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Work in Progress: Developing a Bachelor of Science Program at the Intersection of Human-Centered Design, Engineering, and Entrepreneurship

Dr. Sebastian Dziallas, University of the Pacific

Sebastian Dziallas is an Assistant Professor of Computer Science at the University of the Pacific. He previously served as a founding faculty member at Fulbright University in Vietnam. He received a Ph.D. in Computer Science from the University of Kent and a B.S. in Engineering from Olin College of Engineering. His research interests in computing education research include using narrative methodologies to understand student experiences and exploring novel work-based learning approaches.

Dr. Shelly Gulati, University of the Pacific

Dr. Shelly Gulati is Professor of Bioengineering and Assistant Dean for Interdisciplinary Programs, Teaching Excellence and Inclusion at University of the Pacific. She has been at Pacific since 2010. She received a BS in Chemical Engineering from Johns Hopkins University and a PhD in Bioengineering from University of California, Berkeley. She also spent two years as a postdoctoral fellow in London at Imperial College. Her research interests are in biomicrofluidics as well as engineering education. Her recent projects have emphasized mentorship of women and underrepresented students and creating engaging learning environments that promote students' sense of belonging, persistence, and success in engineering.

Dr. Mehdi Khazaeli, University of the Pacific

Mehdi Khazaeli is an Associate Professor in School of Engineering and Computer Science at University of the Pacific. He also serves as Director of Pacificâ€™s Technological Innovation and Entrepreneurship (TIE) Program. He teaches courses in Building Info

Dr. Bidisha Burman, University of the Pacific

Dr. Bidisha Burman (Ph.D. Louisiana State University) is a Visiting Professor of Marketing in the Eberhardt School of Business at the University of the Pacific. Prior to ESB, she has served as Associate Professor of Marketing at University of Mary Washington and Appalachian State University. Her research interests are pricing, advertising, consumer judgment and decision-making, services marketing, and sustainability marketing. Her work has been published in Journal of Business Research, Journal of Consumer Psychology, Journal of Retailing, Journal of Product and Brand Management, Journal of Hospitality Marketing and Management, among others. She has recently served as co-program chair for Academy of Marketing Science (AMS) and currently serves on the editorial review board of the Journal of Consumer Marketing.

Dr. Maryam Heidaripour, University of the Pacific

Maryam Heidaripour is an Assistant Professor of Design, Innovation, and Entrepreneurship at the University of the Pacific. She holds a Ph.D. in Design from the Illinois Institute of Technology and an MBA in General Management from the University of Tehran. She also spent two years as a Visiting Assistant Professor at Indiana University Bloomington's Department of Informatics. Her research interests include design strategy, new venture development, and exploring future interactions with advanced energy technologies to foster sustainable, equitable, and thriving communities.

Dr. Leili Javadpour, University of the Pacific

Leili Javadpour is an Associate Professor in Business Analytics and Associate Dean at Eberhardt School of Business at University of the Pacific. She earned her PhD in Engineering Science from Louisiana State University in 2013. She holds a M.S. in Product Design and Management from University of Liverpool and a B.S. in Industrial Engineering from Isfahan University of Technology. Her research focuses on data analytics and natural language processing in different areas of Business such as Marketing, Finance and Sports.

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Abstract
This work-in-progress Academic Practice paper presents an effort at the University of the Pacific to build a new interdisciplinary undergraduate major at the intersection of human-centered design, engineering, and entrepreneurship. Traditionally, there is not a history of interdisciplinary programs at the university. In this paper, we report on the process that led to the development of a new Bachelor of Science in Product Design and Entrepreneurship (PDEP) and situate it in the literature on other human-centered design programs. This new program aims to equip students with the skills and mindset required to create innovative products and solutions that address real-world challenges. It will be offered for the first time in the fall 2025 semester, and we plan to collect and examine data on student pathways and outcomes in the future.

Introduction

The convergence of physical and digital domains is increasingly evident in areas such as the Internet of Things (IoT), wearable technologies, and advanced manufacturing. These interdisciplinary fields require a workforce skilled in integrating physical artifacts with digital platforms to create seamless, innovative solutions. Higher education institutions are increasingly turning to interdisciplinary approaches to address these demands, integrating diverse fields of study to create innovative programs that prepare students for complex, real-world challenges [1], [2].

This paper presents the development of a new interdisciplinary undergraduate program at the University of the Pacific, the Bachelor of Science in Product Design and Entrepreneurship (PDEP). Situated at the intersection of human-centered design, engineering, and entrepreneurship, this program seeks to equip students with the skills and mindset necessary to create innovative solutions that address pressing societal and market needs.

This paper provides an overview of the process that led to the creation of the PDEP program, detailing the collaborative efforts, curriculum design, and strategic considerations involved. In the following, we first discuss related efforts in the literature on before turning to the context at the University of the Pacific, the development of the PDEP program, and the resulting curriculum.

Prior Work & Related Programs

Existing undergraduate programs in product design, which are often housed in schools of design, emphasize aesthetic and functional aspects of design while incorporating user research and prototyping but do not always explicitly integrate entrepreneurial skills. In engineering education, human-centered design (HCD) has become an important component. HCD emphasizes empathy, user-centered problem-solving, and iterative prototyping and often incorporates project-based learning, collaborative teamwork, and real-world engagement [3]. Some institutions have embedded human-centered design throughout their curriculum, such as James Madison University [4] and Harvey Mudd College [5]. Engineering design projects are also commonly found in first-year courses and capstone project [6], [7], [8]. Several

undergraduate programs now explicitly emphasize human-centered design, such as the Human-Centered Engineering Design program at the University of Michigan-Dearborn [9], the Design Engineering program at the Colorado School of Mines [10], and the Human-Centered Design and Engineering program at the University of Washington [11].

Programs that integrate design, engineering, and entrepreneurship at the undergraduate level remain relatively rare. This may be in part due to the deeply engrained disciplinary structure in higher education. However, many academics also recognize that complex real-world topics cannot be addressed with perspectives of a single discipline. Some institutions have sought to shift the academic culture by strategically targeting certain initiatives and relaxing some of the institutional barriers that prevent integrated programs. Successful interdisciplinary academic programs teach students to integrate concepts and methodologies from two or more related disciplines to understand a complex topic.

One example is a "collaboration of graduate programs that bring together design, engineering, and business though a human-centered design process" [12]. This includes Stanford University's Masters in Design [13] and Northeastern University's Masters in Engineering Design Innovation [14], among others. However, few undergraduate programs provide comparable opportunities, such as the Arts, Technology, and Business of Innovation program at the University of Southern California [15]. Some institutions offer certificates, minors, or double majors, rather than full programs. Examples include the Engineering Design, Innovation and Entrepreneurship additional major at Carnegie Mellon University [16], the Innovation and Entrepreneurship certificate at Duke University [17], and the Human-Centered Design minor at Dartmouth College [18].

Context

University of the Pacific is a private, medium-size university with Asian American and Native American Pacific Islander-Serving Institution (AANAPISI) and Hispanic-Serving Institution (HSI) status. Its School of Engineering and Computer Science offers ABET-accredited degrees in bioengineering, civil engineering, computer engineering, computer science, electrical engineering, engineering management, and mechanical engineering.

All undergraduate students at University of the Pacific complete two core seminars emphasizing written and oral communication, as well as a series of general education distribution requirements. Students in the School of Engineering and Computer Science also take part in a cooperative education (CO-OP) program, which is required for engineering students and strongly encouraged for computer science students, and a senior project. The school offers several traditional degrees, including in bioengineering, civil engineering, computer and electrical engineering, and mechanical engineering, among others. It currently does not have a formal thread of design courses throughout the curriculum, although there have been efforts to incorporate design into the introductory experience for all engineering and computer science students [19], and a design thinking course is offered as an elective.

While University of the Pacific does not have a history of interdisciplinary programs, more recently, two interdisciplinary majors have been launched in collaboration with other schools at the university: one in data science and another in sustainability. The new interdisciplinary program in Product Design and Entrepreneurship was similarly developed in collaboration with multiple schools – engineering and computer science, liberal arts, and business. In the following, we describe the development process (shown in Figure 1) and the resulting curriculum for the new program.

Development Process

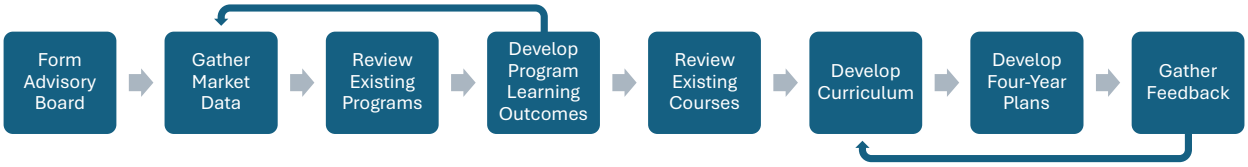

Figure 1: Iterative Product Design and Entrepreneurship Program Development Process

The idea for a new program in product design and entrepreneurship (PDEP) initially emerged from a Curriculum Innovation Day organized by the university's provost. This event was intended to provide faculty from different schools within the university with the opportunity to develop proposals for new interdisciplinary programs. It led to the formation of a faculty advisory board with a total of nine representatives from three schools (engineering and computer science, liberal arts, and business).

The advisory board met regularly during the spring 2024 semester, as well as five times over the summer. It worked to define the overall vision and goals for the program, such as an emphasis on project-based learning and interdisciplinary skill development and began initial brainstorming on the curriculum structure. This also included discussions about which of the represented disciplines to emphasize as part of the new program, how to provide an academic "home" for students in the program, and whether to pursue ABET accreditation (there are currently no plans to do so). The program will be overseen by a dean and a new program director. While faculty teaching in the program will continue to associate with their existing schools, students will affiliate directly with the new program.

The advisory board collaborated with the university's Enrollment Strategy team to gather data on industry needs. By using a specialized tool labor market data and analytics tool (called Lightcast), we were able to obtain market research data, including the number of open job opportunities in various fields (such as for industrial designers, product developers, and UX designers), average graduate salaries, and the skill sets required for such positions. However, as the new program is situated at the intersection of multiple disciplines, it did not always map neatly onto the traditional job titles and degrees provided by the tool.

The advisory board also reviewed existing programs at several other institutions (as discussed in the introduction above). Our analysis of regional and national academic offerings revealed that

many existing programs emphasize either physical design or digital experience but rarely provide a cohesive integration of both. The challenge was to design a comprehensive program that balances breadth and depth, ensuring students gain substantial expertise within a four-year period. To address this, we decided to develop a program with two domain depths which students select based on their individual interests: 1) Physical Design + Manufacturing, and 2) Digital User Experience + AI.

Building on the earlier discussions about the goal of the program and our research, we brainstormed knowledge, skills, and attitudes graduates from the program should possess. We then used them to develop the program learning outcomes (PLOs) for the program as shown in Table 1.

Table 1: Program Learning Outcomes for the PDEP Program

- Students will demonstrate the ability to apply creative and critical thinking skills to develop innovative, user-centered designs and solutions that address real-world challenges.
- Students will develop their communication and storytelling abilities, allowing them to effectively convey the value and impact of their ideas to various stakeholders through a variety of media.
- Students will connect diverse ideas and concepts, integrating knowledge from various disciplines to generate innovative solutions to complex problems.
- Students will develop and build prototypes using an iterative design process, incorporating feedback from stakeholders to ensure that strategy, planning, and implementation are grounded in the needs and experiences of the end-user.
- Students will effectively collaborate on teams whose members collectively provide leadership and create an inclusive work environment.
- Students will develop conceptual design, product (digital/physical) modelling, and prototyping skills to enhance the functionality and effectiveness of their designs and solutions.
- Students will demonstrate curiosity by actively exploring new concepts, emerging technologies, and new market trends, seeking to identify and engage with potential opportunities for innovation.
- Students will cultivate an entrepreneurial mindset, including the ability to conduct market research and financial forecasts to drive innovation that positively impacts society and the economy.
- Students will develop reliable, high-quality products with market appeal, within the budgets and time demanded by competitive businesses.

The advisory board then reviewed existing course offerings at the university and generated an extensive list of potential course options for inclusion in the program. One key observation here was that numerous units were already offering design thinking courses at various levels with little coordination. The team then narrowed this list down by evaluating each course against several key criteria. They included:

- Relevance of the course to the topics to be covered in the PDEP program,

- Alignment of course units with the program's overall credit requirements,
- Feasibility of prerequisites to ensure accessibility for students in the program,
- Mapping to general education requirements.

This also helped us to identify gaps where new courses needed to be developed specifically for this program. While the majority of courses in the new program are existing course offerings, there are also several new courses that were purpose-built for this program. This was mainly the case for cohort experiences for the new program (i.e. a first-year seminar and a capstone course), as well as for the domain depths in areas where no existing course met the needs of the program (e.g. in material processing and selection and advanced UX design). The newly developed courses include:

- Product Design and Entrepreneurship Seminar (2 units, first year)
- Material Processing and Selection (4 units, third year)
- AI for Designers (4 units, second or third year)
- UI Techniques and Applications (4 units, third or fourth year)
- Capstone I (4 units, fourth year)

The advisory board then developed a detailed four-year plan to detail a student's journey through the program, incorporating general education requirements, prerequisites, core and elective program-specific courses, domain depth courses, as well as a capstone. This process helped to identify courses where adjustments to existing prerequisites needed to be proposed to allow sufficient flexibility for students in the program. Finally, the program learning outcomes were mapped with the proposed curriculum.

Resulting Curriculum

The resulting curriculum consists of the following areas as shown in Figure 2 and in Appendix 1:

- Core Courses & Prerequisites
- Design Core (Principles of Design, Communication through Media and Technology, Research Methods, Cognitive and Learning Processes)
- Business Core (New Product Development, Management, Marketing, Finance, Entrepreneurship)
- Domain Depth
    - Physical Design + Manufacturing (CAD, Materials, Manufacturing)
    - Digital User Experience + AI (UX Design, App & Web Development)
- Capstone I + Entrepreneurship Practicum (Capstone II)
- Electives

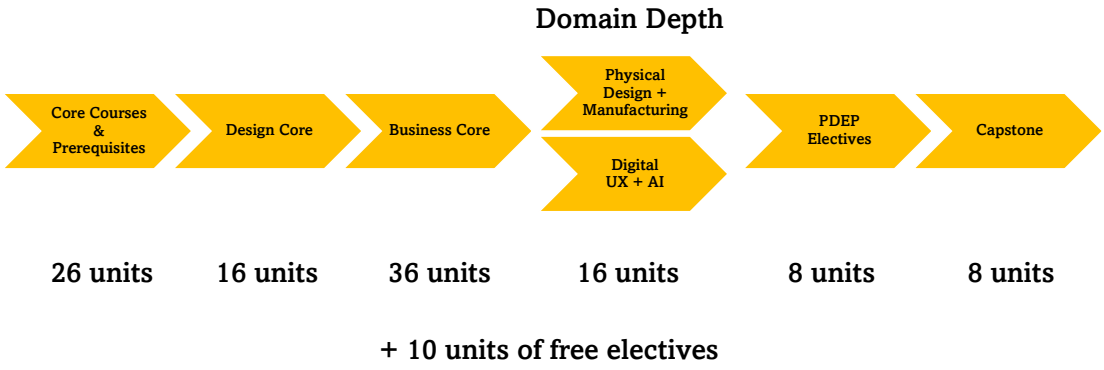

Figure 2: Product Design and Entrepreneurship Curriculum

The domain depth in Physical Design + Manufacturing focuses on foundational skills in prototyping, production methods, and material science; competencies that are critical for careers in industrial design, product development, and advanced manufacturing. Our goal is to equip students with the skills necessary to act as key facilitators of collaboration among designers, product managers, and engineers in the product development process. In addition, the domain depth in Digital User Experience + AI reflects the increasing reliance on intuitive, user-centered interfaces across industries and consumer products. By cultivating expertise in every step of the creation of a digital product, students will acquire versatile skill sets that prepare them for roles such as UX designers, systems integrators, and digital product managers.

Some of the areas in the curriculum allow a choice of options, whereas others are required depending on a student's domain depth. For instance, students pursuing the Physical Design + Manufacturing domain depth take 3D Design, whereas those in Digital User Experience + AI take Introduction to Digital Design. More details are provided in Appendix 1.

Approval Process & Next Steps

As a next step, the advisory board leaders prepared a detailed proposal for the new program, including curriculum details, program objectives, alignment with university competencies, and projected outcomes. This also involved developing a budget for new hires, marketing, and operational needs. Throughout this process, they had to coordinate with deans from all three schools to gain support and resources for the program.

The proposal also had to be reviewed by each school's curriculum committee. The advisory board leaders presented the proposal to each school's committee individually and answered questions about the program. A number of issues were identified during this process. The main challenge related to requests to align the program with specific knowledge, skills, and attitudes from the different disciplines that students needed to develop. This made it difficult to combine courses into a cohesive interdisciplinary major, as each curriculum committee tended to focus on course sequences and competencies in their schools rather than the integrated program. For example, in entrepreneurship, students taking the Entrepreneurship Practicum are expected to understand Entrepreneurial Finance. To achieve this, they must first learn about financial

instruments and institutions, which require prior knowledge of Principles of Financial Accounting as well as Microeconomics and Macroeconomics. In design, if students are expected to develop 3D art forms, websites, or applications, they must first take courses in 2D and 3D drawing and media.

Another constraint was the availability of space and the student-to-instructor ratio, as studio art courses must remain small to ensure close guidance and mentorship by art and design faculty. In engineering, for manufacturing classes that include working with polymers, composites, ceramics, and metals, students need a foundation in Mechanics of Materials and the microscopic and macroscopic structure of materials. These prerequisites require prior coursework in Chemistry and Differential Equations. While we aimed to utilize existing classes without altering their prerequisites where possible, this underscored the need to develop new courses or tailored sections of existing courses specifically for the PDEP major. These new courses would focus on the practical application of the major rather than in-depth specializations in design, manufacturing, marketing, or finance.

The proposal was then presented to the larger university committees, such as the Undergraduate Academic Curriculum Committee and the University Academic Council and finally submitted to the university's Board of Regents for review and approval. Following the approval of the program, attention has now turned to ensuring timely and effective marketing to attract potential students and coordinating administrative tasks and faculty assignments.

Challenges & Lessons Learned

The advisory board encountered several challenges in the development of this new program. We share these challenges here in the hope that they can inform similar efforts at other institutions.

Faculty Representation & Interdisciplinary Perspectives

While the idea for the new program emerged organically from the Curriculum Innovation Day, the advisory board leaders worked to include faculty representatives from all relevant schools in the process. This also meant aligning diverse perspectives and priorities of different schools and balancing the curriculum across the three disciplines to ensure that the core skillset remained intact.

Existing Curricular Constraints

Since the program incorporates courses from design, business and economics, and engineering, this meant that pre-requisites of existing courses had to be incorporated into the curriculum for the new program. In some cases, this meant negotiating prerequisite waivers with individual schools and faculty committees. For instance, the prerequisite for Financial Management was adjusted to allow students in interdisciplinary programs to take the course without requiring a course in Macroeconomics first. In other cases, some courses were not included in the end due to their extensive pre-requisite chains. This effort also highlighted potential pre-requisite chains that could be streamlined to facilitate interdisciplinary access for all students.

Time Constraints

Following the Curriculum Innovation Day, the advisory board had to complete its work in the spring and summer terms, due to the deadlines for the inclusion of any new courses into the course catalogue and the approval of new programs. These time constraints were exacerbated by the limited number of Curriculum Committee and Faculty Council meetings before the final submission deadline to the Academic Affairs Committee on Undergraduate Studies and by subsequent revisions that required repeated committee approvals across schools.

Conclusions

The development of the Bachelor of Science in Product Design and Entrepreneurship (PDEP) at the University of the Pacific is an example of a new interdisciplinary undergraduate programs that integrates human-centered design, engineering, and entrepreneurship. By leveraging insights from existing programs and fostering collaboration across business, engineering, and liberal arts, the program exemplifies a holistic approach to equipping students with the skills needed to tackle complex, real-world challenges. The dual-track structure, with domain depths in Physical Design & Manufacturing and Digital User Experience & AI, allows the program to bridge the physical and digital aspects of product and system development while maintaining a focused and in-depth learning experience.

As the program prepares to launch in fall 2025, this work-in-progress paper highlights the foundational processes and principles that guided its development, which may be of interest to other institutions seeking to develop similar programs. We plan to explore the program's impact on student pathways, sense of belonging, skill development, and career outcomes in future work.

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Appendix 1: Curriculum for Product Design and Entrepreneurship Program

Category	Area	Course Name	Notes
Core		Product Design and Entrepreneurship Seminar	required
		AI for Designers	
		Introduction to Finite Mathematics and Calculus	
		Introduction to Statistics and Probability	
		Principles of Financial Accounting	
		The Legal and Ethical Environment of Business	
		Introductory Microeconomics	
Design	Principles of Design	3D Design	required for Physical Design
		Introduction to Digital Design	required for Digital UX
	Communication through Media and Technology	Digital Narratives	choose 1
		Digital Communication	
		Digital Visualization and Storytelling	
		Persuasion	
	Research Methods	Introduction to Research Methods in Psychology	choose 1
		Social Science Research Methods	
		Introduction to Interpersonal Communication	
		Political Science Research	
		Introduction to Digital Humanities	
	Cognitive and Learning Processes	Introduction to Psychology	choose 1
		Introduction to Cognitive Science	
		Sensation and Perception	
		Behavioral Psychology	
Business	New Product Development	Engineering Design Thinking	choose 2
		Design Thinking	
		Design and Innovation	
		Product Innovation	
	Management	Management and Organizational Behavior	required
	Marketing	Marketing Management	required
		Marketing Research	
	Finance	Financial Management	required
		Entrepreneurial Finance	choose 1
		Intermediate Financial Management	

	Entrepreneurship	Introduction to Entrepreneurship	required
		Product Design Capstone	
		Entrepreneurial Management Practicum	
		Entrepreneurship & Business Strategy	
Physical Design + Manu-facturing	CAD	Mechanical Engineering Graphics	required for Physical Design
	Materials	Material Processing and Selection	required for Physical Design
	Manufacturing	Manufacturing Processes	required for Physical Design
		Sculpture	choose 1
		Product Design and AM	
Digital UX + AI	UX Design	Human-Computer Interface Design	required for Digital UX
		UI Techniques and Applications	
		Digital Marketing	choose 1
		Digital Well-Being	
		Media Tools	
		Principles of Storytelling	
	Computer Science	Introduction to Computer Science	required for Digital UX