Not for the Poor: Impacts of COVID-19 on Engineering Students from Lower Socioeconomic Backgrounds

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Introduction

Like many other fields, engineering is working to become more diverse. Part of this effort includes supporting students pursuing a field who do not fit the traditional archetype of an engineer [1]. This outlier population is heavily composed of students who have an intersection of identities, one of these identities being a member of a low-income household [1]. The COVID-19 pandemic evoked major changes in the lives of many individuals and economic challenges were one of the main characteristics of the time including, but not limited to, individuals losing their jobs, increased financial strain on households, and finding supplementary working responsibilities to meet financial needs. These challenges have negatively impacted minoritized populations the most and these difficulties were further compounded for those studying engineering through the additional stress beyond academic rigor [2].

While there is literature examining the quantitative data associated with the socioeconomic status of engineering students, there is a lack of research examining the complex experiences associated with these numbers within the pandemic's context [3]. This paper explores the experiences of minoritized undergraduate and graduate students in engineering during the onset of the COVID-19 pandemic. By examining student micro-narratives in response to the prompt; "*Imagine you are chatting with a friend or family member about the evolving COVID-19 crisis. Tell them about something you have experienced recently as an engineering student*". The analysis of student stories will seek to answer the following research questions:

R1: How do engineering students from low socioeconomic backgrounds describe their experience of the COVID-19 pandemic?
R2: What responsibilities do engineering students from low socioeconomic backgrounds have?
R3: How does engineering education support students belonging to families who are from low socioeconomic backgrounds?

To address these research questions, the thematic framework developed by Lester Tobias titled, "*The Thriving Person and the Thriving Organization Parallels and Linkages"* was used to analyze the micro-narratives of participants. Themes were observed using the curated paradigm for a "thriving" individual [4]. To account for students, from low socioeconomic backgrounds, responses were filtered to only include students who reported a family income of $100,000 or less. By exploring these experiences, we sought to find patterns in student stories and provide insight into how minoritized engineering students *from low socioeconomic backgrounds* thrive during times of uncertainty.

Review of Literature

Undergraduate students from low socioeconomic backgrounds face a range of systemic barriers that impact their access to and success in higher education [5]. One significant issue is the growing number of students in poverty. Community colleges, for instance, have seen a notable increase in the number of dependent students from impoverished families, rising from 13% in 1996 to 27% in 2016 [6]. The rising cost of college coupled with the slow rise of income and lack of awareness of financial support can lead some families to believe that college is out of reach [5]. The purchasing

power of the Pell Grant, developed for students whose families meet certain income criteria, has significantly declined over the past few decades further exacerbating these challenges [7]. Academic preparation is another barrier, as disparities in college completion rates exist between high-income and low-income students, even among those academically qualified for college. This suggests that beyond financial constraints, academic readiness poses a significant hurdle for low-income students pursuing higher education [8].

Amidst these challenges, the pandemic introduced its unique set of difficulties, with a notable impact on students from low socioeconomic backgrounds and the pandemic-driven shift to online learning. Students from low socioeconomic backgrounds encountered obstacles such as limited technology access, inadequate study spaces, and distracting home environments, underscoring the need for enhanced support from educational institutions [9]. Thousands of low-income students were deferring and dropping college plans, facing significant challenges such as technological barriers, financial hardships, and inadequate learning environments at home due to COVID-19 [10], [11]. These issues were compounded by increased food and housing insecurities and mental health struggles due to the stress of the pandemic [12]. Despite some support from institutions and organizations, such as ScholarMatch, many students lacked sufficient resources and assistance, exacerbating educational inequalities, and underscoring the need for targeted support to ensure their academic success [13], [14]. A study by Lee et al found that students from low socioeconomic backgrounds greatly valued the ability to study at their own pace, citing it as the primary benefit of online learning due to its flexibility and convenience. However, a significant challenge faced by these students was difficulty with self-regulation.in their learning process, maintaining focus, and avoiding distractions online. These findings highlight the complex experiences of low-income transfer engineering students in online learning settings during the COVID-19 pandemic, illustrating the importance of acknowledging both the advantages and challenges of online educational formats [15].

The transition to online learning also impacted the nature of engineering education, which traditionally relies heavily on hands-on experiences and master-apprentice relationships. This abrupt shift removed critical elements of practical learning, potentially leaving graduates less prepared for their professional roles [16]. These findings underscore the complexities of delivering quality engineering education during unprecedented times, especially for students from low-income backgrounds, who lack the resources and support systems available to their more affluent peers.

Methods

Participants

During June and July of 2020, 500 micro-narratives were collected from minoritized undergraduate and graduate engineering students. Research participants were recruited through the personal networks of researchers, social media, and organizations such as the National Society of Black Engineers (NSBE) [17]. In addition to sharing micro-narratives, respondents were asked to answer quantitative questions directly afterward. For the protection of participant identity, all responses were collected anonymously to encourage free sharing without repercussions [17]. Moreover, respondents indicated who could read their story by answering the question, *"Who would you share this story with?"* and they had the option of answering: 1) Everyone 2)

Researchers Only, or 3) No one [17]. Participants who chose options 1 and 2 were used to complete data analysis and reported responses to this question were filtered by option 1.

SenseMaker

Data collection was accomplished through the platform *SenseMaker*. Sensemaking is a research approach used to understand complex and ambiguous data such as narratives [18]. This tool uses mixed methods analysis to allow participants to use quantitative responses to reflect on their micro-narratives. The process of utilizing this data collection method consists of four steps: 1) Initiation; 2) Story Collection; 3) Sense-making; and 4) Response [18]. The qualitative component of this method requires students to respond to an open-ended prompt. Participants in this research were asked to respond to the following prompt:

"Imagine you are chatting with a friend or family member about the evolving COVID-19 crisis. Tell them about something you have experienced recently as an engineering student."

Following their responses, students used five triads, three dyads, and 6 to 8 multiple choice questions to make sense of their previously provided micro-narratives. The design of this framework follows that of a similar study conducted at the University of Georgia [19]. The use of triads and dyads gives students a method of visualizing how they are making sense of their narrative. Triads and dyads allow the student to move the dot on the triangle (triad) or slider (dyad) to fit their narrative best [19]. This data was recorded using coordinates and analyzed for trends.

Thematic Coding

Students provided data on their income by selecting from the multiple-choice question that asked: "In 2019 my family's income was…". The answers students could choose from were 1) Less than $25,000; 2) $25,000-$50,000; 3) $50,000-$100,000; 4) $100,000-$200,000; 5) More than $200,000; and 6) Prefer not to answer or blank. Responses of students who reported a family income of less than $100,000 were filtered from the larger data set. Data was imported into the web application *Dedoose*; a platform that manages and analyzes data used in mixed methods research. The filtered data set was analyzed using the nine dimensions highlighted by Tobias in *"The Thriving Person and the Thriving Organization Parallels and Linkages"* as themes [4]. The nine dimensions and their definitions are included in Appendix A. To further the analysis, narratives were organized into subcategories that more specifically highlighted how students exhibited the dimensions within their narratives.

Results

After filtering the data set of 500 micronarratives, more than 50% (n = 267) of participants met the criteria for being considered low-income. Out of the 267 low-income students, 254 shared a micro-narrative available for analysis. To further respect student privacy, 166 participants indicated that everyone could read their story, and these are the micronarratives that will be highlighted in this paper. Using high-level thematic analysis, we sought to answer the research questions using the paradigm for thriving described in Appendix A.

Initiative

Initiative was defined by 21 instances. There were seven accounts of students seeking out additional academic help, four accounts of students prioritizing their health, eight instances of students obtaining or maintaining employment, and four instances of time management. Table 1 provides excerpts from students who exhibited initiative and their reported family incomes.

Table 1. Occurrence of *Initiative* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Employment	8	*"As an engineering student I secured a highly competitive internship with a major organization but then all of the sudden I felt like that could be taken away. And even more financial stress set in. Thankfully, it looks like things are returning to some sort of normalcy. My way out of this situation was to adapt quickly rather than just sit and watch everything crumble."* [$25K-50K]
Health	4	*"I suffer from depression and anxiety and I coped with the uncertainty by escape sleeping. I enrolled in an intensive outpatient program (IOP) to learn Dialectical Behavioral Therapy to stop sleeping and become more productive. I graduated from the program but it was an uphill battle for 12 weeks."* [< $25K]
Academics	7	*"Doing 19 credits online and not having in person office hours stressed me out, but then I started interacting with the teaching assistants more personally because no one else was really showing up."* [$25K-50K]
Time management	4	*"I simply implemented time management with my family's expectations and expect them to respect my time as well. I recognize that my family worked incredibly hard to get to where they are now which is why they expect a lot from their offspring"* [$25K-50K]

Discipline

The data illustrated that there were 13 instances of students exhibiting discipline. There were five accounts of students overcoming adversity, three instances of students exhibiting persistence, three instances of students tending to their health needs, and five accounts of time management. Table 2 provides excerpts from students who exhibited discipline and their reported family incomes.

Table 2. Occurrence of *Discipline* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Overcame adversity	5	*"I am a first-generation college and PhD student. I am the only black person in my department (including faculty) and I was incredibly uncomfortable with sharing about my circumstances at home because of it. So instead of being the unproductive grad student taking advantage of work from home I begrudgingly wrote the manuscript, attended meetings that should have been emails, and put on a smile."* [$50K-100K]
Persistence	3	*"I would have to take 2 round trips on the metro in the midst of a pandemic to get my food. That's my only means of transportation."* [$25K-50K]
Health	3	*"A stressful enough situation of applying for jobs and figuring out my meaning in life beyond my engineering education became even more difficult due to COVID. I lost my method of stress relief, which was going to the university gym and working out 6 days a week. I had to take up cardio and self-motivation become much harder to obtain since I couldn't see my friends and compare progress with them."* [$25K-50K]
Time management	5	*"However, once lectures became asynchronous, I thought this would allow my schedule to become more flexible. Instead, I found myself skipping lectures and never going back to watch them. It took more discipline to set a time for yourself everyday to go and watch a lecture rather than having a set time to watch it."* [$50K-100K]

Accountability

The data indicated that there were 22 instances of accountability of those accounts, nine acknowledged failures, two felt responsibility for their health, four felt responsible for finances, and 11 still felt responsible for their success. Table 3 provides excerpts from students who exhibited accountability and their reported family incomes.

Table 3. Occurrence of *Accountability* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Acknowledge failure	9	*"Finally I ended the semester, ended up doing not as well as I hoped (I got a D on my final for a class!). Nonetheless, I was done."* [$50K-100K]
Health	2	*"My grandfather in the past year had been diagnosed with stage 3 lung cancer, and so me staying home and taking care of him as well as bringing him to his treatments became very detrimental. I became more aware than all of my peers the importance of social distancing and proper disinfecting methods for his as well as my grandmother's safety."* [$25K-50K]
Finances	4	*"This was supposed to be my last year for my PhD but there are so many schools with hiring freezes I might have to put that on pause. This is more stressful because my family needs me to be at that point where I'm actually earning money. I have other siblings who want to go to college so I need to be earning money."* [$50K-100K]
Success	11	*"I made through my classes with the lowest letter grade of a C and the highest letter grade of an A+. It was not easy, trying to make it through as these classes were upper level division science classes, I can't afford to fail."* [< $25K]

Investment

Investment was defined by 23 instances. There were nine accounts of students balancing their priorities, 11 instances of students investing in themselves, and 11 instances of students seeking out resources. Table 4 provides excerpts from students who exhibited investment and their reported family incomes.

Table 4. Occurrence of *Investment* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Balanced priorities	9	*"I am glad that I was able to compromise with my family where I would designate time to help my siblings with homework, have set days where it's my turn to make dinner, and consider family time to keep a close connection."* [$25K-50K]
Invested in self	11	*"It took me close to three weeks to transition and adjust to working from home. My internet was fixed. I upgraded my computer and developed the discipline needed to work from home."* [< $25K]
Sought out resources	11	*"I took it upon myself to go to virtual office hours more to get help rather than relying on them to help me."* [$50K-100K]

Openness/Reflectiveness

Openness/reflectiveness was defined by 32 instances. Within the micronarratives, there were 11 accounts of students acknowledging failure, 19 accounts of students being optimistic, and two instances of students questioning societal norms. Table 5 provides excerpts from students who exhibited openness/reflectiveness and their reported family incomes.

Table 5. Occurrence of *Openness/Reflectiveness* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Acknowledge failure	11	*"I was faced with adversity and was discouraged from trying to set up zoom meetings with my instructor for extra help when I needed it."* [< $25K]
Positive outlook	19	*"In all honesty, COVID-19 slowed things down for me and that is something that I really needed. Classes, although online, moved at a slower pace because professors felt the need to be more thorough in their instruction, technical difficulties were taken into account, and pre-recorded lectures allowed me to revisit confusing content. In my opinion, it shouldn't take a pandemic for professors to incorporate these things. Although COVID-19 is awful, it gave me the chance to finally feel like a regular student."* [$50K-100K]
Questioned norms	2	*"I decided my house was not the best place to study, and since I still paid rent for my apartment at school, why not go back? I made the announcement to my family who argued with me saying I was*

		risking my health just to run away from home. My stepdad was disgusted with me saying that I am unappreciative of everybody's support for my education. I kept trying to explain in the nicest way possible that it would be best if I went back to school. He then asked, what is in your apartment that isn't here? I broke down in tears and said, freedom." [$25K-50K]

Flexibility

Flexibility is defined by 18 instances, where there were three instances in which respondents had to shift their income source, 12 accounts of students having to relocate, three instances in which students had to find study alternatives and six instances where students had to shift their responsibilities. Table 6 provides excerpts from students who exhibited flexibility and their reported family incomes.

Table 6. Occurrence of *Flexibility* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Study alternatives	3	*"I had to make drastic changes to my academic approach because I could no longer rely on the tools and resources that were previously available to me. For example, my chemistry lab did not create a sufficient office hours equivalent post COVID transition."* [< $25K]
Relocated	12	*"I remember when I was abruptly kicked off of campus by student housing at the start of the COVID-19 crisis, I had to move all my belongings out by myself and move into my sister's one bedroom apartment. She was the closest person I could go to for shelter and I didn't want to go home and endanger the lives of my older parents in case I was a carrier. I really just remember sharing a cramped one bedroom apartment, sleeping and continuing school on an uncomfortable futon, and rationing food because we wanted to make the least amount of trips to grocery store and we didn't know how bad things would escalate."* [$50K-100K]
Shifted income	3	*"Sources of income dried up. I was left to desperately seek out pandemic aid, unemployment assistance, to charging rent on a credit card. I had to jeopardize my credit store to try and stay afloat, this is a temporary measure that I know I would need to work hard to rectify. Finally, I had to look for side hustles. Experiencing financial instability and precariousness is directly linked to Covid-19."* [$25K-50K]

Shifted responsibilities	6	*"Receiving the information that schools were going to virtual classes for the rest of the year was fine for me but for my younger siblings and parents it was very hard. I had to quickly pack up and move back home to help out and to basically homeschool them."* [$25K-50K]

Autonomy

There were 11 instances of students exhibiting autonomy. From this analysis, we found three instances of students living alone, three instances of students teaching themselves, and six accounts of students having to financially support themselves. Table 7 provides excerpts from students who exhibited autonomy and their reported family incomes.

Table 7. Occurrence of *Autonomy* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Moved/stayed alone	3	*"But since the move to online I spend weeks without living my property here. It's quiet but it has given me the chance to reflect and work on side projects I've been interested in starting."* [< $25K]
Taught themselves	3	*"Generally, if I have to teach everything completely to myself, there's no reason to pay thousands of dollars to UGA."* [$50K-100K]
Finances	6	*"I am what they consider an essential worker. In the last week, the grocery store I work at has sent out 8 new COVID case alerts. My WFH internship starts in two weeks. It's the worst waiting game as I continue to go to work as financial pressure mounts."* [$25K-50K]

Alignment with Others

Of the analyzed micronarratives, 38 respondents suggested that they had alignment with others. There were reported five instances of students caring for others, 21 accounts of empathy or sympathy for others, 20 instances of social consciousness, and seven narratives mentioned valuing interactions with others. Table 8 provides excerpts from students who exhibited alignment with others and their reported family incomes.

Table 8. Occurrence of *Alignment with Others* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Cared for others	5	*"As the virus ran rampant through the nation, my parents started to tell me about my uncles and grandfather. They were showing severe symptoms and we're moving back and forth between the ER because they couldn't breathe. After hearing this I rushed back home to NY city for support. Because I left after the housing cutoff date I couldn't get any kind of refund for housing for the spring semester. My uncles and grandfather persevered and with time their symptoms disappeared."* [$50K-100K]
Empathy/sympathy	21	*"Professors give us work and work and don't realize that some people at home can't focus as well because they live with 7 other people or a lot of children. They end up stressing and stressing to complete assignments having a negative toll on mental health. I've experienced this and as well as several other engineering students I've talked to."* [$50K-100K]
Socially conscious	20	*"I am disappointed in the Nation that I live in with the handling of COVID-19 and the following handling of George Floyd and the countless black deaths before him. When I went into Engineering I did so with the intention of using my degree to participate towards something bigger than myself. But I do not know what this Nation stands for anymore and a Nation that stands for nothing is not a Nation. Rest in Power my dead Brothers and Sisters we will find a better way."* [$50K-100K]
Values interaction	7	*"The one thing that got through the remainder of the semester was a group of my peers. We worked together throughout the remaining 7 weeks via FaceTime. We helped each other with homework, studying, and through our collaborative exams. Without this level of camaraderie, I wouldn't have been able to finish so strong. Although this made me realize that I really do need to be on a campus with peers to learn best."* [$50K-100K]

Internal Alignment

Internal alignment was found in 33 of the micronarratives. There were 28 instances of transparency, three instances of students exhibiting mature values, eight accounts of humility, and 23 accounts of self-awareness. Table 9 provides excerpts from students who exhibited internal alignment and their reported family incomes.

Table 9. Occurrence of *Internal Alignment* and examples from student stories

Sub-Code	Number of Instances	Example Micro-Narrative
Humility	8	*"One can easily stratify my classmates on the basis of wealth and access based on the background of their homes on Zoom. I'd hoped to use the zoom automated background to disguise the reality of my life at home, but it turns out that my computer is not fancy enough to enable that feature. I often put my video off unless I'm called upon to state my opinion or give an answer. I feel very disconnected from my learning."* [$25K-50K]
Mature values	3	*"I did not expect I would fear the lives of my family put at risk every single day. But the science goes on as some of faculty members would say. Or find ways to be productive. News flash, I am not productive, and I cannot be productive when my safety or my family's safety is threatened every single day. Science needs to change."* [$50K-100K]
Transparency	28	*"I believe people have different have styles of learning and mine is definitely not suited for virtual learning. I learn best by doing and visual demonstrations. I'm addition, my home is not an adequate learning environment. I'm at my most productive when I'm at a library instead of my home. Not only has this impacted my education/learning, but it also my ability to do my work."* [$25K-50K]
Self-aware	23	*"I foresee myself not being completely comfortable with regular interaction whenever all phases are complete. For this reason, I'll be ostracizing myself from the lab group."* [$25K-50K]

Discussion

Through conducting a high-level thematic analysis, we gained insight into the experiences of low-income engineering students during the COVID-19 pandemic and informed the answers to our research questions. While the previous framework provided by Tobias was a good indicator of a thriving individual in 2004, there is much more to consider amidst a global pandemic. Student responses detailed what thriving might look like during more difficult times.

There was a large occurrence of students whose stories resonated with the dimension of "*Internal Alignment*" which Tobias defines as; "Is internally aligned, personally integrated, genuine, authentic, transparent; has a well-developed and well-articulated self-concept and value system

that are consistent with feelings and behavior; stands for something; has a unifying philosophy and sense of purpose/mission; has vitality, zest/appreciation for life; has integrity and an ethical sense; is self-aware, insightful; is able to resolve internal conflicts; has humility and self-esteem; is realistic, objective, able to adopt a balanced perspective; exhibits a minimum of hypocrisy" [4].

This pattern in the data showed that many of the participants chose to be transparent about their experiences, whether it was owning up to poor grades, being vulnerable about their mental health, or acknowledging their feelings about the current state of the country; these students opened up about their experiences in being an engineering student during the spread of COVID-19. The methodological implications of this study are like that of Lee et al. in that students of this demographic were able to freely discuss their experiences without the pressure of an interviewer, therefore producing authentic representations of their realities [15]. One of these points of vulnerability was students sharing that they had difficulty making the transition from the life of a regular student to completing their coursework during a pandemic. This was characterized by many students having to relocate back with their families, which presented many challenges according to patterns in the data. This pattern was also observed in the dimension of "*Flexibility*". Completing engineering coursework remotely already was an obstacle that students had to face due to the lack of instructor-student and hands-on interaction. This does not consider the additional barriers that low-income students may have to face. Not having access to appropriate learning spaces and having to balance household responsibilities make learning already challenging material more difficult. This aligns with the literature stating that students have more difficulty making this transition due to the lack of structure at home and increased distractions [19]. We speculate that low-income students may have a more trying time with this change given that their at-home responsibilities may be increased.

The dimension "*Openness/Reflectiveness*" also had a high occurrence in student stories. A large majority of stories coded for this dimension, revealed students being optimistic. While this hopeful attitude can be closely associated with thriving, we hypothesize that students feel this way out of obligation. Thriving is a form of resilience that is common culturally but may not be common from an empirical standpoint. From this, we can conclude that thriving is not new for marginalized communities because these demographics have always had to adjust to barriers and seek solace in times of distress. These patterns can also be found within the dimensions of "*Initiative*" and "*Accountability*". Students shared that they felt compelled to fulfill certain responsibilities or feel a sense of gratitude for having their families, being healthy, and receiving an education. This obligation to find the silver lining dismisses the reality of being a low-income engineering student during this time.

The patterns in the data further prove previous studies relating to how engineering students thrive and experience belonging. From this literature we found that disadvantaged STEM majors revealed that they struggle with internalizing the stigma of "deficient preparation and competence that they sensed was held by other students and by sometimes faculty, as well." [20]. We feel that this may provide reasoning for why many students were reluctant to seek out help, struggled with engagement, and empathized with students who shared similar experiences.

To address the need for support of low-income students in engineering, it is essential to first understand how financial challenges can impact learning and engagement. Peña et al. compiled a list of ten rules for supporting low-income students in STEM (science, technology, engineering, and mathematics) [21]. In this context, the rules that would be beneficial given the patterns in the data are embracing differences, openly discussing impostor syndrome and offering holistic mentoring, and advocating for students to receive institutional support. The compilation of rules suggests "embracing collaborative group science or finding ways for students to bring their families and communities into the work they're doing." [21] is a good way to embrace differences in the learning environment. This is prevalent given that many students had to return home to their families and communities and need to find ways to remain engaged in their new learning spaces while also fulfilling their at-home duties. Openly discussing imposter syndrome and offering holistic mentoring pushes students to be their "whole selves". When this conversation is initiated by leaders in the classroom, it creates a safe space for students to confront their anxiety around learning. Holistic mentoring of students offers the "reframing [of] the difficulty of the work" and the "appreciation for nuances in academic norms" [21], [22]. In the context of learning during COVID-19, this approach is necessary because it normalizes student experiences and creates a sense of belonging. Lastly, advocating for students to have institutional support will allow students to feel that they have someone upholding their needs and experiences when institutional decisions are being made. This can come in the form of offering supplemental instructional opportunities and redesigning academic policies [23]. By informing institutional policies around the academic needs of low-income students, engineering programs can seek to relieve academic pressure and increase student success.

Limitations

One of the limitations to this thematic analysis includes missing specific location information of participants to understand the full scope of their financial circumstances. Because we conducted a nationwide survey but did not collect information about city or state or household size, we had no specific indication of where students were located or the number of people in their household and thus, we determined the criteria for a low-income student based on the median household income by region. According to the United States Census Bureau, during the year 2020, the median household income by region is as follows: Northeast ($75,211), Midwest ($66,968), South ($61,243), and West ($74,951) [24]. Given the income ranges for our data are < $25K, $25K - $50K, $50K – $100K, we included participants whose families may have earned more than this amount. Furthermore, we acknowledge that the income data we collected was based on how much families earned in 2019 and not necessarily how that could have changed due to the pandemic. Additionally, we did not consider participants' financial aid packages or the type of institution they attended given that some were unsure about this information. We also note that socioeconomic status is not a singular determination of how individuals managed during the pandemic and the data collected does not account for potential changes in this status during and since the COVID-19 pandemic.

Additionally, we are aware that this analysis does not represent the complete experience of a low-income student in engineering, but in sourcing out prior literature on similar studies, we can expect compounded effects from this population. This research can be used in future explorations of the

data for students indicating having a family income of more than $100,000 and can inform a comparison between low-income students and their more affluent peers.

Conclusion

The COVID-19 pandemic has been especially trying for low-income students as they have had to take on new responsibilities, work to provide for themselves, and satisfy the needs of others. Our analysis indicates how the framework of thriving can be applied during stressful and traumatic times, and how low SES students demonstrated examples of this in various ways. Marginalized students are denoted as "thriving" because their experiences have led them to be resilient during times of uncertainty. As the field of engineering education evolves, it is imperative to consider how student experiences impact their learning and from this, implement programming that accurately addresses these hardships. By making this adjustment, we advocate for change in the engineering climate.

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APPENDIX A - Dimensions of Thriving Paradigm and Sub-Themes

Dimensions of Thriving	Sub-Codes	Code Description
Initiative	Employment	Students maintained or obtained employment
	Health	Students prioritized mental and/or physical health
	Academics	Students who sought out academic help by attending office hours, communicating with teaching assistants or professors, and/or developed different study habits
	Time management	Students who expressed how they balanced their time
Discipline	Overcame adversity	Students shared an experience of fulfilling goals while facing barriers
	Persistence	Students exhibited effort towards a long-term goal
	Health	Students prioritized their mental and/or physical health
	Time management	Students constructively used their schedule
Accountability	Acknowledge failure	Students shared experiences of failing or not fulfilling their goals
	Health	Students took ownership over their health
	Finances	Students took ownership over their finances
	Success	Students took ownership over their success
Investment	Balanced priorities	Students optimized their current situation to obtain long term success

	Invested in self	Students who expressed they are putting time, money, and energy into bettering themselves
	Sought out resources	Students acquired additional resources to obtain long term success
Openness/Reflectiveness	Acknowledge failure	Students shared experiences of failing or not fulfilling their goals
	Positive outlook	Students who were optimistic about their future or current state
	Questioned norms	Students who disagreed with traditional values or how the pandemic was being addressed
Flexibility	Study alternatives	Students who had to find alternate means for studying academic material
	Relocated	Students who expressed they moved off campus
	Shifted income	Students who had to find another source of income
	Shifted responsibilities	Students who had to take on additional responsibilities
Autonomy	Moved/stayed alone	Students who decided to live by themselves
	Taught themselves	Students who took ownership over their education and taught themselves
	Finances	Students who had to provide financially for themselves
Alignment with Others	Cared for others	Students who physically, mentally, or emotionally cared for others
	Empathy/sympathy	Students who expressed empathy and/or sympathy towards the challenges of others
	Socially conscious	Students who expressed concern about the state of society

	Values interaction	Students who indicated that they needed and/or sought out human interaction
Internal Alignment	Humility	Students who viewed themselves equal to others
	Mature values	Students who had a well-developed value system that they practiced through their actions
	Transparency	Students who were honest and accountable for their emotions, thoughts, and actions
	Self-aware	Students who were in tune with their thoughts, emotions, and actions