‘Do I Belong Here?’: Persistence and Retention Implications of Engineering Belongingness and Identity in Academically At-Risk Populations

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***Abstract*— Full Paper: Research. Students create their identities as engineers throughout their experiences in college, and these identities significantly impact engineering persistence. This paper uses Godwin’s identity formation framework to examine engineering identities in academically at-risk populations. We expand this framework by presenting an individual-institutional-social model to help understand how engineering identities are iterated as students confront academically at-risk labels. We also examine how belonginess interacts with identity construction using the National Survey of Student Engagement (NSSE) belongingness indicators. We develop two measures – a non-belongingness score that applies NSSE characteristics to student demographic data, and an identity-vulnerability score derived from survey responses. We hypothesize that students with higher non-belonginess scores are less likely to be retained in the major, as they self-select out after being notified that they are on probation. Conversely, students who have stronger engineering identities and who have greater affinity in groups that traditionally ‘belong’ in engineering will not be as deterred by the academically at-risk status and will be more likely to persist. This research is significant as it contributes to increasing retention in engineering and computer science, as well as improving equity and inclusion in STEM fields.**

Keywords—belongingness, engineering identity, retention, persistence

I. Why is Engineering Identity Important?

Academic persistence and retention are significantly linked to engineering identity development [1, 2, 3, 4]. Students who do not identify as engineers are more likely to change majors, while students who develop strong identities as engineers are more likely to persist [2]. Demographic information, social relationships, and institutional structures impact engineering identity formation [3, 5]. These identities are intersectional – for example, minoritized women in engineering have different experiences than white women [5, 6].

Students actively produce and perform identities as engineers by connecting with other engineers, which is reinforced by group affinity and recognition [4, 5]. Some identities within engineering are more visible than others – i.e., Faulkner’s in/visibility paradox: women are simultaneously invisible as engineers and hyper-visible as women [4, 7]. Other barriers to engineering identity include historically racist and ableist institutional policies that effectively render engineering classrooms as socially privileged spaces [4, 7, 8]. Identities are iterated and reiterated in social situations – technical (masculine) skills become preferred over social (feminine) skills, and campus culture plays a critical role in valuing or undermining the power relationships between these identities [4, 7].

So, why is understanding engineering identity important? In addition to improving persistence and retention, it can also improve recruitment [9]. Economic stability is a strong motivating factor for pursuing engineering, however, students need to have positive career outcome perceptions. Performance/competence, interest, and recognition underpin these career expectations [1, 9].

A note on language use: the authors use ‘minoritized’ broadly, encompassing students of color, (dis)ability status, neurodiversity, LGBTQIA+, economic status, and first-generation status. Further, the authors use ‘women’ rather than ‘female’ to recognize gender identity instead of sex assigned at birth, while also noting that this does not sufficiently capture non-binary students. Our dataset defined gender as binary man/woman; therefore, we were unable to capture other gender identities.

II. Research Question and Hypotheses

Our primary objective focuses narrowly on the engineering identity disruption that occurs after students are notified of academically at-risk status. We limited our data collection to students who are experiencing this at-risk status for the first time; i.e., students who matriculate and are accepted into an engineering or computer science major, who are then designated at-risk by the institution. We formulated the following research question:

- Do characteristics of belonging and identity impact student persistence and retention for students academically at-risk in engineering or computer science programs?

National Survey of Student Engagement (NSSE) data show that various characteristics, i.e., first generation, gender, race, transfer status, etc. contribute to student self-perceptions of belongingness in higher education institutions [4, 10]; see Table I. Engineering identity literature also shows that many of these characteristics are associated with identity construction and interact with Godwin's model of performance/competence perceptions, interest, and recognition [1]. Further, these non-belongingness characteristics are socially or institutionally determined. We propose two hypotheses:

- Academically at-risk students with multiple non-belongingness characteristics will have more vulnerable engineering identities and will be more likely to self-select out of engineering after being placed on at-risk status.
- Academically at-risk students with high identity-vulnerability indicators are more susceptible to social and institutional barriers to success, and therefore may require resources outside of the individual sphere of influence.

III. How is Engineering Identity Developed?

Identity is produced both individually and in groups. Tonso discussed Gee's four types of identity: natural/inherent, recognition as part of an institution, discourse, and group membership/affinity [4]. Academically at-risk students are vulnerable in three of these four groups, in that their recognition and membership in an institution/engineering community (group) is threatened, and they are susceptible to dismissive rhetoric in communications regarding their at-risk status.

Tonso describes key characteristics of professional engineers as: technical competence and problem solving, interpersonal skills (i.e. communication and teamwork), work ethic, and moral standards [4]. Students who persist in engineering have stronger identities as engineers – both collectively as members of a larger community and individually/professionally. Traditionally masculine stereotypes like math and science expertise are also strongly associated with engineering identities [4]. This preference for technical excellence further marginalizes academically at-risk students – which is compounded by membership in other marginalized groups including low socio- economic status, women, LGBTQIA+ identification, and students of color [4]. Favoritism is shown to those who look and act like engineers and is rewarded with professional development opportunities that function like compounding interest – widening the divide between those who look like engineers and those who do not.

A. Threshold Value: Academically At-Risk Status

Educational and professional identity perceptions are linked, and in many ways, becoming an engineer parallels becoming an adult. Key indicators of self-identification as an engineer are institutional recognition and social belonging [3]. Students' progress through these developments in phases, as introduced by Erik Erikson in the 1950s [3]. Similarly, Arnett's Emerging Adulthood Theory chronicles identity exploration as it relates to and defines emerging adulthood and self-perceptions as adults. Students move through these phases of development while constructing their identities as engineers [3]. As they progress through each phase, they become more likely to identify as engineers – however, there are key differences: for example, men consistently self-identify as engineers more than women throughout college development stages, and first year women have the lowest rate of self-identification as engineers [3]. This paper argues that academically at-risk students' progression through these phases is disrupted – they experience initial identity construction as engineers, and this identity is questioned by the academically at-risk designation. This impacts future career plans, confidence, and performance perceptions, and: "What you call a student matters. Calling engineering students engineers may reduce their isolation and enhance feelings of community toward engineering" [3, p. 127]. We argue that calling students academically at-risk undermines engineering identity formation. [9].

IV. Methods and Data Collection

Data were collected from a four-year public research institution. Academic standing was defined by STEM GPAs (grades in all math, natural science, engineering, and computer science classes). Academic Probation and Dismissal Eligible standings are considered 'at-risk' in this context.

1. Good standing: STEM GPAs greater than or equal to 2.0
2. Academic probation: STEM GPAs 1.4-1.99
3. Dismissal eligible: STEM GPAs less than 1.4

A. Student Records Review: Non-Belongingness Score

We conducted an extensive records review of approximately 600 engineering and computer science students who were placed

TABLE I. NON-BELONGINGNESS INDICATORS

Belongingness Indicator	Dominant = 0	Non-Dominant = 1
Gender	Men	Women
Underrepresented Minority (URM)	White, Asian	Black, African American, Indigenous, Hispanic or Latinx, Other
Citizenship	United States (Domestic)	Non-United States (International)
First Generation (First Gen)	Not First Generation	First Generation
Enrollment Status	Full Time	Part Time
Admission Type	First Year	Transfer
Pell Eligible	Not Pell Eligible	Pell Eligible

TABLE II. ACADEMIC STANDING AND BELONGINGNESS INDICATORS

Belonginess Indicator (0 = Dominant, 1= Non-Dominant)	**Fall 2019**			**Fall 2020**		
	Good Standing	***Academic Probation***	***Dismissal Eligible***	***Good Standing***	***Academic Probation***	***Dismissal Eligible***
Gender	0.19	0.12	0.12	0.21	0.21	0.17
Underrepresented Minority (URM)	0.19	0.26	0.11	0.20	0.24	0.32
Citizenship	0.10	0.11	0.25	0.09	0.08	0.12
First Generation (First Gen)	0.16	0.17	0.16	0.16	0.17	0.17
Enrollment Status (Part Time Score)	0.06	0.43	0.61	0.07	0.49	0.73
Admission Type (Transfer Score)	0.19	0.25	0.26	0.18	0.27	0.28
Pell Eligible	0.32	0.41	0.35	0.22	0.42	0.43

on academic probation/dismissal eligible status after the Fall 2019 or Fall 2020 semesters. These data were coded per a subset of NSSE Belongingness Indicators including: gender, underrepresented minority (URM), citizenship, first-generation status, enrollment status (full or part time), transfer status, and financial need (measured by Pell Grant eligibility) [5, 10] See Table I.

We developed a non-belongingness score using a binary scale. Students in the dominant category were given a 0 score, and students in the non-dominant category were given a 1 score See Table I. The sum of these measures indicates the level of non-belonginess indicators for a particular student – for example: a woman (1), white (0), domestic/United States (0), first generation (1), full time (0), first year (0), Pell eligible (1) student would have a non-belonginess score of 3. We then reviewed these data considering three student retention outcomes:

1. Not Retained: student did not enroll in the institution the semester following academic probation or dismissal eligible notification.
2. Retained in Institution: student enrolled the following semester, however changed majors out of engineering/computer science.
3. Retained in ENG/CS: student enrolled the following semester in an engineering or computer science major.

We evaluated non-belonginess characteristics in terms representation across academic standing status. We simply calculated an average across students within each status – so, results closer to 0 indicate that there are a high number of students with the dominant belonging score in that category. Results closer to 1 indicate that the category has more students with the non-dominant belonging characteristic. See Table II.

B. At-Risk Communications Discourse Analysis

We analyzed academic probation and dismissal eligible notification letters. We are particularly interested in identity and belonging rhetoric as present or not present in these communications, and how these communications support or undermine engineering identity construction and belonging. We used a positioning analysis approach, noting passive and active positioning throughout the communications.

C. Qualitative Survey Analysis: Identity-Vulnerability Score

We collected data from a survey administered to academic probation students after the Fall 2019 and Fall 2020 semesters. See Table III. This survey asked students to identify contributions to academic difficulties, as well as successes and methods for improvement. The qualitative analysis coded open-ended and binary survey responses considering both NSSE belongingness factors and other indicators indicative low engineering identity (i.e., changing majors).

TABLE III. SURVEY QUESTIONS: IDENTITY-VULNERABILITY (IV)

Survey Question (% of students responding 'yes')	Fall 2019	Fall 2019 IV >=5	Fall 2020	Fall 2020 IV >=5
Q1.1 Not attending all classes	26.2%	36.7%	29.0%	34.9%
Q1.2 Choice of major (in wrong major; major is too difficult; don't see how studies connect to interests)	12.5%	30.6%	10.2%	31.8%
Q1.3 Unclear professional/career goals	12.1%	40.8%	12.2%	33.3%
Q1.4 Poor study skills (cramming vs. studying, reading, reviewing, memorizing)	53.2%	67.4%	58.4%	72.7%
Q1.5 Poor test taking skills (test anxiety, inability to concentrate, unprepared)	46.8%	73.5%	51.0%	78.8%
Q1.6 Not academically prepared for courses	14.9%	30.6%	16.9%	27.3%
Q1.7 Difficulty understanding course material	45.2%	51.0%	45.1%	48.5%
Q1.8 Not sure where to get tutoring/assistance or embarrassed about needing help	24.6%	44.9%	25.1%	42.4%
Q2.1 Not studying enough	49.6%	57.1%	59.2%	60.6%
Q2.2 Trouble keeping up with coursework (homework and reading)	57.3%	57.1%	58.8%	72.7%
Q2.3 Outside influences (gambling, social media, gaming, alcohol/drugs)	21.8%	44.9%	27.5%	45.5%
Q2.4 Too many social distractions and/or extracurricular activities (clubs, partying, athletics)	13.7%	6.1%	13.7%	16.7%
Q2.5 Family responsibilities (caring for children, parents/grandparents, siblings)	13.7%	36.7%	23.5%	51.5%
Q3.1 Busy work schedule (not enough time for school)	21.4%	34.7%	22.8%	30.3%
Q3.2 Financial difficulty (inability to take lighter course load and longer to graduate/summer classes, delayed registration)	17.7%	38.8%	16.5%	39.4%
Q3.3 Course registration was impacted by requirements to maintain New York State Financial Aid (such as STEM Scholarship, TAP, Excelsior Scholarship)	12.9%	14.3%	16.9%	21.2%
Q4.1 Personal/emotional issues (relationships, grief issues, feeling depressed)	41.9%	81.6%	56.5%	86.4%
Q4.2 Health concerns (sleeping habits, eating habits, illness, medical issues)	29.0%	59.2%	37.3%	69.7%
Q4.3 Inadequate support system (friends, family, staff, instructors)	11.3%	36.7%	18.4%	47.0%
Q4.4 Poor access to food, housing, or basic needs (living in car, getting enough to eat, having clothes/school supplies)	1.6%	6.1%	3.1%	6.1%

We aggregated these survey data into an identity-vulnerability score. Prior research shows that choice of major and clear professional goals are critical to engineering identity [3, 7, 8] therefore we weighed "yes" responses to these questions by two (Q1.2 and Q1.3). The other questions included in the identity-vulnerability score are Q1.5, Q1.6, Q1.8, Q2.3, Q2.5, Q3.1, Q3.2, Q3.3, Q4.1, Q4.2, Q4.3, and Q4.4. See Table III for the percentage of students responding 'yes' to each question. Q2.4 was included as a positive identity indicator (social activity) so "yes" responses to this question were deducted from the total identity vulnerability score. We defined high identity vulnerability as a 5 or higher.

V. Results

A. Non-Belongingness Indicators

The average non-belonginess score of all engineering and computer science majors was 1.3 in both the Fall 2019 and Fall 2020 cohorts. Students in good standing had a score of 1.2, suggesting that these students affiliate with more dominant belonginess indicators than the average engineering or computer science major. Students on academic probation had higher non-belonging scores (1.8 and 1.9) and students eligible for dismissal after the first semester (the most academically at- risk population) had scores of 2.0 and 2.2. These results indicate that more non-dominant belonginess indicators are correlated with academically at-risk status. See Figure 1. We then viewed these data in terms of retention to the next semester. For the Fall 2019 cohort, dismissal eligible students with high non-belongingness scores (2.3) were largely retained in engineering/computer science. Perhaps this is not surprising, as these students were permitted to continue in their majors for another term. However, students in good standing who were not retained had a higher-than-average non-belonginess score for good standing students (1.6). These results present an opportunity to increase retention, especially given their low academic at-risk status. Finally, students on academic probation who were retained in engineering or computer science had a lower non-belonginess score than those who were not retained; however, it was higher than students retained in institution (changed majors). This suggests that students on academic probation with more dominant belonginess indicators are more likely to be retained in engineering and computer science. See Figure 2.

We see slightly different trends for the Fall 2020 cohort. Specifically, for the dismissal eligible students, the non-belongingness score in the Not Retained group increased significantly to 2.4, and the retained in engineering/computer science score decreased to 2.1. This suggests that, in the Fall 2020 cohort, students who were most academically at risk (dismissal eligible) were more likely to be retained in engineering and computer science if they had lower non-belonginess scores (2.1) versus retained in institution (2.5) and not retained (2.4). Dismissal eligible students who were not retained at all or who changed majors (retained in institution) had higher non-belongingness scores that students retained in engineering/computer science. See Figure 2.

B. Impacts of Specific NSSE Belongingness Indicators

Enrollment status (Part Time) appears to be heavily affiliated with at-risk status, as more than half of the Fall 2019 (0.61) students in the highest at- risk category (dismissal eligible) were enrolled part-time. Pell eligibility also appears to be affiliated with at-risk status, as does International, Transfer, and URM. Gender (women) appears to negatively related to at-risk status given the higher representation of women in good standing compared to probation and dismissal. First generation status is relatively constant across at-risk statuses. Part-time status becomes even more impactful in Fall 2020, with dismissal eligible students scoring 0.73, and academic probation students scoring 0.49. See Table II.

Pell eligibility continues to correlate with students in academic difficulty, as does URM, and Transfer status. International appears less impactful, however the COVID-19 pandemic limited international student enrollment during this semester. Gender is marginally positively correlated with better academic standing in Fall 2020, and first-generation status is relatively consistent.

Figure 1: Average Non-Belongingness Score and Academic Standing

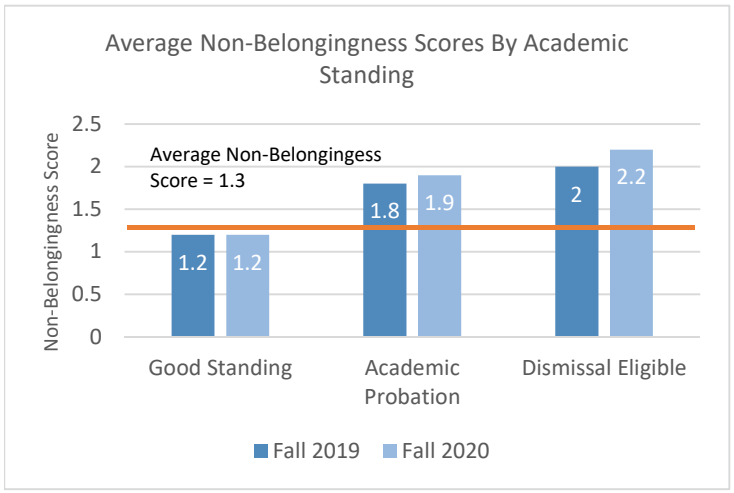
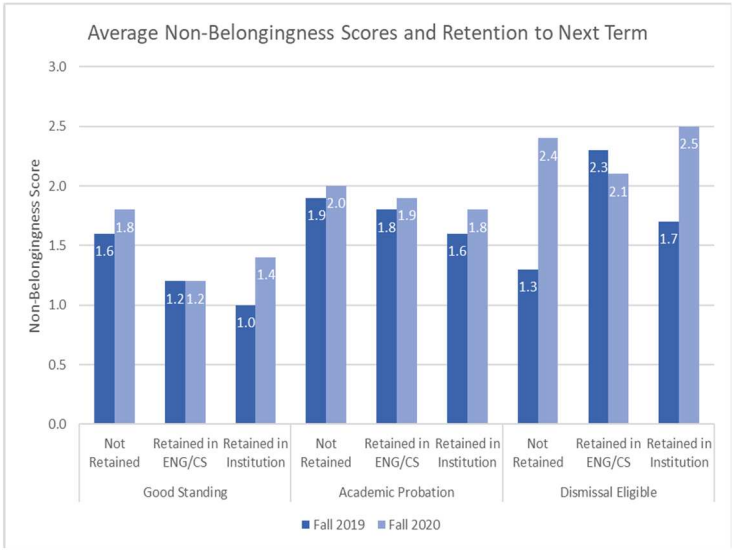


Figure 2: Average Non-Belongingness Score and Retention to Next Term



We further analyzed these data to see how these belongingness indicators were represented in terms of retention in major, retention in institution, and not retained. See Table IV. We are specifically interested in retention to the second term because this is a critical junction in development of engineering identity. These students must make critical decisions to persist in engineering despite the lack of recognition, group affinity, and performance/competence indicators, or self-select out of the major or institution.

For example, while we noted above that Gender (women) does not seem to be negatively correlated with academic standing status, it is impactful in terms of retention and non-belongingness score. We analyzed the complete dataset and found that female students on academic probation who were not retained had a non-belongingness score of 3.5 and dismissal eligible with a score of 3.3, compared to male students not retained with a 1.8 and 1.6, respectively. This suggests that being a woman in engineering impacts retention when academically at-risk and when combined with other non- belongingness factors. Dismissal Eligible women who were retained in the institution (not ENG/CS major) had the lowest non-belongingness score. Further, female students in good standing who were not retained have a higher average non- belongingness score (2.4), which suggests another opportunity to support belongingness and identity formation in these cohorts to improve retention. See Table IV.

URM students have consistently higher non-belongingness scores across all at-risk categories. Dismissal eligible URM students who are not retained in the institution or not retained at all have higher non-belongingness scores than students who were retained in the major. We found opposite results for URM students on academic probation – students retained in the major had higher non-belongingness scores. And, URM students in academic good standing who were not retained also had higher non-belongingness scores than students retained at the institution or in the major. We see similar results for transfers, first generation, and Pell eligible students. We do not see a correlation between international student non-belongingness and retention. See Table IV.

TABLE IV. RETENTION DATA AND NON-BELONGINGESS SCORE BY NSSE CHARACTERISTICS

Gender	**Women**			**Men**		
	Good Standing	***Academic Probation***	***Dismissal Eligible***	***Good Standing***	***Academic Probation***	***Dismissal Eligible***
Not Retained	2.4	3.5	3.3	1.5	1.8	1.6
Retained in Institution	1.6	2.3	1.5	1.0	1.4	2.1
Retained in ENG/CS	1.9	2.5	2.9	1.0	1.7	2.1
Underrepresented Minority (URM)	**URM**			**Not URM**		
	Good Standing	***Academic Probation***	***Dismissal Eligible***	***Good Standing***	***Academic Probation***	***Dismissal Eligible***
Not Retained	2.6	2.6	3.0	1.3	1.7	1.6
Retained in Institution	2.1	2.5	3.2	1.0	1.6	1.6
Retained in ENG/CS	2.3	2.8	2.8	1.0	1.5	1.9
Admissions Type	**Transfer**			**First Year**		
	Good Standing	***Academic Probation***	***Dismissal Eligible***	***Good Standing***	***Academic Probation***	***Dismissal Eligible***
Not Retained	2.5	2.8	2.7	1.3	1.3	1.1
Retained in Institution	1.7	2.8	2.9	1.2	1.4	1.8
Retained in ENG/CS	2.3	2.8	3.0	1.0	1.5	2.0
First Generation Status	**First Generation**			**Not First Generation**		
	Good Standing	***Academic Probation***	***Dismissal Eligible***	***Good Standing***	***Academic Probation***	***Dismissal Eligible***
Not Retained	2.9	3.0	3.2	1.5	1.7	1.5
Retained in Institution	2.4	3.1	3.6	1.0	1.2	1.4
Retained in ENG/CS	2.4	3.1	3.1	1.0	1.6	2.1
Pell Eligibility	**Pell Eligible**			**Not Pell Eligible**		
	Good Standing	***Academic Probation***	***Dismissal Eligible***	***Good Standing***	***Academic Probation***	***Dismissal Eligible***
Not Retained	2.5	2.6	2.4	1.2	1.4	1.4
Retained in Institution	2.0	2.8	3.1	0.8	0.9	1.1
Retained in ENG/CS	2.0	2.6	2.9	0.8	1.3	1.8
Citizenship	**International**			**Domestic**		
	Good Standing	***Academic Probation***	***Dismissal Eligible***	***Good Standing***	***Academic Probation***	***Dismissal Eligible***
Not Retained	1.4	2.0	1.2	1.7	1.9	1.9
Retained in Institution	1.6	1.3	2.0	1.2	1.7	2.1
Retained in ENG/CS	1.9	2.2	2.5	1.1	1.8	2.1

C. At-Risk Communications Discourse Analysis

Students receive email notifications of academically at-risk status at the end of each term. The academic probation letter begins with a policy statement defining good standing. Bold text follows, stating:

> **After careful review of your academic record, I regret to inform you that you are hereby placed on academic probation. It is critically important that you improve your academic performance. Students who remain on probation for two or more semesters have a very low probability of graduating with a [INSTITUTION] degree. Failure to improve your academic performance may lead to dismissal from [INSTITUTION].**

This rhetoric positions the school as the relaying policy information and positions the individual student as responsible for improving their academic performance. It does so while noting that students who remain in this situation have a low probability for success and are likely to be removed from the major (no longer recognized as part of the engineering group). The letter then outlines various conditions the student must meet within a specific timeframe and consequences for failure to comply with these conditions.

The dismissal eligible communication contains similar rhetorical positioning of the university as a passive actor conveying policy information, and the student as responsible for compliance with these policies to retain engineering group affinity and recognition:

> **Our records indicate that your grades meet the criteria for dismissal from [INSTITUTION]. We do not dismiss students after one semester at [INSTITUTION], and consequently you will be placed on academic probation. It is critically important that you address whatever issues may be contributing to your lack of success and turn around your academic performance. Failure to improve your academic performance may lead to dismissal from [INSTITUTION].**

This message also includes instructions for students to change majors out of engineering. Here, we can see the institution undermining engineering identity by explicitly pointing the student to non-engineering majors.

Of course, the institution has good motivation to offer major change intervention strategies. Many of these students have significant financial concerns. This is important context, as students must find an appropriate major in a timely manner to retain financial aid. We know that 31% student loan borrowers fail to earn at least an Associate's degree, so allowing students to continue an unsuccessful trajectory for multiple semesters can be financially devastating [11].

D. Survey Data Analysis

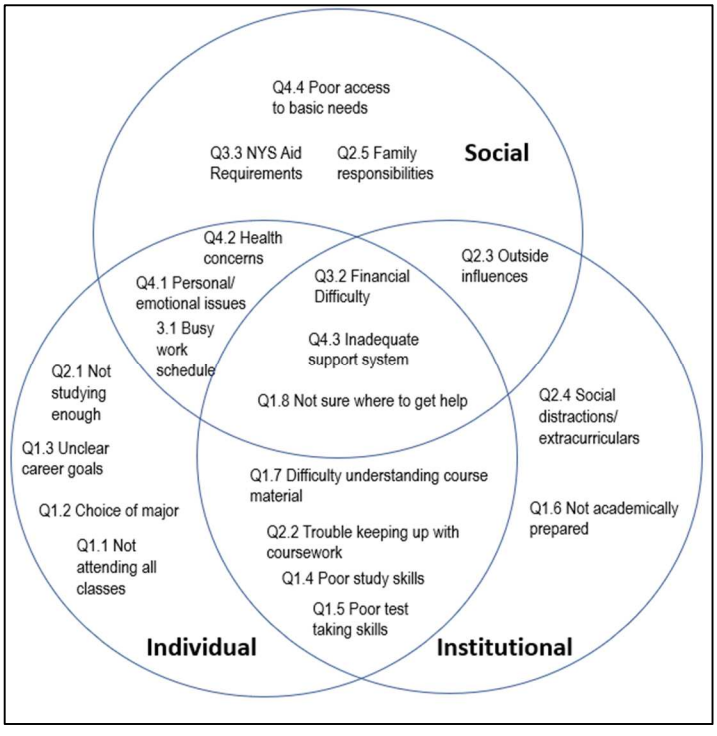
We classified each survey question on an individual-institutional-social continuum, as we recognize that students have varying degrees of control over these items. See Figure 3. We then compared the percentage of all students responding "yes" to each question to the percentage of students with a high identity vulnerability score responding "yes". We found that high identity vulnerability students responded "yes" significantly more frequently to Q1.5, Test Taking, Q4.1 Personal/Emotional Issues, Q4.2 Health Concerns, and Q4.3 Inadequate Support System. Refer to Table III. These questions have social implications – they are largely outside of the individual student's sphere of influence. Returning to the rhetorical positioning discourse in at-risk communications, we note that emphasis is placed on individual responsibility for improving academic performance, however these high identity vulnerability students consistently indicate that social and institutional issues negatively impact their ability to succeed. This supports our second hypothesis in that students with high identity vulnerability may not be able to time-manage their way to academic success. More robust institutional and social supports are required to mitigate these success barriers.

We thematically analyzed the open-ended questions. The top themes emerging from open-ended question 1 (If you are comfortable, please share any other factors that contributed to your academic difficulties) on the surveys were remote learning, mental health, outside job/financial concerns, and academic workload.

Unsurprisingly, COVID-related concerns were widely reported in the Fall 2020 data. Remote learning, family illness, and general COVID responses emerged in the top five themes. However, mental health and outside job/financial concerns ranked as #2 and #3 respectively in Fall 2020. Both themes fall into the social sphere of responsibility, as neither can be fully remediated by individual student action. Mental health is consistently the top concern, except for remote learning in Fall 2020 due to COVID. However, filtering for students with high identity-vulnerability scores returns mental health to the top concern for this cohort, surpassing COVID matters.

The second open-ended question invited students to reflect on the successes from the past semester. The top theme for both

Figure 3: Academic Review Survey Questions on the Individual-Institutional-Social Continuum



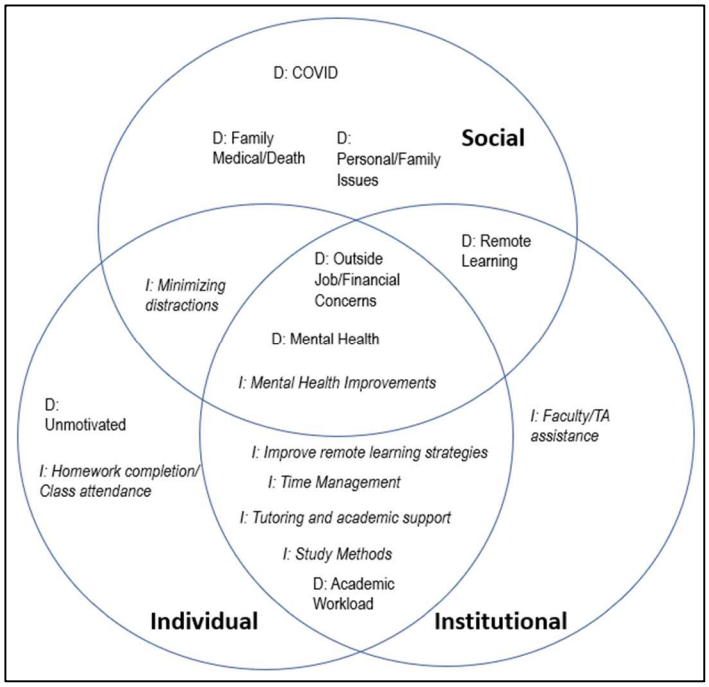
cohorts was passing some/all classes. Students interpreted passing at least some classes as a success. Perseverance emerged as a theme in the Fall 2020 cohort, with several students commenting that simply making it through the semester was a success. Finally, many students reported variations of "none" or "not sure."

The third open ended question asked students to identify strategies for improvement. Here, we can see that many of these strategies focused on the individual sphere of influence despite the survey's acknowledgement of institutional and societal factors that can negatively impact academic performance. For example, time management and study methods were widely cited as improvement strategies, however few students provided specific information.

Mental health was recognized as both a barrier to academic success and, to a lesser extent, a strategy for improvement. We situate this concern in the middle of the individual-institutional-social continuum, as the student must take individual action to seek help, however, the institution is responsible for providing accessible mental health services. Notably, "mental health improvements" as a specific improvement strategy increased in Fall 2020, likely due to increased mental health concerns stemming from COVID (social issue).

Outside job/financial concerns is a consistent barrier to academic success. Time management could be considered a mitigating strategy; however, it is not a sufficient solution. 38.8% of high identity-vulnerability students responded "yes" to the financial difficulty question (Q3.2) in Fall 2019, and 39.4% responded "yes" in Fall 2020. We found similar results to the busy work schedules and family responsibilities questions (Q3.1 and Q2.5).

Figure 4: Difficulties and Improvement Themes on the Individual-Institutional-Social Continuum



We consistently found that the top strategies for improvement reported by students tend to be in the individual sphere of influence with institutional implications See Figure 4. For example, 'study methods' was frequently cited as a mechanism for improvement. The individual student can work to develop better study methods, and the institution can provide tools and resources, however improving study methods will not address the top difficulties – including mental health, outside job/finances, COVID, and so on. See Figure 4 for a mapping of the top reported difficulties (D) and top reported strategies for improvement (*I*).

VI. Discussion

A. *Research Question: Do characteristics of belonging and identity impact student persistence and retention for students academically at-risk in engineering or computer science programs?*

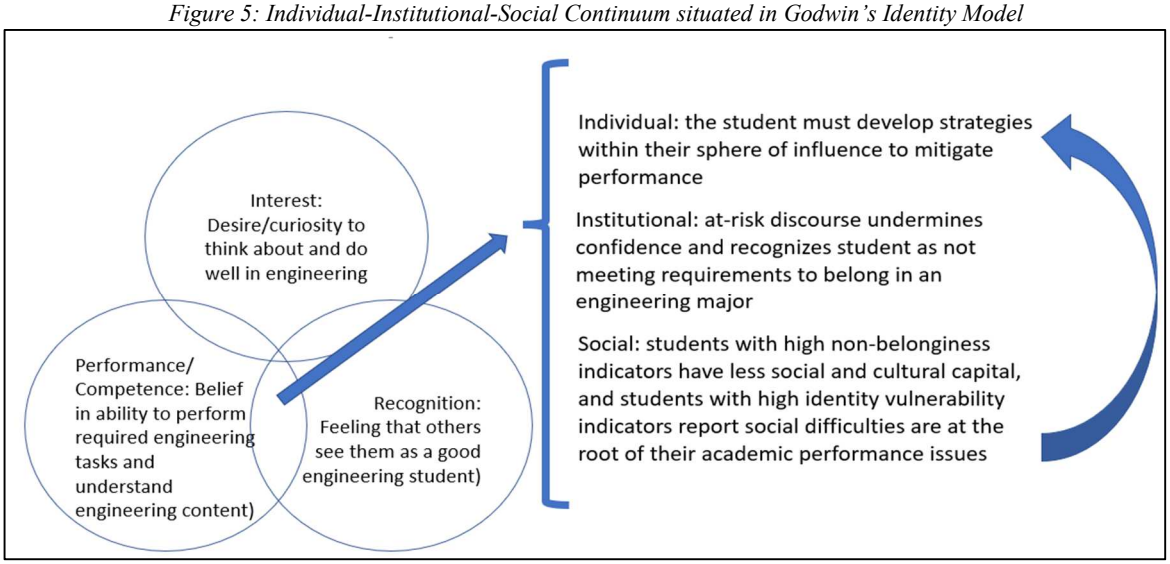
These data indicate that dominant and non-dominant belongingness indicators correlate with persistence in academically at-risk populations, as students who are retained in engineering and computer science majors tend to have lower non-belonginess scores. When viewed in the context of specific non-belonginess indicators, i.e., gender, we see that non-dominant students who are not retained have significantly higher non-belongingness scores. Students with the most belonginess characteristics (lowest non-belongingness scores) were in good standing. Students with the least belongingness indicators (highest non-belongingness scores) were the most academically at-risk (dismissal eligible). The academic probation cohort consistently shows that students with higher non-belonginess indicators are not retained. The dismissal eligible retention data is promising for the Fall 2019 cohort, however this trend reverses is Fall 2020 – students in this population with the lowest non-belonginess scores were more likely to be retained.

Academically at-risk communications position the student as responsible for their at-risk status and impose conditions to clear institutional barriers. There is an abundance of 'you' rhetoric – i.e., 19 versions of 'you' and 'yours' in each letter, compared to just four mentions of 'we/I' that refer to the university. There is clear differentiation of the university and the student. The university is a passive actor conveying policy information, and the student is positioned as capable of repairing their academic situation. There are clear performance/competence and recognition implications. Performance/competence is questioned, and membership in the engineering community is in endangered.

B. *Hypothesis 1: Academically at-risk students with multiple non-belongingness characteristics will have more vulnerable engineering identities and will be more likely to self-select out of engineering after being placed on at-risk status.*

We found evidence to support this hypothesis in our evaluation of women, particularly women who were not retained in the institution (self-selected out of not just the major, but the institution as well). Dismissal eligible URM students who were both not retained at all as well as not retained at the institution (changed majors) had multiple non-belongingness indicators, as did URM students in good standing – this finding indicates that

Figure 5: Individual-Institutional-Social Continuum situated in Godwin's Identity Model



non-belongingness negatively impacts retention across academic standing. Transfers and Pell eligible students who self-selected out of engineering but were retained in the institution also exhibited high non-belonginess scores. Students who were not retained had higher-than-average non- belongingness scores across academic status. Similarly, students who were not retained in engineering/computer science (but who were retained in the institution) also have high non-belongingness scores.

C. *Hypothesis 2: Academically at-risk students with high identity vulnerability indicators are more susceptible to social and institutional barriers to success, and therefore may require resources outside of the individual sphere of influence.*

Students with high identity-vulnerability scores responded 'yes' more frequently to concerns in the social and/or institutional spheres of influence, indicating that individual strategies for success like time management and improving study methods, while necessary, are not sufficient mitigate barriers for success. 'Yes' responses to questions in the individual sphere of influence were relatively consistent across the general population and identity-vulnerable students.

Identity-vulnerable students confront several social/institutional barriers that are beyond their sphere of influence. We center these findings at the intersection of Godwin's Performance/Confidence and Recognition realms and note that these relationships interact with engineering identity formation. See Figure 5.

Students consistently cite mental health as a difficulty, as well as outside job/financial concerns and other social or cultural issues. Very few of the improvement strategies that were reported are sufficient to address these concerns. Instead, improvements to time management and study habits were the most popular strategies for improvement, and we argue that these strategies are simply not adequate to remediate many of the concerns reported.

VII. Implications, Limitations, and Further Research

First, we see substantial opportunities to improve retention for students with multiple non-belonginess indicators, and these opportunities are not limited to students in academic difficulty. Institutions should ensure they are providing adequate support and recognition of non-dominant identities, including inclusive language in at-risk communications. This can be as simple as repositioning the institution from a passive actor relaying information to a partner in academic success. For example, these communications can explicitly recognize academically at-risk students as engineers and valued members of the engineering community, and use 'we' language to indicate that 'we value your contributions' and 'we are committed to helping you succeed.'

Second, students with vulnerable engineering identities report at-risk reasons that are often socially constructed. These difficulties are not easily addressed with time management and study skills, so institutions should inventory support mechanisms that address these concerns – for example, outside job/financial concerns might be addressed with financial aid packages, or flexible attendance policies to accommodate working students. Here, the institution has more power than the individual student to mitigate success barriers.

We were limited in our survey data collection in that it could not be connected to retention outcomes, however the resulting individual-institutional-social model highlights how these success barriers are not equal and that identity-vulnerable students experience more socially constructed barriers. We advocate for future research that connects identity vulnerability and retention outcomes to improve belonging-identity-persistence models for engineering and computer science students who are academically at-risk.

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