Board 138: (Re)Engineering Student Success: Constructing Knowledge on Summer Bridge Students' Experiences to Encourage Holistic Student Success

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Shaylin is invested in identifying ways to improve the collegiate experience for future generations of engineers. Her participation in Summer Bridge, IMAGE, and the McNair Program led her to pursue graduate degrees in engineering. She loves working with engineering programs, outreach, mentoring, and learning how teaching and learning environments can be enhanced to encourage student success. Her goal is to become a faculty member and administrator. Follow Shaylin on Instagram @phd.progress to see her journey through academia.

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Abstract

If a group of engineering deans was asked whether students at their institutions were successful and why, what information might they immediately or subconsciously use to measure or gauge the engineering students' success? If only academic performance outcomes like GPA, individual course grades, or graduation rate race to their minds, then their rationale aligns with the majority of researchers. My research seeks to shift the mindset that frames engineering student success mainly within the boundaries of academic performance measures. Measuring students' self-determination and motivation levels by gauging perceived autonomy, competence, and relatedness within their programs, one can more accurately assess whether engineering students are achieving holistic student success. By utilizing a baseline survey and exit interviews for freshmen Summer Bridge Program (SBP) participants and interviewing past SBP participants, this research is gathering more in-depth information on students' experiences.

Preliminary results from SBP freshmen interviews indicated that key program components affecting students' experiences and success included community building, structured studying, field trips and real-world experiences, residential life, and mentorship. Preliminary findings for past SBP participants, whose classifications range from sophomore to senior, include emphases on being Black in engineering, program structure, program leadership and connections, and relatedness in SBP being non-transferable to undergraduate departments. The ongoing analyses of this qualitative data, coupled with the collection of quantitative data from engineering seniors (additional study), will offer valuable insight into ways to approach persistent issues in engineering education.

In turn, one can better understand how the structures of engineering summer and undergraduate programs either contribute to or detract from student success and motivation. This information can be used in practice for enhancing programmatic planning and design as well as potentially developing novel program components that contribute to students becoming more self-determined, motivated engineers. It is my hope that one day in the near future, engineering education faculty, administrators, and leaders will cultivate and measure success based on a more comprehensive assessment of lived experiences. Additionally, this research is intended to help leaders better recognize how their decisions regarding programmatic structures impact students' experiences and success.

Introduction and Literature Overview

Inequalities are deeply rooted in the U.S. education system. Students from underrepresented groups have faced intentional obstacles limiting access to quality education and resources [1]. These disparities span back only one or two generations for many underrepresented minority (URM) students and their parents [2]. The effects of these systemic injustices are still seen today, despite efforts to level the playing field and right the wrongs of decision-makers before us [3]. Moreover, institutions of higher education were originally designed for wealthy White men training to be clergymen [4]. While vast amounts of work have been done to progress higher

education and STEM, several issues remain evident even in 2023 [5]–[7]. With this, we continue to push for diversification and increased representation among engineering professionals in all disciplines.

To aid in the attainment of more progressive goals at many universities, countless programs and initiatives for higher education have been created. With the historical evidence of URM students being excluded from engineering spaces, it would be useful to examine how URM students today develop within programs that were designed to correct remaining consequences of inequality. One program, the Summer Bridge Program (SBP), has historically aimed to support URM students in STEM during the pivotal transition from high school to college [8]. SBPs tend to focus on academic preparedness skills [9], [10]. More recently, literature has investigated how SBPs impact academic performance in undergraduate programs along with sense of belongingness among participants.

Student Success in Engineering

The bulk of engineering education research examining student success has focused primarily on academic performance measures like course grades, GPA, retention rate, and graduation rate. Researchers reported conducted a study and reported that the "successful" engineering students at their institutions were disproportionately Asian students with good math preparation [11]. In contrast, the present study is positioned in congruence with researchers like May and Chubin [12], who called attention to the importance of institutional commitment as opposed to affirmative action alone and even called out minority engineering programs (MEPs) for focusing too much on academics without incorporating other aspects of students' experiences [12].

Researchers have even gone as far as stating that social engagement may not be an important factor for students' success in engineering [13]. This claim is not only counterproductive for all students who will need more than technical skills but is especially harmful to URM students who face compounded challenges that can arise from a lack of social integration [14]. On the other hand, some studies highlight social integration as being important [15]. Other studies even look specifically at external factors that disproportionately affect URM students, like college literacy for first-generation students, jobs, and financial pressures [16], [17]. The problem here is that researchers have typically framed these external factors and disparities as affecting academic performance. While these studies yielded important findings, this viewpoint re-affirms the idea that factors outside the classroom affected academic performance and viewed academic performance as the "end-all." Factors like social integration and student support are treated as a means to achieve academic success as opposed to being examined in congruence with academic success as equal contributors to holistic student success.

More recently, researchers have begun taking more critical approaches to examine URM students' experiences and success in engineering. Newman [18] delved into the role mentorship played in engineering student success, specifically among African American males. With findings in three main areas, the author emphasized the notion that students found "lone wolves," who were among the few faculty members these students viewed as mentors [18]. Holly and Manstra went a step further, calling attention to how funding agencies cite issues related to underrepresentation in STEM, but fail to acknowledge or discuss how Whiteness "instituted the standards of admission,

acceptance, and success that affirm the cultural norms of White people while demeaning others" [19]. Recognizing the value of more critically examining engineering student success, the current study intends to contribute to the more progressive and emergent lines of research.

Motivation

Consistent with student affairs practitioners' line of thinking, I assert that holistic student development is more important than students' development in any one area and is central to overall student success [20], [21]. Using Self-Determination Theory (SDT), the current study seeks to shed light on the comprehensive, multi-dimensional nature of students' experiences within SBPs. SDT was developed by phycologists Ryan and Deci and is widely used in psychology and other social science fields [22]. Surprisingly, SDT has not been adopted in many engineering education studies. I believe SDT could be a useful lens to help gather valuable information related to persistent issues in engineering, such as ways to increase diversity and better support URM students.

SDT is a macro-theory with 6 mini-theories that can be used to guide research inquiries [23]. The present study employs the Basic Psychological Needs Theory (BPNT) to delve into three major constructs. The mini-theory posits that psychological well-being and a person's optimal level of functioning are dependent on the person's autonomy, competence, and relatedness [24]. Contexts and environments that support these three major constructs should invariantly impact wellness [25].

In the context of engineering programs, autonomy relates to whether students feel they have the free will to make their own choices, as opposed to being coerced or pressured. Autonomy could also refer to the freedom students feel within the programs, such as being able to pursue their interests and express creativity in various ways. Competence corresponds to students' beliefs about their abilities to successfully complete engineering tasks or do engineering-related work. Finally, in engineering, the relatedness construct focuses on whether students feel socially integrated and connected to their peers, departments, program leaders, and other professionals in their field.

This study uses SDT as a lens for examining and interpreting students' lived experiences and progress from their inception to the SBP through its conclusion and beyond. SDT is uniquely positioned to gather information on multiple aspects of students' experiences, and in turn, the holistic nature of their success in engineering programs. With SDT as a guiding theoretical framework, this study aims to answer the following questions.

Research Questions

1. How does a Summer Bridge Program (SBP) affect students' experiences and success in engineering from a self-determination viewpoint?
2. Which program characteristics and components either contribute to or detract from SBP students' experiences and success in engineering?

Methods

To gain a more in-depth understanding of the experiences of both current and past SBP participants, this study's methodology included two distinct parts. The participants included for both parts attend a public 4-year institution in the southern U.S. region. The first group of interest, SBP freshmen, included participants comprising the summer 2022 cohort. These students stayed on campus for approximately 5 weeks in a residential hall and closely followed a pre-made SBP schedule. All participants in this group graduated from high school in the Spring semester before the SBP and been accepted to engineering programs starting the fall 2022 semester. The second group of interest was continuing students who had previously participated in the SBP at the same institution in either 2019, 2020, or 2021. Table 1 includes information for the freshmen SBP students (Summer 2022 cohort).

Table 1
SBP Freshmen Participant Summary.

Pseudonym	Engineering Discipline	Ethnicity	Prior (K-12) Engineering Experience	Gender	Comments
Auria	Chemical	Black	Yes	F	
Brittney	Biomedical	Black	No	F	
Cameren	Electrical	Black	No	Non-binary	
Candace	Mechanical	White/Asian	Yes	F	Changed ethnicity on end evaluation
Gavin	Computer	Black	Yes	M	
Ken	Mechanical	Black	No	M	
Lacey	Chemical	Black	No	F	
Michael	Biomedical	Black	Yes	M	
Patrick	Civil	Black	No	M	
Quinton	Mechanical	Black	Yes	M	
Rachel	Biomedical	Black	Yes	F	
Shane	Aerospace	White	No	M	
Sydney	Biomedical	Black	Yes	F	Withdrew from SBP
Taylor	Civil	Black	No	F	
Travis	Industrial	Black	Yes	M	
Victoria	Chemical	Black	No	F	
Warren	Electrical	Black	Yes	M	
Whitney	Aerospace	Black	Yes	F	
Zion	Mechanical	Black	Yes	M	

For the SBP freshmen, the first part of data collection was conducted via a Qualtrics survey. The survey was created based on two existing, validated SDT scales: the Intrinsic Motivation Inventory (IMI) and the Aspirations Index (AI). The survey took approximately 30 minutes to complete and was administered to all 19 SBP participants at the beginning of the SBP to establish a baseline for perceived autonomy, competence, and relatedness, among other constructs. In the survey, students responded to questions about demographic information and their backgrounds, 7-point Likert scale

items related to the IMI and AI, and were able to leave open-ended feedback regarding their experiences up until that point.

The second part of data collection, which was conducted for both the SBP freshmen and the continuing students, was an interview. In the absence of an existing, standardized SDT interview protocol, a protocol was developed based on the IMI and AI as well as the research questions. The interview protocol originally consisted of 12 core questions designed for the SBP freshmen. The core questions were each linked to a specified construct that can be used to critically examine SBP students' experiences using SDT as a theoretical lens. Core questions were also accompanied by probing questions which were used to gather additional information related to anticipated responses. The protocol included a participant information section at the beginning, as well as guiding prompts and directions for beginning and ending the interview. The questions in the freshmen protocol were modified to fit the context of a past SBP participant and continuing student before being used with the second group of interest. The recorded portions of interviews for both groups of participants averaged approximately 30 minutes.

For the freshmen, after completing the baseline survey and the majority of the SBP, students signed up for exit interview slots. Eighteen one-on-one, semi-structured interviews took place from July 5th, 2022 to July 7th, 2022. For the continuing students, emails were sent out to all past participants from 2019, 2020, and 2021 to request their voluntary participation in an interview. Interested students were able to schedule interview times and dates based on their availability. Seven past SBP participants completed interviews between October 17th 2022 and October 19th, 2022, with two students doing a joint interview at their request.

The IRB protocol for studies conducted with SBP freshmen and continuing student participants were granted an exemption determination due to minimal associated risks. For both freshmen and continuing SBP participants, consent forms were signed, and verbal consent was also granted before interview commencement. All interviews took place in a private room on the campus housing the SBP. All interviews were audio recorded, transferred to a password-secured Dropbox, and transcribed using Rev transcription service. Recordings were deleted from the institution-issued recorders after being transferred. Participants were assigned pseudonyms, and all identifying information was cleaned from the transcripts to maintain confidentiality.

The cleaned interviews were coded in Dedoose using a codebook developed specifically for this study. Like the baseline surveys the SBP freshmen completed and the interviews all students participated in, the codebook was based on the IMI, AI, and research questions. The coded interviews of each group of interest were then able to be compared and analyzed to support the synthetization of emergent themes. Analyses for the past SBP participant group is ongoing.

Preliminary Results

Preliminary results from SBP freshmen interviews indicate that key program components affecting students' experiences and success in the engineering transition program include community building, structured studying, field trips and real-world experience, residential life, and mentorship. In the interest of keeping things concise, I present each theme below with one supporting quote from a participant transcript.

1. Theme 1: Community building and establishing a sense of relatedness is integral to the SBP but can only happen if a student decides that some aspect of the program is valuable.

Gavin (2022 SBP participant), when asked about the expected long-term impact of his SBP participation:

And then I already have, I guess a group of supportive people, that like, if I was ever to need anything, or we can work together, study together, be there for each other to support each other. I won't be- Won't be like, I guess coming in alone. I already have somebody... some people who I know I can trust.

Brittney (2022 SBP participant), when asked about her favorite part of the SBP:

My favorite part would have to be the, I guess, just interaction with people. I'm not that social, I don't know if you can tell, but I did like just being around other like-minded individuals and everything and just making friends, other engineering friends because it's going to be a little hard meeting other people like me in engineering. So this was just really a great opportunity. I'm glad I got to do it."

2. Theme 2: Structured studying is valuable for and instilled in all students. Allotted time for academic preparation is emphasized by students reporting lower perceived competence at the SBP's commencement while establishing a routine and socializing are often added for students with higher perceived competence.

Taylor (2022 SBP participant), when asked what she thought the most valuable part of the SBP was:

Being able to study three hours a day really helped me a lot. And I would definitely bring that into the fall semester with me because you're going to have to study a lot a lot to actually get to know the material. So that really helped me and was valuable to me.

Victoria (2022 SBP participant), when prompted to finish the statement "It wouldn't be Summer Bridge without [blank]" and to give an explanation:

Victoria:
Study hall.

Interviewer:
Why?

Victoria:
That's when you really... Yeah, when we're in class and stuff, we connect too, but study hall is like... First of all, they teach you how to study. They teach you study habits that you're going to need, whether they think so or not and that's just when you get closer to people, you get to see everybody's real personality and everybody comes out their shell because you don't have a phone… nothing- you're just there.

3. Theme 3: Field trips, real-world experience, and hands-on experiences are interesting to students and allow them to better understand engineering and engineers. These experiences

are especially impactful for students with lower baseline perceived competence scores and/or no K-12 engineering experience.

Patrick (2022 SBP participant), when asked about his favorite part of the SBP:

I think when we had gone to the lab over there and it was hands-on... the asphalt and stuff. Because it was basically in my field, like the civil engineering field. And that's how I learn really… just with hands-on things. And it was like, being interactive with stuff.

Quinton (2022 SBP participant), when prompted to finish the statement "It wouldn't be Summer Bridge without [blank]" and to give an explanation:

Trips. The trips. It gives people stuff to do and they can actually see how engineering relates to the real world because I heard most of them say that going to [petroleum company in southern state] and these other places, they were like, "I didn't even know that this little basic thing required this much math and stuff like what we talked about in school."

4. Theme 4: The residential life component is an important part of students' maturation, growth, and acclimation to campus from their inception into the SBP through its conclusion. Perceived choice did not appear to play a role in whether students experienced these benefits.

Zion (2022 SBP participant), when asked what he "got the most out of" during the SBP:

Being free, living on my own, having to make my own decisions. Because growing up, I was very indecisive. I still am indecisive, but now it's like I can see... to where my mind is like "I know what I have to do, and I have more conviction to actually go and do it."

Michael (2022 SBP participant), when asked what his favorite part of the SBP was:

I would say just having freedom because my parents, they're really strict. So just having the freedom to go out and just learning before I come here, there's certain things that I can do and I can't do. Like, I can't stay up till 2:00 studying, then try to go to 8:00 AM class.

5. Theme 5: Many students perceive mentorship as valuable, and it stems from multiple avenues within the SBP. Students are more likely to recognize the value of mentorship if they are more social and/or open to asking questions in more private settings.

Travis (2022 SBP participant), when asked what the most valuable part of the program was:

'Honestly, it's like I'm going to word this answer weird but it's like... asking questions. Whether it be to the counselors, to the alumni spotlight people, to the people that came and talked to us from the companies, or to the graduate students, or from the people on the tours. That's really what I think the most helpful thing for me is just asking questions and getting feedback from A, B, C, and D.'

Gavin (2022 SBP participant), when asked what the most valuable part of the program was:

'I think the most valuable thing is just the conversations. […] talking to the counselors, talking to the professors, talking to people at [southern petroleum company] being able to actually talk to actual engineers who spend their daily lives doing the stuff that you know, many of us

want to do. Being able to do those things, developing friendships and relationships with the people here. I think that once the program is over, that's the stuff that's going to stick for sure.'

6. Theme 6: Many students believe the required effort, difficulty, and academic experiences within the SBP may be dependent on prior (K-12) engineering experiences as well as high school rigor. Those with in-depth, sustained K-12 engineering experiences heavily emphasized a perceived effort/ difficulty gap between themselves and less experienced peers.

Rachel (2022 SBP participant), when asked if the SBP was harder or easier for certain people, and why:

> *'For some people I felt it was easy, but for everyone else, it was hard. I want to say it was probably half and half because some people found all the classes really easy and then everybody else was just like, "what in the world?" They had more- like at my school; we didn't really have a certain class for like engineering. I took more of the health sciences. So I knew more of the math and science part of things with engineering. But with engineering itself, I knew I would need help with that. So with some people they knew, and they probably had privileges for engineering classes, so that's why'*

Whitney (2022 SBP participant), when asked if her prior (K-12) engineering experiences impacted her SBP experience:

> *'I think it did. But I came in here and knew what I was doing. But the thing is, other people didn't. They had little experience with engineering. That's fine. It was just more so they felt that I was a bit controlling, which I try not to come across that way, but it was more so I just knew what I was doing because I had done it twice before. Structured like this, like we're given a project or task and we're going to make it, print it and do slides and present it to a panel of judges. I did that with my [space company] internship, with my engineering thing, and I'm doing it here. So I feel like I'm just more, I guess, knowledgeable about it than most people in this program. But that's not to brag. It's just to say my experiences was different, if that makes sense.'*

Preliminary findings for continuing SBP students, whose classifications range from sophomore to senior, include emphases on being Black in engineering, program structure, program leadership and connections, and relatedness in the SBP being non-transferable to undergraduate departments. More specific theme synthetization and data analysis for this past SBP participants is ongoing.

Discussion

Current SBP Participants

Theme 1 was created because nearly all participants emphasized the importance of and value associated with forming community during the SBP. Theme 2 focuses on the benefits students stated they derived from participating in structured study hall hours throughout the duration of the SBP. Students who began the program with lower engineering perceived competency scores appreciated being able to work on their SBP coursework routinely and diligently. Other students

appreciated having time to collaborate in teams and getting to continue building community in learning spaces. Many students enjoyed the hands-on experiences and real-world problems they encountered during the program. This was especially valuable for students who started the SBP without prior (K-12) engineering experience or exposure. Theme 4, related to the residential life component, captures many participants' narratives about living independently for the first time and getting their first adult life experiences. Theme 5 focuses on participants' emphasizing the impact of positive mentorship in the SBP. Interestingly, students who mentioned being shy or perceiving that they did not have the best "social skills" did not speak about the importance of mentorship in the SBP as frequently as other students. Lastly, theme 6 is related to the increased perceived difficulty and/or effort required to do well in the SBP for students who had less rigorous course offerings in high school or fewer engineering experiences in K-12.

Past SBP Participants

While theme synthetization and data analysis for the past SBP participants is ongoing, preliminary overarching themes can already be deciphered. One major idea that past participants stressed is the notion of being Black in engineering. While some SBP freshmen spoke about this with the community building theme (theme 1), past participants spoke more specifically about the importance of being a part of a URM engineering community as they matriculate further into their undergraduate programs. Past participants also spoke about how program structure impacts the SBP overall. With these students having participated in 2019, 2020, or 2022, their SBP programs took place before, during, and after the peak of the Covid-19 pandemic. This impacted the delivery of the SBPs and students' relatedness among their peers during the programs. Unlike freshmen SBP students, past participants often emphasized the role of the SBP Director after the program's conclusion in the summer. As they began and continued in their degree programs, they noted the importance of the director's involvement and efforts to keep the spirit of community alive. They also spoke about the importance of having URM speakers during the SBPs who sometimes turned into long-term mentors and professional connections. Lastly, students introduced the notion that relatedness in the SBP context differs from relatedness in undergraduate programs and departments. Many past participants felt connected to their cohort and other SBP cohorts and used these connections to make up for the lack of connections and belongness within their undergraduate departments.

Limitations

Typical with majorly qualitative studies, the current study consists of relatively small sample sizes. Also, all students attended the same institution. The findings and ongoing analysis provide valuable insight that can be used to better approach persistent engineering issues related to engineering diversity, equity, and inclusion. However, it is important to note that SBPs may vary at different institutions. Therefore, these findings may not be generalizable for all SBP contexts. Instead, they provide a model for investigating student success and experiences above and beyond solely relying on academic performance measures or a unidimensional viewpoint.

Additionally, while SDT provides valuable information about students' perceptions and experiences across multiple domains, it does not account for objective measures. Coupling SDT

with other theoretical lenses and or methods may prove useful for providing a more well-rounded picture of students' journeys to and through engineering programs.

Conclusion and Future Work

With continued efforts and calls to diversify the engineering workforce and engineering programs at institutions across the globe, re-examining students' experiences in the SBP is a plausible starting point. SBPs have historically targeted participation from URM groups but did so to ensure academic preparedness for "at-risk" students. Consistent with Celedon and colleagues [26], the present study took an asset-based approach to determine whether programs are properly supporting students, where programs excel, and where programs may fall short [27], [28]. SDT provides useful information about students' holistic experiences, as opposed to traditionally reported grades and retention rates after SBP participation.

By looking at current and past SBP participants' perceived competence, autonomy, and relatedness within the context of engineering programs, one can better understand what is helping or hindering students in the pursuit of engineering degrees and careers. I have found that freshmen express common sentiments and share some similar experiences in the SBP, but those experiences may be described differently for students with different SDT scores or different K-12 experiences (RQ1). More specific SBP components contributing to positive experiences are structured studying, residential life, and real-world experiences (RQ1a). One component warranting special attention is avenues for mentoring students with various personality traits (RQ1a). For SBP past participants, I am finding that being a URM student in engineering becomes more challenging as students move away from URM-focused SBPs into their undergraduate programs. Past participants also stress the importance having of sustained contact with SBP leaders and cohorts after the program ends.

I am excited to uncover what the rest of the past SBP participant data suggests and to disseminate that information. Looking forward, I hope that this information can be used to catalyze a shift away from looking at one aspect of the student experience (E.g., sense of belonging or academic performance) and/or basing engineering student success solely on academic performance (E.g., retention and graduation rates). Students' perceptions and lived experiences may be a more accurate measure of success and predictor of career trajectory toward engineering or non-engineering occupations. Similarly, gathering and disseminating rich information on multiple dimensions of students' experiences will allow engineering leaders and administrators to better cater programs to the needs of students. When programs are intentionally designed and reformed with holistic student success at their core, the engineering education field may begin to reap the benefits. Immediate future work includes investigating engineering seniors' SDT levels and determining whether and which SDT constructs are significant predictors of students' likelihood to pursue engineering or non-engineering jobs after graduation.

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