Examining an NSF S-STEM Community College program through an Identity Lens

Dr. Jan Edwards, College of Lake County

Jan L. Edwards is a Professor of Engineering at the College of Lake County in Illinois. She received her Bachelor's and Master's degree in Materials Science and Engineering at Michigan Technological University. She completed her Ed.D. at Northern Illinois University with an emphasis in College Teaching. Dr. Edwards teaches general engineering courses, manages outreach initiatives and the CLC Baxter Innovation Lab at the community college. She is also serving as the Principal Investigator on the college's NSF S-STEM grant, Building an Academic Community of Engineering Scholars.

Dr. Ana Mazilu, College of Lake County

Earned PhD in Physics from UIC, focus on solid state physics, specifically on high-Tc superconductors. Served as a physics tutor as part of three consecutive NSF grant-based scholarship programs for the engineering students at College of Lake County.

Examining an NSF S-STEM Community College program through an Identity Lens

Introduction

Community colleges are well positioned to assist in fulfilling the National Science Foundation (NSF) mission developed for the S-STEM program: increase the number of academically talented, low-income students who graduate and contribute to the American innovation economy with their STEM knowledge [1]. Students frequently start at community colleges not only due to the proximity to their home but also to lower their overall costs because of their own financial limitations. In addition, community students are often from underserved communities and populations enabling them to bring a broader perspective to the classroom and ultimately their workplace [2], [3].

As important as it is for these students to gain access to the degree path, it is equally important to retain them throughout their educational journey. This includes both supporting their first-year experiences as well as successful transfer from the community college to complete their bachelor's degree. Earlier studies have shown that how connected students feel, how they view themselves, and their belief in their own capabilities have significant influence on motivation and persistence [4] - [6]. Connections can be measured in terms of peer and faculty interactions at an institution, within a classroom or within a discipline. Variation between 2-year and 4-year institutions has been observed, with a lower sense of belonging noted at 2-year institutions [7]. It has also been observed that first generation or underserved students may experience a lower sense of belonging depending on the institution [8].

A sense of belonging and inclusion can provide a strong foundation for developing an engineering identity [9]. However, these psychosocial attributes are typically based on relationships within a specific institution and must be re-established when students transfer to complete their degrees. Thus, there is also a need to assist students in establishing a strong engineering identity which is a personal connection to the discipline. The engineering identity framework used in this research was developed by Godwin [10] as an extension of the well-known work of Hazari et al.'s [11] exploration of students' physics identities and Carlone and Johnson's [12] grounded theory development on women in science. All of their frameworks consist of three interrelated constructs: interest, performance/competence, and recognition (of self and by others) specific to science or engineering.

Prior research has shown that a strong engineering identity encourages students to persist in their studies despite academic challenges [10], [13] - [17]. The identity constructs include internal qualities and external support, both cited by students as necessary for the profession [10]. This perceived connection to their longer-term career goals may also enable students to see the value of their current academic tasks [18] - [21]. Thus, it enables students to develop their identity during engineering experiences such as coursework, internships and extracurricular activities.

The engineering identity framework has been applied to specific courses, first year experiences and advancement through the degree program. A linear progression of increasing identity was observed as students advanced and attributed predominately to increases in recognition and performance [16], [22]. However, a dip was noted in the second year [22] which corresponds

with the year that the most engineering courses are taken at a community college. This research aims to fill in the gap of limited literature available on the progression of engineering identity development in the community college context.

This paper will explore the following questions:

- Do students recognize themselves as engineers prior to transfer?
- Do students feel a sense of belonging in their Engineering and Computer Science programs?
- Does being an NSF S-STEM Scholar impact either of these outcomes?

Method and Analysis

Setting

A Midwest comprehensive community college (pseudonym - MWC) has an enrollment of more than 13,000 students annually and full-time equivalency enrollment of roughly 7,000. It is located in a county with a population diverse in education, racial and ethnic groups, levels of income, and additional demographic and socio-economic factors. As a Hispanic serving institution, the overall ethnicity profile is 40% Latinx, 38% White, 8% Black, 8% Asian and 7% other for college credit seeking students. The gender distribution is 53% female and 47% male with approximately 27% of the population enrolled full time.

The S-STEM grant, Building an Academic Community of Engineering Scholars, was awarded at MWC in fall of 2019. The program was focused on enhancing technical self-efficacy and sense of belonging for Engineering and Computer Science (ECS) students using the campus makerspace as a central hub for cohort activities. The scholars received financial assistance each semester, intentional advising, mentoring and transfer support. Weekly study hall/tutoring sessions were made available to all ECS students and were strongly encouraged for the scholars. In addition, scholars were advised to complete the Introduction to Engineering course which emphasizes research on engineering disciplines, team building activities, academic planning and internship preparation.

Reviewing the academic outcomes of these scholars compared to other ECS students from spring of 2020 to spring of 2024 demonstrates the positive impact of the program (see Table 1). The NSF Scholars were observed to have higher graduation and transfer rates, a higher cumulative grade point average and complete more courses in the program. The comparison group for this analysis was selected using the same guidelines as the scholars including engineering or computer science degree seeker, full-time student status, math level of college algebra or higher, and cumulative grade point average of 2.5 or higher. While the NSF Scholars perform higher than the comparison group, the graduation and transfer rates in this timeframe are lower than past performance as a result of the pandemic. More ECS students paused their education or delayed transfer due to the online nature of courses in 2020 and 2021.

Seventy-one scholarships have been awarded to unique students to date. The analysis reported in this paper does not include the 2024-2025 academic year thus a smaller number of scholars is listed. Demographically the scholars have been observed to have a slightly higher percentage of

combined women and underserved ethnic populations than the comparison group (78.6% and 57.2% respectively). Additionally, 66% of the scholars were first generation while the comparison group consisted of 43% first generation students.

Table 1. Comparison of academic outcomes from Spring 2020 to Spring 2024

Outcomes	NSF Scholars N=61	Comparison group N=776
% Still enrolled in community college in spring of 2024 (in an ECS program)	32.8% (85.0%)	27.3% (80.2%)
% Associate degree completed	42.6%	27.7%
% Transferred to complete B.S.	45.9%	32.5%
Mean number of college credits completed	65.2	44.5
Average cumulative GPA	3.15	2.75

Participants and Data Collection

Since the spring of 2020, students have been completing surveys during the first six weeks of the fall semester and during the last four weeks of the spring semester. For each survey iteration, the entire ECS population was invited to participate regardless of full-time status, GPA or current math level. The contact list was generated by the Institutional Effectiveness, Planning & Research (IEPR) office based on students' degree program of Engineering or Computer Science transfer. Over the timeframe for the nine surveys, email invitations to complete an online survey were sent to 1801 distinct students and 380 responded for a 21% return rate. The NSF Scholars and Other Respondents columns in Table 2 represent those students who completed the survey. Gender and ethnicity were extracted from the students' records. Their year in the community college program was self-reported from the following options: first year (52.3%), second year (34.4%) or three plus (13.3%) years. The Other Respondents category is a reasonable representation of the overall ECS population with a slight under sampling of the Latinx populations and slight over sampling of the White population.

Table 2. Demographic comparison of the overall ECS population, NSF Scholars and ECS students who completed at least one survey from Jan. 2020 to May 2024

	ECS population invited N=1801	NSF Scholars Respondents N= 55	Other Respondents N=325
Gender (% women)	15.3%	25.5%	16.3%
Gender (% men)	84.2%	74.5%	82.5%
Gender (% nonbinary)	0.5%	0%	1.2%
Race (% Asian)	11.5%	16.4%	11.4%
Race (% Black)	5.6%	5.5%	4.0%
Race (% Latinx)	37.7%	50.9%	32.6%
Race (% White)	38.8%	21.8%	44.9%
Race (% Other)	6.4%	5.5%	7.1%

Survey items

This paper will focus on the survey items that explored engineering identity, inclusion, sense of belonging to the community and sense of belonging to their major. Additional questions were present in the surveys to document on-campus student experiences and reflective open-ended questions were added each spring.

Engineering identity was examined using 11 statements grouped by constructs of Interest, Recognition and Performance [10]. Each value was self-reported using a Likert scale from 1–strongly disagree to 4-strongly agree when a variety of statement prompts were provided. This scale was a modification from the original surveys to eliminate the neutral selection. Data is only provided on these identity statements for the last 4 surveys. Prior to that a series of self-efficacy questions had been employed but it was decided that the engineering identity measures would provide more meaningful data [23].

Sense of belonging was examined both within the major and the overall college community. The instrument developed by Smith et al. [24] was limited to the six statements which address these concepts. Inclusion measures, while similar to belonging, focused more narrowly on peer interactions. Four statements were drawn from the research accomplished by Trauth et al. [25]. As with the engineering identity questions, each value was self-reported using a Likert scale from 1–strongly disagree to 4-strongly agree when a variety of statement prompts were provided.

Data Analysis

To review semester by semester relationships, all of the responses were examined with minor cleaning to remove essentially blank responses. These responses were used to generate descriptive statistics for each semester and to compare student reported data by semester at the community college. To compare the responses based on demographic descriptors or NSF Scholar status, the data set was sorted to create only one record per student. If a student had multiple responses over the nine surveys, the response with the least blanks was kept or one was randomly selected.

Descriptive statistics from the nine surveys were calculated for both individual statements and composite factors. The combined results were disaggregated according to student type (scholarship participant vs. other respondents), binary gender identity and ethnicity (white vs. underserved). In addition, a series of independent one-tail t-tests with a 95% confidence level were conducted to assess whether any of the differences in means between scholars and other respondents were statistically significant. Additional one-tail t-tests were conducted to compare responses based on gender identity and ethnicity. A one-way Analysis of Variance (ANOVA) was applied to determine if the variation observed as students progressed through each year of community college was significant.

Results

The overall results suggest that the students surveyed are developing an engineering identity and have a sense of belonging both within the community college and within their major. In addition, their positive peer interactions have created a sense of inclusion. When asked if they intended to keep their current major, 89% responded that they were very or fairly likely to do so. This increased to 94% for the students who were NSF Scholars.

Engineering Identity

Analyzing the aggregate responses, using one response per student, the mean engineering identity item values are all three or higher indicating positive agreement with the statements with the exception of the recognition item: Others ask me for help with engineering. Table 3 contains the mean values for all the items and composite constructs. Overall Recognition has the lowest composite mean (M=2.94, SD=0.63), followed by Performance (M=3.16, SD=0.49) and then Interest has the highest mean (M=3.46, SD=0.54). This hierarchal relationship was consistent across each semester as well. The timing of the surveys, comparing fall to spring, did not result in any predictable increases or decreases in the construct values.

Reviewing the disaggregated data, the role of NSF Scholar had a positive impact on the students' perception of recognition. The difference between the composite mean for the Scholars (M=3.11, SD=0.46) and the other respondents (M=2.90, SD=0.66) was significant $t(49)=2.05$, $p=0.023$. While all the statement item values were higher, only two items had a significant difference: 1) "My instructors see me as an engineer" where $t(136) = 1.79$, $p=0.038$ and 2) "Others ask me for help with engineering" where $t(51) =1.84$, $p=0.036$.

Analyzing performance data, the mean composite value (M=3.08, SD=0.47) was significantly lower for historically underserved students compared to white students (M=3.27, SD=0.51) where $t(158) = 2.34$, $p=0.010$. The only performance statement where there was not a significant difference was "I can understand engineering outside of class." A significantly lower grade point average (M=3.01, SD=0.69) was also observed for the underserved student population when compared to the white students (M=3.26, SD=0.62) where $t(315) = 3.33$, $p<0.001$. On the other hand, there was a significantly higher grade point average (M =3.31, SD=0.59) observed for Scholars compared to the other respondents (M =3.11, SD=0.66) where $t(300) =2.02$, $p=0.021$. However, a corresponding significant difference in the self-reported performance mean was not observed. There were no significant differences observed for the performance composite mean, the performance statement items, or grade point average based on gender.

Community college students progress through the degree at different paces and transfer in credits from high school AP courses as well as prior university experiences. Thus, the self-reported year in college data was used to track time in degree progression rather than use the number of credits completed. Table 4 displays a consistent increase for each composite identity construct as the time spent in college increased. A significant increase in the composite mean value for recognition was observed from year 1 (M= 2.85, SD=0.59) to year 2 (M=3.06, SD=0.62) where $t(187)=-2.44$, $p=0.008$. In addition, a significant increase in the composite mean value for performance was observed from year 1 (M=3.11, SD=0.46) to year 3+ (M=3.36, SD=0.50) where $t(145) = -2.66$, $p=0.004$.

Table 3. Composite Factors and Individual Engineering Identity Item Scores for evaluating program impact

Composite Factors & Individual items	Overall Mean N=170	SE	NSF Scholar Mean N=26	SE	Non-NSF Scholar Mean N=144	SE
Interest	3.46	0.04	3.47	0.10	3.46	0.04
I am interested in learning more about engineering	3.56	0.04	3.44	0.11	3.57	0.05
I enjoy learning engineering	3.46	0.04	3.46	0.11	3.46	0.05
I find fulfillment in doing engineering	3.39	0.05	3.40	0.11	3.39	0.05
Recognition	2.94	0.05	3.11*	0.09	2.90	0.05
My peers see me as an engineer	3.00	0.06	3.12	0.11	2.97	0.07
My parents see me as an engineer	3.15	0.06	3.18	0.12	3.13	0.07
My instructors see me as an engineer	3.07	0.06	3.30*	0.14	3.02	0.06
Others ask me for help with engineering	2.67	0.07	2.88*	0.12	2.63	0.08
Performance	3.16	0.04	3.21	0.10	3.14	0.04
I can do well on exams in engineering	3.07	0.05	3.18	0.12	3.04	0.06
I can understand engineering in class	3.26	0.04	3.33	0.11	3.25	0.05
I understand concepts I have studied in engineering	3.19	0.05	3.15	0.09	3.19	0.05
I can understand engineering outside of class	3.19	0.05	3.15	0.14	3.20	0.05

Significance observations for a one-tailed t-test with a 95% confidence level: * $p<0.05$

Table 4. Composite engineering identity scores based on self-reported year at community college

	Year 1 Mean N=114	Year 1 SE	Year 2 Mean N=75	Year 2 SE	Year 3 Mean N=29	Year 3+ SE
Interest	3.42	0.05	3.51	0.06	3.63	0.08
Recognition	2.85	0.06	3.07*	0.07	3.23	0.09
Performance	3.11	0.04	3.21	0.05	3.36**	0.09

Significance observations for a one-tailed t-test with a 95% confidence level: * $p<0.01$, comparing year 1 and year 2, ** $p<0.01$, comparing year 1 and year 3

Sense of Belonging & Inclusion

Similar to engineering identity, when analyzing the aggregate responses, the mean values for the composite sense of belonging and inclusion constructs are all three or greater indicating positive agreement. Belonging in Major had a composite mean of 3.33 (SD=0.48), Belonging in the Community has slightly lower with a mean of 3.12 (SD=0.54) followed by the Inclusion mean of

3.07 (SD=0.50) as shown in Table 5. Two individual inclusion item statements had means that were less than three: 1) “I have a lot in common with the other students in my classes” (M=2.91, SD=0.69) and 2) “The other students in my classes share my personal interests” (M=2.91, SD=0.65). These were offset by “I can make friends with people from different backgrounds and/or values” which had a higher mean value of 3.46 (SD=0.59).

Table 5. Composite Factors and Individual Sense of Belonging and Inclusion Item Scores for evaluating program impact

Composite Factors & Individual items	Overall Mean N=380	SE	NSF Scholar Mean N=55	SE	Non-NSF Scholar Mean N=325	SE
Belonging in Major	3.32	0.03	3.54***	0.06	3.27	0.03
I feel accepted by my instructors in my major	3.40	0.03	3.48	0.08	3.38	0,04
I am comfortable in my major	3.26	0.04	3.54***	0.08	3.21	0.04
I am supported in my major	3.34	0.03	3.62***	0.07	3.29	0.04
Belonging in Community	3.12	0.04	3.39***	0.07	3.10	0.04
People at this school are friendly to me	3.40	0.03	3.54*	0.07	3.37	0.03
There is a real sense of community at this school	3.07	0.04	3.26*	0.11	3.02	0.05
There is a strong feeling of togetherness on campus	3.03	0.04	3.36***	0.10	2.96	0.05
Inclusion	3.07	0.03	3.23***	0.05	3.05	0.03
I can make friends with people from different backgrounds and/or values	3.46	0.03	3.60*	0.08	3.43	0.04
I can relate to the people around me in my classes	3.08	0.04	3.31***	0.07	3.04	0.04
I have a lot in common with the other students in my classes	2.91	0.04	3.09**	0.06	2.88	0.05
The other students in my classes share my personal interests	2.91	0.04	3.00	0.08	2.89	0.04
I can relate to the people around me in my extracurricular engineering activities	3.02	0.04	3.23**	0.08	2.97	0.05

Significance observations for a one-tailed t-test with a 95% confidence level: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

The role of NSF Scholar had a significant impact on almost every individual statement item when compared to the other respondents as shown in Table 5. All composite means were significantly higher: Belonging in Major where $t(317)=3.71$, $p<0.001$, Belonging in Community where $t(312)=3.30$, $p<0.001$ and Inclusion where $t(94)=3.24$, $p<0.001$. A significant difference

for Belonging in the Community based on ethnicity was also observed. Unlike Performance where the underserved students had a lower mean value, for Belonging in the Community these students had a significantly higher mean (M=3.23, SD =0.51) than the white students (M =3.08, SD=0.66) where t(239)=-2.13, p=0.017. The only individual item related to belonging in the community that was not significantly higher for underserved students was "People at this school are friendly to me" which had a mean value of 3.42 (SD=0.51). This value was still higher than the overall composite mean. While no significant differences in sense of belonging were observed based on gender, the composite mean for Inclusion was significantly lower for women (M=2.98, SD=0.48) compared to men (M=3.10, SD=0.46) where t(318)=1.82, p=0.035. The mean value for women was lower for each individual inclusion statement item.

Across the nine surveys a higher composite mean was consistently observed for Belonging in the Major followed by Belonging in the Community and then Inclusion. While a slight increase in the composite means was observed as students advanced from year 1 to year 2 as shown in Table 6, there were no significant differences based on time in college.

Table 6. Sense of Belonging and Inclusion scores based on self-reported year at community college

	Year 1 Mean N=222	Year 1 SE	Year 2 Mean N=151	Year 2 SE	Year 3 Mean N=69	Year 3+ SE
Belonging in Major	3.32	0.03	3.37	0.04	3.32	0.08
Belonging in Community	3.16	0.04	3.22	0.05	3.15	0.09
Inclusion	3.07	0.03	3.15	0.04	3.12	0.07

Discussion and Implications

This study examined the self-reported engineering identity of community college students pursuing engineering and computer science transfer degrees. The results showed that all of the students report strong agreement with being interested in engineering. A high percentage (89%) of these same students reported that they intended to complete a degree in their current major. If we accept that engineering identity can serve as a driver for persistence [6], [26]-[27] their level of interest should aid in completing that goal. An increase in the interest level, although slight, was observed as students completed more semesters in the program. This may be a result of completing additional technical engineering courses later in the program. Regardless, it is important that interest is maintained as students are finalizing the decision of their specific engineering discipline and transfer school during their last year of community college.

Recognition was observed to have the lowest mean value of the three constructs. Specifically, students did not see themselves in the role of helping other students. A significant increase in recognition however was noted as students progressed from year 1 to year 2. This could be attributed to the students now being able to take on the informal role of tutor with first year students as well as increased interaction with engineering faculty members. Students may

interpret faculty recognition solely based on grades, but faculty can provide recognition beyond grades through conversations outside the classroom [27]-[28]. This may account for the increase in recognition observed for the NSF Scholars who routinely work with other students and faculty members outside of class during the weekly study hall sessions.

Since performance and recognition have been shown to support resilience, the lower performance composite mean observed in the underserved population raises significant concerns. In addition, the lower grade point observed for the same population suggests that further research is needed to reveal the underlying causes and determine if this is impacting persistence in an engineering degree. The transfer rates are similar to other populations, but the data warehouse does not always include major at the transfer institution. To encourage persistence, faculty members are able to reassure students with consistent and timely feedback acknowledging that to struggle is real and normal [27]. Also, it is important to emphasize how the work being done in the classroom ties to career aspirations and community impact, since prior studies have shown this is more significant than academic performance on promoting persistence [29]-[31].

A dip was not observed for any of the engineering identity constructs, as shown in the longitudinal study completed by Goodwin and Lee [22]. Instead, each of the identity construct composite means was observed to increase with time in the program. However, a similar increase is anticipated to occur after transfer as was observed in their research. The transfer students will be collaborating with a larger population of engineering students and faculty members providing more opportunities for recognition. In addition, the upper-level courses include more lab-based courses allowing for the type of tasks most engineering students associate with being a competent engineer.

Overall, students self-reported a positive sense of belonging both within the community and within their major. This is important since a student's feeling of belonging in STEM fields can predict how well they will perform academically and whether they will persist in their studies [8]. It is also interesting to note that while the gender representation is negatively skewed from the community college population, the ECS population directly aligns with the college in terms of ethnicity representation. This may contribute to the consistent sense of belonging observed regardless of ethnicity. Prior studies [7] have also shown similar relationships between belonging within a major and a community where students report a higher sense of belonging within their major. At a commuter college, students have the opportunity to form stronger relationships within the classroom and spend less time on campus participating in extracurricular activities. As a result, they may perceive a lower sense of belonging to the campus community.

The students in this diverse ECS community expressed no concerns over making friends with people from different backgrounds, yet they did not feel that other students shared their interests. We expect that the students may have more in common than they realize but haven’t taken the opportunity to explore their interests outside of class. The higher values observed for NSF students may be a result of the icebreaker and social activities that occur each semester. This camaraderie is further supported by the weekly study hall sessions open both to Scholars and other students pursuing ECS degrees. The lower inclusion values reported by women are likely due to being isolated in the classroom. It is not uncommon for there to be only one or two women present in the sophomore level engineering courses such as Dynamics or Mechanics of Materials. The advice offered that seems most applicable is for faculty to ensure that their

classroom culture fosters mutual respect and to encourage collaborative projects [9]. This supports not only students in the minority, but everyone in the classroom.

Future Research and Limitations

There is a bias present in any survey based on who chooses to respond. In this study 89% of the respondents reported that they were fairly or very confident that they would keep their current choice of major. This may skew the data on identity and sense of belonging to be overestimated.

Future work could benefit from exploring relationships between the different constructs. In addition, if sufficient data was present, it would be helpful to further disaggregate the data to accommodate intersecting identities of gender and ethnicity as well as explore part-time and full-time status. Further understanding of the details behind the ratings could be accomplished through individual or focus groups interviews.

Another aspect of the program to explore is the impact of the Introduction to Engineering course. While it is highly recommended for the NSF scholars to complete the course, approximately 2/3 of the students in the engineering program will also complete the course. The emphasis on team-based work and introduction of technical content could provide increases in perceived inclusion and interest.

Conclusion

In summary, this study provided evidence of identity development, sense of belonging, and inclusion for the community college students. The values to their responses appeared to increase as they completed additional semesters. Evaluating the effectiveness of the NSF program, it is apparent these students experience both an increase in academic gains and engineering identity development compared to their peers as well as an enhanced sense of belonging. These gains are supported by the additional interactions with faculty members and other students that occur during the weekly study hall sessions and social activities.

Acknowledgement

This material is based upon work supported by the National Science Foundation under Grant No.1929983. Any opinions, findings and recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

1. National Science Foundation, “NSF Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM),” NSF 25-514, USA [Online]. Available: https://new.nsf.gov/funding/opportunities/s-stem-nsf-scholarships-science-technology-engineering-mathematics
2. A. M. Ogilvie and D. B. Knight, “Post-transfer transition experiences for engineering transfer students,” *Journal of College Student Retention: Research, Theory & Practice*, vol. 23, no. 2, pp. 292-321, 2021.
3. P.T. Terenzini, L. R. Lattuca, H. K. Ro, and D. B. Knight, *America’s overlooked engineers: Community colleges and diversity,* Research Gate, 2014.

4. P. O'Keeffe, "A sense of belonging: Improving student retention," *College Student Journal,* vol. 47, no. 4, pp. 605-613, Nov 2013.
5. T. L. Strayhorn, *College Students' Sense of Belonging: A Key to Educational Success for All Students,* New York and London: Routledge, 2019.
6. H. M. Matusovich, R. A. Streveler, and R. L. Miller, "Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values," *Journal of Engineering Education*, vol. 99, no. 4, pp. 289-303, 2010.
7. M. Gopalan and S. T. Brady, "College students' sense of belonging: A national perspective," *Educational Researcher*, vol. 49, no. 2, pp. 134-137, 2019.
8. S-STEM REC American Association for the Advancement of Science, "STEM Students & Their Sense of Belonging: S-STEM Programs' Practices & Empirically Based Recommendations," 2023. [online] Available: https://sstemrec.aaas.org/resource/stem-students-their-sense-of-belonging-s-stem-programs-practices-empirically-based-recommendations
9. K. Rainey, M. Dancy, R. Mickelson, E. Stearns, and S. Moller, "Race and gender differences in how sense of belonging influences decisions to major in STEM," *International Journal of STEM education*, vol. 5, no. 1, pp. 1-14, 2018.
10. A. Godwin, "The development of a measure of engineering identity," in 2016 ASEE Annual Conference & Exposition Proceedings, New Orleans, Louisiana: *ASEE Conferences,* Jun. 2016, p. 26122. doi: 10.18260/p.26122
11. Z. Hazari, G. Sonnert, P. M. Sadler, and M.-C. Shanahan, "Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study," *J. Res. Sci. Teach*., p. n/a-n/a, 2010, doi: 10.1002/tea.20363
12. H. B. Carlone and A. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens," *J. Res. Sci. Teach*., vol. 44, no. 8, pp. 1187–1218, Oct. 2007, doi: 10.1002/tea.20237.
13. S. L. Rodriguez, C. Lu, and M. Bartlett, "Engineering identity development: A review of higher education literature," *International Journal of Education in Mathematics, Science and Technology*, vol. 6, no. 3, pp. 254-265, 2018.
14. K. Doran and J. Swenson, "'Do I belong here?': Persistence and retention implications of engineering belongingness and identity in academically at-risk populations," In *2022 IEEE Frontiers in Education Conference (FIE)* pp. 1-9, IEEE, 2022.
15. M. L. Espino, S. L. Rodriguez, and B. D. Le, "A systematic review of literature: Engineering identity and students with financial need in community colleges," *Community College Journal of Research and Practice*, vol. 46, no. 5, pp. 352-363, 2022.
16. B. E. Hughes et al., "Entering the community of practice: changes in engineering students' engineering identities and perceptions of the field," *European Journal of Engineering Education,* vol. 46, no. 6, pp. 968-986, 2021.
17. A. D. Patrick and A. N. Prybutok, "Predicting persistence in engineering through an engineering identity scale.," *International Journal of Engineering Education*, vol. 34, no. 2a, 2018.
18. A. Godwin and A. Kirn, "Identity-based motivation: Connections between first-year students' engineering role identities and future-time perspectives," *J. Eng. Educ.*, vol. 109, no. 3, pp. 362– 383, Jul. 2020, doi: 10.1002/jee.20324.

19. J. Chen, M. A. Hasan, X. Du, and A. Kolmos, "Exploring students' perception of the influence of PBL elements on the development of engineering identity," *IEEE Transactions on Education, vol. 66, no.* 4, pp. 393-403, 2023.
20. J. M. Lakin, A. H. Wittig, E. W. Davis, and V. A. Davis, "Am I an engineer yet? Perceptions of engineering and identity among first year students," *European Journal of Engineering Education,* vol. 45, no. 2c, pp. 214-231, 2020.
21. K. Scalaro, I. Chatterjee, D. Satterfield, A. Vollstedt, and A. Kirn, "From knowing to doing: Changes in competency beliefs of developing engineers" *in ASEE 129th Conference & Exposition*, Minneapolis, MN, USA, June 2022.
22. A. Godwin and W. C. Lee, "A cross-sectional study of engineering identity during undergraduate education" *in ASEE Annual Conference & Exposition*, Columbus, OH, USA, June 2017.
23. J. Edwards and A. Pizano, "Work in progress: Developing an engineering community in a fablab," *in ASEE 129th Conference & Exposition*, Minneapolis, MN, USA, June 2022.
24. T. F. Smith, D. Wilson, D. C. Jones, M. Plett, R. A. Bates, and N. M. Veilleux, "Investigation of belonging for engineering and science undergraduates by year in school," *in 2012 ASEE Annual Conference & Exposition,* San Antonio, Texas, USA, June 2012.
25. A. Trauth, J. Buckley, S. I. Rooney, J. A. Enszer, T. N. Barnes, and R. Davidson, "Adjusting the Lens: Comparison of Focus Group and Survey Data in Identifying and Addressing Issues of Diversity and Inclusion in Undergraduate Engineering Programs," In *ASEE Annual Conference & Exposition,* Tampa, FL, USA, June 2019.
26. A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice," *Journal of Engineering Education*, vol. 105, no. 2, pp. 312-340, 2016.
27. J. A. Henderson, B. L. McGowan, J. Wawire, L. S. S. Benjamin, K. Schaefer, and J. D. Alarcon, "Photovoice: Visualizing the engineering identity experiences of sophomore students," *Journal of Engineering Education*, vol. 112, no. 4, pp. 1145-1166, 2023.
28. K. Scalaro, I. Chatterjee, A. M. Vollstedt, J. LaCombe, and A. Kirn, "A two-step model for the interpretation of meaningful recognition.," *in 2021 ASEE Virtual Annual Conference Content Access Proceedings,* Virtual Conference: ASEE Conferences, Jul. 2021, p. 36626. doi: 10.18260/1-2--36626.
29. J. P. Concannon and L. H. Barrow, "A cross-sectional study of engineering students' self-efficacy by gender, ethnicity, year, and transfer status," *Journal of Science Education and Technology,* vol. 18, pp. 163-172, 2009.
30. M. Kopparla, T. T. Nguyen, and S. Woltering, "Maps of meaning: journeys of first year engineering students," *European Journal of Engineering Education*, vol. 47, no. 6, pp. 930-949, 2022.
31. A. Rainey, D. Verdín, and J. Smith, "Classroom Practices that Support Minoritized Engineering Students' Sense of Belonging (Research)," *in 2021 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual Conference: ASEE Conferences, Jul. 2021, p. 36797. doi: 10.18260/1-2--36797.