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Full paper: Student persistence in STEM: Exploring the experiences of mechanical engineering students at Loyola Marymount University

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Student persistence in STEM: An ongoing exploration of the experiences of mechanical engineering students at Loyola Marymount University

Abstract

There is a growing body of literature that documents how the majority of students who enter college as a Science, Technology, Engineering, or Mathematics (STEM) major switch out or drop out before graduation. The exit rates from STEM disciplines are even higher for women and other minority groups. In this work, we seek to contribute to the countermeasures by interviewing current mechanical engineering students at Loyola Marymount University (LMU) in an effort to understand the factors that influence their continued persistence towards their degree. This study is based on an anti-deficit framework, meaning that it is aimed at learning from students who are successfully persisting in order to develop interventions that would provide critical support to students who may otherwise leave engineering.

The interviews in this study were typically 30-60 minutes long, and the associated questions were centered on three areas: (1) when participants' interest in STEM began and what drew them to majoring in mechanical engineering, (2) how participants conceptualize the discipline of engineering and how strongly they personally identify with their understanding of the necessary skills or traits of an engineer, and (3) what challenges to academic success participants have faced and what supportive resources they rely on. In this list, the first area provides context for analysis of the subsequent items, the second area indicates the status of participants' engineering identity, and the third area explores both their discouraging and encouraging experiences. We are primarily interested in investigating how students interact with academic obstacles, as their strategies for navigating college and their mindset influence persistence. In addition, at the end of the interview, demographic information is collected to allow for the discovery of any related patterns in the experiences of participants who associate with diverse identities.

At the present stage in the study, the audio recordings from 23 interviews have been transcribed, and the master codebook has been created via open coding of the transcripts from five diverse participants. The intent of this paper is to report on our investigative procedures and emergent preliminary themes from our ongoing work. The final coding process is currently underway, to form the basis of developing conclusions via a grounded theory approach. Data collected in this study informs the development of a peer-mentoring program within engineering at LMU, which seeks to improve students' sense of community, provide strategies for overcoming challenges, and address other themes discovered in this study.

1. Introduction and motivation

The issue of student retention in Science, Technology, Engineering, and Mathematics (STEM) is known as an important problem across the United States. There is a disappointing trend in national retention data, which shows that more than half of the students who enter college as a STEM major switch out or drop out before graduation.[1] Furthermore, exit rates are higher for women and other minority groups.[2-4] In addition, recruitment may present an even larger concern than retention for certain minority groups, such as Latinx students.[5] These results point to issues with equity and inclusion within STEM education.

Even though retention rates at Loyola Marymount University (LMU) are generally higher than national averages, we still lose over 30% percent of freshmen from mechanical engineering before they become seniors, according to averaged statistics from cohorts starting in 2008 to 2015.[6] Moreover, the largest percentage loss of the original freshmen cohort occurs between students' sophomore and junior years.[6] For women and ethnic minorities, the sample size is often too small to be reported, and so analysis in this area is limited. However, the retention issue for STEM students is systemic and much more can be done to help students succeed by eliminating unfortunate reasons for leaving, such as lack of support.

In this work, we seek to learn from the experiences of current mechanical engineering students at LMU as a precursor to developing tailored educational interventions aimed at supporting student persistence. The style of our study is based on an anti-deficit framework,[7] meaning that it is focused on gleaning the keys to persistence from students who are prevailing towards their Bachelor's degrees. This gained wisdom would then become central to the creation of said educational interventions for our community that could provide critical support to students who may otherwise leave engineering. Based on the results so far, the current intervention under development is a peer-mentoring program that is focused on strengthening students' belongingness to engineering communities and self-efficacy in overcoming academic obstacles.

The data collection in this study comes from individual interviews with current mechanical engineering undergraduate students at LMU that are audio-recorded and transcribed. While the majority of the interview protocol is focused on both positive and negative experiences of these students during college along with the effect of these occurrences on students' connection to engineering, some of the questions ask students to describe their early interest in STEM and what drew them to their major. All three researchers leading this study are also within the field of mechanical engineering, allowing for a deeper understanding of the interview content. Furthermore, the researchers belong to minority groups in engineering, which provides a careful lens on how differing student experiences may be influenced by personal identity and belonging.

As this work is ongoing, the scope of this paper is to report on our motivation and approach as well as on early preliminary findings. Our emphasis is on being transparent about our investigative procedures and in sharing the master codebook that we have created from an "open coding" approach[8-11] to analyzing the interview transcripts in search of themes. Future publications will report on the final results of our full coding analysis as well as on the status of our newly implemented educational interventions.

2. Methodology

Participation in the study was open to all current mechanical engineering undergraduate students at LMU, ages 18 and over. This research study was approved by the Institutional Review Board (IRB) at LMU (approval number: LMU IRB 2019 SP 21-R), and informed consent was obtained in writing at the start of each interview. The primary forms of recruitment were flyers posted in campus buildings and a short "elevator pitch" delivered in a few mechanical engineering classes for sophomores, juniors, and seniors. Participants were thanked with $15 gift cards to nearby eateries for individual interviews, which typically were 30-60 minutes long. The research team consisted of three members: one principal investigator (PI), who is an assistant professor of mechanical engineering at LMU, and two research assistants (researcher 1, researcher 2), who are upperclassmen in mechanical engineering at LMU. The PI was present at all interviews, sometimes accompanied by researcher 1. When both the PI and researcher 1 were present in the interview, they took turns asking the interview questions. In either case, the full set of questions from the interview protocol was delivered.

Interview text was generated from the audio recordings via Amazon Web Services (AWS) Transcribe. Next, the PI or researcher 1 checked and corrected the transcripts by comparing the AWS output to the audio files. During this checking phase, summarizing memo notes were also taken to keep track of main points from each interview as well as potentially emerging themes.[9, 11] After this transcript preparation phase was complete, the initial coding began, as a vital step in creating the master codebook to be used in the final coding of the transcripts. More details of the interview protocol and our coding approach can be found in the following sections.

2.1. Research questions

The overarching research question that drives the current study as well as our related efforts is "What are the best practices in developing educational interventions that work to counteract the retention issue in STEM?" At the current stage of our work, this overarching research question is narrowed and divided into three main parts for our initial study. In particular, for our subject pool of current undergraduate students in mechanical engineering at LMU, we focus on the following three questions: (1) "What leads to their academic success in mechanical engineering?" (2) "What are the primary obstacles that they face?" (3) "What more can be done to help them succeed?" In addition, underlying the previous three research questions is a fourth question, which concerns diversity: "What are the differences, if any, in the experiences of students who belong to minority groups in engineering?" Specifically, we want to see if any identity-correlated patterns develop in participants' responses to the previous three questions. We focus on addressing these questions at our immediately accessible junction of the leaky pipeline in STEM, specifically for mechanical engineering students at the college level. In addition, our particular context is a medium-sized, undergraduate-focused, private, Catholic, liberal arts university.

2.2. Interview protocol

The majority of questions asked during the individual interviews of current students centered around three focus areas, which were constructed to address our driving research questions.

Given the interconnected nature of students' experiences, motivation, identity, and mindset, these focus areas as well as the associated questions do have some inevitable overlap. Table 1 defines the three focus areas and provides a subset of the questions asked during the interviews.

Table 1: Example interview questions and associated focus areas from our protocol

Focus Areas	**Sample Interview Questions**
Area 1: Initiation The initiation of participants' interest in STEM and reasons for majoring in engineering	When and/or how did your interest in science, engineering, or math start? What drew you to majoring in engineering?
Area 2: Connection to Engineering Participants' conceptualization of the discipline of engineering and the strength of their connection to engineering	How would you describe what engineering is? What skills does an engineer need? Are there any experiences that made you question continuing in mechanical engineering? What sustains your interest or keeps you going despite the challenges? How strongly do you connect with your definition of what engineers do?
Area 3: Challenges to Success Challenges to academic success and effective resources for support	What challenges to your academic success have you been faced with in your college experience so far? What has contributed to your academic successes in college so far? Who are the people in your life who support your academics? What else can be done or provided to help you and your peers succeed?

The first focus area of the interview questions primarily serves to provide context for analysis of the subsequent areas. The second focus area indicates the status of participants' engineering identity with respect to their own description of the profession. Finally, the third area explores both their discouraging and encouraging experiences, with an emphasis on investigating how students interact with and overcome academic obstacles.

After the audio-recorded portion of the interview concluded, participants were asked to complete a one-page on-paper demographic survey. The survey questions can be divided into two types: basic information, and minority status in STEM. In the first section, participants were asked to report their undergraduate level, transfer student status, and age. In the second section, they were asked to indicate whether they personally associate with any of the following identities: woman, LGBTQ+, first-generation college student, African American, American Indian or Alaskan Native, Latinx, person with disability, or additional (please specify). The survey was administered at the end of the interview in an effort to minimize the effect of stereotype threat and other identity-based biases. The purpose of collecting the demographic information is to connect this identity component to the experiences of individual students, allowing for specific challenges to be addressed in the development of future academic interventions.

2.3. Coding approach

Our approach to the qualitative analysis of interview transcripts is based in grounded theory, which is a perspective that allows the eventual theories developed to emerge from the results and analysis structure that arose naturally in the raw data.[8, 10, 12] In doing so, we started by performing "open coding," which allows "codes" to be generated by assigning significant phrases or segments of the transcript with labels that capture their essence.[13] Performing this initial coding on multiple transcripts and discussing the results as a research team resulted in the creation of our master codebook, which is a vital tool that serves as a rubric for performing the final coding of all transcripts.

In order to produce the master codebook, the transcripts from five diverse participants were chosen based on the type of information collected in the demographic survey. Each of the three members of the research team then initially coded these first five transcripts individually. In doing so, all initial codes that arose naturally from each team member separately reading each of the first five transcripts were collected together in a brainstorm fashion. After roughly organizing these preliminary codes by similarity in context, the research team collaboratively distilled the initial codes into a draft of final codes and developed a hierarchical coding structure via discussions over multiple meetings. This draft of the master codebook was then revised and finalized after checking for completeness by comparing the codebook against the first five transcripts again. Afterwards, the codebook was declared as finalized, meaning that no new structural changes or coding items could be added as the coding analysis continued.

Coding analysis in qualitative research generally consists of at least two stages, which can be repeated and intertwined: initial coding and focused coding. For open coding, the initial stage involves generating the preliminary codes from reading the transcripts and then sorting and refining the codes, whereas the focused stage encompasses using the codes to label the data.[11] As described above, the creation of our master codebook involved initial coding that included three researchers and thorough discussions, as well as another round of revision via pseudo-focused coding. With any coding analysis, the codebook would have to eventually be locked before performing the absolute final round of focused coding. In our case, we decided to finalize the master codebook somewhat early, for three main reasons: the implicit inclusion of influence from all transcripts by the PI attending all and researcher 1 attending most interviews in the study, the depth of the codebook draft, and the preliminary nature of this study within our overall research agenda. Consequently, we did not feel the need to revise the master codebook further over many more iterations. However, in recognition of the limitations from locking the codebook early, we chose to also include an “other” placeholder for each coding string combination in the master coding table. These extra cells allow us to take note of anything that may not quite fit into the current codebook version, for future consideration.

The hierarchical structure of the master codebook that we created includes five layers: topics, categories, codes, subcodes, and subsubcodes, and a diagram of this structure can be found in Figure 1. Each relevant segment of a given interview transcript is then labeled with a “coding string,” which is a linked set of items from the master codebook (i.e. a topic, category, code, subcode, and subsubcode, when applicable). The complexity of the codebook structure was not predetermined and, instead, arose from an emerging need to clarify the deeper context of each code to promote the later development of grounded theories in our continued work.

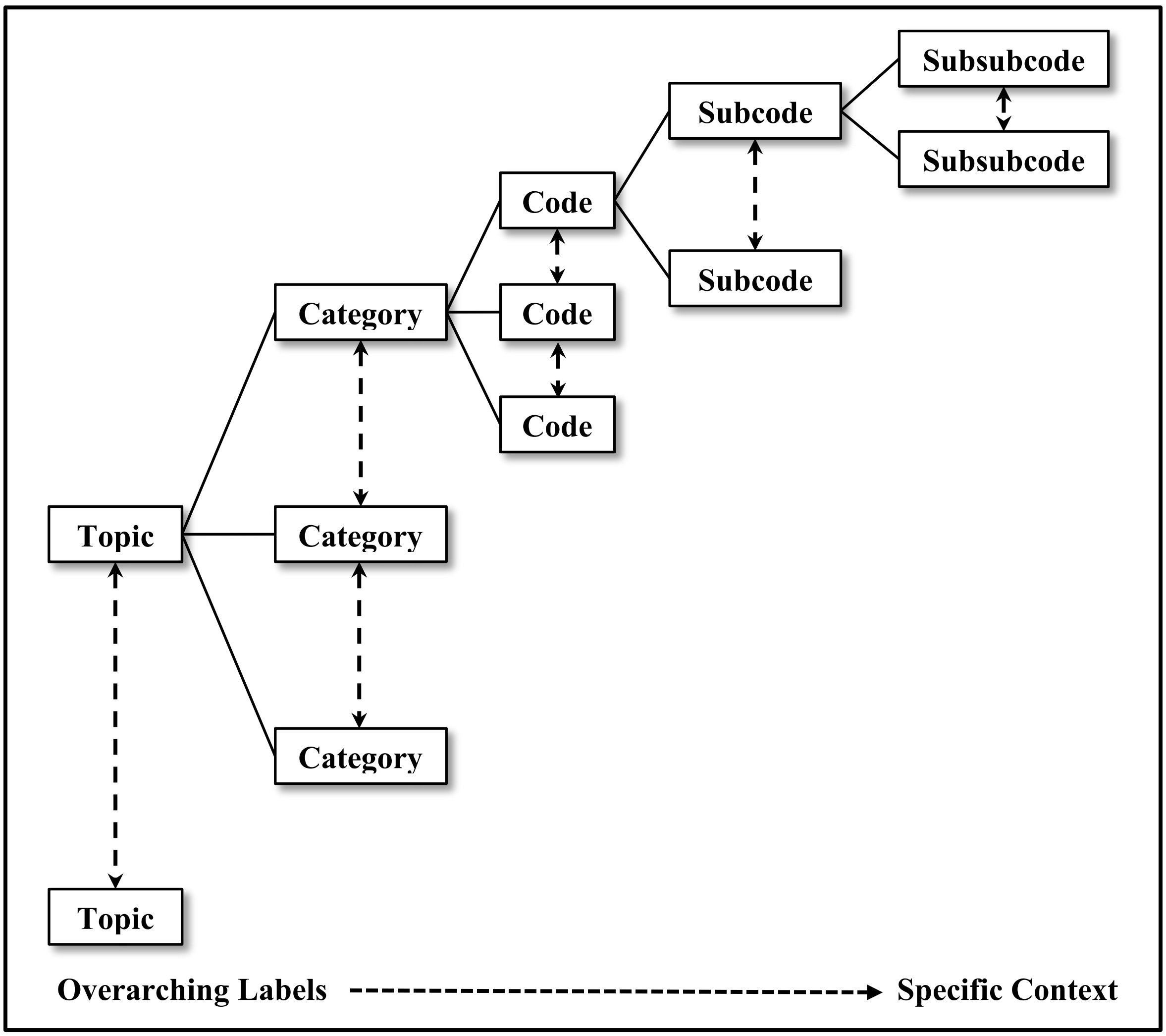

Figure 1: Hierarchical structure of master codebook

At the current stage in our ongoing study, the locked master codebook was used to perform final focused coding of six interview transcripts, including essentially re-coding the first five transcripts as well. In doing so, researcher 2 served as our “lead coder.” In the first step, they coded the transcript alone. In the second step, they read the memo notes generated by the PI or researcher 1 and then met with that team member to finalize the coding results together. Our reasoning behind this approach is that having a lead coder provides some consistency, as they are involved in the coding of every transcript, and the discussions with a second team member allow for updating and authenticating the coding results.

3. Results

So far, the majority of the output of this study has been the development and implementation of our master codebook. Our recruitment efforts have yielded 23 participants, all of whom have been interviewed. These mechanical engineering undergraduate students at LMU come from a pool of approximately 160 students in the major, as we typically have 40 students per cohort.

As previously mentioned, the final coding of the set of transcripts is in progress and the master codebook was created directly from open coding of five representative samples. However, we see all 23 interviews as indirectly influencing our preliminary results, given that the PI was present in all interviews, and researcher 1 was additionally present in 10 out of 23. Accordingly, in the following results, we start by reporting on the demographics from the full set of interviewees (Figure 2 and 3) to provide context for the subsequent results and discussion.

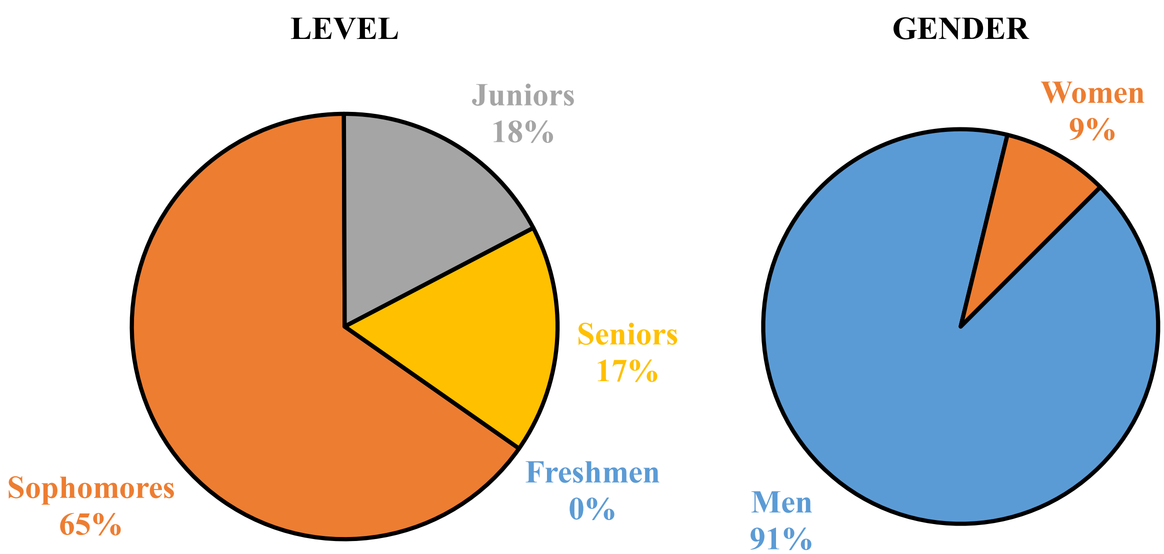

Figure 2: Undergraduate level and gender of the 23 study participants

As shown in Figure 2, the majority of our participants were sophomores, and we had an even split between juniors and seniors. Despite participation in the study being open to all four academic levels of students, none of the participants were freshmen in the end. Overall, recruitment was a challenge in this study, and we suspect that this unintended exclusion of freshmen may be due to a lack of direct recruitment. In terms of gender, only two of our participants were women. This turnout is below the average percentage of women in mechanical engineering at LMU in recent years, which typically hovers around 20%.[14] We suspect that this result was skewed in part by the high turnout of sophomores, as that cohort happened to have a percentage of women that is around half of the typical value.

As shown in Figure 3, the majority of our participants were not first-generation students, about half indicated association with at least one of the minority identities included in the demographics survey (listed in Section 2.2. Interview protocol), and nine out of 23 indicated being Latinx as part of their identity. In addition, all participants with first-generation status were also Latinx. The percentage turnout for our study is higher than the statistic from Fall 2018 of 25% of our students in mechanical engineering at LMU identifying themselves as Hispanic or Latino.[14] Moreover, we also suspect that our percentage turnouts in the first two categories of Figure 3 are higher than department-wide averages. We hypothesize that this skewing may be due, in part, to students' connection to minority groups allowing for a strengthened alignment with the objectives of this study and, hence, motivation to participate.

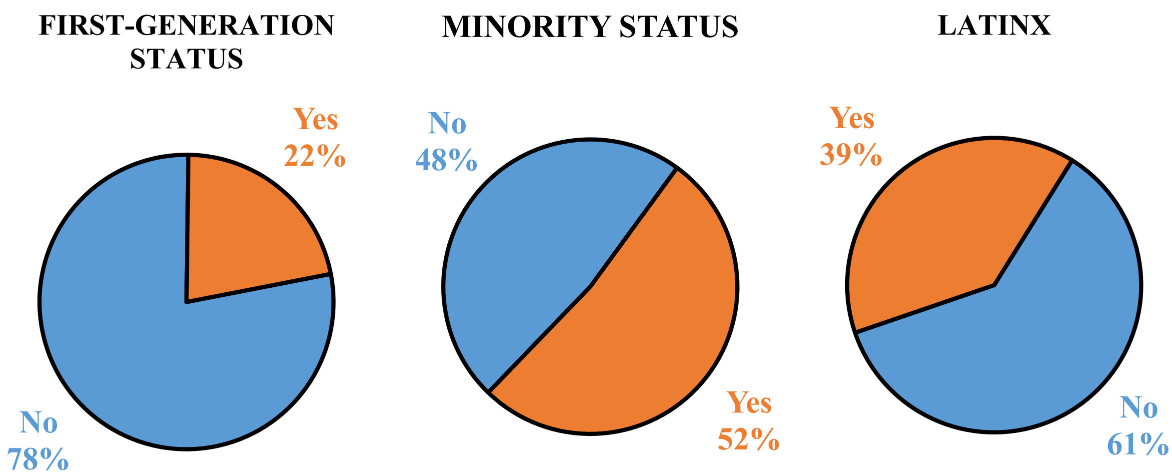

Figure 3: Association with minority groups of the 23 study participants

With the demographic context provided by Figure 2 and 3 in mind, the main result of our study so far is the master codebook itself, as shown in Table 2. The codebook follows the hierarchical structure depicted in Figure 1, and is divided into six topics: engineering discipline, engineering experience, engineering connection, support for success (during college), obstacles and deterrents (during college), and reflection on engineering identity. Within this structure, the codebook includes 89 codes, and many additional combinations via subcodes and subsubcodes. Our intent behind this detailed structure is to enable us to keep track of the relevant context and implied aim of each occurrence. Still, some overlap in the coding remains, but we are accepting of this redundancy because the structure was built to allow for variants on the same code within different topics or categories. We suggest that simply reading the master codebook and considering the combinations already provides insight into the experiences and perspectives of the mechanical engineering students at LMU.

Table 2: Master codebook for final coding analysis

Topic	Category	Codes	Subcodes	Subsubcodes
Engineering Discipline	Skills	Technical Foundation, Diverse Knowledge, Creativity, Revision, Diligence, Teamwork, Effective Communication	Personal, Impersonal	N/A
	Mindset	Thirst for Understanding, Lifelong Learning and Improvement, Following Systematic Procedures, Taking Initiative and Calculated Risk, Dedication and Resilience		
	Processes	Solving Problems, Creating and Constructing, Analysis Incorporating Intuition, Merging STEM with Art, Combining Diverse Concepts and Tools		
	Motivators	Specific Institution or Role, Goal of Entrepreneurship, Serving Society, Job Security and Satisfaction, Dynamic Profession, Enjoying Challenges, Sense of Accomplishment and Prestige, Desire to Make Believers Proud, Inspiration via Role Models		
Engineering Experience	Structured Activities	Course, Program, Competition	Elementary School, Middle School, High School, College	N/A
	Unstructured Activities	Hobbies, Clubs and Organizations, Interaction with Role Models		
	Lessons Learned	Support of Peers is Crucial, Teachers Can Make a Significant Difference, Must Learn from Failures and Adapt		
Engineering Connection	Associations	Affinity for Skills, Shared Mindset, Enabling Goals, Interdisciplinarity, Aversion to Alternative Fields	Reasons for Joining, Means for Strengthening	N/A
	Experiences	Enjoy Processes, Positive Feedback, Inspiration via Role		

<table>
<tr><td></td><td></td><td>Models, Exposure, Outreach, Research</td><td></td><td></td></tr>
<tr><td rowspan="3">Support for Success (during college)</td><td>People</td><td>Peers, Upperclassmen or Recent Graduates, Parents, Friends and Family, Professors, Visitors</td><td rowspan="3">Experienced, Suggested</td><td rowspan="3">Emotional, Practical</td></tr>
<tr><td>Resources</td><td>Office Hours, Small Campus and Tight Community, Communal Spaces, Clubs and Organizations, Learning Supplements</td></tr>
<tr><td>Self and Belonging</td><td>Dedication and Resilience, Time Management Skills, Sense of Belonging,
Asking for Help, Making Changes for Improvement, Prioritization and Sacrifice</td></tr>
<tr><td rowspan="4">Obstacles and Deterrents (during college)</td><td>Personal</td><td>Self-Doubt, Differing Expectations, Unable to Utilize Resources, Feeling Overwhelmed, Burning Out, Considered Leaving</td><td rowspan="4">At LMU, In General</td><td rowspan="4">Experienced, Perceived</td></tr>
<tr><td>Interpersonal and Belonging</td><td>Comparison with Other Students, Disconnected from Peers, First Generation, Minority in STEM, Disappointing Teammates, Bad Interaction with Professors or Advisors, Bad Fit with Major</td></tr>
<tr><td>Negative Feedback</td><td>Difficulty Understanding Course Material, Bad Grades, Academic Probation</td></tr>
<tr><td>Established</td><td>Rigor, Insufficient Prerequisite Knowledge, Difficulty Connecting Material to Applications or Other Courses, Learning Style Differences, Learning Disability, Lack of Time or Balance, Lack of Real Breaks, Commuting</td></tr>
<tr><td>Reflection on</td><td>Fit</td><td>Current</td><td>Partial Match,</td><td>Improvable, Stagnant</td></tr>
</table>

Engineering Identity		Future	Complete Match, Unsure or Avoidance	

4. Preliminary findings and discussion

Given the current stage of analysis in our ongoing study, it is too early to provide final coding results from all transcripts. Instead, we present early findings in the form of preliminary themes (Table 3). These five preliminary themes were generated by using the master codebook to code the first six of our 23 interview transcripts, arising from coding strings that came up repeatedly. Table 3 also provides support via sample quotes from our interviews with the associated pseudonyms used to protect the identity of the participants and example coding strings.

Table 3: Preliminary themes with support from interview transcripts and coding analysis

Preliminary Themes	Sample Quotes from Transcripts	Example Coding Strings
Theme 1: A key component of students' reasons for joining engineering and means for sustaining their interest is a desire to "learn how things work"	"I've always been interested in like figuring out how things work, like ever since I was really young, so basically my whole life." – *Abel* "When I learn something that I've always wanted to learn, I'm just like, 'Woah,' like I get really excited and […], it motivates me." – *Dean* "I was first driven into [engineering] because I like to learn how things work." – *Tim* "Life is like a lifelong learning process, and I always wanted, like, to find understanding and meaning of things" – *Oliver*	Engineering Connection – Associations – Shared Mindset – Means for Strengthening Engineering Discipline – Mindset – Lifelong Learning and Improvement – Personal
Theme 2: Practical support from engineering peers is a key resource for academic success	"You work with your peers: you work together to make sure you're learning it right and you're understanding it right – it'll definitely make a difference." – *Oliver* "I spend, like, a good amount of time in the [communal space for engineering students],	Support for Success (during college) – People – Peers – Experienced – Practical

<table>
<tr><td></td><td>working on stuff and trying to get help from other people if I need it or help other people if they need it.” – Blake

“Figuring things out within, like a group, […] that always strengthens my kind of like confidence and my presence in mechanical engineering.” – Dean</td><td>Engineering Experience – Lessons Learned – Support of Peers is Crucial – College</td></tr>
<tr><td rowspan="2">Theme 3: Emotional connection to engineering peers provides key support for academic success</td><td rowspan="2">“When you hang out with your engineering friends and you're all working together and you’re having fun, like hanging out with them as well as doing homework with them, it makes it a lot more bearable. So if you don't make those connections soon, like you kind of feel off in the wind and it’s just not a fun feeling.” - Oliver

“Just the (peer) community of engineers like since you know you don't feel like you're in a sea of a million engineers.” – Tim

“Kind of a group mentality of the entire engineering community (at LMU) definitely helps.” – Blake</td><td>Support for Success (during college) – People – Peers – Experienced – Emotional</td></tr>
<tr><td>Engineering Experience – Lessons Learned – Support of Peers is Crucial – College</td></tr>
<tr><td rowspan="2">Theme 4: Workload and rigor associated with engineering major creates an obstacle for academic success and happiness</td><td rowspan="2">“I knew that it was gonna be a hard major coming into it, but I didn’t expect it to be that mind-boggling.” – Dean

“Being an engineer puts you under a lot of stress and, like, sometimes it just feels overwhelming.” – Ella

“Just the workload itself has definitely contributed to like the difficulties […]. That’s honestly it: just like the amount of work.” – Blake

“I’ve kind of opted out of a lot of things that I was once involved with, and I’m just taking a lot more time to kind of like focus on, you know, the challenge that is like the rigor of mechanical engineering, as far as being a student.” – Dean</td><td>Obstacles and Deterrents (during college) – Negative Feedback – Difficulty Understanding Course Material – At LMU – Experienced</td></tr>
<tr><td>Support for Success (during college) – Self and Belonging – Prioritization and Sacrifice – Experienced – Practical</td></tr>
</table>

Theme 5: Persisting students are dedicated to their engineering major and adapt their habits when receiving negative performance feedback	"I would definitely say just being able, or just developing a strong work ethic has definitely contributed a lot to my academic success in school." – *Blake* "You have to be very persistent, and a lot of people weren't expecting that because there's a huge gap from high school to LMU." – *Oliver* "I really buckled down: just kind of did everything that I had to do. Um, and yeah, like I overcame the potential kind of leave of absence (due to academic probation), which brought me back this year." – *Dean* "For me, part of the challenge was like accepting defeat (in withdrawing from a course)." – *Ella*	Support for Success (during college) – Self and Belonging – Dedication and Resilience – Experienced – Practical Engineering Experience – Lessons Learned – Must Learn from Failures and Adapt – College

The themes presented in Table 3 connect to the interview focus areas from Table 1. Specifically, theme 1 connects to area 1 (initiation) in students' draw to majoring in engineering as well as to both area 2 (connection to engineering) and area 3 (challenges to success) in connecting to engineering via a shared curious mindset and in having intrapersonal sources of support for academic success in engineering, respectively. Themes 2 and 3 both connect to area 3 (challenges to success), as having practical and emotional support from peers contributes to students' success while being disconnected from peers creates an obstacle to persistence. In addition, the emotional support from peers in theme 3 connects to area 2 (connection to engineering) in strengthening students' sense of belonging in engineering. Themes 4 and 5 both connect directly to area 3 (challenges to success), as the obstacles of high workload and rigor are academic aspects that students must overcome to persist, and the ability to make useful adjustments to their own habits in response to negative feedback appears to be a necessary skill for students' success, respectively. Furthermore, themes 4 and 5 are indirectly associated with area 2 (connection to engineering), as the interaction with obstacles may lead to students questioning their connection, whereas students' motivation to adapt instead of giving up represents a dedication to engineering that is likely fueled by the strength of their connection.

A combination of preliminary themes (mainly themes 2 and 3) and observations in this study are related to the critical role that peers can provide in supporting students' persistence in STEM majors. This inference is consistent with other studies, which identify the support from peers and student-professors interactions as powerful, especially for women and students of color.[7, 15-16] Furthermore, one of the primary intentions of the new peer-mentoring program at LMU that is under development is to support persistence via strengthening this connection to peers and the engineering community.

In reference to theme 5, the seeming prevalence of this deep dedication among the participants to do "whatever it takes" to complete their undergraduate degree in engineering came as somewhat of a surprise to our research team. Interestingly, this tenacious mentality brings up associations with grit and having a growth mindset.[17-19] Having the trait of grit seems to be synonymous with the "all in" perspective of our persisting students.[18] In addition, we see growth mindset represented in the way that the students appear to be ready and willing to adapt and improve, as a fixed mindset, on the other hand, would be in direct contradiction to these efforts.[19]

5. Future work

In an effort to address our driving research questions, the next steps of our ongoing work in this study will be focused on completing the final coding of all 23 transcripts. As a component of our process in developing conclusions via a grounded theory approach, we will report on the relative prevalence of any coding strings from our master codebook. In addition, we also plan to search for patterns that may point to potential causal links between occurrences. As a hypothetical example, maybe having a positively impactful interaction with a teacher or professor early on in a student's career in STEM leads to a strengthened engineering identity that, in turn, provides increased resilience and, hence, potential to overcome academic obstacles. We hope that the results of our continued efforts in this study will contribute effectively to the growing body of literature on valuable insights that inform best practices in the development, implementation, and assessment of educational interventions that support students with diverse identities to persist in engineering.

Bibliography

[1] President's Council of Advisors on Science and Technology (PCAST) (2012). *Report to the President, Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, Executive Office of the President.

[2] Higher Education Research Institute at UCLA (2010). *Degrees of Success: Bachelor's Degree Completion Rates Among Initial STEM Majors*, HERI Report Brief.

[3] National Academy of Sciences and National Academy of Engineering and Institute of Medicine (2011). *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, The National Academies Press, ISBN: 978-0-309-15968-5.

[4] Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A.-B, & Handelsman, J. (2013). Increasing Persistence of College Students in STEM, *Science Education*, *341*(6153), doi: 10.1126/science.1240487.

[5] Camacho, M. M., & Lord, S. M. (2013). Latinos and the exclusionary space of engineering education. *Latino Studies*, *11*(1), 103-112.

[6] Institutional Research and Decision Support (2019). Undergraduate Freshmen Retention Rates Official Statistics, *Official Statistics and Other Reporting*, Loyola Marymount University , last updated October 24, 2018.

[7] Harper, S. R. (2010). An Anti-Deficit Framework for Research on Students of Color in STEM, *New Research Directions for Institutional Research*, *148*, doi: 10.1002/ir.362.

[8] Case, J. M., & Light, G. (2014). Framing Qualitative Methods in Engineering Education Research, *Cambridge Handbook of Engineering Education Research (CHEER)*, Cambridge University Press, ISBN: 978-1107014107.

[9] Maxwell, J. A. (2012). Qualitative research design: An interactive approach, *Applied social research methods series*, 41, Sage publications, ISBN: 978-1-4129-8119-4.

[10] Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology*, *13*(1), 3-21.

[11] Thornberg, R., & Charmaz, K. (2014). Grounded Theory and Theoretical Coding, *The SAGE Handbook of Qualitative Data Analysis*. SAGE Publications, Inc., 153-169.

[12] Glaser, B., & Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine Publishing Company, Chicago, IL.

[13] Saldaña, J. (2009). An Introduction to Codes and Coding. *The Coding Manual for Qualitative Researchers*, 3.

[14] Institutional Research and Decision Support (2019). Enrollments of Westchester Campus Official Statistics: Headcounts for Fall Term, *Official Statistics and Other Reporting*, Loyola Marymount University, last updated October 24, 2018.

[15] Rayman, P., & Brett, B. (1995). Women science majors: What makes a difference in persistence after graduation? *Journal of Higher Education, 66,* 388–414.

[16] Pierrakos, O., Beam, T. K., Constantz, J., Johri, A., & Anderson, R. (2009, October). On the development of a professional identity: Engineering persisters vs engineering switchers. In *2009 39th IEEE Frontiers in Education Conference*, 1-6.

[17] Widman, J. M, Chen, J., Self, B. P., Chambers, C. E., Ghazvini, A., & Kusakabe, L. M. (2019). Benchmarking SUCCESS: How do non-cognitive and affective factors vary among college students?, In *Proceedings of the American Society of Engineering Education (ASEE) Pacific Southwest (PSW) 2019 Conference*, Los Angeles, CA.

[18] Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and passion for long-term goals, *Journal of Personality and Social Psychology*, 92(6), 1087.

[19] Dweck, C.S. (2016). *Mindset: The New Psychology of Success*, Random House, New York, NY.