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Supporting and Identifying Student Agency and Holistic Growth in an Engineering Program

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Introduction

Traditional engineering curriculum and course structures prioritize preparing students for technical and logical reasoning skills that are intrinsic to becoming an engineer. While these skills are undeniably vital for an engineering career, these courses often fail to provide opportunities for students to explore skills that go beyond the traditional curriculum and classroom walls. In addition, course structures often reinforce the stereotypical narrative in engineering that there is a dichotomy between the social and technical aspects with the latter being more important. Preparing students for both social and technical sides of engineering, requires a reorganization of how learning environments are designed and how engineering programs and faculty evaluate how learning occurs.

The need to prepare students to work on socio-technical issues is better reflective of how they will be working as an engineer and the types of 21st century problems that are currently in need of attention [1]. Global-scale, complex, socio-technical problems are often referred to as convergent problems in the field of engineering [2]. A key characteristic of convergent problems is that they are not well addressed by traditional approaches, because they require the sharing and application of ideas and methods across multiple disciplines and partners in order to create new ideas, methods and potential disciplines that can address these challenges. Creating education models that allow students to work on convergent problems requires programming that highlights engineering expertise, personal knowledge and experience, as well as insights from broader fields such as the social sciences, humanities, policy, and education. Preparing students to work on convergent problems goes well beyond the technical knowledge required to be an engineer. It requires students to demonstrate their own agency in making decisions, setting goals, and working with others. The kind of learning effective in supporting students in these areas is framed as being holistic to encourage critical thinking, creativity, and empathy [3]. By focusing on student agency and holistic education, we aim to create more impactful learning opportunities to prepare students to address convergent problems and be better prepared to address complex challenges in the 21st century.

To address these challenges, an Electrical and Computer Engineering (ECE) department is redesigning its curriculum and learning environments. The redesign is also aimed at supporting students who have been historically marginalized in engineering. This includes providing opportunities to better prepare students to enter a variety of fields, including but not just limited to engineering [4]. This study investigates the process of designing a “course” that students take for seven of the eight semesters they are enrolled in the ECE program to promote student agency and have a holistic engineering education experience. The course is designed to integrate with the department curriculum to make out-of-class learning more visible. This allows students to pursue personal interests, and promote a more personalized and collaborative engineering education model that nurtures both academic and personal growth. Another inspiration for this course is to support students in building relationships and connections with each other and faculty. Students enrolled in the ECE program have communicated that they want to connect with other students in the program, especially across class years. These connections are valuable

because they enable students (and faculty) to learn more from engaging with multiple perspectives that can position students to better navigate the program and the structures of the university. This course is also intended to serve as an ongoing semi-formal opportunity for peer interaction that can carry over into more formal teamwork settings in other parts of the curriculum.

In this paper, we present initial findings from the pilot version of this course. The pilot version included two faculty (the first and second author) and eight students that co-designed an experimental course in the department. This study is considered Year 0 in a four-year longitudinal study of multiple iterative cycles of the design and redesign of the course to meet the following goals. (1) Create time, space, and support for students to integrate and align their learning across their co-curricular and personal experiences. (2) Provide students with opportunities for self-driven exploration of their interests and values and the connection with their engineering interests. (3) Create environments for students to build, contribute to, and receive support from the collaborative community around them. Due to the iterative structure of this four year design and redesign of a course experience, we employ design-based research (DBR) methods to better address both practical and theoretical challenges that arise through multiple designs and implementations of a course, while also prioritizing engaging students in the co-creation of the experience [5]. We identified the following research questions for this effort.

1. How did students and faculty work collaboratively to conceptualize student agency and holistic education throughout this course?
2. What specific course design elements significantly influenced student agency and the development of holistic growth?
3. What barriers and challenges did students and faculty encounter when designing this course?

Findings from this study will be incorporated into the next iteration (or Year 1) of this course to further examine how students develop their own agency and holistic growth. In the remaining sections of this paper, we begin by describing student agency in the context of this study. Then we discuss what holistic education is in an engineering context. This is followed with a description of the methodology and context of the study. We then explore the themes that we identified in student reflections and faculty memos as criteria that can support a course that promotes student agency and holistic growth. Finally, we conclude with a discussion of challenges and barriers encountered, as well as next steps for revising the course design.

Student and Relational Agency

Social theorists have long argued the role that agency has in human behavior [6]. Agency is often discussed as the ability that individual actors have in making and acting on their own choices. This ability to choose is dependent on the boundaries of others, including the social and institutional structures that may or may not be in opposition with their agentic practices. Such dynamics illustrate how agency is less of an individual outcome and more of a sociocultural function [6]. In education, agency is a component of reform-based learning that is often linked to critical thinking, collaboration across disciplines, problem solving, teamwork, professional development and career interest, and other criteria that are described as valuable 21st century

skills [7]. Previous studies that examined student agency in undergraduate engineering education have focused on student agency in relation to career choice [8]; collaborative problem solving and project based learning [9]; and supporting historically marginalized students experiences in engineering programs [10].

A vital aspect of student agency is relational agency, which is understood as the ability to offer support and ask for support from others [11]. Relational agency exists between students and their peers, as well as student to faculty and faculty to faculty. Here, agency is not only decided as how students respond and act on different opportunities or lack thereof, but also understood as a capability shaped by the interaction between students and faculty, and among faculty members. The role of an instructor that seeks to center student agency, can be considered more of a coach, a moderator, or facilitator of learning experiences. Within the context of engineering education, relational agency is extended to how people work together in complex interdisciplinary environments [12], acknowledging that it is required to solve problems when there are different skill sets, expertise, and experiences needed.

Holistic Engineering Education

To understand how this course reflects the whole student, we frame the learning experiences as a practice of holistic engineering education. Holistic education refers to learning that goes beyond classroom and disciplinary boundaries to address the growth of the *whole* person. This ecompasses the intellectual, social, physical, emotional, spiritual, and other characteristics that make up an individual. These types of qualities are broadly encouraged in a liberal arts education [13]. Deriving from the Greek word *holos*, holistic refers to an entire system that is indivisible and made up of interconnected parts [14]. A holistic education is therefore understood as the interconnectedness of living in this world by incorporating self-awareness, social collaboration, and preparing students to meaningfully and responsibility engage in the world [3]. This situates the student as an active participant in their learning. In this setting, the role of the educator is more of a facilitator of student learning, guiding students through different experiences and choices. A perspective of holistic learning recognizes that wholeness does not equate to sameness. Rather, there are multiple ways of knowing and doing that shape the experience of reality within a single learner, just as there is within an entire learning community.

Holistic education is often conceived as contrary to a more mechanistic, pragmatic approach that is actively preferred in engineering education [15]. Yet, many engineering practices can be explained through interdisciplinary systems that result from holistic understandings of how people, environments, and things function. Grasso and Berkins write that holistic engineers “are engineers who manage, lead, and understand complex, interdisciplinary systems that bring the power of engineering through issues spanning and connecting technology, law, public policy, sustainability, the arts, government, and industry” (p. 1) [16]. A holistic engineering education equips students with a multitude of skills and experiences that better reflect collaborative problem-solving in the real world. It is then reasonable to conclude that a holistic engineering education can better prepare future engineers to work in fields that are in continual flux. Similar to convergent work, holistic engineering education moves beyond traditional disciplinary knowledge to address societal challenges [17]. This is most commonly applied in cross-disciplinary methods, where students are encouraged to practice problem-solving that

moves beyond technical solutions, both while pursuing their own interests and collaborating with others. Faculty who provide students with opportunities to shape their own learning, promote agency, self-awareness and collaboration are considered important to the development of engineering programs and the holistic engineer [16].

Methodology

Design based research (DBR) focuses on developing interventions grounded in iterative cycles of design, enactment, analysis and redesign in real-world settings. This methodology is often applied in educational research to create both practical and theoretical knowledge that addresses recurring challenges in educational settings [18]. Developed from socio-cultural learning [19], a key requirement of DBR is to examine a learning environment as a dynamic system. This includes the relational perspectives of multiple different actors (e.g. students, educators, researchers, etc.) and context-specific tools, as well as the environment where the activities occurred. DBR moves beyond an understanding of examining interventions as successes and failures towards an understanding of learning as a cyclical approach of "messy situations" [5], which involves continual refinement. In this context, the process of iterative design allows for a more nuanced understanding of how learning takes place.

In this study, faculty and students collaboratively designed a course as they were participating in it. The two instructors of the course (the first and second authors) wrote reflexive memos during and after the course documenting its progression [20]. This included reflecting on how students responded to different activities, and how they built a collaborative environment. At the same time, students wrote reflections on the different activities that they participated in. We identified three themes from the memos and student reflections: self-awareness, professional exploration, and collective collaboration. These themes were further mapped onto specific components of the course design to better understand their pedagogical impact. While this study is context-specific, the approach and findings are relevant to a range of educational contexts seeking to support student development through collaborative, cohort-based models.

Context

This study took place in an ECE department at a liberal arts university in the Mid-Atlantic region of the United States. In contrast to degree programs in research universities, engineering in a liberal arts context typically offers more breadth, including options to study across disciplines; smaller class sizes; and greater ability for professors to engage with students on an individual basis. Student cohorts in the department (enrollment per year) range in size from 15-35 students, resulting in tight-knit peer groups within their class year. However, there are typically few in-class opportunities for students in this program to connect with other ECE students across class years, especially for first and second year students. The department has a great deal of control over the students' academic experience; it specifies 75% of the courses that students take. Meeting the Accreditation Board for Engineering and Technology (ABET) requirements is fairly simple in the areas of electrical and computer engineering because there are only a small number of specific course requirements [21]. Approximately 50% of the required courses in the ECE curriculum are taught by the department. The faculty in the department often view the program as the primary nexus of a student's experience at the university, as at least half of their

time in the program is spent in ECE classes. We acknowledge that the structural aspects inherent to a liberal-arts focused university provide the flexibility to create non-traditional approaches like a multi-semester “course” experience that might be more difficult to carry out elsewhere.

The department, being fairly small and controlling much of the students' time, also serves as a major center of community. While students often engage with Greek letter organizations, sports, residential programs, and other campus activities, many ECE students form strong connections within the ECE community, with faculty, staff, and of course, peers. A hallmark of the student experience, often acknowledged by alumni, is the personal connections that they have with the faculty and staff in the program. This context uniquely positions the program to pilot this type of initiative without the need for major changes to university requirements or structures.

Co-Designing with Students

The pilot course was offered to students as an optional elective course. We recruited students from the sophomore, junior, and senior classes in the department via a broadcast email. Eight students volunteered and all were accepted, because we did not have any exclusionary criteria as a component of the study and the number was manageable. Four of the students were pursuing a minor outside of engineering and one student was pursuing a second major outside of engineering. Three were female, four were male, and one was non-binary. Three of the students were from underrepresented racial/ethnic groups in engineering. Three of the students were first-generation college students. These demographics are not representative of the department as a whole. A majority of our students are male and white or Asian which match the demographics of electrical and computer engineering nationally [22]. Further analysis is required to understand if the demographic profile in our study shaped any of the findings.

In the course, we tested several exercises and collected student feedback. Because this small class met in a conference room with a single large table, we often engaged in whole group discussions related to or stemming from the assignments or topics. A book discussion scaffolded the beginning of the course and a collection of other assignments followed. Some assignments were run once, modified based on feedback, and run again later on. At the end of the course, we asked the students to create the syllabus and assignment calendar for the next iteration.

Findings

In this section, we describe three themes that we identified to address our research questions: self-awareness, professional exploration, and collaborative network. In addition, we discuss the challenges and barriers encountered during the course implementation.

Self-Awareness

Self-awareness emerged as the first major theme from our pilot course necessary to support both holistic education and student agency. In the context of the course, self-awareness is defined as understanding oneself and pursuing personal growth. This theme was addressed across many of the course activities and intentional self-reflection prompts.

One of the primary tools to promote ongoing self-awareness was weekly reflections, where students responded to prompts in their course ePortfolios. While initially intended to document student experiences in the pilot course and inform future course iterations, these reflections proved to be a valuable tool for students encouraging introspection and enabling students to identify areas for agentic growth. Additional key course activities supporting self-awareness included the following activities.

- Reading, discussing and completing exercises from *Designing Your Life* by Burnett and Evans, 2018 [23]
- Attending campus events that encouraged exploration and engagement
- Identifying and completing personal "quests" that supported individual development goals

Reflection, an integral component of learning, enables students to externalize thought, making thinking visible and integrating new knowledge with existing understanding [24]. Our previous work suggests that even a single exposure to ePortfolio activities during the first year enhances reflective thinking, preparing students to engage more effectively in reflection throughout subsequent courses [25].

Two key areas where course activities and reflections promoted self-awareness were exploring personal interests and reflecting on experiences.

Personal Interests and Their Impact: A key objective of the course was to encourage students to reflect on their personal interests and integrate them with their educational experiences and future professional goals. Early in the course, one of the reflection prompts asked students to list their interests, select their top two, and explore ways to connect these interests to course events and quests. At the end of the course, one student reflected on this exercise: "*I thought this was really helpful in identifying what I really enjoy. This helped me later to decide what my next quest would be*."

The personal quests, in particular, provided meaningful opportunities for growth and exploration. One student shared, "*Quests were undoubtedly the highlight of the course for me. My quest focused on the development of my skills, directly related to my brand. It proved to be incredibly rewarding*". These reflections illustrate the course's ability to support students in connecting their personal interests with meaningful activities and how this can lead to greater self-awareness and more purposeful decision-making.

Value in Reflecting on Experiences: Many universities have struggled with declining student engagement and lower attendance at campus events post-COVID [26]. In the pilot course, students expressed excitement about the encouragement they received to attend events. While many students were interested in these opportunities, prior to the course they often did not make them a priority. Reflecting on events as part of the course allowed students to gain deeper insights and greater value from these experiences, even if they might have attended without the course's added incentive.

Students appreciated the chance to explore and engage with a broader part of the university. Students shared their excitement about this reflective process: "*Events! I love going to events, and it is so fun to reflect, or take pictures at the events and then write about them for class credit. I also love going with people to events, so this is a great way to access the rest of the university.*" Another student remarked, "*My favorite aspect of the course has been being able to explore [our university] (mostly through events) but also my own interests. I already went to a lot of events, but reflecting on them and having to develop my thoughts and either things I learned or other useful aspects made me appreciate the things we have here.*"

Developing self-awareness is inherently challenging because it requires individuals to confront and critically examine their own thoughts, emotions, and behaviors, which can be uncomfortable and difficult to navigate without external guidance or reflection. In the course, trust had to be built before students were comfortable with this level of sharing and introspection. Reflective prompts were assigned with varying levels of structure and guidance, and some students expressed discomfort with the more open-ended prompts. Additionally, time constraints and competing academic demands can make it difficult for students to reflect thoroughly beyond a superficial level. Looking ahead, weekly reflections may become less feasible in future course iterations, as the reduced credit hours will provide students less time to dedicate to the course. Some example prompts are included below.

- Create a list of times when you have failed - you may keep this to yourself or share. Talk about the commonalities that you see in your list? In your view, what constitutes a failure? How has your mindset of failure changed over time? During college?
- Provide feedback on this week's peer advising session regarding course registration. Reflect on the session's strengths and areas where improvement is needed. Additionally, suggest changes that could make future advising sessions more beneficial for students.
- Connecting across courses - Organize your courses into groups, each based on a unique theme - one theme per group. Each course you have taken must connect to at least one theme. Briefly explain the theme of each group and why each course fits in with that theme. The goal is to maximize the number of themes, maximize the number of courses in each group, and maximize the diversity of themes and courses in groups. In short, more is better, in every dimension. Which courses appear most / least frequently and why? What else did you notice as you created these groupings?

The course provided students with both the opportunities and structure to expand their experiences while reflecting on their learning and growth. Through exploration of their interests and intentional reflection, students gained a clearer understanding of themselves and developed a clearer vision of how to integrate their values and passions into their academic and professional journeys. This process of self-discovery was a critical element of our approach to a more holistic engineering education.

Professional Exploration

Professional growth emerged as another key theme, with students expressing a strong desire to be better prepared for campus career fairs, job interviews and the transition from college to a professional career. This course has replaced the curriculum's two-course seminar course sequence, where many of these topics were covered but not always aligning with when students

needed them. While the pilot course did not heavily emphasize traditional professional development, its activities and reflections clearly promoted growth, transferable skills and exploration which are essential foundations for career readiness. However, one challenge of integrating traditional professional development into engineering courses is that students often view it as disconnected from their technical curriculum. While many recognize its value, their focus on mastering technical content often leads them to brush professional development aside. As a result, some students saw this course as an ideal context to incorporate practical professional development experiences that align with their technical studies.

The discussions and activities from the Design Your Life book used in the pilot course supported professional development among the students. The book encourages readers to consider various career paths and create prototypes for potential future careers. One student reflected on an exercise in the book, stating, *"Another favorite of mine is how we discussed our paths. I know that at the time it took a lot of brain power to come up with multiple different 5-year plans, but this really helped me sort out some of my priorities and I think could be beneficial for everyone."* Another student added, "*I liked having the idea of redesigning my life because it is a fun and flexible way to be thinking*."

Collaborative Network

The value of collaborative networks is the final theme that emerged from this pilot course. Collaboration is essential not only for the success of the course but also for the development of students' social and professional networks. Collaboration between multiple departmental faculty members from the initial design phase helped to align the course objectives with student needs and broader department goals. The pilot course was co-instructed with close collaboration between the two instructors in all aspects of its design and delivery. Additionally, since the purpose of the pilot was to co-design the future course with student input, both faculty and students played an active role in shaping this experience and the next iteration.

For students, one of the most significant aspects of collaboration in the course was the peer-to-peer interactions. Students reported appreciating the unique opportunity to engage with classmates at various stages of their academic journey. One student shared, "*I enjoyed our class discussions and getting to know more about the department from my peers as well as the faculty. I looked forward to class every Monday and Wednesday, which is not a common theme for all of my courses.*" Another noted, "*I liked the communication part that was drawn from the in-class exercises. I found them to be extremely useful in connecting my life as well as hearing from others who are at different points in their life.*" The small-group discussions that centered around student experiences helped both instructors and students build trust, community, and collaboration within the group.

However, co-designing the course presented challenges. Faculty and students sometimes had differing views on which activities and components were most valuable. For example, one of the instructors questioned the benefits of the quests, suggesting their removal from future iterations, while student reflections support their inclusion. One student wrote, "*My favorite part of this course was the quests. I'll continue to advocate for their use in [the course] until the bitter end.*

Personal development, especially in areas that allow me to take my focus off of my usual courses and recover from some stress, are very important to me."

Additionally, while students were enthusiastic about collaboration, some felt collaboration could be expanded further. Suggestions included increasing group activities and organizing cohort-wide events to foster deeper connections. One student remarked, *"I think one thing that could be further developed is group work and connecting with people in the class. I understand that [future iterations] would likely prioritize that more and that we also had a different plan than [future iterations], but it would have been nice to get to know the other people more."* Another added, "*...a negative element of the course that needs improvement is more group/class activities. I know we had the eclipse-watching and then the milkshakes after, but I felt like more events as a cohort would be really helpful, especially for a course like [the Year 1 course] where it would be best for different years and new students to get to know one another*."

Collaborative networks play a critical role in creating a supportive and rewarding learning environment. While challenges like differing perspectives on course elements and the need for further collaboration were identified, the valuable feedback and insights from this pilot course will guide improvements in the next iteration. Collaboration is a key element of holistic education, helping students learn from different perspectives and preparing them for team-based, dynamic professional settings.

Conclusion and Next Steps

This study focused on a pilot course collaboratively designed by faculty and students to inform the creation of a program-length course centered on increasing holistic learning and student agency. Developing trust was a key element of this experiment, enabling the eventual reduction of the power differential that is typical in engineering learning environments. This created space for open and candid conversations, where the focus was more about growth than grades and evaluation. Given agency, students chose to engage in events and pursued self-identified quests, which they integrated with their academic learning and experiences. The course highlighted and increased the visibility of the opportunities that students value and pursue.

Students exercised significant freedom in selecting events and quests that aligned with their interests. For these activities and other course components, they were encouraged to reflect, often guided by prompts designed to explore integration across professional and personal experiences. Additional in-class exercises and discussions further supported students in making meaningful connections across various aspects of their lives and experiences.

There were a number of challenges along the way. There were several initial structural issues as we worked to add this type of requirement to the curriculum. All requirements at our university are tied to courses, but we wanted to create something beyond the typical single-semester course experience. We had hoped we would have some freedom in choosing a grading scheme for the course such as options for A-F, pass/no pass, etc. We were told that an A-F scale was the norm, pass/no pass required a difficult-to-get exception, and there were no other options. Physical space was another challenge. Finding a space or spaces that would eventually accommodate the entire departmental enrollment of about 100 students while also facilitating reflective conversations in

a welcoming and comfortable environment turned out to be difficult and remains an unsolved problem. The only spaces that meet the environmental needs were smaller and associated with student life. Academic classes may not reserve these spaces by policy. In terms of course exercises, a minor issue arose with the intentionally open definitions of the events and quests. One of the students completed a quest that was a color-by-numbers painting that we thought was a bit too far off of our intentions. These definitions were refined as the course progressed in order to focus on more developmental activities. Within the departmental faculty, there were perceived differences in the overall value of the course and what should be included. For example, one student quest received polarized feedback from other faculty in the department, some of whom believed we should not be encouraging students to do anything outside our technical expertise. This particular quest focused on physical health. We are still determining what is acceptable in this space. Finally, despite the positive feedback from our initial student group, we are concerned about how students with a strong technical focus will respond to this course, based on our past experiences with them. The students who volunteered to participate in the pilot course tended to have broader interests. It is worth noting that the department chair was one of the initial course instructors and has committed to being involved in the rollout to help address and mitigate some of these challenges.

The findings from this study will be used to redesign the next iteration of this course to better align with the goals of supporting students as they integrate their personal and professional interests. Looking ahead, the Year 1 course will provide more structured opportunities for professional development. A student suggested adding more public speaking and presentations to the course, saying *"I think there [should be] more opportunities for presentations. Even though I sometimes really struggle with public speaking and presenting work, I think presenting quest deliverables and events could be a fun way to share how we individually are benefiting from the course."* Additional professional development opportunities may include allowing students to choose options from a curated list of professional growth activities, engaging guest speakers from various industries, and providing extra support to help students connect their course experiences to their career aspirations.

The first "production" offering of the course will be in Spring 2025. Looking to future semesters, we intend to integrate students across class years in some fashion and expect the more senior students to help lead discussions and provide peer mentoring to more junior students. We plan to increase the agency afforded to each class year as they become more adept at identifying their own path and supporting their own growth. Future papers in this series will detail the process, rationale, and challenges as this initiative evolves and the course expands to include all students in the department.

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