (GSF per person served, including exterior access)	200

Construction Costs:

• Track (per mile)	\$2,100,000
• Right-of-Way Acquisition (per acre)	\$50,000
• Overhead Electric Lines (per mile)	\$750,000
• Displaced Families (per family unit)	\$250,000
• Mental Health Facility (per GSF)	\$850
• Children's Hospital (per GSF)	\$825
• Major Rail Terminus (per GSF)	\$750
• Rail Station Stops (per GSF)	\$525
• Retail Space (Separate from space at station stops) (per GSF)	\$575
• Garden Spaces/Green Spaces (per SF)	\$225

Community Impact

• Healthcare Access (per person annually)	\$15,000
• Greater Retail Access (per person annually)	\$8,000
• Community Parks/Greenspace (per person annually)	\$1,250

Appendix 3: Prompts for Restorative Cities Concept Check Paper

- 1) Discuss the interdisciplinary nature of Restorative Design by weaving together at least three of the following fields: Behavioral Economics, Health Science, Environmental Psychology, Engineering, and Health Psychology. You may select any three but be sure to describe examples of how the three disciplines work together (e.g. what types of problems and solutions they tackle).
- 2) Using your text and three relevant abstracts from the research literature, what are two possible biochemical mechanisms may be responsible for the link between urban green space exposure and health/mental health outcomes? In other words, how do researchers explain what green exposure is doing to the brain and body?
- 3) Describe three examples of urban blue spaces in our city that you think have the best odds of reducing disability adjusted life years (DALYs). Support your answers with research mentioned in the text and/or what you find independently. Describe at least two other elements of the restorative model (sensory, neighborly, or inclusive) that are present in the space. You may upload pictures if helpful.
- 4) The photo below shows a park in an urban environment. A) Identify the Restorative City elements you see in this photo and justify your answer. B) Based on this photo, let's say you have a 10x10 foot space to use for play as defined in class. What would you include that would enable at least 2 different examples of play? Describe your response and justify how these meet the definition of play. C) What are the engineering infrastructure considerations needed to support the park below and the 10x10 "play space" that you identified?

