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In Their Own Words: The Community College Experience toward an Engineering Baccalaureate Degree

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Abstract

Women and underrepresented minorities can help fill the ever-growing demand for engineers in the United States. Quality teaching methods, an understanding of the cognitive aspects of learning, and faculty addressing biases help ensure student success in engineering majors. Accordingly, the community college engineering pathway can help fill the national need for engineers.

This phenomenological study sought to describe the experience of students who choose the community college pathway toward a Bachelor of Science degree in Engineering. Thirteen participants were interviewed; all took engineering courses at the same community college, transferred to a four-year engineering university, and were progressing toward or have earned a bachelor's degree in engineering.

The community college pathway offers a lower-cost, quality education, allowing students of all math levels access to an engineering degree with courses that transfer to a four-year institution. These students gained the skills necessary to be successful and were able to earn an engineering degree with little debt. Relationships with peers and authority figures were crucial to the students' successful journey.

Through collaboration, students learn more and gain a deeper understanding of the material. Students need multiple sources of encouragement, recognition, and successes to persist toward an engineering degree. Seeing themselves in a role model is beneficial. Engineering lifestyle, comfort, money, and making a positive difference were factors in choosing an engineering major. Each participant experienced community, relationships, friendships, and were grateful they chose the community college pathway. The full results of this study are found in [1].

I. Introduction

A. Background

Although the United States was once the world leader in engineering innovation, this is no longer the case. "[T]he data clearly show the evolution of the United States in the global [science and engineering] enterprise. Increasingly the United States is seen globally as an important leader rather than the uncontested leader" [2]. The trend of growth in research and development in Asian countries has outpaced growth in the United States [2].

The United States Bureau of Labor Statistics predicts an average 6% increase in all engineering jobs from 2020 to 2030. Some areas of engineering are predicted to have a higher than average increase, including industrial engineers (14%), chemical engineers (9%), and civil engineers (8%). Additionally, these are well-paid jobs with a median annual wage for architecture and engineering occupations of $83,160 in May 2020 [3].

The infrastructure report card is generated every four years by the American Society of Civil Engineers. Infrastructure is the roads, bridges, airports, railroads, drinking water, and parks that form the backbone of a civilized society. The 2021 infrastructure report card gives the United States a C-minus. The grade is based on the need for investments and improvements and the physical condition of the infrastructure. Although this represents an increase from a D-plus four years ago, there is a clear need to invest in improvements and for the civil engineers required to provide the necessary solutions [4].

The data indicates there are students interested in science and engineering. In 2021, more than 10,000 first-year students applied to the University of Minnesota, Twin Cities, College of Science and Engineering. However, only 1,453 of those students matriculated. This was the largest class to date [5]. Therefore, at least 8,500 students with an interest in science and engineering were not accepted or did not enroll. Although students may have enrolled elsewhere, some of these students with an initial interest in science and engineering could have chosen an alternate path away from engineering.

Women, Black or African American people, Hispanic or Latinx people, American Indian people, Alaska Native people, and the intersection of these groups, are underrepresented in engineering bachelor's degrees earned and in the engineering profession. We look to data to find these inequities, as shown in Table 1, for 2017, the United States (U.S.) percent of people earning bachelor's degrees and the percent of engineering professionals [6].

Table 1

2017 United States Engineering Underrepresented Demographic Data

	Percent of U.S. population (2017)	Percent of U.S. engineering bachelor's degrees (2017)	Percent of U.S. engineering professionals (2017)
Women	51.5%	21%	15.6%
Black or African American	12%	4%	3.6%
Hispanic or Latinx	14%	10%	8.3%
American Indians and Alaska Natives	< 4%	0.8%	0.2%

These numbers and the discrepancies they represent cannot be ignored. It would be remiss not to consider the disparities of gender and race in engineering. Increasing the number of women and underrepresented minorities completing engineering degrees could fill the need for engineers in this country.

It is essential to avoid considering any group as a uniform monolith. There is intersectionality between gender and race, as well as other factors in a person's experience. Other considerations include ethnicity, class, sexual orientation, disabilities, and the first-generation status of students. We seek out patterns and commonalities without erasing uniqueness [7].

B. Student Success

Community colleges are seen as an important solution to the shortage of students in the STEM pipeline. If they are to be a part of the solution, community colleges will need to address the social and institutional gender barriers that are in place, including success factors [8].

For those students who have interest, are accepted, and enrolled, the graduation rate of United States engineering students has remained steady for decades. Of all students who enroll as engineering majors approximately 50% will graduate, with a disproportionately high attrition rate for women and minorities [9].

Understanding and addressing student success factors is a critical element to supporting diverse and thriving engineering graduates. Among the main factors [9] found for students leaving engineering were classroom and academic climate, self-efficacy and self-confidence, and race and gender issues. Academic success is not solely based on abilities and aptitudes; it is also influenced by sense of belonging in the academic environment [10].

Sense of belonging is seen as a significant factor for student success. An academic sense of belonging is defined by [10] as the extent to which a student subjectively feels accepted, valued, and a legitimate member of their academic domain. Belonging is an essential driver in a person's psychological and physical well-being. Sense of belonging is an essential factor in academic achievement and persistence.

It is vital to an academic sense of belonging for students to connect with peers and have role models. Specific suggestions for educators are given in [10]. In general, faculty should avoid stereotypical materials in lectures and worked problems. It is better to emphasize effort over brilliance, and assure students that it is common to have doubts about belonging and explain ways to cope. Structuring the classroom to give students a chance to connect, and including a value-affirmation intervention will help to improve students' sense of belonging. Outside influences can also provide much-needed social support [10]. Sense of belonging is additionally referenced in [13] – [18]. Stereotype threat [11] is another burden impacting student success. Stereotype threat significantly, negatively affects women and minorities. Additionally, females must unduly manage gender bias.

C. Gender Bias

The study [12] is an example of the damaging effects of implicit or unintended gender biases in faculty. This randomized, double-blind study (n=127), looked at science faculty at research universities who received and rated application materials for a laboratory manager position. The materials had been randomly assigned either a male name or a female name and were otherwise identical. The faculty (both male and female) rated the male candidates significantly more competent and hirable than the *identical* female candidates. The faculty assigned higher salaries to the male applicants than to the female applicants. Males were given a 14% increase in mean

salary over the females. The faculty also offered less career mentoring to the female candidate than the male candidate. Interestingly, the gender, scientific field, age, and tenure status of the faculty were not significant in these results. The observed gender bias seems to be pervasive among all faculty.

It was found in [19], as others have, that there is not a difference in innate mathematical ability between genders to explain the gaps. Furthermore, [20] studied the role of the community college in closing the gender gap and reported that the most cited barrier for female students in STEM fields was a "chilly climate" negatively impacting the likelihood of persisting.

D. Community Colleges

Community colleges, originally known as Junior Colleges, were authorized by the Land Grant Act officially called the Morrill Act of 1862 and 1890. There are more than one thousand community colleges. These are primarily two-year, non-profit institutions, that are lower-cost colleges providing the first two years of a four-year degree [21].

The growth of community colleges was a direct response to the growing demands placed on schools in general. Schools are expected to solve a variety of social and personal problems. Factors cited by [22] that contributed to the rise of community colleges include the growing need for worker training, extended adolescence requiring an extension of high school, and desires for social equality and more expanded access to higher education. The curricular functions of the community college include preparation for transfer, occupational education, continuing education, developmental education, and community service.

Developmental, also known as remedial or basic skills, education is an important service of community colleges. Developmental-level courses are designed to remedy gaps in prior education. These courses typically do not earn college credit but may be a prerequisite to prepare students for college-level courses. Community colleges are typically vital to literacy development (reading, writing, and math) especially for nonnative-English speakers. "Nationwide, 44 percent of first-time community college students enroll in between one and three developmental courses; and 14 percent take more than three" [22].

E. Affordability

For the 2020-2021 academic year, the cost of tuition including required fees and a surcharge for the College of Science and Engineering at the University of Minnesota, Twin Cities was $17,142 [23]. While the average 2020-2021 academic year tuition of the Minnesota State system community colleges with engineering programs was $5,665 [24] or approximately one-third the cost of the University of Minnesota.

F. Engineering Pathway

"Community Colleges play a key role in preparing Americans to enter the workforce with associate's degrees or certificates or to transition to four-year educational institutions" [2]. Nearly half (47%) of all U. S. students who earned bachelor's degrees in science and engineering between 2010 and 2017 did some coursework at a community college, and 18% earned associate degrees [2]. Students can take the first two years of a four-year engineering

degree at a community college, and then transfer to and graduate from a four-year engineering program. This is considered the community college pathway toward a Bachelor of Science degree in Engineering.

II. Research Study

A. Problem Statement

There is an ever-growing need for engineers in the United States. To stay competitive in innovations we need a variety of voices. Women and underrepresented minorities are an underutilized human capital resource that can help fill this need for engineers. Quality teaching methods, an understanding of the cognitive aspects of learning, and faculty addressing biases help ensure student success in engineering majors.

The community college pathway is a more cost-effective way of earning a bachelor's degree. Community colleges provide developmental education courses which help prepare students for college level courses. Thus, community college engineering pathways can help fill the national need for more engineers. Even so, many students lack awareness of the engineering pathway through the community college. There is some literature on choice of community college, transfer to four-year institutions, and choice of engineering. However, literature on why students choose the community college pathway for engineering or about the experience of students taking the community college pathway to earn a Bachelor of Science degree in engineering was not found.

B. Research Questions

The characteristics of the qualitative transcendental phenomenological research are outlined in [25]. The research questions should seek to reveal more fully the human experience essences and meanings. The elements of interest are what the individuals experienced and how they have experienced it. The following research questions guided this study: What were the students' lived experience in choosing to major in engineering and to attend community college? How did the students experience the community college pathway toward a Bachelor of Science degree in Engineering?

C. Significance of the Research

This study intends to contribute to the understanding of the overall phenomenon of engineering students who take the community college pathway. The results describe the students' experiences and illuminate how to increase awareness of the engineering pathway through the community college to a wider population. It is an opportunity to increase engineering student enrollments and the number of future engineers.

D. Research Rationale and Design

Qualitative research is used when "we need a complex, detailed understanding of the issue. This detail can only be established by talking directly with people . . . and allowing them to tell the stories unencumbered by what we expect to find or what we have read in the literature" [26]. We use qualitative research when quantitative or statistical analysis does not fit the question [26]. A

phenomenological approach to a qualitative study is focused on finding common meaning for multiple individuals' lived experience and addresses questions of everyday experiences. "The defining characteristic of phenomenological research design is its focus on the 'essence' of a phenomenon from the perspectives of those who have experienced it" [27].

III. Results

The findings of this research study and the participants' self-reported demographics are presented. Full participant profiles can be found in [1]. The process of data collection and analysis is outlined. The findings are reported by themes that emerged from the data analysis process. The participants own words are used in direct quotes. The names used were chosen by the participants to protect anonymity.

A. Research Site and Participants

The site for this research is a community college located in a suburban area just outside of a major metropolitan area in the North Central United States. The engineering program at this Community College offers an Associate of Science degree in Engineering Fundamentals. The courses required for this degree constitute the first two years of a four-year engineering degree. Students who complete these courses transfer as junior-level students to mechanical, civil, aerospace, or other engineering majors at a four-year engineering institution. The highest number of students transfer to the large, highly-selective R1 university, "the U," in the nearby major metropolitan area. Some students also transfer to state universities or private universities in this state or around the country.

B. Participants and Criteria for Selection

The next step was to determine the participants in this study. A random sample is only necessary or useful in a quantitative study. "Instead, since qualitative inquiry seeks to understand the meaning of a phenomenon from perspectives of the participants, it is important to select a sample from which the most can be learned. This is called a purposive or purposeful sample" [27].

Recruitment goals of eight participants with a minimum of five [28] were set. The ultimate goal is saturation—the point at which the same themes come out repeatedly and where no new themes are collected from additional participants. The essential criteria were that the student went to a community college, transferred to a four-year institution, and is progressing toward graduation or has recently graduated with a bachelor's degree in engineering. In the end, a total of 13 participants were interviewed, exceeding the minimum and the goal number of participants. Saturation was achieved with this number of participants.

All participants signed an informed consent document – the plan for respecting the privacy of participants, concern for participants welfare and not placing them at risk, and treating participants equitably and fairly [26].

Diversity of student identity in the sample is preferred but not critical. This diversity would include demographics of gender, race, ethnicity, sexual orientation, first generation college student status, age, and persons with disabilities. Also, of interest is whether the student is

married, a parent, a veteran, an immigrant, and whether the student was Pell grant eligible. These are of secondary interest in data analysis.

C. Participant Demographics

The information found in Table 2 through Table 5 was self-identified by the participants.

Table 2

Participant Transfer Institution	Number of Participants
Transfer to nearby large R1 university	10
Transfer to a state university	3

Table 3

Participant Engineering Major	Number of Participants
Mechanical Engineering	6
Civil Engineering	4
Chemical Engineering	1
Electrical Engineering	1
General Engineering	1

Table 4

Average Age (years)	26
Participant Age at Time of Interview	Number of Participants
21-22 years	4
23-24 years	4
30-32 years	3
Late 30s	1

Table 5

Participant Self-Identified Demographic Data	Number of Students

Total Participants	13
Black/African American	1
Asian	3
Hispanic or Latinx	1
White (non-Hispanic)	8
Female	5
Male	7
Transgender	1
LGBTQIA+	2
Pell Eligible	7
First generation[1]	8
Immigrants	3
Developmental Math	6
Average Student Loan Debt	$8,654
Participants with $0 Debt	6
Homeschooled	2
PSEO[2]	3

[1]First generation is defined using the federal definition: neither parent has completed a bachelor's degree.

[2]PSEO is post-secondary enrollment option in Minnesota. This is a dual-enrollment program in Minnesota that allows qualified high school students to take college courses for free.

Six students started college at the developmental math level. And while seven students started in college-level math, five were not calculus-ready. Starting college at Calculus I is typically the math level necessary to be able to earn an engineering degree in four years.

D. Data Collection

In a phenomenological study, "data collection procedures typically involve interviewing individuals who have experienced the phenomenon" [26]. The phenomenological interview is described as involving open-ended questions that are not overly structured. The goal is to make the participant comfortable and respond honestly [25].

Interviews were conducted in a conversational manner. It was important that the student feels comfortable and safe. Active listening was practiced as the semi-structured interviews were conducted. Prepared questions were used to help move the conversation along.

E. Data Analysis

To find the essence of their experience, it is important to set aside any preconceptions and to report what the participant actually say. It is not about ignoring or eliminating bias. It is about actively acknowledging our biases, judgements, and preconceived ideas, and then intentionally setting these aside or suspending these. Transcripts of the interviews were generated. Each recording was watched and listened to multiple times to accurately transcribe what the participant said. Extraneous information and non-pertinent quotes were eliminated. A summary of each participants significant statements or horizons was generated. This is a composite description and meaning for each participant. At this point, the transcript and summary were sent back to the participant for accuracy checks.

Next, all participant key points and quotes were sorted by themes. Participants' themes were synthesized and combined into a single document. The themes are organized by the critical incidents and factors leading to 1) the choice of attending community college, 2) the choice of majoring in engineering, and 3) the overall experience of taking the community college pathway. The last step in a transcendental phenomenology is to write a composite description that represents the lived experience of taking the community college pathway toward a bachelor's degree in engineering for all participants. This combined description is found in [1].

IV. FINDINGS

In reporting the themes here, the number of participants who introduced the theme in their interview was used to indicate the level of saturation of the theme. The themes are listed by level of saturation. A topic introduced by eight or more participants (most) is considered a saturated theme. A topic introduced by six or seven participants (many) is a 50% saturated theme. And a topic introduced by three to five participants (some) is a theme that was unsaturated but considered relevant.

A. General Themes

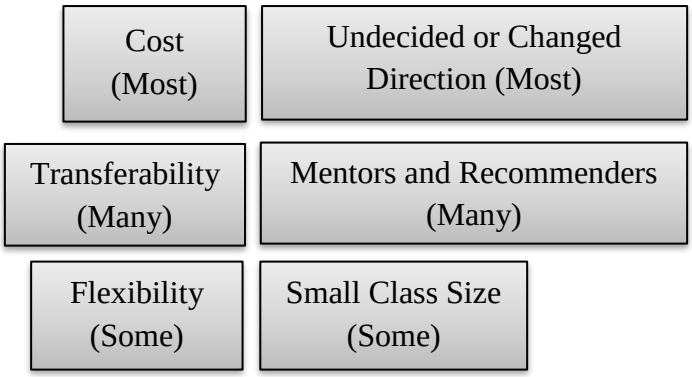
General themes surfaced through the data analysis process. Six themes emerged with regard to the choice of attending the community college. Seven themes emerged with regard to the choice of majoring in engineering. Overall, through organizing the data, a picture of the students' experience in taking the community college pathway toward a bachelor's degree emerged with six themes. Note that only the general experience is fully described in this article. For brevity, the themes for 1) the choice of attending community college and 2) the choice of majoring in engineering are listed without full details. See [1] for full results.

B. Community College Choice

Through the interviews, the following themes emerged to create an image of what the students' lived experience was in choosing to attend the community college. Figure 1 notes the themes; the details are left out here for brevity. For full results refer to [1].

Figure 1

Community College Choice Themes

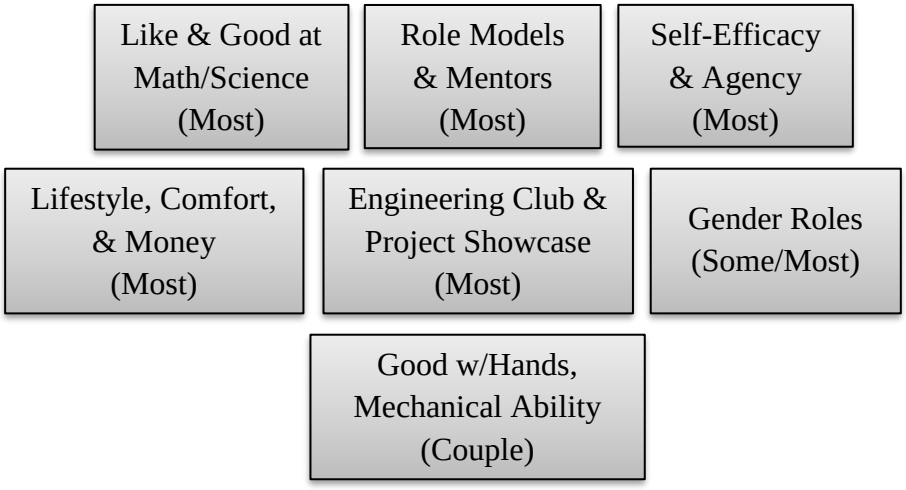


C. Engineering as a Major Choice

Through the interviews, the following themes emerged to create an image of what the students' lived experience was in choosing to major in engineering. Figure 2 notes the themes; the details are left out here for brevity. For full results refer to [1].

Figure 2

Engineering as a Major Choice Themes

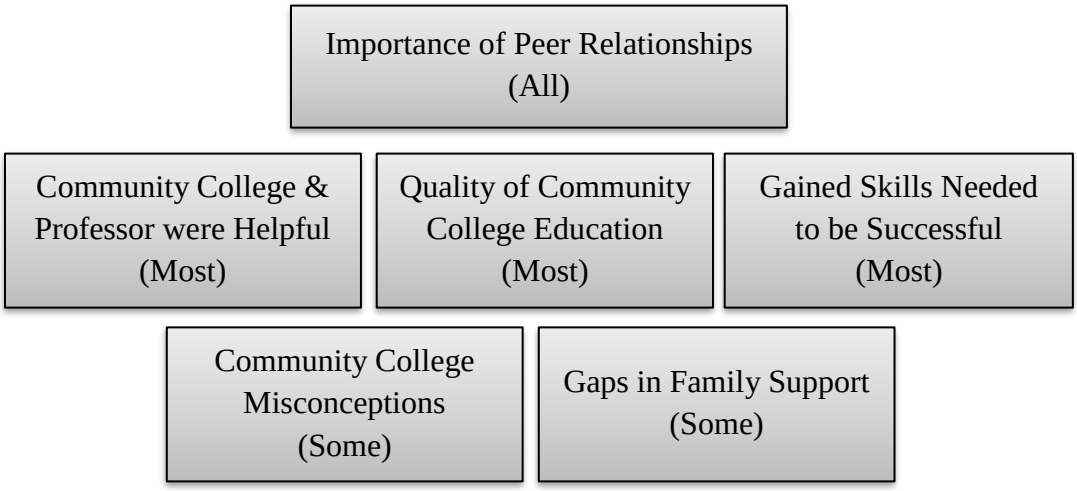


D. Community College Pathway Experience

The themes that emerged from the interviews and the analysis are noted in Figure 3. This is how the students experience the community college pathway toward a Bachelor of Science degree in Engineering. Representative quotes are included for each theme.

Figure 3

Community College Pathway Experience Themes



1) Importance of Peer Relationships: Comments were made by 13 of 13 participants. This is a saturated theme. Every participant spoke about the importance of peer relationships and the relative ease of making relationships at the community college. These peer relationships carry on when the participant moved to the four-year institution. The community college is a community. Collaboration at the community college, as opposed to the competitiveness of the four-year institutions, was raised.

Michael – "The people who go to the community college, they are not there to compete with other people. They are not there to stroke their ego about going to a big university. They are there to learn and better themselves and build their skills and create a future career for themselves. It is nice because you can really get to know those people a lot better than say someone you are competing against for grades your class. [Competitors] do not want to help you out, because with the curves and the way [the U] grade everything, it is not advantageous to work with other people and help them out. You do not get a lot of help with peers unless you are a good friend of theirs."

Monica – "[At the community college,] I actually really liked going to school, going to class, and seeing those people every single day and spending all that time together. We spent a lot of time together in the Learning Center, working on homework and discussing things. I thought it was really good environment and that helped me get through. When I think about engineering at the University, it is so much different. Yeah, I have some people I work with but it is just not the same. I have really good memories. I am really happy that I went to the community college."

Bonell – "It is more beneficial to socialize with people in the same academic path. You know, your engineering friends. For example, for me, socializing at the math center, working on problems and talking to people [taking the same classes]. Being able to help each out when we were stuck. To build a foundation when we were transferring to a four-year college, you keep that same thing going on. That was a good thing that started at the community college."

Sarah – “I think the students and the community that you create at a two-year community college just was more supportive in my opinion, compared to the four-year one, which just felt more cutthroat.” “You could text somebody, email somebody, or flag someone down in the hallway and ask them a question. Even if they slightly knew you or had seen you in the same class as theirs, they would stop and want to help. That was not something that I necessarily saw at my four-year.”

Mark – “I think that was probably one of the biggest things for me at the community college was how much of a community it really was. It felt like everybody in the engineering pathway was a family. You are all doing the same classes and the class sizes are so small that you see them everywhere. It is pretty cool. It was a good experience for me. I really enjoyed it.”

Jennifer – “I think just having that kind of close-knit environment with all these different people just made such a huge difference in my education and really solidified that I am going down the right path.” “Meeting all these people and forming connections. I think it really transformed me into a much different, better version of myself.”

2) *Community College and Professors Were Helpful:* Comments were made by 10 of 13 participants. This is considered a saturated theme. Students discussed how the community college in general was approachable and helpful. Students had differing experiences at their four-year institutions. The community college application process overall is easier. For international students the TOEFL score requirement is lower at the community college. Students received help and support from the community college faculty and staff. English, Ceramics, Math, and Engineering faculty members are mentioned by name. Learning Center personnel, Counselors, and Advisors are also named. Professors who care about their students make all the difference. Close relationship with teachers made it easier to learn. There was comfort asking questions of most professors at the community college.

Monica – “One person, I think about getting me connected to engineering, is the English professor I had my first semester. She knew that I liked math and science and she said, you need to meet [the engineering faculty]. I feel she was a good person to help connect students to engineering. The engineering pathway, I felt there was a really good support system.”

Jennifer – “Most of the professors that I had at the community college made me feel comfortable asking questions.”

Marcus – “I had professors that you could tell were there for the students. They are passionate about what they are teaching. And, you can just tell when they are the opposite, it shows.”

Max – “I realize that teachers can be utilized as an actual resource. With community college, I was able to actually ask those questions and I was actually challenged.”

3) *Quality of Community College Education:* Comments were made by nine of 13 participants. This is considered a saturated theme. Overall the students felt they left the community college with a strong engineering foundation. The depth of understanding the material learned at the community college helped the students in their upper division courses. They felt academically prepared to succeed at the four-year institution.

Michael – "I learned more from the community college than I did at the U. I say that the teachers care a lot more at the community college than they do at the U." "Especially since COVID, pretty much all the classes [at the U] have been graded on a curve. At the U, the majority of the people in the class are technically failing [class average ≤ 50%] and not understanding anything. You do not really learn or take away a lot from those classes. I have talked to a lot of other people that I have met there. They feel the same way. Whereas the people that I have had classes with at the community college, they retain a lot more from the classes that they had there."

Jennifer – "Starting at community college, getting that really good foundation in all of these subjects that inevitably come back [prepared me for the U]."

Matt – "When I went from the community college to the U, it was a really big change. The class size and how things are graded. You are graded on a curve, it is really hard. There is this caliber of kids there that was kind of nuts, just smart. I really thought that [the community college experience] helped you gain skills to get into that curve. It was seeing what engineering is like. Classes were affordable and you can get way more help at a community college than you can at a four-year university."

JK – "I had a good experience in community college. Especially, when we take the engineering classes with you. Because we really learn a lot that was helpful for me when I moved to University. I understand so deeply everything before moving on to university. It makes sense for me."

Stella – "The professor is a very important too, because the way you teach make us very easily understand."

4) *Gained Skills Needed to be Successful:* Comments were made by eight of 13 participants. This is considered a saturated theme. Participants noted the important communication skills, study skills, and overall maturity they gained at the community college.

Jennifer – "Communication skills and study skills developed are just so critical. Being able to meet people, talk to them, and to form friendships and study groups. Because honestly, in a major like this it is so hard. It is imperative that you be able to make connections because, you are bound to run into multiple problems, multiple times of frustration and it is better not to deal with that alone. You have to be comfortable enough to meet new people, asked for help."

Mark – "I was able to grow up there and learn about money. Saving money and paying for college, more in cash and not so much in loans."

Max – "[The community college,] really helped me spark my interest for learning a lot more."

Michael – “For people who are uncertain or for people who might not have been academically inclined growing up, it is a very encouraging environment to start learning and working in. It really helps build your skills and competence when you do transfer.”

Patrick – “Coming out of high school, I remember I had never really had to study or really try. At the community college, I was encouraged to try, to study, and just focus to do my best to learn the content and material. That really pushed me towards being better and applying myself more at the University.” “I have absolutely no regrets about the community college route. I loved it. I met a lot of good people. I had a lot of fun. I learned a lot about myself, about working, about how to learn. It was overall a fantastic experience.”

5) *Community College Misconceptions:* Comments were made by five of 13 participants. This is considered an unsaturated theme and yet the theme is considered relevant. Participants mentioned misconceptions of the community college. These include the quality of education, relationships with professors, and the opportunities they had at the community college including scholarships and internships.

Bonell – “Some students are skeptical about the community college experience, thinking that there are not enough opportunities for them. For myself, at the community college, I was able to get the opportunity of winning a scholarship with ties to [an Industry Partner] and that gave me that golden opportunity of my first internship when I was in College Algebra II. I am graduating in December and right now I am doing my fifth internship. I know that if I started at a four-year college, I would probably not get my first internship as a freshman. I do not see that happening.”

Jennifer – “It just feels like the professors at community college are there to teach you and they are there to clarify things when you need it. At a four-year college, it is not necessarily like that. Especially when most of your professors are doing research, you are really mainly talking to TAs. And with TAs, it is really hit or miss.”

Marcus – “I think more people need to know that this is an option.”

Patrick – “People tend to think of community college as sunshine and easy stuff. But we struggled, we had a tough time in those classes too.” “It definitely was a different first two years of college experience than my friends had. I think [the college experiences] are super similar in a lot of aspects. You are obviously not living in dorms on campus. But if you make it what you want it to be, you can have a very similar college experience [to a traditional four-year institution student]. I saved a lot of money.”

6) *Gaps in Family Support:* Comments were made by five of 13 participants. This is considered an unsaturated theme and yet considered relevant. The parents of two participants had less than an elementary education. Their families were unable to help navigate college. Both of these participants are immigrants. For three other participants their family did not present college as an option. There was no support for this option. All of these participants made their way on their own.

Jennifer – “For me, figuring out college and planning my education was completely my responsibility to figure it out. And on top of that, completely my responsibility to pay for it. My

mom is unemployed and my dad owns his own small business and they kind of have their own issues between themselves. It was not a priority for them that I even go to college."

Marcus – "[College] just was not an option. Unfortunately, in my family, it was not presented as an option."

Monica – "I do not know how to navigate this process. Neither of my parents went to a four-year university. I did not really have anyone to ask for advice."

V. Discussion

A. Relationship to Literature

The purpose of this qualitative transcendental phenomenological study was to describe the experience of taking the community college pathway toward a Bachelor's of Science degree in Engineering.

1) Success Factors for Engineering Students: A sense of belonging is a significant factor for student success [10], [13]-[18]. It is vital for students to connect with peers and have role models [10]. As all participants described in the Importance of Peer Relationships theme, the relationship with their peers was vital to the students' success. The Engineering Club, the Learning Center and the classroom were places where students formed these relationships. Role Models and Mentors, Engineering Club and Project Showcase, Community College and Professors were Helpful themes all have elements that indicate that for the participants, sense of belonging was a key element in their success.

The Importance of Peer Relationships theme also addresses the significance of collaboration instead of competition among students [29]. Feminist theory seeks to deconstruct the current masculine culture/structure in engineering education which includes competition. Collaboration benefited all participants, no matter their gender.

The Role Models and Mentors theme describes the importance of role models for most of the participants. This was particularly true for the female participants. Having a female STEM role model opened the participant to the possibilities of an engineering major. This is also illustrated in the Gender Roles theme.

The Quality of Education at the Community College theme highlighted that students felt well prepared to move on to the four-year university. The curriculum at the Community College was relevant and well presented with a focus on learning. The Role Models and Mentors theme also reveals the positive influence an engineering professor can have on students. Student success factors are foundational to any engineering education. Past research [30], [31] notes the importance of a quality educational system with good curriculum and qualified teachers. To be a STEM pipeline it is necessary to address the social and institutional barriers at the community college [8].

Six main reason that students leave engineering were found in [9]. Faculty have control over factors in the classroom that could reduce or alleviate the six main reasons students leave engineering.

1. Creating a positive classroom climate: A positive classroom climate starts with a professor teaching with excellence – with both content and pedagogy expertise – and focusing on collaboration not competition [29]. This creates a classroom in which each student belongs [32], [17], and [20].
2. Conducting frequent testing: Testing should be focused on the outcomes of the course, which should directly relate to the material taught. The goal of testing is assessing what has been learned and discovering what still needs to be learned. As engineering educators, we need to eliminate rote testing, the "weed-out" model of education, and grading on a curve [18]. If the class average is too low, the focus should be placed on the teaching and testing methods utilized.
3. Helping students build self-efficacy and self-confidence: The belief in one's abilities to succeed grows with each success. Self-efficacy develops with recognition of the student's success, and by providing critical feedback on needed improvements, while also positively affirming a student's ability to achieve. Leading the student to work hard and be persistent [10], [13].
4. Building on previous knowledge: Although professors cannot change the student's high school or previous educational experiences, teachers can scaffold the material from where the student is to where we need them to be.
5. Advising and mentoring students: Students leave because of lack of interest and changing career goals. Through advising and mentoring the students, professors can help students determine if engineering is the right profession for them [33]. If, after gathering information, the student chooses a different field, that is still a success. Engineering is not for everyone.
6. Actively striving for equality and equity: Inequities are embedded in the structures of engineering education [12], [29], [34]. Teaching is a profession that can perpetuate inequality and inequity. Acknowledging that truth can help us actively work to combat these and help to teach in an anti-racist, anti-sexist, anti-homophobic, and anti-transphobic way. This starts with learning our own implicit biases [36] and working to incorporate value-affirmation interventions [14], [30], [31], [35] in our teaching practices.

Addressing these factors creates a warmer classroom [13], [17], [19], [32], which has been shown to provide reassurance for students to persist, higher performance and higher grades for female students, and a higher perception of fundamental engineering skills. Students are more willing to ask questions, which helps them to learn and understand the material. These are crucial aspects needed for engineering student success. Community college engineering pathways can help fill the national need for more engineers.

2) Choice of Community College: There is limited prior research on why students choose to enroll in community college. Six themes emerged from the data analysis process with regard to the choice of attending the community college. These themes are Cost, Undecided or Changed Direction, Transferability, Mentors and Recommenders, Flexibility, and Small Class Size. This study found factors similar to those found by [37] regarding the college choice process for Black males attending community college.

The community college pathway is a more cost-effective way of earning a bachelor's degree. The community college in this study, is about one-third the cost of the R1 University. The participants in this study had an average student loan debt of less than $9,000, with nearly half

having zero debt. Also, the class cap, or the maximum course enrollment, for an engineering course (ex: Statics) at the community college is 30 students while the equivalent course at the R1 University has a cap of 90 students. The Calculus I course has a cap of 40 at the community college and a cap of 192 at the R1 University.

One important function of the community college is providing Developmental Education, also known as remedial or basic skills education [22]. Most of the students in this study started college at a math level lower than is necessary to earn an engineering degree in four years. In this study, six of the 13 participants began in developmental-level math. All six of these participants noted liking and being good at math in their interview. Once they began, all six were one semester from college-level math. While seven students started in college-level math, five were not Calculus-ready. Starting college at Calculus I is the math level necessary to be able to earn an engineering degree in four years. Typically, four-year engineering institutions will not accept engineering students who are not Calculus-ready. Taking the community college pathway allowed students of all math levels access to an engineering degree. The community college fills this gap.

The themes of Undecided or Changed Direction and Flexibility demonstrate that an important benefit of taking the community college pathway is that a student is able to explore and to build confidence in the subject they decide to major in. The four-year programs are seen as rigid and inflexible. Attending the community college allows students to decide if they are interested in engineering. Additionally, they have the chance to decide which of the many branches of engineering is the best fit for them. There is the potential for institutional barriers at the community college level which could inhibit a student's progress [38]. However, the participants in this study were able to transfer seamlessly to the four-year institutions.

3) *Choice of Engineering Major:* There is some research on why students choose engineering as a major. Seven themes emerged from the data analysis with regard to the choice of majoring in engineering. The themes that were found in this study are Liking and Being Good at Math and/or Science; Role Models and Mentors; Self-Efficacy and Agency; Lifestyle, Comfort, and Money; Engineering Club and the Project Showcase; Gender Roles; and Being Good with their Hands and/or Mechanical Ability.

Liking and being good at math or science is noted in past research [39] – [42] as a key factor in choosing engineering or STEM fields. Role Models and Mentors and Gender Roles were addressed in Success Factors for Engineering Students section. Additionally, the Gender Roles Theme is in line with research by [8] that found social and institutional structures that create gendered pathways that favor men and limit women. As these researchers note, community colleges need to address these structures if they are to be part of the solution. This is an on-going process that takes active work and begins by acknowledging these structures exist.

Mechanical ability or being good with your hands are stereotypes often referred to as indicating an aptitude for engineering. However, only two participants, who both identify as white males, mentioned this in their interview. In this researcher's opinion it works in only one direction. If you are good with your hands, loved playing with Legos, building things, or working on cars, then engineering may be a good fit for you. However, not having this ability does not exclude

you from pursuing a career in engineering. This concept is limiting, exclusionary, and overused in two directions.

B. Implications of Findings

"Sometimes I think about these tiny gaps that I had to sneak through to be where I am right now. It is just fascinating. I sometimes just surprise myself that I got here." – Bonell

Although Bonell had more than his share of challenges and roadblocks, each of the participants in this study made their way through gaps toward a bachelor's degree in engineering. The community college serves as a mechanism to support students through these gaps. By providing developmental education, English language learner and math students are given the chance to remedy gaps in prior education and to prepare for college-level courses. Subsequently, college-level math students become Calculus-ready and prepared for engineering courses. Counselors, advisors, and helpful professors fill gaps in family support. The Learning Center and helpful faculty provide academic support. Most faculty are willing to answer questions and provide academic assistance and encouragement. There is flexibility at the community college "allowing for exploration" (Michael). Students see the four-year universities as rigid. There is no changing direction once you have entered a major. Starting at the community college allowed students the chance to find engineering as a major and the specific branch of engineering that is a good fit for them.

1) *Importance of Relationships:* Relationships are the underpinning of the experience of taking the community college pathway toward a bachelor's degree in engineering. Relationships are the support structure needed to be successful.

The Importance of Peer Relationships was referred to by all participants. A community surrounded the students. They made friends. They encountered people with different backgrounds from themselves, and yet they all had taking engineering courses in common. These collaborative relationships deepened the students understanding of the material.

Helpful professors, advisors, counselors, mentors, recommenders, and role models were there along the pathway, supporting and encouraging the students. These relationships with authority figures were crucial to the students' journey. Students often need multiple sources of encouragement and recognition to persist on the pathway to an engineering degree. It may take multiple successes for students to truly believe they can earn an engineering degree.

2) *Collaboration Produces Better Results:* The impacts of collaboration at the community college and competition at the four-year universities was an important result of this study. Through collaboration students learn more and gain a deeper understanding of the material. Competition breeds distrust and uncooperativeness. Grading on a curve is not solely a four-year institution construct. The origins of using a curve stem from a mistaken belief that intelligence fits a normal curve. For every A there is an F. Using this method of grading is arbitrary and hurts student learning. It also drives competition and discourages collaboration. If the class average is 50%, students are not learning the material or they are being tested on material they did not learn. This is an issue with the teaching of the material or the testing instrument and is the responsibility of the professor. Equitable education practice begins with a structured (although

not rigid) learning environment in which each student knows exactly what it takes to succeed. The results of this study and the students' comments on collaboration point to the need to eliminate use of the "weed-out" model of grading on a curve and to encourage collaboration. Collaboration benefits all students. Additionally, collaboration is the backbone of engineering as a profession. There is no competition within an engineering office. Everyone is working together with a common goal. It is ironic that engineering education is historically built on competition.

3) *Engineering Club and Project Showcase:* The Engineering Club and the Project Showcase provide a safe space to practice engineering and to develop relationships. Engineering Club provided a place to work on projects with other students. The projects were proposed by students, planned by students, and executed by students. All problem solving and trouble shooting was done by students. This gives students a chance to try on engineering in a collaborative environment. It also gives them a place to make mistakes and even fail. The students find that failing is another mechanism for learning. Along the way, they build relationships and gain skills necessary to be successful engineers. The Project Showcase at the end of the semester is a chance to show the projects they have been working on. It is an opportunity to present their work in a supportive low-stakes environment. Learning and gaining skills that will be necessary and have higher-stakes in the future. Students first saw engineering as a possibility when they attended the Showcase as observers.

4) *Lifestyle Factors:* Engineering lifestyle, comfort, and money was important to most participants. The participants want interesting work, with critical thinking and problem solving. They want their work to make a positive difference. They are interested in life outside of work. They see engineering as a profession where they will have sufficient money. They want to not constantly worry about money. Engineering offers this lifestyle.

At the foundation of it all is student success factors in the classroom. A quality educational system, with good curriculum and qualified teachers, is essential to a solid engineering education.

C. Limitations of the Current Study

This study is limited to undergraduate students who studied engineering at the same community college and transferred to a four-year university engineering program. The participants in this study transferred over three years, had varying backgrounds and demographics. And yet similar themes emerged from the interviews. Readers will have to determine applicability to other circumstances.

This researcher has worked to incorporate Steele's recommendations for "wise strategies" [13], and value affirmation interventions [31] in the classroom. Being a woman did not spare me from having an implicit or unintended gender bias [12]. This showed up clearly in the Project Implicit® [36] implicit association test. However, a change is noticed with conscience effort and deliberate work on implicit biases. It takes acknowledgement, practice, and diligence. Continual monitoring of words and actions and being quick to apologize and own behavior when a mistake is made is important. All engineering related courses taught at this Community College transfer seamlessly to the U. Not all community colleges are teaching at this level.

Three students were taking classes at the community college in March, 2020 at the onset of the global pandemic—the last six weeks of their community college education. All the remaining participants had transferred prior to this time. Therefore, the experience for all participants is primarily pre-COVID-19.

VI. Conclusions

This study sought to understand the experiences of students who choose the community college pathway toward a Bachelor of Science degree in Engineering. The participants were thoughtful, generous people and the methods used focused on representing the essence of their experience. Themes emerged from the data analysis process and are presented in the Results section.

While there are many differences between the participants, there are shared similarities. Each student experienced community, relationships, friendships, and overall gratitude for having taken the community college pathway. Most believe they would not have earned, or be progressing toward their engineering bachelor's degree if they had not attended the community college. The community college offered a lower cost, quality education, that transferred seamlessly to the four-year institution. Students were able to earn a Bachelor of Science degree in Engineering with little debt.

The importance of collaboration instead of competition among students benefited all participants. Through collaboration, students learn more and gain a deeper understanding of the material. As engineering educators, we need to eliminate the "weed-out" model of education and grading on a curve. Grading on a curve drives competition and discourages collaboration. Each and every student should know exactly what is required to be successful.

The community college serves as a means to fill gaps for students. Academic support is provided. Professors, advisors, counselors, mentors, recommenders, and role models were there along the pathway supporting and encouraging students. These relationships with authority figures were crucial to the students' journey. Through developmental education, students remedy gaps in prior education and prepare for college-level courses. Most of the students (11 of 13) started college at a math level lower than is typically necessary to be accepted at a four-year engineering institution with nearly half starting in developmental math. Taking the community college pathway made access to an engineering degree possible for students of all math levels.

There is flexibility at the community college not found at the four-year universities; where it is very hard to change once you have started on a path. Starting at the community college allowed students the chance to find engineering as a major and the branch of engineering that fit for them. As students, they had access to internships, scholarships, and importantly strong relationships with their peers and their teachers.

Relationships are the underpinning of the experience of taking the community college pathway toward a bachelor's degree in engineering. Relationships are the support structure needed to be successful. A community surrounded the students. They made friends. These collaborative relationships deepened the students understanding of the material.

Engineering lifestyle, comfort, and money were important to most participants. The participants want interesting work, with critical thinking and problem solving. They want to make a positive

difference. They are interested in life outside of work. They see engineering as a profession where they will have sufficient money and a desired lifestyle.

Students felt academically prepared to succeed at the four-year institution. The participants noted the important communication skills, study skills, and overall maturity they gained at the community college contributed to their overall success. Gratitude was noted in each interview. The participants were grateful they chose the community college pathway toward a Bachelor of Science degree in Engineering.

At the foundation of it all is student success factors in the classroom. A quality educational system, with good curriculum and qualified teachers, is essential to a solid engineering education. If educators focus here, we will close the disparities of gender and race in engineering. The community college engineering pathways can help fill the national need for more engineers. The hope is that this research study will increase awareness of the community college pathway toward an engineering degree.

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