GIFTS: An Interdisciplinary Collaboration to Foster Students' Sense of Belonging in Engineering

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Introduction: Getting Started

This GIFTS paper outlines the development of a first-year *Engineering Design Experience* course designed to enhance belonging for incoming students at a Hispanic Serving Institution (HSI). Recognizing the connection between belonging and persistence in engineering, the course uses interdisciplinary methods to introduce students to foundational engineering mindsets. It emphasizes belonging through culture, the course, the engineering discipline, and the university itself. This paper discusses the pedagogical approach, activities, assessment methods, and future evaluation plans, along with reflections from the instructor team and recommendations for similar curriculum initiatives.

Our institution is an open-access, research-intensive HSI on the US-Mexico border with approximately 84% Hispanic students. Anyone with a high school diploma or GED who applies to the university at the undergraduate level is accepted, creating opportunities for all while also posing unique challenges in the classroom. For instance, many of our students enter engineering with diverse experiences and backgrounds that may not have led to them being expected to complete higher-level math courses at their high schools, though they are perfectly capable if given the opportunity. Additionally, students at our institution declare their major from the onset when many (if not most) do not know what it means to be an engineer or why they want to pursue a specific discipline. When coupled with engineering programming that requires our students to be calculus-ready, these students do not experience engineering content until several semesters into their academic careers. The situation also creates barriers to building a sense of belonging in engineering and at the university, from which students would otherwise benefit (i.e., staying in their major, persisting to graduation). Given what we know about the benefits of an early introduction to engineering [1], we are at risk of these students changing their majors before they even get to experience the engineering content. What is more, the historically high bar for math preparation to engage with engineering content also prevents students from other disciplines from experiencing or benefiting from exposure to the engineering mindset, regardless of whether they want to be engineers.

To remedy this, we created a first-year engineering design course to introduce foundational engineering concepts to students in their first year from any level of preparation and discipline, building an understanding of engineering and math skills along the way. We saw this as an opportunity for interdisciplinary collaboration to develop an engineering design course that seamlessly integrates engineering and math concepts in a way that levels the playing field for students with varying backgrounds and provides opportunities to build a strong sense of belonging. An interdisciplinary team of faculty of all ranks from engineering, math, computer science, and English was assembled. The team included representatives from outside engineering as math and communication were identified as important outcomes for the course. Each undergraduate engineering discipline offered at the institution was represented and the College of Engineering's leadership supported the initiative. The final learning outcomes include building a sense of belonging, building an engineering mindset for all students, developing navigation skills for college life, and connecting content in math, communication, and design to applications in engineering. Six sections of the three-credit hour course were piloted in Fall 2024 for 160 incoming students.

Project Approach: Course Overview

The result was a project-based course called *Engineering Design Experience*. All class meetings were interactive, activity-based sessions focused on an engineering product redesign project based on a KEEN resource card for redesigning a flashlight [2]. Specific activities were crafted to focus on building students' sense of belonging. Our selection of a familiar product was itself an intentional decision intended to foster a sense of belonging by helping students to see things in the world around them and understand how they were designed, a skill necessary for all engineers. This course leveraged IDEO's design thinking process of Inspiration, Ideation, and Implementation [3]. The course was divided into three cycles, each including a complete pass through the design process. At the end of each cycle, students presented their resulting redesigned flashlights and described their process in a design review presentation. Each cycle was supported with activities and assignments intentionally designed to support students' achievement of the intended learning outcomes. While most activities were designed around the product redesign, students also completed math assignments, learned about foundational engineering concepts, and researched various engineering disciplines throughout the semester. For the sake of this paper, we share how we approached the design of activities to support students' sense of belonging.

Sense of Belonging

Sense of belonging is defined as one's perception of how well one fits in a given context, whether it be within a community, discipline, or institution. Research on sense of belonging in engineering has been well established and can have impacts on retention, persistence, academic performance, and achievement, especially for Hispanic students [4, 5, 6]. We designed the course by integrating sense of belonging in each of four intersecting areas. Table 1 illustrates the motivation for focusing on each area, along with a mapping of course activities and assessments.

<u>Culture - Who we are Teaching</u>

We want students to realize their personal and cultural identity is relevant to their career goals in engineering, in almost all cases focusing on Hispanic culture, given our student population. Activities during the semester included a focus on community cultural wealth [7] in which students completed an assets worksheet that they used to populate their resumes. Being bilingual was a common asset students identified; however, they were surprised they could leverage that skill in an engineering context. Once they built their resume, students attended the university's Career Expo to learn about internship opportunities. For their assessment, we had them reflect on that experience and many were excited to have had the practice of networking with professionals.

The design journal was another way we wanted students to gain a sense of belonging within their community and culture. Each student was tasked with identifying "thoughtless acts" [8] and observing the things in their environment that could use an intentionally designed solution. Students took photos of objects in their homes, workplaces, and at school, demonstrating how design is all around them. By bringing their typical environments into the classroom, we were able to connect parts of their culture to an engineering context.

<u>Course – How we are teaching</u>

We intentionally sought to build students' sense of belonging in the course through community-building activities, teaming, small section sizes, and teaching assistant selection. In

this case, community-building refers to the community of practice within the classroom. Students entering our institution have varying degrees of preparation, especially in math and science. We aimed to foster a sense of belonging within the course by leveling the playing field for all students. Community building started the first day when students engaged in a Wallet design activity [9] with their classmates. This activity encouraged building connections and communication while illustrating major design activities of problem definition, user interviews, brainstorming, iterating, and rapid prototyping. We were deliberate about class size by limiting sections to 30 students, allowing instructors, teaching assistants, and students to interact with each other consistently. We also deliberately selected undergraduate teaching assistants who could answer student questions about the course content and other topics relevant to the student experience, sharing their own perspectives as fellow students.

Table 1. Integrating sense of belonging in the course

Sense of Belonging	Motivation	Course Activities	Assessment
Culture	Context of HSI to be truly Hispanic serving	• Community cultural wealth/asset worksheet (Appendix A) • Resume building • Attend Career Expo • Design journal	• General assignment rubric (Appendix B) • Reflection assignment for Career Expo
Course	Level the playing field for students with varying degrees of preparation	• Wallet design activity • Various in-class activities • Individual and team projects • Design presentations • Math assignments • Course structure and support	• Presentation and general rubrics • Team evaluations • Automatic grading of math assignments • Limited course section to 30 students with designated TA
Discipline/College	Increase retention in engineering	• Focus on discipline activities • Lab tours • Lab testing • Faculty interviews	• General rubric • Discussion for each focus on discipline activity • Reflection of faculty interview
University	Increase retention at the university	• Campus scavenger hunt • Access to campus resources • Collaborated with tutoring centers	• Complete/incomplete grade

Discipline/College - What we are teaching

We emphasized discipline/college sense of belonging in several ways. First, the semester-long project had a multidisciplinary emphasis, weaving engineering disciplines with math and communication – skills that all engineers need. The selected project was a flashlight redesign, which had elements from electrical, mechanical, materials, and other engineering disciplines. Furthermore, throughout the semester, we incorporated “focus on disciplines” activities in which students learned to navigate departmental websites from civil engineering to aerospace engineering and answered key questions about the discipline, current research projects, and how the discipline impacts the community. Sense of belonging within the College of Engineering was also supported by research lab tours, lab testing, and faculty interviews. This helped students get

acquainted with research and testing that occurs in different disciplines as well as networking with faculty who conduct research in the students' areas of interest.

University – Where we are Teaching

The course aimed to foster students' sense of belonging at the university level as well. We incorporated campus resources, like tutoring centers and Excel tutorials, into the learning management system, had visits from academic advisors, and emphasized the navigational skills necessary to be successful in college. In several cases, students visited the tutoring centers together. Teaching assistants shared opportunities and encouraged students to be involved in university-wide events, including a back-to-school rally. Additionally, students attended the university-wide career expo during their first semester in college, gaining important networking skills that could help them secure internship opportunities. These experiences facilitated their ability to continue at the university and begin to imagine themselves in an engineering career.

Results and Discussion: Reflection on Facilitation and Implementation

Student feedback and instructor reflections are two important areas that contribute to continuous improvement efforts for the course. For example, during weekly instructional team meetings, we discovered that an extended class period using a two-day-a-week course structure, giving a full 80 minutes per class session, was more suitable for the project-based course than a three-day-a-week course with 50-minute sessions. Subsequently, the course will no longer be offered as a three-day-a-week course. The instructors also noted that getting students involved in design from day one set the tone for the rest of the semester. Instructors received some feedback from students, including the need to integrate math assignments into the course more seamlessly. For others considering developing a new course, it was important for us to have buy-in from top leadership (Dean's office) as well as the departments. Having buy-in from both directions allowed us to create a course that benefited all stakeholders.

Ongoing evaluation efforts will include measuring retention in engineering and at the institution after the first semester and at the end of each subsequent year until graduation. We expect to see higher retention rates after the first year and beyond as students will have made an informed decision about their major (staying or leaving engineering) earlier, given their initial introduction to engineering design in the first semester. In addition to retention, we will also look at the benefits this course has on students' preparation for future math courses and supplement activities, like finding an internship. We will be launching a retrospective post-survey using validated instruments, including sense of belonging, engineering design self-efficacy, math perceptions, and career intentions. We are currently pursuing IRB approval for a more systematic evaluation of the course's impact.

In conclusion, this paper described the development and implementation of the first-year Engineering Design Experience course at a Hispanic Serving Institution. By intentionally integrating activities that foster a sense of belonging across culture, the course itself, the engineering discipline, and the university, this course aims to improve student retention and persistence in engineering. Initial instructor reflections and student feedback have already yielded valuable insights into course improvement. Future evaluation, including tracking retention rates and assessing the impact on math preparedness and career development, will provide a more comprehensive understanding of the course's effectiveness and inform the development of an expanded first-year engineering experience.

References

[1] H. Nguyen, L. Wu, C. Fischer, G. Washington and M. Warschauer, "Increasing success in college: Examining the impact of a project-based introductory engineering course," *Journal of Engineering Education,* vol. 109, no. 3, pp. 384-401, 2020.

[2] "Card Dashboard," [Online]. Available: https://engineeringunleashed.com/card.

[3] "Design Thinking Defined," [Online]. Available: https://designthinking.ideo.com/.

[4] A. Patrick, M. Andrews, C. Riegle-Crumb, M. R. Kendall, J. Bachman and V. Subbian, "Sense of belonging in engineering and identity centrality among undergraduate students at Hispanic-Serving Institutions," *Journal of Engineering Education,* vol. 112, no. 2, pp. 316-336, 2023.

[5] E. Seymour and N. M. Hewitt, Talking about leaving: Why undergraduates leave the sciences, Westview Press, 2000.

[6] T. L. Strayhorn, College students' sense of belonging: A key to educational success for all students, Routledge, 2012.

[7] T. J. Yosso, "Whose culture has capital? A critical race theory discussion of community cultural wealth," in *Critical race theory in education*, Routledge, 2014, pp. 181-204.

[8] J. F. Suri, Thoughtless acts?: Observations on intuitive design, Chronicle Books, 2005.

[9] "Wallet Project - English," [Online]. Available: https://dschool.stanford.edu/resources/the-gift-giving-project.

Appendix A: Assets Worksheet

Name: _____

Date: _____

Academics: What academic knowledge, skills, and beliefs do you bring with you from high school or other college courses?	

Professional: What knowledge, skills, and beliefs do you bring with you from your work or other extracurricular experiences?	

Aspirations: What hopes and dreams motivate you?	

Familia: What wisdom, values, and stories do you bring from you home communities?	

Communication: What communication strengths do you bring into your college career?	

Social: What connections and resources do you already have that could support your college career?	

Navigational: What type of help-seeking behaviors do you use to navigate your college career?	

Resistance: How do you engage in social justice work in our institution and in your own communities?	

Appendix B: General Rubric

General Assignment Grading Rubric

This rubric can be used for reflection, participation, or design assignments that are not associated with a specific project or math module

Criteria	Exemplary (5)	Proficient (4)	Developing (3)	Needs Improvement (2)	Unacceptable (1)
Completeness	All required elements are present, fully developed, and exceed expectations.	All required elements are present and fully developed.	Most required elements are present and adequately developed.	Some required elements are missing or underdeveloped.	Many required elements are missing or underdeveloped.
Organization	Information is presented in a clear, logical, and highly effective manner.	Information is presented in a clear, logical, and coherent manner.	Information is generally well-organized, but may lack clarity in some areas.	Information is somewhat disorganized and difficult to follow.	Information is poorly organized and confusing.
Depth of Analysis	Demonstrates exceptional depth of understanding with insightful, original analysis and critical thinking.	Demonstrates a strong understanding of the topic with insightful analysis and critical thinking.	Demonstrates a solid understanding of the topic with some analysis and critical thinking.	Demonstrates a basic understanding of the topic with limited analysis.	Demonstrates little understanding of the topic and lacks analysis.