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WIP: Exploring First-Year Student Mentoring Program Engagement Through Service Blueprinting

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Arath Dominguez is a first-generation college student with a passion for mentorship, educational equity, and innovation. He is a graduation senior at Southern Methodist University pursuing a double major in Computer Science and Data Science.

Throughout his time in college, Arath has remained committed to creating opportunities for others, particularly students from underrepresented backgrounds in STEM. He has served as an active member of the Lyle Thrive Scholars Program, a peer-mentorship program for first-year engineering students, as a peer-mentor and currently serves as a Student Coordinator of the Thrive Scholars Program.He is also proud to have served in SMU's Society of Hispanic Professional Engineers (SHPE) chapter as President and Senior Advisor.

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Zoe is an undergraduate student studying Civil Engineering and Public Policy & International Affairs at Southern Methodist University. She is interested in the intersection between the technical aspects of engineering and policy processes. Moreover, within civil engineering, she is interested in land development and structural engineering and in public policy, she is interested in foreign development and sustainable infrastructure.

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Outside of her studies, Zoe enjoys engaging in interdisciplinary policy discussions, mentoring and leading first-year students, and exploring ways to connect her passion for engineering with her passion for foreign development and equity.

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Alain Mota is a Program Manager at the Caruth Institute for Engineering Education at the Bobby Lyle School of Engineering in Sothern Methodist University. In this role, he is part of a leadership team that manages a peer mentoring program designed to provide academic and social support for first year and transfer students who are traditionally underrepresented in the fields of engineering and computer science. He also manages the summer engineering camps an effort that services about 300 North Texas middle school and nationwide high school students exploring engineering design and engineering identity. Before joining the University Alain worked at the Dallas Independent School District as both a mathematics and science instructional coach for elementary and middle schools. Prior to becoming an educator Alain worked in Environmental consulting. In this space his experiences ranged from aquaculture management and research for an aquatic toxicology firm to doing statistical analysis for the nutrient criteria standards at the Texas Commission of Environmental Quality. Alain has a Master of Science in Interdisciplinary Environmental Studies with a focus on Environmental Engineering, Geophysics and Public Health and a Master of Arts in Design and Innovation. His research doing microbial risk assessment of import products from Mexico is published on the Journal of Food Safety.

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Introduction

The purpose of this exploratory work-in-progress (WIP) research paper is to examine the operational structure of a peer mentoring program for first-year engineering and computer science students in order to identify the key structural and procedural elements that significantly influence student engagement and retention. First-year retention is a priority for many postsecondary institutions, as success during a student's initial semesters is strongly associated with long-term persistence and degree completion. Nationally, retention rates in STEM fields, including engineering and computer science, remain disproportionately lower than those in non-STEM disciplines [1]. These disparities are even more pronounced for students from traditionally underrepresented backgrounds. For example, Black, Latinx, and Native American students collectively earned only 26% of all bachelor's degrees in science and engineering in 2020, despite comprising a much larger share of the college-aged population [2]. These data highlight the need for targeted interventions that promote first-year success and advance equitable educational outcomes.

Academic and social integration are widely recognized as foundational to student retention, particularly during the first year of college [3]. Students' support networks, motivation, self-efficacy, and sense of belonging similarly play significant roles in their likelihood to persist [4]. Commonly cited factors contributing to early attrition in engineering and computer science programs include a lack of academic support, limited engagement with peers and faculty, and difficulty navigating the transition to college [5], [6], [7]. These challenges are amplified for racially minoritized students pursuing STEM degrees at predominantly white institutions (PWIs).

Students who develop a strong sense of belonging demonstrate higher retention rates, underscoring the critical role that academic support programs play in facilitating structured engagement [3], [8]. Peer mentoring programs, in particular, represent an effective strategy for fostering both social and academic integration by creating formal opportunities for first-year students to build meaningful connections within their campus communities [9][10]. In engineering contexts, peer mentoring initiatives have been shown to significantly enhance academic performance and boost persistence among participants [11]. Peer mentors provide essential support through practical guidance, such as assisting with course selection and navigating institutional resources, and by serving as advocates and role models who enhance mentees' confidence and belief in their ability to succeed [12]. For first-generation college students, mentors play a critical role in demystifying the hidden curriculum by helping mentees navigate the often-unspoken norms and expectations of higher education [13]. For students who frequently encounter prejudice, discrimination, and exclusion, which are factors known to negatively impact academic and social outcomes, peer mentoring may be particularly impactful.

Despite substantial evidence supporting the benefits of peer mentoring programs, limited research has examined the internal structures and specific delivery mechanisms of undergraduate peer mentoring programs within engineering education. This gap underscores the importance of

closely analyzing how program design elements influence student outcomes, particularly regarding retention and academic success.

Informed by a design-based research perspective, this study employs *service blueprinting* as an analytical framework to visualize the components of a peer mentoring program for traditionally underrepresented first-year students to surface and understand how operational features relate to student outcomes. Service blueprinting is widely used in the for-profit sector to enhance customer experiences [14]. Design-based research offers a framework for investigating and refining educational interventions in real-world settings, with an emphasis on improving practice while contributing to theoretical understanding. In this context, service blueprinting provides a structured, visual approach to analyzing program operations and identifying leverage points for improvement [15], [16]. By mapping the program's structure and key interaction points, this study seeks to identify the components and communication pathways that most directly support student engagement and retention.

This analysis is expected to reveal both areas of operational strength, as well as opportunities for improvement, that can inform the efficacy, sustainability, and scalability of similar peer mentoring efforts. While the study focuses on program design, its findings may also have implications for improving student support structures within engineering education more broadly. The research questions guiding this design-based investigation are:

1. To what extent do specific elements of the peer mentoring program's operational structure, as visualized through service blueprinting, appear to influence student engagement and retention among first-year engineering and computer science students?
2. What areas for operational improvement or redesign emerge from the service blueprint analysis that could enhance the efficiency and impact of the peer mentoring program?

Method

To address the research questions, this study employs a design-based implementation research (DBIR) approach, using service blueprinting as the central methodological tool. DBIR emphasizes iterative inquiry in real-world educational settings, with the dual aim of improving practice and contributing to design theory [17]. In this context, service blueprinting enables a structured, visual analysis of the peer mentoring program's operational design by mapping key components, stakeholder interactions, and information flows that influence student engagement and retention.

Service blueprinting is a visual method used to analyze and improve complex service systems by mapping the interactions, processes, and resources that shape user experiences [14], [18]. Originally introduced in the business sector as a tool to enhance customer service operations, it has since been adapted across a variety of sectors, including education. The blueprinting process distinguishes among three layers of service: (1) the *frontstage*, which includes all user-facing interactions; (2) the *backstage*, consisting of behind-the-scenes actions performed by service providers; and (3) the *infrastructure*, which refers to the physical and digital systems that support service delivery [19], [20]. These components are typically visualized in parallel *swim lanes* to clarify roles, visibility, and information flow across service touchpoints [20].

In the context of this study, service blueprinting was used to analyze a peer mentoring program's structure and operational flow, with the goal of identifying service patterns, interaction breakdowns, and opportunities for improvement that affect student retention and engagement. The frontstage captures mentee-facing interactions, such as meetings with mentors, seminar participation, and touchpoints with staff, while the backstage includes mentor preparation, reporting processes, and program administration. The infrastructure layer documents tools and systems, including digital meeting trackers, survey platforms, and communication tools that support program coordination.

Program Context

The Peer Mentoring Program for Engineering and Computer Science (PMPECS) is housed within the School of Engineering at a private, four-year PWI in the Southwestern United States. The program was developed to improve engagement and retention among first-year engineering and computer science students, particularly those from backgrounds historically underrepresented in STEM disciplines. Launched in Spring 2022 with an initial cohort of 30 students, the program has expanded in scale and complexity, with enrollment and design operations stabilizing between the 2023-2024 and 2024-2025 academic years.

Each first-year student in the program is paired with an upper-division peer mentor, and pairings typically remain consistent throughout the academic year. In addition to mandatory biweekly one-on-one meetings, students participate in a required seminar series that addresses common themes related to the transition to college, such as time and stress management, course enrollment, and financial literacy, as well as other topics related to academic, personal, and professional development. Mentors also attend and engage in the seminars, which serve as a platform for community building among participants.

Program staff, consisting of faculty, professional staff, and student leaders, track mentee engagement through seminar attendance and digital meeting reports submitted by mentors. PMPECS operations rely on several digital tools to support program tracking and oversight. Mentors are expected to log biweekly meetings using a shared online spreadsheet and submit detailed reflections via Qualtrics™, an experience management platform, with prompts focused on retention risk indicators (e.g., academic, social, financial, and mental health updates). These systems allow the leadership team to monitor mentor-mentee engagement and surface student-level concerns in real time. Mentor participation in weekly leadership meetings also provides an opportunity to review cases where mentees are at risk of disengagement. However, this system currently involves multiple overlapping platforms, which may create inefficiencies or gaps in communication.

Data Collection and Blueprint Development

The service blueprint was developed through a participatory design process involving the program's leadership team, including three student leaders who have experienced the program in different capacities such as mentees, mentors, and coordinators within PMPECS. Under the guidance of the Program Manager, who holds academic training in Human Centered Design, the team held weekly meetings over the course of an academic year to collaboratively identify key

program interactions and information flows [21]. These sessions incorporated concept mapping, examination of program documentation, and reflections based on firsthand experience at multiple levels of the program. Informed by this iterative process, the team constructed a multi-layered blueprint that captures the full lifecycle of the mentee experience: from program entry and matching to ongoing mentorship, seminar participation, and administrative monitoring. Interactions between students, peer mentors, and leadership staff were mapped to clarify touchpoints, delays, and communication dependencies across the service system.

Analytical Focus

The blueprint analysis focuses on identifying structural and procedural elements that support or inhibit mentee engagement and persistence. Frontstage processes were examined for patterns of contact, clarity, and consistency in mentee-facing activities. Backstage components were analyzed for workload distribution, information flow, and responsiveness among mentors and staff. The infrastructure layer was assessed for its impact on scheduling, data visibility, and communication efficiency. Together, these analyses aim to uncover potential pain points (e.g., delays, missed interactions, or gaps in support) and highlight critical decision points where improvements in operational design may positively affect student outcomes [15].

Limitations

As a qualitative, design-based study in progress, this research does not seek to establish causal relationships between participation in PMPECS and student retention outcomes. Rather, it aims to generate operational insights that can inform iterative program improvement and future empirical evaluation. Findings are grounded in the context of a single institution and program model, and it may not be generalizable beyond similar higher education environments. Further, while the blueprint was developed collaboratively with student leaders who have served as mentees and mentors in PMPECS, the current version does not include direct input from the Fall 2024 cohort of first-year participants. This absence of end-user perspectives represents a limitation, as the service blueprinting method places high value on incorporating the experiences of current users to fully understand service design effectiveness [21]. Future iterations of the blueprint will address this gap.

Results

In Fall 2024, there were 167 first-year students enrolled in the School of Engineering. Of these, 103 students (approximately 62%) were identified as eligible for the program based on available institutional demographic data. Fifty-two students, representing approximately 51% of the eligible population, accepted the invitation to join and actively participated in PMPECS during their first year. Table 1 presents demographic data for the full first-year cohort and for PMPECS participants. PMPECS mentees were more likely to identify as Black or Hispanic and to be Pell-eligible, consistent with the program's goal of supporting underrepresented populations in engineering and computer science.

Table 1. First-Year Engineering Students: 2024 Cohort (N=167).

	Total First-Year Cohort (N=167)		PMPECS Participants (N= 52)	
Variable	N	Percent	N	Percent
Gender				
Female	60	35.93	21	40.38
Male	107	64.07	31	59.62
Race/Ethnicity				
Asian	20	11.98	6	11.54
Black or African American	20	11.98	13	25
Hispanic of any Race	28	16.77	18	34.62
Native Hawaiian/ Other Pacific Islander	0	0	0	0
International Student of any Race	10	5.99	5	9.62
Race and Ethnicity Unknown	6	3.59	1	1.92
Two or More Races	10	5.99	2	3.85
White	73	43.71	7	13.46
Pell-Eligible	47	28.14	28	53.85

First-Term Retention

First-term retention was determined using institutional enrollment records from the Fall 2024 and Spring 2025 census dates. Students who remained enrolled within the school of engineering at the institution were considered retained. Students who participated in PMPECS had a 100% retention rate into the second term, compared to 96.2% among eligible students who did not participate and 95.7% among students from non-traditionally underrepresented backgrounds. Although descriptive and not statistically analyzed, these findings suggest a promising association between program participation and early student persistence, especially for students from populations that have historically experienced higher attrition in engineering disciplines.

Student Engagement

The frequency and consistency of student engagement with the program were evident in the interaction data collected during Fall 2024. A total of 340 mentor-mentee meetings were completed, with each meeting averaging 1.03 hours in duration. In addition to these biweekly meetings, mentees were expected to attend at least two seminars per month. Weekly seminars were held throughout the term, with average attendance at 19.2 mentees per session. This number excludes students who were unable to attend due to class conflicts. These metrics reflect the program's emphasis on structured, sustained interaction between mentors and mentees, as well as the importance of consistent touchpoints for building community and maintaining engagement.

Service Blueprint Development and Visualization

The service blueprint was developed through a collaborative, participatory process led by three student leaders who had previously served in multiple roles within PMPECS, including as mentees, mentors, and program coordinators. Under the guidance of program leadership, the team engaged in weekly design sessions over the course of an academic year to co-construct the blueprint based on their lived experiences, administrative insights, and documentation of program processes [21].

The blueprint visualized the program across three key layers: frontstage (student-facing interactions such as mentor meetings and seminar participation), backstage (administrative and mentor actions such as training, oversight, and leadership team coordination), and infrastructure (tools, processes, and communication platforms that enable program delivery). These infrastructure components included mentor-mentee meeting trackers, Qualtrics™ reporting forms, and shared drives used by mentors and the leadership team. This visual representation of the program structure helped clarify where strengths existed, where inefficiencies were occurring, and how information flowed through the system.

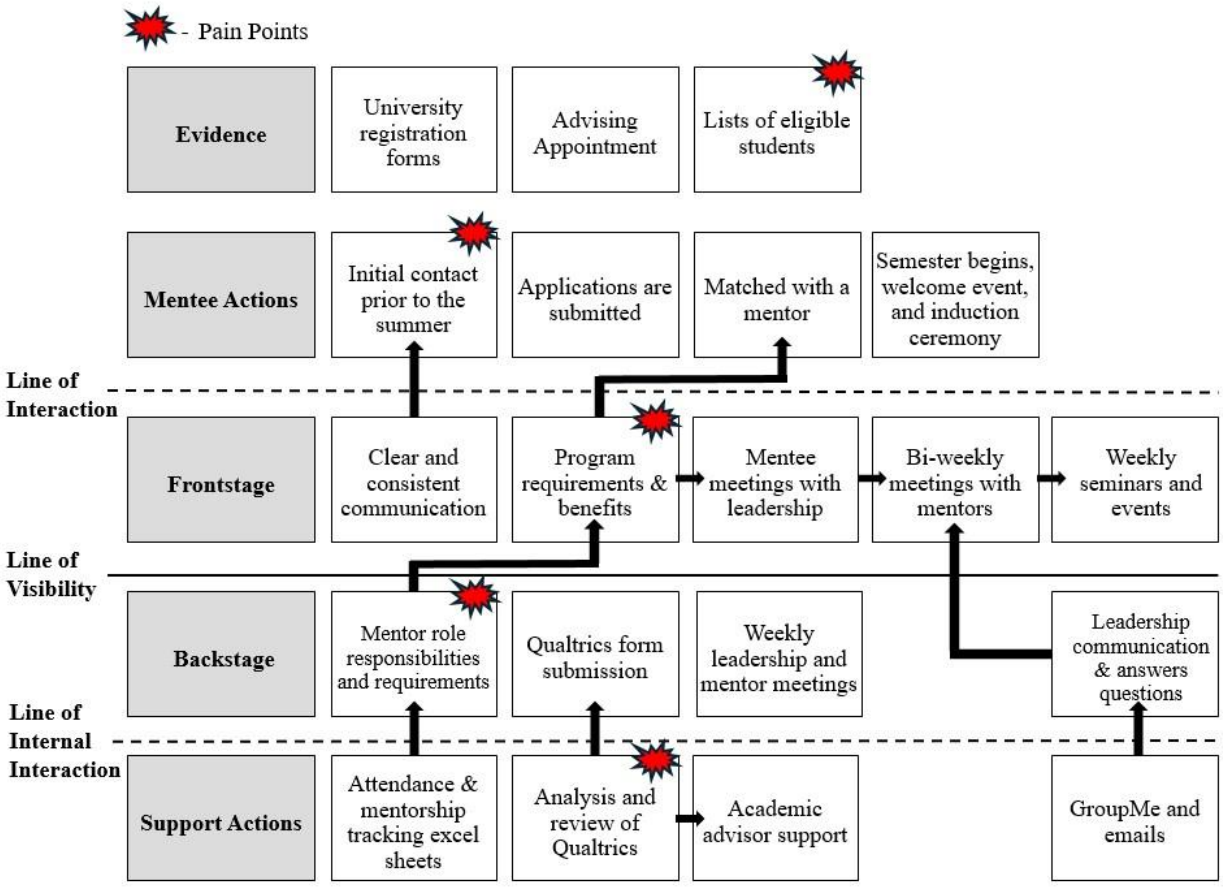

Figure 1: Service Blueprint Multidirectional Engagement

Discussion

Strengths in Operational Design

The blueprint illuminated several key strengths in the design and implementation of PMPECS. The program's structured engagement, including biweekly mentor-mentee meetings, consistent seminar attendance, and regular mentor-leadership interactions, help establish a reliable framework for student support. These interactions facilitate personal, academic, and professional development while reinforcing accountability among participants. Additionally, the program's adaptability allowed the leadership team to respond to students' evolving needs in real time, further enhancing the mentee experience. Frequent communication across stakeholder groups, including mentors, mentees, and program staff, created a network of touchpoints that may have contributed to strong student persistence outcomes.

Pain Points and Opportunities for Improvement

Despite these strengths, the blueprint revealed several operational pain points [15]. One key challenge emerged at the point of initial contact during student recruitment: the program relies on the university's communication systems to disseminate information to eligible first-year students. However, incoming students often experience information overload and may overlook institutional emails. This oversaturation can result in eligible students missing the opportunity to join the program. As a solution, more personalized methods of outreach, such as mailed letters, phone calls, or targeted messaging, could improve initial enrollment.

Another challenge involved seminar participation. Although seminar attendance is a core program requirement, students occasionally miss sessions due to scheduling conflicts with classes or other obligations. While seminar times are selected based on the majority's availability, this approach inevitably excludes some students. The current response protocol requires mentees to notify the leadership team of absences, and mentors are expected to communicate seminar content to mentees who were unable to attend. While this strategy helps bridge the gap, offering asynchronous materials or more flexible session times could further increase accessibility. Communication breakdowns were also noted between mentees and mentors, and between mentors and the leadership team. These lapses can disrupt the flow of essential information and hinder mentee engagement. Establishing standardized communication protocols and reinforcing shared accountability could mitigate these issues.

Additionally, the reporting and tracking system, though comprehensive , relies on multiple platforms, including a mentor-mentee meeting tracker, Qualtrics™ forms, and centralized shared drives. While these tools support oversight, mentors reported difficulty in consistently updating all components. Incomplete or delayed reporting can create blind spots for the leadership team and reduce their ability to intervene when students experience hardships or disengage. Consolidating these tools into a unified platform could streamline data collection, reduce administrative burden, and improve the timeliness and accuracy of interventions.
Finally, the absence of long-term tracking mechanisms represents an important gap in the program's design. Without systems to monitor mentees beyond their first year, it is difficult to assess the sustained impact of the PMPECS experience. Developing longitudinal assessment

tools, such as follow-up surveys or institutional data tracking, would enable the program to evaluate outcomes related to degree progression, continued engagement, and professional development.

Methodological Limitations

Several limitations should be acknowledged. While the blueprint reflects the experiences and insights of student leaders who held diverse roles in the program, it does not incorporate input from current first-year mentees. This omission limits the blueprint's ability to fully capture the user perspective, a key component of service blueprinting methodology [21]. In future phases, the research team plans to conduct interviews and focus groups with current program participants to validate and expand the blueprint. Additionally, the data informing this study are primarily self-reported by mentors and staff, introducing the potential for bias in interpretation.

To advance this work beyond its current WIP status, the research team will conduct additional rounds of blueprint development that include direct feedback from current first-year students. These data will support further refinement of the blueprint and allow for more robust analysis of the connections between specific program features and retention outcomes. The team also plans to develop a streamlined, integrated platform for mentor reporting and expand data collection to track students beyond their first year.

Conclusion

This study demonstrates the utility of service blueprinting as a design-based, diagnostic tool for surfacing delivery and gaps of service evaluating peer mentoring programs in higher education. Through a collaborative and participatory mapping process, the blueprint revealed how structured student engagement, operational coordination, and communication pathways contribute to a robust mentoring experience. While still in its preliminary phase, the blueprinting process has already informed actionable improvements and highlighted opportunities for further development. As the PMPECS continues to evolve, service blueprinting will remain a valuable method for assessing capacity, identifying bottlenecks, and guiding iterative program redesign. More broadly, this work offers insights for institutions seeking to enhance student support structures, particularly for first-year students in engineering and computer science. By adopting service blueprinting as a mapping method, educators and administrators can gain a clearer understanding of program dynamics, reduce inefficiencies, and implement data-informed strategies to improve student retention and success.

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