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Reimagining Summer Bridge: An Evolution in Best Practices to Support Incoming First-Year Engineering Students

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Abstract

The purpose of this Complete Research paper is to discuss a shift in the programmatic structure of a six-week engineering summer bridge program, designed to support the academic and social integration of incoming first-year students into the Pennsylvania State University community. Along with acclimating students to their chosen engineering or science-based discipline, the program includes structured social and cultural events that encourage students to build relationships with one another and relate in-class activities to out-of-class experiences. A primary goal of the program is to guide participants toward academic success, providing them with a head start in the challenging yet rewarding fields of engineering. Participants, traditionally underrepresented students in engineering, are engaged in math preparation, metacognitive skill development, group study sessions, near-peer mentorship, professional development workshops, and community building activities.

With a shift to an online format over the past two years, various components of the program structure were reimagined to accommodate the online learning environment and to emphasize interconnectivity between all community members, including participants, student leaders and program staff. Upper division student leaders, who completed the program the previous summer, were empowered to take on specific roles within the program and were engaged in development of program goals, activities, and reflections. They were provided autonomy over several key program components including academic preparation, community building, metacognition facilitation and robotics challenge implementation. The student leaders' intentional engagement within various facets of the program led to an emphasis on and strengthening of interpersonal connections.

This work discusses program development, including goal setting, schedule development, community building, reflection generation and assessment. Results from qualitative and quantitative assessments around perceived mattering and sense of belonging will be discussed in the context of program component implementation. Challenges associated with engagement in an online learning environment and those associated with program structure will also be discussed in detail.

Background

Historically, summer bridge programs have operated as spaces of transition for incoming college students entering challenging disciplines such as those in STEM (science, technology, engineering, and mathematics). In addition to encouraging retention and academic success in rigorous disciplines, summer bridge programs have a variety of goals related to academics, social engagement, culture, and identity formation. A review spanning 25 years of literature on summer bridge programs identified 14 different types of goals and classified them into 3 broad categories: 1) academic goals success such as enhancement of student knowledge of material and increased graduation rate, 2) psychosocial goals such as improved sense of belonging and self-efficacy, and 3) department-level goals such as increasing recruitment into a specific discipline and enhancing diversity [1]. The review also drew attention to the importance of starting with programmatic goals and implementing a design-based research (DBR) approach to increase understanding of how specific programs work, develop theory, and make evidence-based improvements. More research is needed about program design and implementation, including details about day-to-day structure, content, and other logistics, as the "how" is often absent from the reporting of final outcomes or pre/post comparisons. This paper provides a model of a summer bridge program that is backwards designed and relies on multiple types of assessment and research findings to inform each iteration of design. In addition to sharing program structure and the shift from residential to online, we will also make transparent the process of triangulating our own ethnographic findings and quantitative assessments with research recommendations.

Over the last thirty years, the Pennsylvania State University College of Engineering has had a long-standing commitment to increasing the retention and graduation rates of underrepresented minority (URM) students through implementation of a series of interventions, including a summer bridge program. Previously referred to as the Pre-First Year Engineering & Science Program (PREF), this six-week math intensive residential bridge program historically focused on academic preparation, social integration, cultural immersion, and professional development, with the goal of preventing participant attrition in engineering and science-based disciplines [2]. The curriculum, having evolved over time, has included intensive academic preparation in many Entrance-to-Major (ETM) level courses such as Calculus, Chemistry, Physics, and English. Participants, all attending the University Park campus, received up to 6 course credits at the start of their academic journeys along with a modest stipend to assist in expenses such as books. PREF participants have been shown to obtain higher GPAs than non-participants as well as a 68% 6-year graduation rate in engineering, which exceeds the 6-year graduation rate in engineering for majority students (60%) and for students of color who did not participate in the bridge program (44%).

In addition to PREF, a second math-intensive summer bridge program was added to the University Park campus geared towards engineering students of color who were to start their Penn State education at a regional campus. At the time, smaller Penn State campuses did not offer bridge programs with similar structures to PREF. This new program, the Academic Summer Enhancement Program (ASE) ran in conjunction with PREF with a focus on a Pre-Calculus math curriculum as opposed to Calculus curriculum. In 2016, NSF IUSE funding was obtained to expand the successful summer bridge model to three regional campuses within the

Penn State system in addition to supporting the bridge programs at the University Park campus (PREF and ASE). This project, known as Engineering Ahead, focused recruitment efforts on underrepresented domestic students (i.e., African American, Hispanic American, Native American, Pacific Islander). Throughout the duration of this project, we were able to examine the relative benefits of attending a bridge program at one's assigned campus as opposed to participating in a summer bridge program at one campus and attending a different campus in the fall semester. Analyses are continuing to be conducted on the efficacy of the new regional campus bridge programs [3] - [4].

Motivation

In recent years, the summer bridge program at the flagship University Park campus created a shift in program culture, combining both the PREF and ASE programs under one umbrella program called Engineering Summer Bridge (ESB). This grew from extensive conversations and assessments of participant outcomes, leading to iterative program design. In 2019, we observed a clear distinction between PREF and ASE, as the programs utilized different names, different orientations, different math preparation (as ASE students prepared for pre-calculus and PREF students prepared for calculus), and even different t-shirt branding. This created a distinct divide among the students attending the University Park campus versus a Commonwealth Campus in the fall. In an informal interview with one of the ASE students, it was noted that they did not spend much time during the program making friends as they would be returning to a different campus in the fall. We decided to combine the two programs into one to disrupt any perceived hierarchy between students in different levels of math preparation and to develop a more inclusive environment. Additionally, our hope was that this would lead to stronger community building, especially for students from Commonwealth Campuses.

In conjunction with the internal structure and culture shift of the summer bridge program, in 2020, the program flipped to a completely online model due to the limitations of hosting a residential program at the initial stages of the COVID-19 pandemic. Recruitment efforts also evolved in 2020 to emphasize URM students as well as those with high financial need. Although the primary focus of the 6-week bridge program remained to provide academic enhancement, the structure was re-imagined, ensuring that students were also exposed to on-campus and off-campus resources, fostered supportive social networks, and engaged in career exploration with alumni and industry representatives.

Online Schedule Development

In both 2020 and 2021, the ESB program was conducted as a fully online synchronous program via Zoom. In this model, it was important to reevaluate the structure of the schedule, to continue to retain essential elements of academic and social integration as outlined in Tinto's theory of college student departure [5] - [6]. The program length remained 6 weeks and was restricted to Monday - Friday so that participants would have weekends to focus on additional obligations outside of the program. Programming was also focused primarily within an eight-hour window, containing several interspersed break periods. Evening activities were contained to two days per week. Program focal areas included academic preparation, team centered engineering design,

campus life orientation, peer mentoring, and networking. A standard week within the program included a daily intense review session, math instruction four times per week, chemistry instruction three times per week, metacognition instruction three times per week, metacognition facilitation once per week, team project development twice per week, enrichment activities once per week, weekly quizzes, and weekly assessments.

The academic component focused heavily on math preparation. Participants, regardless of campus starting location, were placed in either a pre-calculus or calculus course based on their high school math courses, Assessment and LEarning in Knowledge Spaces (ALEKS) score, and instructor developed math pre-test assessment score. Students engaged in chemistry preparation as both calculus and chemistry are ETM courses for most disciplines within the college of engineering. In addition, students participated in a metacognition course based on Sandra McGuire's Teach Yourself How to Learn text. The course encouraged exploration of various learning strategies, focusing on maximizing learning and transitioning from memorization to understanding and analyzing. Lastly, students were required to participate in one of two intense review sessions where they were able to seek additional support from graduate student facilitators and upper division student mentors. Tablets were mailed to each student to assist in utilizing Zoom capabilities to solve problems together in real time.

During the residential program, we partnered with the Penn State Applied Research Laboratory (ARL) to engage participants in the Office of Naval Research sponsored Sea Air Land (SEAL) Challenge. Teams of 5 to 6 built and coded a robot over the course of the 6-week program, culminating in a competition where each team's robot navigated an obstacle course. In our transition to a fully online program, we continued our partnership with ARL and shifted the focus to providing the participants with a foundation for engineering design. The goal of the challenge was to engage participants in design thinking, foster strong teamwork and communication skills, and introduce SolidWorks 3D modeling software. Each team developed a technical report, including an executive summary, problem definition, design evaluation, prototypes, economic analysis, and feasibility. Along with the technical report, teams presented an elevator pitch to a panel of professional engineers where they discussed their design features. Each group was evaluated on the novelty of their approach, design requirements, practicality, cost, teamwork, and effective communication.

Participants were engaged in several enrichment activities throughout the program aimed at exploring engineering majors, exposing students to campus resources, and networking with alumni and industry representatives. Sessions included workshops and panels pertaining to LGBTQ student voices, equity and inclusion in engineering, undergraduate research, global engagement opportunities, resume/interview preparation, career exploration with alumni, and financial literacy.

One critical element that we sought to maintain in our virtual programming was the establishment of community among participants. Previously established hybrid and fully online summer bridge programs have noted that the ability to foster community and create sustained

bonds between participants is an essential programming outcome that is difficult to achieve in a fully online format [7] - [8]. Recognizing that we would lose informal periods established during down time in a residential program, we incorporated two, one-hour community building sessions into the schedule each week so that participants would be able to engage in conversations outside of the classroom setting. These were designed as evening sessions so that participants would have time to eat dinner and unwind prior to engaging in fun activities with their peers.

Student Leader Focal Areas

In examination of previous online summer bridge programs, we found that in addition to web-based learning systems for academic instruction, other critical elements included peer mentoring and community building among participants [7] - [9]. With this in mind, we determined that we would restructure the roles and responsibilities of the upper division near peers serving as student leaders within the program. Previously, in addition to residing in the residence halls with participants, the student leaders received a brief training, attended courses, assisted in review sessions, and assisted in arranging fun activities for the students [2]. We re-envisioned the role of the upper division student leader or program assistant through empowerment and engagement in the development of program goals, activities, and reflections.

Rising second-year students who had completed the ESB program the previous year were provided autonomy over several areas of priority including academic preparation, community building, metacognition facilitation and robotics challenge implementation. The program assistants were highly motivated students with the ability to work collaboratively, think creatively, manage time and scheduling, communicate effectively, and develop community-oriented programming. They worked 40 hours per week and received a stipend. In addition to their particular areas of focus, the program assistants' general responsibilities included 1) logging participant attendance, following up with any absences, late arrivals, or early departures, 2) mentoring a group of 5-6 participants, 3) facilitating sessions related to academic, professional, and social development, 4) creating opportunities for participants to engage in community building activities, and 5) responding to mentee's weekly video reflections.

Each focal area consisted of two to three program assistants. The academic team focused on enhancing the academic development of participants through tutoring sessions and assisting both graduate student facilitators and course instructors. There were two program assistants who focused on pre-calculus and calculus and one who focused on chemistry. They attended faculty-instructed courses, facilitated intense review session tutoring, and assisted with grading homework, quizzes, and assessments. The academic program assistants implemented best practices in encouraging participants to work together for collective understanding of material, utilizing technology to probe for questions when concepts were unclear, and providing positive affirmations when grading coursework.

Two program assistants were assigned the role of Metacognition facilitators. Their job was to attend metacognition instructional sessions and develop a weekly facilitation session, exploring topics from the student perspective, having recently completed their first year as a college

student. Activities focused on introspection, healthy study habits, learning strategies, wellness and navigating college life.

The implementation of the robotics challenge was also headed by two program assistants. They worked directly with partners at ARL to develop the virtual SEAL challenge as well as taught participants SolidWorks/CAD, guided them through the construction of both a design report and poster, assigned roles within the teams, facilitated competition preparation, and continually updated the staff on the progress of the competition. The robotics program assistants brought in their peers as guest speakers to discuss what they learned from participating in previous competitions and how what they learned translated to their current internship/research experiences. They also met with individual students and teams separately to discuss areas for growth and to assist in improving skill acquisition.

The two program assistants responsible for community building were tasked with helping participants to establish long-lasting connections, with the goal of encouraging a sense of belonging. They planned and prepared virtual community building activities, facilitated dialogues related to college life, and shared their personal perspectives to connect with participants through vulnerability. The program assistants were keenly aware of community dynamics, finding creative ways to involve non-engaged participants based on inventory of interests and encouragement, all the while utilizing inclusive language and setting norms for participants to emulate inclusive behavior.

Goal Setting and Mentor Development

Prior to the commencement of ESB, the program staff engaged in a week-long intensive training session. Topics included goal setting, mentorship training, Counseling & Psychological Services, Title IX and violence prevention, public speaking, conflict resolution, sense of belonging development, and reflection. We began the training week with an orientation focused on planning and goal setting in a backwards design model. The entire program staff came together to address the following critical questions: 1) How will we facilitate and observe student progress and development, 2) How will we meet the needs of participants as they arise, 3) How will we create a sense of belonging, 4) How will we provide space and opportunity for building confidence and self-efficacy, and 5) How will we provide tools for self-reflection and preparation? With these questions in mind, we were able to differentiate and articulate goals at distinct time points in the program related to participant orientation, week-to-week experiences, and end of program aspirations, as well as project ahead to identify ideal outcomes for participants' future semesters and beyond. Each week during the program, we met as a full staff and were able to go back to our list of goals and discuss what had been accomplished, what we were able to measure, and make iterative adjustments. We then began to draft a set of best practices and resources that would enable participants to reach these goals.

During the training week, special emphasis was placed on program assistant mentor development, as mentorship has been identified as a key practice in increasing student retention in STEM [10] - [11]. Program assistants learned how to clarify roles, build trust, develop

empathy, ask powerful questions, and actively listen. They were also taught how to assist mentees in reflecting on their personal experience, setting goals, creating action, and developing accountability. Each program assistant had a mentor team of 5 to 6 participants for whom they would engage in a structured check-in each week as well as informally throughout the duration of the program. During check-in meetings, they would discuss their mentees' successes and highlights of the week, challenges and areas of support, and probe them to expand upon the areas for which they were looking forward to gaining a deeper understanding in the coming weeks. The program assistants would also respond to their mentees' weekly video reflections, providing words of encouragement such as "You will always have support in everything you do from your community! I promise that! I'm so proud of how far you have come!! You are going to be GREAT in college and beyond."

Assessment

Throughout the duration of the program, we performed an iterative program assessment consisting of pre and post surveys, along with weekly assessments to evaluate development over time. We also collected field notes and observations that were discussed in weekly staff meetings, performed informal interviews, and had participants respond weekly to a series of prompts in the form of video reflections. One critical area that we sought to explore in our weekly assessments was participants' sense of belonging and perceived mattering during the online bridge program. Results from the 2020 program, in combination with data from the Engineering Ahead project, showed that there was a statistically significant increase in both sense of belonging and perceived mattering over four weeks during the online bridge program [4].

We also sought to understand participants' perceived value of the program by asking them to respond to the following prompt at the end of the program, "What is your most significant take-away from the program as a whole?" Participant responses from both 2020 and 2021 cohorts were analyzed with an emerging coding system, leading to generation of 7 themes: 1) metacognition skills, 2) robotics challenge, 3) math preparation, 4) knowledge building, 5) community/relationship building, 6) preparation and exposure to college atmosphere, and 7) communication. Table 1 depicts the percentage of participants from both 2020 and 2021 who responded to the survey and their perceived value of these emergent themes which relate to key programmatic elements. The combined response rate for 2020 and 2021 was 85%.

A consistently emergent theme was the development of metacognition skills. 46% of participants discussed this theme as a key take-away from the program. One participant shared that "The concept of metacognition is definitely the most significant take-away from the whole program. I would have never thought I needed to learn how to learn, but with metacognition I now feel prepared to tackle college courses with these new strategies." Another participant expanded on the next most notable theme, community/relationship building, stating that "The way many students and PAs were able to bond and connect with each other was very special. I thought it was amazing considering it was all through zoom. We were able to get to personal stuff and actually know each other better than just our grades, majors, and some interests." 31% of

respondents highlighted this theme as a key take-away. Additional outcome assessment pertaining to the 2020 and 2021 fully online programs is currently ongoing.

Table 1. Emergent Themes Developed from Participants' Perceived Programmatic Value

Themes	Years			
	2020	2021	Total	% of Respondents
Metacognition Skills	16	15	31	46%
Robotics Challenge	1	1	2	3%
Math Preparation	4	2	6	9%
Knowledge Building	2	0	2	3%
Community/Relationship Building	12	9	21	31%
Preparation & Exposure to College Atmosphere	12	8	20	29%
Communication	1	1	2	3%

Implications and Future Directions

Restructuring ESB to adapt to a fully online program, provided several notable benefits. First, the overall cost associated with executing the program decreased significantly. This in large part was due to cost saving in areas such as housing, meals, and excursions. In turn, the cost associated with program participation was also reduced significantly for students. In addition, students with additional commitments such as work responsibilities were able to both participate in the program and fulfill their work obligations, allowing them to save additional funds for college expenses. Program assistants were able to participate in additional activities such as asynchronous coursework while fulfilling their duties.

In opposition to the benefits stated above, there were also several challenges that were noted throughout the program regarding the online format. Although participants were allowed to choose either the morning or evening intense review session, those residing on the west coast found difficulty in acclimating to the time difference, as the program catered primarily to those residing on the east coast. Participants with additional responsibilities outside of the program such as work, and sibling caregiving found it difficult to balance their time during the week. Some participants found it difficult to concentrate for long periods of time on Zoom. Additionally, it was difficult to determine whether students absorbed the material as cameras were often turned off, preventing instructors from gauge facial expressions. Communication was also a notable challenge in the beginning of the program as participants were reluctant to fully engage prior to establishing connections with peers and program assistants.

There are several critical elements of the reimagined ESB program that will be retained in subsequent years when returning to residential programming. We were able to effectively build a welcoming community for students that reinforced their sense of belonging in a fully online program due to the specialized attention that was given to developing bonds both between peers and between program assistants and participants. One of the most significant program enhancements was the restructure of the roles and responsibilities of the upper division student

leaders. The focal areas of autonomy assisted tremendously in dividing the workload for the program assistants. In addition, it provided them with a sense of purpose and leadership over their areas of expertise. In future work, we plan to examine to what extent program assistants' designated roles provide opportunities to develop agency, engage in professional and personal growth, and positioning from others as a leader. We will also utilize survey responses, reflection responses and focus group interviews to examine the benefits, challenges and affordances of near peer mentorship of both the program assistants and participants in the reimagined ESB program.

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