

Article

Flash On: Capturing Minoritized Engineering Students' Persistence through Photovoice Research

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Abstract: Background: The attrition of engineering students remains an issue, and even more so for historically marginalized students at some institutions. This study aimed to investigate the challenges minoritized students face in engineering and the ways they navigate toward success. Method: We used photovoice, a methodology where participants take pictures in response to a prompt, and collectively identify the strengths and weaknesses of their community. The final aspect of photovoice is a collective sustainable change, such as policy change. We used thematic analysis of focus group interview transcripts triangulated with results from a pre-survey, photos and their associated hashtags, and written descriptions of photographs as sources of data. Results: Two themes emerged, financial constraints and engineering stress culture, as barriers to student success, while social networks (e.g., student organizations, faculty, and family), finding balance, and positive reassurance were determined to be facilitators to their success. Conclusions: While underrepresented, engineering students continue to face challenges; their collective reflection and discussion initiated by photovoice served as psychosocial support. As institutions grapple with how to support students better, the power of photovoice as a sustainable practice has implications for the teaching, research, and service that can improve student success.



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Citation: Herrera, L.; Schaefer, K.L.; Benjamin, L.S.S.; Henderson, J.A. Flash On: Capturing Minoritized Engineering Students' Persistence through Photovoice Research. *Sustainability* **2023**, *15*, 5311.

<https://doi.org/10.3390/su15065311>

Academic Editor: Andreas Ch. Hadjichambis

Received: 31 January 2023

Revised: 11 March 2023

Accepted: 14 March 2023

Published: 16 March 2023

Keywords: photovoice; diversity; barriers; motivators; underrepresented students

1. Introduction

Almost 25 years after the term “broadening participation in engineering” was coined, all segments of the engineering pathway continue to struggle with representation among traditionally minoritized people. For example, among US engineering students in 2019, only 11.4% of bachelor’s degrees were awarded to Hispanic students. Black students earned 4.2% of bachelor’s degrees, Native American students earned 0.5% of bachelor’s degrees, and 21.9% of bachelor’s degrees were awarded to women [1]. Despite the efforts of some researchers and practitioners, the percentage of minoritized graduates remains stagnant [1]. As institutions continue to grapple with student departure from engineering [2,3], one thing is clear: engineering students, especially those who are traditionally marginalized, continue to face barriers.

Traditionally, the literature around these barriers has been deficit-framed. It does not foreground the success strategies students use to persist and complete their degrees. As such, researchers have called for assets-based approaches to examine students’ experiences in STEM [4–6]. Using assets-based perspectives, low retention, and completion rates have been attributed to structural and systemic challenges that students face. For example, they may face hostile environments [7,8], have an underdeveloped sense of belonging in formal education spaces [9,10], experience racial microaggressions and feelings of isolation [11], or have identity interference [12–14].



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Although prior work seeking to center the voices of students of color has provided key insights, it leaves us wanting to know more about how we can increase the participation and success of these students in engineering [15–17]. In this study, we contribute to the knowledge base by using photovoice to help illuminate and understand the barriers/challenges of minoritized undergraduate engineering students and the sources that positively contribute to their academic success (i.e., motivators). We chose photovoice as our methodology because it offers sustainable practices that can be used to uncover the experiences of students. Photovoice uses photography to empower participants who are often perceived as having “little money, power, or status” [18,19]. The final products of photovoice projects should also have a life beyond journal articles. Sustainable change is initiated once photos are shared with leaders, policymakers, and the broader public and used to enact policy changes [18,20,21]. Our research questions were: (1) Using photovoice, how do engineering students illustrate their barriers/challenges as they progress through their engineering programs? (2) Using photovoice, how do engineering students illustrate motivators to their success as they navigate their engineering programs?

2. Photovoice

Adherence to the theoretical underpinnings of photovoice necessitates that researchers ensure that the voice of participants’ challenges and community-driven solutions are foregrounded [22,23]. Photovoice is critical. Thus, it involves more than participants taking photos and describing them [21]. Participants become knowledge co-constructors, planners, and data interpreters and are the expert counter-narrative carriers [24–29]. Three objectives of photovoice include: (1) Documenting and critically reflecting on strengths and weaknesses in one’s community; (2) Engaging in collaborative group discussions; (3) Promoting change by reaching out to leaders and decision-makers within that community [21,24]. This article describes how we approached the first two of these objectives.

Photovoice has been used as a promising practice in various domains, from healthcare to education research [25,29–31]. For example, in education, Chelberg and Bosman [31] used photovoice to understand the needs of underrepresented STEM students in postsecondary education, particularly American Indian students and explored the benefits of photovoice and photo elicitation. They found that photovoice and photo elicitation were sources of psychosocial support for historically marginalized students’ transition to postsecondary education and retention.

Additionally, Amon [25] conducted a photovoice study to explore the lived experiences of women pursuing leadership positions in the male-dominated STEM workforce. The study included 46 participants who attended leadership workshops and were prompted to take photographs of their past leadership experiences and future in leadership. The study illuminated women’s motivations, the barriers they faced, and the ways they coped with the difficulties they experienced. The women reported challenges with interpersonal relationships (including lack of authority), energy-intensive awareness of what they perceived others thought of them (how they might come across to others), and gender stereotypes. An example of energy-intensive awareness was their perception of themselves as being too emotional when working with mostly men and having to put in the effort to be emotionally sensitive and egalitarian when working with women. Achievements, social support from mentors, family, friends, peers, and work–life balance helped them cope with barriers.

Anderson and colleagues [30] used photovoice to understand students’ perceptions of “good teaching”. The photographs in their study illustrated that students conceptualized good teaching as being delivered by professors who demonstrated care in delivering course content and attempted to make personal connections with students [30].

Last, closely related to our work, Wawire and colleagues [29] studied how four sophomore engineering students’ experiences affected their engineering identities through a semester-long photovoice study. They used engineering role identity constructs (interest, performance, and recognition) as the theoretical framework to guide study prompts. In describing their engineering identities, the students pointed to challenges of school–life

balance and ways of creating balance, to the interpersonal relationships that they found supportive or discouraging, and to the struggle of prioritizing their mental health.

While the studies mentioned above guide the implementation of photovoice in education, fewer studies have been published adopting this approach among engineering students. Therefore, a goal of this project was to use photovoice as a tool to understand and illuminate engineering students' experiences and better support their persistence.

3. Methods

3.1. Research Setting

We conducted this study at Beatrice College (pseudonym), a large public doctoral university with very high research activity [32]. Beatrice College is also designated as a Hispanic-serving institution and an Asian American and Native American Pacific Islander-serving Institution (AANAPISI). The college of engineering at Beatrice College is composed of 27.4% women and 72.6% men. Table 1 shows representation by university-designated ethnicity/race and six-year graduation rates within the college of engineering by race/ethnicity. Black students have the least representation in the college of engineering. Additionally, the six-year graduation rate in the college of engineering is the lowest for Black and Hispanic students.

Table 1. Beatrice College enrollment and engineering graduation percentages.

Race/Ethnicity	Engineering College Enrollment (%)	Engineering College Six-Year Graduation (%)
Asian American	20.93	76
Black	4.87	53
Hispanic	27.64	56
International	20.44	68
Other	5.56	73
White	20.58	66
Overall	–	65

3.2. Participants

We recruited study participants in four ways. First, we sent an institutional review board (IRB)-approved recruitment email to the engineering communications office of Beatrice College for broad distribution. We also sent our recruitment email to an institutional gatekeeper who had extensive contact with engineering students to aid in sharing with students. We requested that students share the recruitment email with others they thought might be interested in the study. Last, we requested that student organization leaders from Engineers Without Borders, the National Society of Black Engineers (NSBE), and the Society of Hispanic Professional Engineers distribute the recruitment e-mail to their members. To be included in the study, participants had to be enrolled as engineering students at Beatrice College at the time of the investigation.

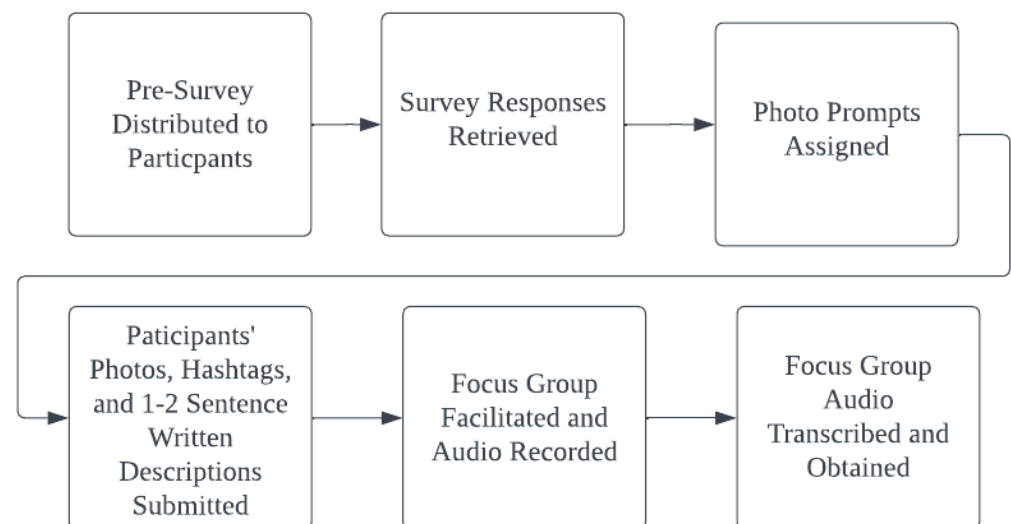
Recruitment yielded four typically aged (i.e., 18 to 22 years old) student participants; each selected a pseudonym, as shown in Table 2. The four participants were second, fourth, and fifth year students at Beatrice College. Three participants majored in mechanical engineering and one in biomedical engineering. One student self-identified as Hispanic, two identified as Black (one African American, another Haitian American), and one identified as Middle Eastern or Arab. We emphasize that we used students' self-identified ethnicity descriptions when describing them as opposed to the generic institution grouping (i.e., African American, Asian American, Hispanic, Other) because these designations would not have been as inclusive for all of our participants. For example, Laila would have been labeled as "Other," but she identifies as Middle Eastern or Arab. In addition, using participants' descriptions amplifies their voices by including what they identify themselves as.

Table 2. Participants and Selected Demographics.

Pseudonym	Pronunciation	Engineering Major	Classification	Gender	Ethnic Identity
Chris	KA-riss	Mechanical	2nd Year	Man	Hispanic or Latino
Xavier	zav-VEE-er	Mechanical	4th Year	Man	Black (African American)
Brianna	Bree-AH-na	Biomedical	5th Year	Woman	Black Haitian American
Laila	LAY-lah	Mechanical	4th Year	Woman	Middle Eastern or Arab

3.3. Data Sources

We collected data via four methods: a pre-survey, photograph submissions with hashtags, written descriptions of each photo, and photovoice focus group interview transcripts. Figure 1 outlines our data gathering process. We introduced participants to the study via an orientation meeting. In the pre-survey, we asked participants to share their race/ethnic identity and engineering major. During the participant orientation, we gave students an opportunity to learn more about the study's aims, which included introducing them to photovoice, the purpose of the study, and requesting that they take photos that highlight the barriers and motivators they experience as engineering students. We selected the words "Barriers" and "Motivators" because they are commonly used and "experience near" [33] (p. 28). In addition to being easily understood and digestible, we wanted to see how participants constructed and illustrated the meaning of these terms through photography [29]. At the end of the orientation, participants received the following prompt for the study:

**Figure 1.** Photovoice data-gathering process.

During the next two weeks, please capture up to two pictures to identify challenges or barriers that negatively impact your educational experience and up to two images that illustrate motivators that positively impact your educational experiences.

We also asked participants to assign hashtags (#) to their submitted photographs and a one-to-two-sentence description of each photograph. To bring students further into the co-construction of knowledge, we encouraged them to assign hashtags of their choosing. Participants had approximately three weeks before submitting their photographs and returning

for their focus group interview with the first author. Before the photovoice focus group, we combined the submitted pictures of each participant into a PowerPoint presentation.

During the photovoice focus group, we used a script to ensure the clear communication of the study objectives and the discussion topics [34]. Given the conversational nature of the focus group, the session lasted for 90 min, resulting in a 12,187 word transcript. When presenting the findings, we searched for and included varying or competing perspectives to illustrate the complex dimensions of participants' experiences and perspectives [34–38].

During the photovoice focus group, once their respective pictures appeared in the PowerPoint, we used an adapted form of the "SHOWeD" Method [21] to elicit descriptions of the pictures participants took. Using our modified SHOWeD Method, we asked participants: (a) What do we see here? (b) What is really happening here? (c) How does this relate to our lives? (d) Why does this situation, concern, or strength exist? What can we do about it? After participants discussed each of their photographs, we invited their peers to provide feedback on similarities and differences in experiences. The 14 participants submitted pictures included images of computer screens, spaces in their university, family members, spaces where participants in the study lived, and an undergraduate student conference. Participants also added a total of 15 hashtags to their photographs. The most notable were: #UpAllNight, #pattern, #whatsnext, #balance, and #binge.

3.4. Data Analysis

The words participants used in the photovoice focus groups were transcribed, analyzed, and incorporated into the dataset for analysis. As a first stage of ensuring data reliability, we reviewed the transcripts and updated them to eliminate transcription errors [36]. We used thematic analysis to guide our data analysis process [39,40]. Specifically, we followed the six phases of thematic analysis outlined by Braun and Clarke [39], which include: (1) Data familiarization; (2) Generating codes; (3) Constructing themes; (4) Reviewing themes; (5) Defining themes; and (6) Writing up the results. We triangulated the thematic analysis of the focus group transcripts with our interpretations of submitted photographs, participant-ascribed hashtags, and their written descriptions of their images. After reading each transcript, we discussed our reflections and instances of disagreement until all of our codes aligned. We routinely returned to the transcripts during analysis to ensure that the emerging themes aligned with the participants' experiences [36,37].

3.5. Limitations

We made some design and analysis decisions that could have limited the study. For example, since the study's goal was not to obtain generalizable results, the sample size was small. We ultimately decided upon a small sample size to examine the participants' idiographic experiences, which may have been overlooked in a larger sample. Three of the four participants were mechanical engineering majors, so we do not know to what extent these findings apply to other engineering majors at Beatrice College or beyond. Readers should assess the relevance of findings to other contexts.

3.6. Trustworthiness

We implemented several steps to enhance the trustworthiness of this study. For example, we deliberately decided only to have one person collect data during the focus group. This researcher was close in age with the study participants and was thus able to build rapport and trust with participants and lessen the power dynamic between the researcher and the study participants [21,29,38]. Having one single interviewer also allowed us to reduce variations in participant reactivity (e.g., the degree to which the interviewer influenced them) in this particular inquiry [37] (p. 124). Additionally, the first author consulted more senior colleagues throughout the study, from research design to data collection and analysis [36,41]. The fourth author served as advisor and debriefer to the first author, while also participating in the data analysis. Authors Two and Three reviewed our data analysis process and served as auditors and editors. After the study audit, we

assembled what we have coined as “times of calibration” [42] and worked to resolve all disagreements. Additionally, we collectively situated ourselves in this research via a positionality statement [43].

3.7. Positionality

As authors, we approached this study from various standpoints and social locations that positioned us in and out of similar proximities as our study participants. Throughout the research process, we were reflexive about our positionalities in this research [43]. We accounted for potential biases or assumptions that may have influenced our interpretations of the data [44]. Despite having some shared characteristics, we each have unique identities, which are strengths that helped in the project design and data analysis process. To highlight these aspects, we share some insight into our identities and positionalities that we judged relevant to this study.

The first author identifies as a Hispanic woman living through her own experiences as an engineering student. The first author was the only author involved in the data collection process, and she also participated in the data analysis, debriefing meetings, and manuscript development. Her experiences as a current engineering student helped her establish rapport with the study participants [45]. The second author identifies as a White woman. She is a licensed mechanical engineer, certified K-12 STEM teacher, lecturer, and engineering doctoral candidate, researching persistence and engineering identity among women in engineering. She assisted with facilitating the orientation, debriefing meetings, manuscript development, and editing. Author Three is a higher education researcher who identifies as an Afro-Caribbean immigrant woman. Her research focuses on exploring minoritized learners’ experiences in various contexts. She assisted with debriefing meetings, manuscript development, and editing. She engaged the team in reflections on how this study did justice to the accounts participants shared [46]. The fourth author is an Assistant Professor in engineering and identifies as a Black man. He initiated the study because he was concerned about persistence in engineering. In his teaching, he seeks to understand the experiences of his students with empathy. He participated in data analysis and peer debriefings and spearheaded manuscript preparation.

We view our collective positionalities as engineering faculty, current and former engineering students, and individuals committed to college student success to be strengths in this inquiry. These strengths enabled us to understand participants’ experiences and contextualize the themes within broader engineering education conversations.

4. Results

Photovoice allowed participants to reflect on their experiences as well as those of their peers. They identified what motivated them and how they coped with the rigorous nature of an engineering degree program and learned ways to manage challenges and strategies to improve their engineering experiences. We inductively developed four themes. Two themes are related to barriers and two are related to motivators.

4.1. Barriers

4.1.1. Financial Challenges

This barrier theme highlights the financial barriers the participants face and how it affects their educational experience.

In discussing barriers, Laila wrote in her description of Figure 2a:

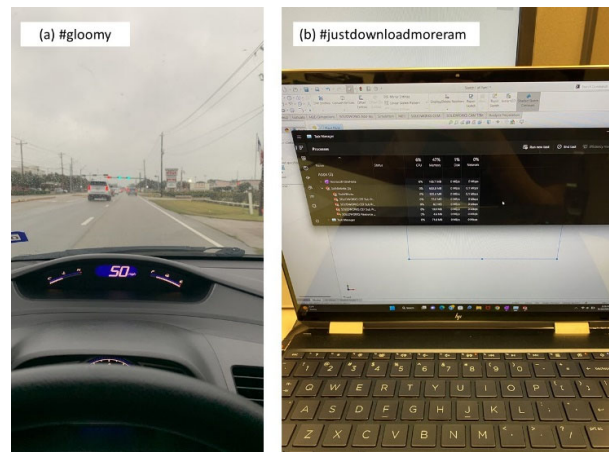


Figure 2. Ways financial barriers impact Laila (a) #gloomy; and Chris (b) #justdownloadmoreram.

This is a photo of me driving, and it represents a challenge because my sister and I both go to Beatrice College, and we share a car. We have difficulties coordinating schedules because her days start early and mine late. We end up having to stay at school for 12+ h, and it becomes exhausting.

In the focus group, Laila explained that she had “lived on campus for three years”, but due to no longer receiving a scholarship for housing for the year prior and the current year, she could no longer live on campus. Although she expressed the ability of her parents to afford her housing, they were not supportive of her living on campus, and she could not pay for it herself. When asked why this situation exists, Laila explained, “So, I can technically take his [her dad’s] old car, but I never bought a parking pass, and it’s like \$800.00 or something. So, I’m not about to spend that much just to park another car. I’ll make it work with my sister”. Xavier agreed that parking was too expensive and said, “Yes, I would find a house, but parking passes are just so much; I just decided to live on the campus”. The transportation arrangement Laila has with her sister is exhausting for her. She spoke on the benefits of living on campus and said:

This is my first year, you know, not having a dorm anymore, and it’s just kind of hard. I don’t know. I can’t just go and take a nap real quick or something. I have to bring so much stuff with me to school if I want to go to the gym or whatever.

The exhaustion from being on campus for 12 or more hours is closely tied to Laila’s financial burden that has negatively affected her engineering experience.

Chris described Figure 2b in his written explanation:

This image highlights the issues engineering students face when working with software that demands a large sum of memory. There are students who lack a well-equipped laptop/computer due to financial constraints and are unable to keep up with the demand.

Chris explained that his computer crashed during a final exam because it required a software application with a memory demand that his computer could not accommodate. Financial challenges were apparent to the group, even if they were not experiencing them themselves. Xavier added during the focus group:

There’s somebody in my class; his backpack is falling apart, and I feel so bad. Like, I want to go buy him a new backpack because I know his financial situation would be different than mine and stuff like that. So, that’s one thing to worry about, resources. You’re not even worried about your grades, just more on your problem.

When the first author asked if they felt they had financial barriers to their engineering degree, three out of four participants raised their hand. We see that financial challenges can add an extra layer of difficulty to an already challenging degree program and can have indirect consequences such as fatigue at school or stress during an exam.

4.1.2. “Domino Effect”

This next barrier theme illustrates how students are attempting to live balanced lives in the face of the stressors that engineering causes, which render them fatigued.

Xavier’s picture in Figure 3a, which he assigned the hashtag #lazy, illustrates the tension students feel when they cannot live a balanced life by their own standards. For example, in the focus group, he said:

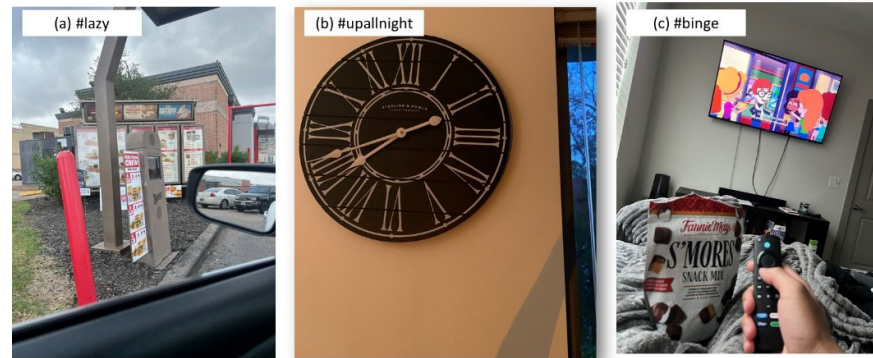


Figure 3. Illustrations of the “domino effect” for Xavier (a) #lazy; Brianna (b) #upallnight; and Xavier (c) #binge.

I think I just got done with a two-hour study session, and I was out of [my] mind. Just wanted to get over it, kind of just like I have to eat. I was so hungry that I just didn't like go into the kitchen, pull out my pots and pans and dishes

Though feeling exhausted after a seemingly intense study session might be totally appropriate, based on his self-ascribed hashtag, he seems to blame himself. Xavier explained why this made him feel #lazy. He said:

Usually, I like trying to stay on track as far as schedule, as I said. So, when I have to go to a fast food [restaurant], I kind of don't really feel the best about it because I'm just kind of like tired or whatever

When Xavier is exhausted with navigating school priorities, it causes a domino effect that renders him “out of his mind.” He concluded with the illustration, “So when one thing gets out of line, it bumps and makes like a domino effect on other things.” In this quote, we also see Xavier fighting for a life of balance and how imbalance is a huge barrier for him.

Brianna also described how her engineering existence has been filled with experiences that are out of balance. During the focus group, two statements by Brianna illustrated the source of the imbalance. First, like Xavier, she blamed herself when she said, “My biggest issue during my entire five years here has been time management.” However, after listening more closely to Brianna, we discovered additional sources of her feelings, which speak to the cultural climate of her engineering program. For example, she said:

So, I think, as far as the imposter syndrome and how everybody is competitive with each other, there's a lot of sleepless nights that engineering students go through. There's a lot of times when we skip meals because we're studying for a test, and there's a lot of things that we give up.

Brianna pointed out that the culture of competition led her to feel like an imposter and under pressure to live a life of sleepless nights.

In addition, as Brianna explained her #upallnight photograph in Figure 3b during the focus group, we saw that she had participated in activities to strengthen her time management ability. She said:

I think that even though the university has the time management workshop, which I think is helpful, I think there should be a lot more mental health resources for students, especially when it comes to sleep management and things like that.

Though Brianna participated in time management workshops, she felt that her institution should provide more resources.

The last image in Figure 3c is another of Xavier's pictures, which he labeled #binge. This image further illustrates how the domino effect takes hold of students. Xavier described the picture by saying:

This is like on a Tuesday at 1:00 PM, I was just really tired, and I did not feel like doing anything like studying, exams are coming up, and I really had zero energy to do anything school-related. [I] Sat down on my bed, [and] binge-watched.

Hearing from Xavier illustrates that once the first domino is tipped, life becomes unbalanced. He used the illustration again:

That domino effect really takes into play. I'd say I was fatigued here; I don't even say tired. I would say more fatigued or exhausted than I'm, just like if I sat down in front of a computer, nothing would happen. I would just kind of sit down and grab my phone, social media or something like that.

Though Xavier recognized the importance of breaks, "You do need breaks, but I feel like it's just weird for me," his experience also suggests that knowing how to and being okay with taking appropriate breaks might help him deal with the potential stressors.

4.2. Motivators

4.2.1. A "Pattern" for Success

In this first motivators theme, participants illustrate the promising practice of establishing and keeping patterns in their lives and how these patterns enable them to balance the demanding nature of engineering. Figure 4 is three illustrations of those patterns.

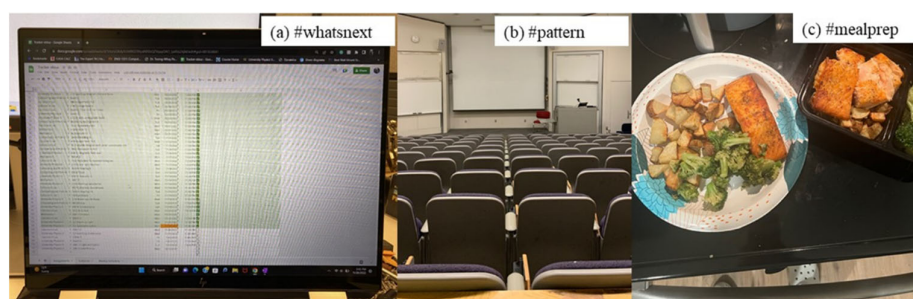


Figure 4. Patterns for success as motivators for Chris (a) #whatsnext; Laila (b) #pattern; and Xavier (c) #mealprep.

Chris submitted an image of his schedule to which he assigned the hashtag "what-next." His written description of this image in Figure 4a was:

This image shows the workload of a sophomore student in mechanical engineering. Many students in this field, including the photographer, always wonder, what's next? Very few, at the end of the semester, take a look back at all they have accomplished.

Chris highlighted how having a track record of success is a motivating factor for him. Reflection was not a large or grand gesture. However, the ability to reflect on all his accomplishments was motivating. In the focus group, Chris expounded on what "#whatsnext" meant to him. He said, "I feel like sometimes, a lot of engineering students, we're always focused on what's going to come up next, and then we just don't take the time to turn around and look [up at] the stuff that we have done and the stuff that we completed." Essentially, his hashtag was a way to resist or kick back against the stress of always focusing on what is next instead of engaging in the sustainable practice of reflection. According to Chris, students must resist the urge to "forget that behind you, you have all these accomplishments and all this stuff that you've done."

Xavier also agreed and said, “yes. It’s important to spend time to realize what you’ve done in the past, with how much you’ve done so far, and you’re doing okay.” To understand what might be causing stress, Xavier expounded, “I realized that I’m never satisfied with myself about the work that I’ve done. Even though this is my fourth year of college, my fourth year of engineering school, I’m just never satisfied with what I’ve done so far.” We heard in Chris’ description and Xavier’s responses that if students would spend time reflecting, it may serve as a motivator for their future success.

Next, we see Laila’s image, Figure 4b, which she called #pattern. Concerning this picture, she wrote:

This photo represents the repetitiveness of going to school every day; although seen as something negative to some, I like having a routine. Going to school every day and working in increments towards larger goals while seeing others around me do the same gives me purpose and motivation (written description)

Laila highlighted the power of patterns when she said, “So, having a routine is kind of good for me because it forces me to be productive and do my work and not let other things get in the way”.

Last, Xavier’s image, seen in Figure 4c, also highlights the importance of establishing patterns as a motivation for student success. Xavier’s physical activities served as a mirroring of where he hoped to exist internally—a place of balance. Concerning his picture, he said:

But it’s important to start my week off right, or just kind of the typical things I do on those days is important for the rest of my week where I would just kind of get out [of line]. So, meal prepping is something that I think is obviously fun and I kind of sometimes look forward to

The small victory or task of meal prepping and exercising is an outward reflection or small victory that Xavier uses to promote his internal and academic motivation. He concluded by saying, “Usually, sometimes I would fall asleep in class, but I started working out, going to sleep early, [and] eating right. I see a difference in my physical health, which helps with my mental”.

Each of the images, descriptions, and hashtags in this theme illustrates how participants value the simplicity of finding balance and having #patterns in their lives. While their patterns were not grand gestures, they were valuable practices they could lean into as motivators for their engineering journeys.

4.2.2. Power of Social Networks

This next motivators theme describes the importance of social networks in motivating the success of participants. Within this theme, participants illustrated in Figure 5 what they felt were essential components of social networks (i.e., peers, family, and professors).

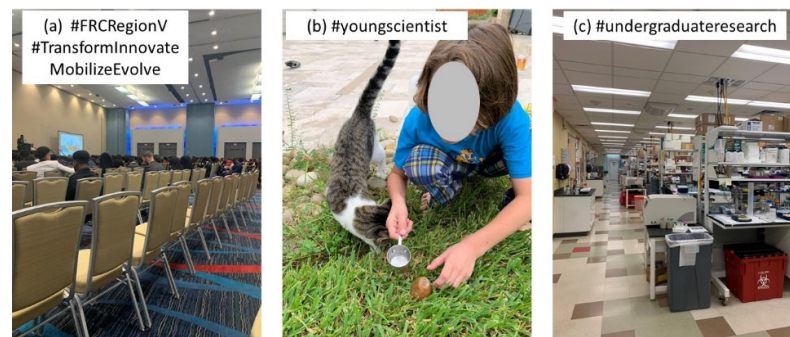


Figure 5. Representations of social networks by Brianna (a) #FRCRegionV, #TransformInnovateMobilizeEvolve; Laila (b) #youngscientist; and Brianna (c) #undergraduate research.

First, we see Brianna’s picture in Figure 5a, for which she assigned two hashtags (#FRCRegionV and #TransformInnovateMobilizeEvolve). The second thread of words is powerful in illuminating Brianna’s description of her pictures. Her social network seems to

have transformed, initiated innovation, mobilized, and enabled her to evolve. For example, when describing attending the NSBE regional conference, her first ever in five years of undergraduate studies, Brianna said, “I think that one of the biggest things was seeing so many people like me and who have the same background as me or who have the same barriers and knowledge as me make it to that point”. For Brianna, seeing people who looked like herself in engineering was important. The power of representation cannot be overlooked or downplayed. The connectedness of having a network that will exist beyond her undergraduate studies was also strikingly important for Brianna. She explained:

I think also not only were there other students there; there were professionals there who had gone through that process and who were in the professional NSBE clubs. So, they stay with NSBE, and they're giving back to a lot of the students by having their companies partner with NSBE. So, having representatives from companies come and look towards opportunities specifically for us, I mean, that's huge.

In this way, the NSBE regional conference was transformative for Brianna, as evidenced by her statement about the NSBE experience, “that’s huge.”

Xavier also said, “finding that sense of comfort is extremely important. Just something that people even just look like you or just are from the same background makes a difference. Just the conversation is completely different”. Xavier’s experience is an emphatic illustration of the importance of representation, seeing people who look like you who have traveled and are traveling where you are hoping to go. Xavier explained further:

I've been to career fairs here at Beatrice College . . . and I was just bored with it. I didn't want to be there, honestly, but I went because it's just a resource . . . I talked to two companies, and I was like, all right, I'm out.” but at the NSBE conference, I think I talked to every company just because it was just so comfortable, and they looked like me, they talked with me. It was just different.

Xavier demonstrated how the NSBE conference allowed him to meet with corporate representatives that looked like him, versus the career fair at his institution, which seemingly had less representation. As we envision ways to support students, providing traditionally minoritized students with opportunities to connect to peers and possible role models from the same background is crucial.

Brianna also elaborated on how the NSBE community was a source of motivation. She said:

Having community, which is the biggest thing that NSBE has provided me; that's been the biggest reason that I've stayed in engineering because my first year, I started off as a biology major because I wanted to be a doctor. As you can see, that did not work out at all because I tried to get involved in clubs, I tried to go to events, and nothing was really clicking.

We learned that when she did not feel a sense of belonging as a biology major, she departed. Brianna’s experience is connected to the broader conversation about what often happens when students do not feel they belong; they depart. Excitingly, building community within NSBE has allowed Brianna not to leave STEM altogether, as is the fate of many minoritized students. Brianna also expounded that her peers provide academic and other types of support. She said, “so, having that community and people in your corner for not only academic stuff but to talk to, that’s been my—the biggest thing”. In this way, having a community was “huge” for Brianna.

Finally, Brianna and Xavier’s excitement for NSBE caused Chris, a Hispanic mechanical engineering major, to interject and say, “I feel like I might just have to join their group. It sounds really cool, yes. I’m in the mechanical engineering one, the club [ASME], and it’s okay, but it’s just not—it’s not great.” Having an organization where he can see people with similar backgrounds as him might be an important future motivator for Chris.

Next, Figure 5b is a picture of Laila’s younger brother. She explained why she submitted this picture, saying:

This is a motivation because this is my younger brother. It's like that, but he's at an age where he looks up to me and my siblings . . . It's a motivation for me to have younger

siblings because I just want to be a good role model to them, and I just want my younger siblings to learn from my mistakes, and I just want to be able to guide them in the right direction, and it's motivating for me to do good so they can do good.

While noting the possible pressure associated with students of color seeing themselves as the sole person responsible for bringing “generational blessings” [47,48] to their families, we also acknowledge Laila’s motivation not to let her younger siblings down as crucial for her success. Xavier supported Laila’s visualizations by describing how his older brother has motivated him. He said:

I have an older brother who's a software developer. He's like 10 years older than me . . . I don't say I don't listen to my parents, but I listen to everything that he says about anything. He motivates me. I take it to heart.

These quotes from Laila and Xavier highlight the bidirectional nature of familial capital [49]. In other words, participants are learning and gaining important motivation from their families and are also a source of support and motivation. Learning and having this capital may serve as a motivator [50].

The last image we bring into this theme, shown in Figure 5c, is another of Brianna’s pictures. She assigned the hashtag “#undergraduateresearcher” to this picture. She first described how important the experience was for her when she said, “getting involved in undergraduate research actually exposed me to what my specific major would be like, so I don’t get into a job and [be] like, “I hate this”. Brianna also described the importance of undergraduate research by stating, “So, if you’re not exposed to that, you’re continually going through sleepless nights, failing classes because you don’t know what’s on the other side”. Educational research has long illustrated the power of undergraduate research [51] to student success. Brianna gives life to this well-known benefit in that undergraduate research could be likened to a bridge that enabled her to see “what’s on the other side”.

In addition, as much as having the opportunity to participate in undergraduate research was transformative for Brianna, she was just as grateful to have a professor in her social network. In the focus group, she stated, “I started undergraduate research when I was a sophomore . . . The doctor that I was working with, she gave me a chance basically because she was like, “Yes, I’ll just teach you and ask me the questions”.

Like traveling to the NSBE conference, undergraduate research seemed to be another “huge” experience for Brianna. She further described in the focus group, “I credit the faculty members here for really opening opportunities for students to get exposed to that”. Brianna’s experience speaks to the importance of positive student–faculty interactions in student success and motivation.

In response to Brianna’s image, Xavier added by mentioning about how crucial a professor was for his motivation. He said, “I went to the first meeting, and as soon as I walked in, Dr. Ashford (pseudonym) literally walked up to me and was like, “what’s your name? Have a seat. You just got here in the engineering program?” Not only did Dr. Ashford welcome Xavier into engineering, but Xavier said that Dr. Ashford told him, “I’ll take you under my wing”. Being mentored by a professor was really important for Xavier. In fact, as he reflected, Xavier concluded by saying:

I look back at that day, and I'm like, “That was the start of something bigger than just him saying, ‘Hey, I got you’.” or whatever. He didn't even know me; he didn't even barely remember my name that day. I think definitely the people here, whether that's faculty or just upperclassmen that, are students . . . That's a really underrated resource . . .

Each of the images in this theme demonstrated participants’ ability to reflect and have gratitude for their networks, how and where they are situated in these networks, and how they can serve as future support for those coming behind them. The authors postulated that all these practices contributed to participants’ motivation towards continuing in engineering.

5. Discussion

The interchange from the focus group, the pictures, hashtags, and photo descriptions highlighted financial challenges and engineering stress culture as barriers for the participants. In addition to being from traditionally marginalized populations, half of our participants are also first-generation college students. As with previous studies, our participants described financial challenges as a barrier [52,53]. For example, we saw that Laila shared her dependence on a housing scholarship, and Chris's academics were compromised because of financial limitations to owning a higher-memory computer. Additionally, three out of the four participants responded to having financial challenges in their education. A lack of financial resources can have many indirect effects on students' education, including a lessened focus on academics' and students' involvement due to needing part-time or full-time jobs, inadequate school supplies, and difficulty paying for tuition. Although we do not have the financial information of the participants, it is apparent that they dealt with financial constraints and noticed this among peers at this minority-serving institution (MSI). This calls to question and challenges researchers and practitioners to re-envision how we support students financially. We also understand that institutional resources might be limited. A few promising practices might include institutions seeking funding from government agencies, such as the National Science Foundation (NSF), that are making more money available to MSIs through initiatives such as the Broadening Participation in Engineering (BPE), Scholarships in STEM, and Hispanic-Serving Institutions Improving Undergraduate STEM Education (HSI IUSE) funding. Additionally, all institutions should develop strategies to partner with the companies that hire engineering students to develop more scholarships and co-op opportunities.

A unique contribution of this work is the participants' nuanced descriptions and illustrations of the barriers they faced as engineering students. They shared that they were experiencing high levels of exhaustion, sleep deprivation, time management struggles, and a competitive culture that led to stress. Photovoice gave students permission to describe these barriers and connect them to the topic of mental health, which has traditionally been taboo in engineering. Photovoice allowed them to kick back against engineering stress culture [54]. While some of our participants started this conversation blaming themselves, photovoice allowed them to mentor and empower each other—and to leave with solutions. We also saw participants' resilience in coping with engineering challenges and, for example, creating a routine and authoring what balance meant in their lives. As we described in the findings, participants emphasized the power of reflection, a mindful practice that opposes the stress culture they had experienced in engineering. Photovoice, in this way, represents a robust, sustainable practice for reflection. It demonstrates the participants' awareness of the benefits of caring for their minds, bodies, and self-esteem. As institutional stakeholders, such as provosts of student success, deans, and instructors, consider ways to support students, they might consider promoting students' engagement in outside interests and rest periods to recharge and retain the stamina needed for obtaining an engineering degree [55]. In addition, for students who desire more formalized support around balancing priorities, proactive advising strategies might also be a strategy for augmenting the student experience [56]. This is because proactive strategies often attend to issues related to time management, school/life balance, and mentoring.

Another motivator for participants was their social networks. For example, our participants highlighted the importance of the psychosocial support of their networks (i.e., student organizations and family). Networks such as NSBE supported our participants' sense of belonging and motivation in engineering. This finding is consistent with the literature highlighting the importance of social networks such as student organizations [57–59] and professors [57]. As we think about what institutions can do to help support students' networks, institutions should consider how similar-race faculty (and all faculty) are rewarded for mentoring students, which is sometimes presented as an additional service load [60,61]. Institutions should also institutionalize ways to support affinity group organizations such as NSBE. For example, based on what we have learned from these participants' own student

support experiences, as well as previous studies, we believe that institutions should ensure institutional support (e.g., budget line items, study, and networking spaces) for interventions and student organizations that help students engage their navigational and social capital [59]. Additionally, to connect students to affinity group organizations or other university organizations, faculty members can allow the organizations to provide information during their classes. We recommend engineering candidates become integrated into student-led engineering organizations and embrace the resources they have to offer. In addition, students, engineering candidates, and student organizations alike might consider using photovoice as a tool to foster connection and combat social isolation (i.e., using photo elicitation as a tool to engage in conversation).

Other recommendations include encouraging faculty members to proactively reach out and introduce themselves to students, as well as emphasizing in different ways the benefits of attending office hours [59].

Similar to the previous literature, we also saw the importance of familial support to student success [57,62,63]. Our participants also highlight the tension that family dynamics may present. For example, sharing a car was a challenge that one of our participants faced, but she also looked forward to mentoring her younger brother, who lives at home.

Participants in this study also highlight the importance of internal motivation. While previous studies have described internal motivations such as persistence [64,65] and self-efficacy [62,66], our participants described and illustrated their processes of developing patterns that helped them create balance, enabled them to persist, and built their self-efficacy. Similarly, through the illustration of the “domino effect”, we gained an appreciation for both the beauty and tension that falling or unaligned dominos might have. Using photovoice as a tool to help students reflect upon the patterns that work for them might be a promising practice that can be easily implemented in engineering courses, student organizations, and mentoring programs.

Finally, though policy change is often slow and incremental and data of all kinds are needed by policymakers to inform a viewpoint and frame a persuasive argument, alternate dissemination outlets of photovoice projects (e.g., photo exhibitions) provide approachable ways for policymakers to be engaged in critical conversations that may inform their decisions. For example, policymakers themselves could engage photovoice as a means for a self-study to understand the experiences of their students.

Implications for Research

The findings from this study offer illustrations of how participants have navigated their engineering experience so far. While adding to the conversation about student barriers and motivators, additional research might help shed more light on the nuanced experiences of participants. For example, longitudinal studies spanning multiple academic years might allow us to gain a deeper understanding of the pressure points for stressors/barriers to student motivation and success. Most of our participants were in a single engineering discipline. Future work should include the perspectives of students from different engineering majors. This would allow us to analyze data for discipline-specific differences or commonalities. As most photovoice studies do not incorporate theoretical frameworks within the study, we propose coupling the photovoice with newer theoretical lenses like “Advancing from Outsider to Insider” [67] to understand how students navigate their engineering identity experiences.

Additionally, the team proposes pushing boundaries by bringing photovoice together with data science analysis techniques, for example, using photo–hashtag combinations to determine what we might glean through artificial intelligence (AI) perspectives when a study has hundreds of photographs. We are currently in the process of creating photo/hashtag databases for such work as AI training.

6. Conclusions

Visual methods have not been a common focus in engineering education studies. However, photovoice proved to be a powerfully promising sustainable practice. Photovoice helped study participants feel more comfortable authoring their stories on their own terms. While many institutional decision-makers are trying to figure out how to support students better, we encourage their empowerment through this approach until institutions have a better grasp on how to enable their minoritized students. Not only did photovoice allow for self-empowerment, but the participants also supported each other through dialogue by relating and validating the struggles they shared. This work in pictures has the potential to yield practical solutions that institutional stakeholders can implement, such as intentionally creating cultures of well-being, financially supporting student organizations, and connecting more with students' families. Lastly, in honor of the tenets of photovoice and its emphasis on collective impact, we plan to collaborate with institutional stakeholders to host an art exhibition to promote critical conversations about engineering student success and identity.

Author Contributions: Conceptualization, J.A.H. and L.H.; Methodology, J.A.H., L.H., L.S.S.B. & K.L.S.; Validation, L.S.S.B., K.L.S.; Formal Analysis, L.H. & J.A.H.; Investigation, L.H.; Writing—Original Draft Preparation, L.H. & J.A.H.; Writing—Review & Editing, K.L.S. & L.S.S.B.; Visualization, L.H.; Supervision, J.A.H.; Project Administration, J.A.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was approved by the Institutional Review Board of The University of Houston (STUDY00003830, Photovoice Engineering Project approved on 1 September 2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and IRB permissions.

Acknowledgments: We thank our study participants for their time and engagement throughout this process for which they continue to be engaged via follow-up gathers and the plan of our engineering experiences photo exhibition. We would also like to acknowledge the Henderson Research Group Members who read earlier versions of this manuscript and participated in times of calibration but do not appear as authors. Last, thanks to Henderson's engineering education mentor, Nicki Sochacka who challenges him to grow as a researcher and writer.

Conflicts of Interest: The authors declare no conflict of interest.

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