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Exploring the Evolution of Engineering Students' Feelings of Inclusion in Their College and the Broader Scientific Community

Dr. Melissa Lynn Morris, University of Nevada - Las Vegas

Melissa Morris is currently an Assistant Professor in Residence in the Mechanical Engineering Department at the University of Nevada, Las Vegas. She previously served as a Teaching Associate Professor for the Freshman Engineering Program, in the Benjamin M. Statler College of Engineering and Mineral Resources at West Virginia University (WVU). She graduated Summa cum Laude with a BSME in 2006, earned a MSME in 2008, and completed her doctorate in mechanical engineering in 2011, all from WVU. At WVU, she has previously served as the Undergraduate and Outreach Advisor for the Mechanical and Aerospace Engineering department and the Assistant Director of the Center for Building Energy Efficiency. She has previously taught courses such as Thermodynamics, Thermal Fluids Laboratory, and Guided Missiles Systems, as well as serving as a Senior Design Project Advisor for Mechanical Engineering Students. Her research interests include energy and thermodynamic related topics. Since 2007 she has been actively involved in recruiting and outreach for the Statler College, as part of this involvement Dr. Morris frequently makes presentations to groups of K-12 students.

Dr. Morris was selected as a the ASEE North Central Section Outstanding Teacher in 2018.

Mr. Joseph Dygert, West Virginia University

Ph.D student in aerospace engineering at West Virginia University

Dr. Robin A.M Hensel, West Virginia University

Robin A. M. Hensel, Ed.D., is the Assistant Dean for Freshman Experience in the Benjamin M. Statler College of Engineering and Mineral Resources at West Virginia University. While her doctorate is in Curriculum and Instruction, focusing on higher education teaching of STEM fields, she also holds B.S. and M.A. degrees in Mathematics. Dr. Hensel has over seven years of experience working in engineering teams and in project management and administration as a Mathematician and Computer Systems Analyst for the U. S. Department of Energy as well as more than 25 years of experience teaching mathematics, statistics, computer science, and first-year engineering courses in higher education institutions. Currently, she leads a team of faculty who are dedicated to providing first year engineering students with a high-quality, challenging, and engaging educational experience with the necessary advising, mentoring, and academic support to facilitate their transition to university life and to prepare them for success in their engineering discipline majors and future careers.

Exploring the Evolution of Engineering Students' Feelings of Inclusion in Their College and the Broader Scientific Community.

Abstract

This complete research paper discusses how students' feelings of inclusion change throughout their undergraduate career. Student responses acquired through focus groups and one-on-one interviews were examined to determine how included the students felt in their engineering college and also the broader scientific community.

A small group of non-calculus ready engineering students enrolled in a large land grant institution in the Mid-Atlantic region consented to participate in the study. The student cohort participated in an NSF S-STEM funded program aimed at fostering a sense of inclusion in engineering by implementing a curriculum focused on cohort formation, career exploration, and professional development. The AcES, consisting of a weeklong pre-fall bridge experience, two common courses, and a variety of co-curricular activities, has been operating for eight years. Students who receive S-STEM funded scholarships participate in three focus groups and two one-on-one interviews each semester throughout their undergraduate studies.

Student responses from the one-on-one interviews and focus groups conducted from 2017-2020 were examined with qualitative coding methods. Questions examined in this work include: 1) Did the engineering in history course help make you feel like you belong in engineering at WVU and that you are included in engineering at WVU?, 2) Do you feel part of the group when working on projects in your engineering courses?, 3) Do you consider yourself a member of the scientific and engineering community here at WVU? Why or why not, and 4) Do you consider yourself a member of the broader scientific and engineering community?

During the exploratory coding phase three codes were established to represent the degree of inclusion felt by students: *Edge of Inclusion, Slight Inclusion, and Feelings of Inclusion*. *Edge of Inclusion* was characterized by student responses such as "almost there but not totally", "just starting to be", and "no, well maybe a bit" while student responses such as "yes, but only a little" and "in some classes or situations" were recognized as *Slight Inclusion*. Examples of student responses such as "yes, I do feel part of it", "absolutely, since I've…", and "I would consider myself part of . . ." were classified with the code *Feelings of Inclusion.*

Since the sample size was limited by scholarship funding, statistically significant results weren't obtainable, but clear themes emerged that can be used to influence engineering curricula and serve as justification for an expanded study. Participating in an internship emerged as a major contributor to students feeling included in the broader scientific community. Interestingly, a decrease in the average degree of inclusion occurred after the students' first semester, prior to increasing in later semesters. It is hypothesized that the emphasis on cohort formation, career exploration, and planned co-curricular activities during the first semester in the AcES program bolstered the initial feelings of inclusion.

A student's feeling of inclusion is known to be a contributing factor in retention. The findings of this research indicate that internships should not only be strongly encouraged, but university resources should be invested in helping students be prepared for, apply to, and obtain internships.

The researchers suggest the study be expanded beyond the AcES program to examine a broader sample and greater number of students.

1.0 Introduction

A background summary of research related to engineering identity formation and feelings of inclusion is included to establish the context of this research. Since this research was conducted with students who participated in a specific program, a brief description of the program is also included. Providing support to students who are traditionally underrepresented in engineering and learning about their feelings in areas that are known to impact retention were the motivations for this work. Through the qualitative coding analysis the coders noticed clear degrees of feelings of inclusion emerge and decided to explore that finding in this paper.

1.1 Summary of Background Research

It is known that students who identify as engineers are more likely to persist to graduation compared to students who lack an engineering identity [1, 9, 11]. A link has been established between the development of an engineering identity and a student's feeling of inclusion in their field of study [3]. A feeling of inclusion is defined by feeling welcomed, respected, and valued in a specific climate [8]. Zoltowski et al. found that a lack of inclusion in engineering programs is an issue in the professional formation of engineers. Engineering programs commonly emphasize quantitative and technical concepts and place little focus on the human aspects of engineering [7].

Engineering Identity has been connected to considerations such as performance, interest, competence, and recognition. A student's engineering identity is linked to their perception of their ability to perform in engineer courses, their perceived ability to understand the engineering content, their motivation to pursue an engineering career, and how their close connections see them in the engineering context [2].

Developing an engineering identity and feelings of inclusion is particularly important for students from traditionally underrepresented groups. Students from groups that are traditionally underrepresented in engineering tend to enter college with lower confidence in their abilities and lesser knowledge of engineering careers [4]. Diversity in the engineering workforce is viewed as an asset to solving the world's most challenging problems. For the engineering workforce to accurately represent the diversity of society, however, students from traditionally underrepresented groups must be retained to graduation and pursue engineering careers.

Lee et al. recommended research into feelings of inclusion as essential to creating a diverse engineering environment and developed the Engineering Department Inclusion Level (EDIL) survey instrument. The EDIL survey examines the factors of caring, diversity, and pride at the university and department levels [8].

Pierrakos et al. found both students who persisted and students who changed majors did not identify strongly with engineering as a profession during their first year in college [5]. An

analysis of survey response from an undergraduate engineering program showed that first-year students regularly experience a lower sense of engineering identity than other students [9]. A likely reason for the low identification of entry-level students is engineering is academically demanding, and frequently seen as an unwelcoming, exclusive environment [6].

Knight et al. examined the impact of Inclusive Excellence Programs on the development of an engineering identity in first-year underrepresented engineering students. The Inclusive Excellence programs included a summer-bridge experience focused on social connections and cohort formation. Professional identity as an engineer was found to be higher during the summer bridge program than in the first semester in engineering [10]. Patrick ad Borrego published a summary of literature related to engineering identity and found that a need exists for research into longitudinal data to examine the connection between identify formation and persistence in engineering [12].

Studies have shown students who study in groups of peers and students who participate in internships are more likely to retain in engineering than students who do not study with peers or partake in internships [1]. The simple act of referring to engineering students as engineers is hypothesized to increase students' feelings of belonging in the major [9]. The more students know about engineering as a profession, the more likely they are to relate to engineering [10].

1.2 Brief Description of Program

Established in 2012, operating with NSF S-STEM funding since 2016, the AcES operates with the overarching goal of diversifying the engineering workforce by retaining traditionally underrepresented students. The AcES consists of a one week pre-fall summer bridge experience, a fall professional development course, and a spring course focused on how engineering developments have shaped society. The aim of the curricular and co-curricular activities is to facilitate cohort formation, develop professional skills, explore engineering careers, provide mentorship and encourage campus resource use. The cohort size is limited to 20-25 first-time full-time students and first preference is given to students who are from a group traditionally underrepresented in STEM, non-calculus ready, and/or demonstrate significant financial need [13].

A subset of the cohort are selected to receive NSF S-STEM funded scholarships. Annual scholarships starting at $4,500 are renewable for up to 5 years and incrementally increase by $1,000 per year through year four. Students must retain in engineering and maintain a cumulative GPA of at least 3.0 to renew the scholarships.

2.0 Methodology

Student participants who receive NSF S-STEM funded scholarships are required to participate in surveys, one-on-one interviews, and focus groups each semester of their undergraduate education. The students provide quantitative data by completing a modified version of the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) survey, the twelve question GRIT survey, and a shortened version of the Motivated Strategies for Learning Questionnaire (MSLQ). The scholarship recipients also provide qualitative data by participating in one-one-

one interviews and cohort-based focus groups each semester. This paper focuses on the students responses recorded during the interviews and focus groups. Table 2.1 displays the interview and focus group schedule. Students in the 2016 cohort did not start participating in the focus groups and interviews until the start of the fall 2017 semester. It should be noted that students of similar demographics to the program participants were invited to participate in the study as a comparison group, but after repeated invitations no students were willing to participate.

Table 2.1: Qualitative Data Collection Schedule

Qualitative Data Collection Schedule																		
	2017			2018						2019						2020		
	Start Fall	Mid Fall	End Fall	Start Spr.	Mid Spr.	End Spr.	Start Fall	Mid Fall	End Fall	Start Spr.	Mid Spr.	End Spr.	Start Fall	Mid Fall	End of Fall	Start Spr	Mid Spr	End Spr
Focus Group	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Interviews	X		X	X		X	X		X	X		X	X		X	X		X

All focus group and one-on-one interview sessions were video and audio recorded. Transcripts of the questions and student responses were then created and analyzed. Students were asked questions related to motivation, inclusion, belonging, value of teamwork, careers, coursework, understanding of engineering, and overcoming challenges. This work focuses on student responses to 4 questions related to their feelings of inclusion. The four questions examined include 1) Did the engineering in history course help make you feel like you belong in engineering at WVU and that you are included in engineering at WVU?, 2) Do you feel part of the group when working on projects in your engineering courses?, 3) Do you consider yourself a member of the scientific and engineering community here at WVU? Why or why not, and 4) Do you consider yourself a member of the broader scientific and engineering community?

Two individuals coded the transcribed student interviews and focus groups. Coding of the interviews was conducted in two phases, an exploratory coding phase (i.e., inductive coding) and a structured coding phase (i.e., deductive coding) [14]. The exploratory coding phase required the coders to independently examine 40 randomly chosen transcripts for emergent reoccurring themes. Each of the coders established an independent list of the reoccurring themes and then compared these lists with each other and decided what codes to include or exclude based on the NSF S-STEM grant research questions. The list of included codes became the master code list applied to the remainder of the transcripts. Each individual coder used the master code list to code all transcripts and then participated in a comparison and debate phase to determine the inter-coder agreement. Coded interviews were entered into an excel workbook to look at every instance of a code agreement between the two coders (i.e., both coders agree on the existence of a code in a response to a question) and every instance of disagreement (i.e., only one coder has identified a code in a response). Inter-coder agreement is calculated by dividing the sum of all coder agreements by the sum of agreements and disagreements.

During the exploratory coding phase both coders noticed that students appeared to report varying degrees of inclusion. A portion of students replied with absolute affirmation when asked if they felt included in specific groups, they would state “yes, I do feel part of it” or “yes, I would consider myself . . .” Other students would make statements like “almost there, but not totally” or “just starting to be” when they were asked if they felt included in specific groups. A third

group of students commented they felt included in "some situations" or "no, but maybe a little", indicated that they felt some level of inclusion, but they did not always feel fully included. This variation in degree of feelings of inclusion lead the coders to create three codes, Edge of Inclusion, Slight Inclusion, and Feelings of Inclusion. These codes were used to indicate where in the range of feelings of inclusion the student responses fit. For example if a student reported they were "just starting to be" or "no, well just a bit" when asked if they felt included in a specific group they would be coded as Edge of Inclusion. If a student responded with a statement similar to "yes, but only a little" or indicated they felt included in only certain situations they were coded as Slight Inclusion. Student responses similar to "yes, I do feel included" or "I absolutely feel included" were coded with Feelings of Inclusion. Coding of "student belonging" was binary, in which student responses were coded as "feelings of belonging" or "no feelings of belonging" since student responses for this category were less nuanced than the responses related to feelings of inclusion.

The cohorts of students were asked these questions throughout their undergraduate studies and their responses were examined for trends of increasing, decreasing, or steady feelings of inclusion in engineering. The responses were also examined to determine if there were any specific periods of time or events that could be connected to changes in the degree of inclusion felt by the undergraduate students.

3.0 Results and Discussion

For all questions analyzed, included those examined in this paper, the inter-coder agreement for the one-on-one interview was 98.2% and the inter-coder agreement for focus groups was 97.8%. This means that after the debate and discussion phase of coding the two coders agreed on 98.2% of the codes found in interviews and 97.8% of the codes found in focus groups.

Students were asked "Did the engineering in history course help make you feel like you belong in engineering at WVU and that you are included in engineering at WVU?" All students participating in the AcES were required to enroll in a course titled Engineering in History during their second semester. The course fulfilled a general education requirement and was taught by one of the program's faculty mentors. The course material covered how engineering advancements have shaped society from ancient times to present. Data was not collected on the impact of the Engineering in History course on inclusion in engineering until the fall 2018, therefore a longitudinal analysis for this question was not completed. Students, however, rarely cited the course as contributing to their feelings of inclusion in engineering. It should be noted, that, due to logistical issues, the course was offered in an asynchronous online modality, so a question is raised regarding the potential influence of the content or modality of the course on students' feelings of inclusion in engineering. Student responses did show the Engineering in History course was responsible for making them feel like they belong in engineering. Examples of student responses to being asked if they history course contributed to their feelings of belonging and inclusion at the institution are shown in Table 3.1.

Table 3.1: Samples of Student Responses Indicating the History Class Contributed to Belonging

"Yeah. It definitely did. It's mainly because a lot of people that became big names in engineering in the past were just individuals with a dream and hope of bettering society and that's why I am here and that's why other kids are here."
"Absolutely it showed me that engineers come from all walks of life because people who became engineers in the past there was no degree they had an idea and they pursued it and in the end they accomplish their goal and they were able to make it a reality and that's no different than this."
"*Yeah it did. It went back to like the beginning of engineering to now. It kind of like made me realize like wow I really like learning this stuff and I actually want to be able to do this kind of stuff for work."*

The students were also asked "Do you feel part of the group when working on projects in your engineering courses?" It should be noted that there was a strong focus on teamwork and the students completed two team design projects in their first semester professional development course. Students also complete several team design projects in the fundamental design courses that require students to be calculus ready. Students were only asked this question in the beginning of the semester interviews, and not at the middle or end of semester interviews or focus groups.

Figure 3.1 shows the distribution of the degree of inclusion responses related to how students feel when working on projects in their engineering courses. All students reported feeling included in their engineering project groups at the beginning of their first semester in college. No responses were coded as "slight inclusion" or "edge of inclusion." The designation "no code" implies that the student response did not include anything that could be interpreted as edge of inclusion, slight inclusion, or feeling of inclusion codes.

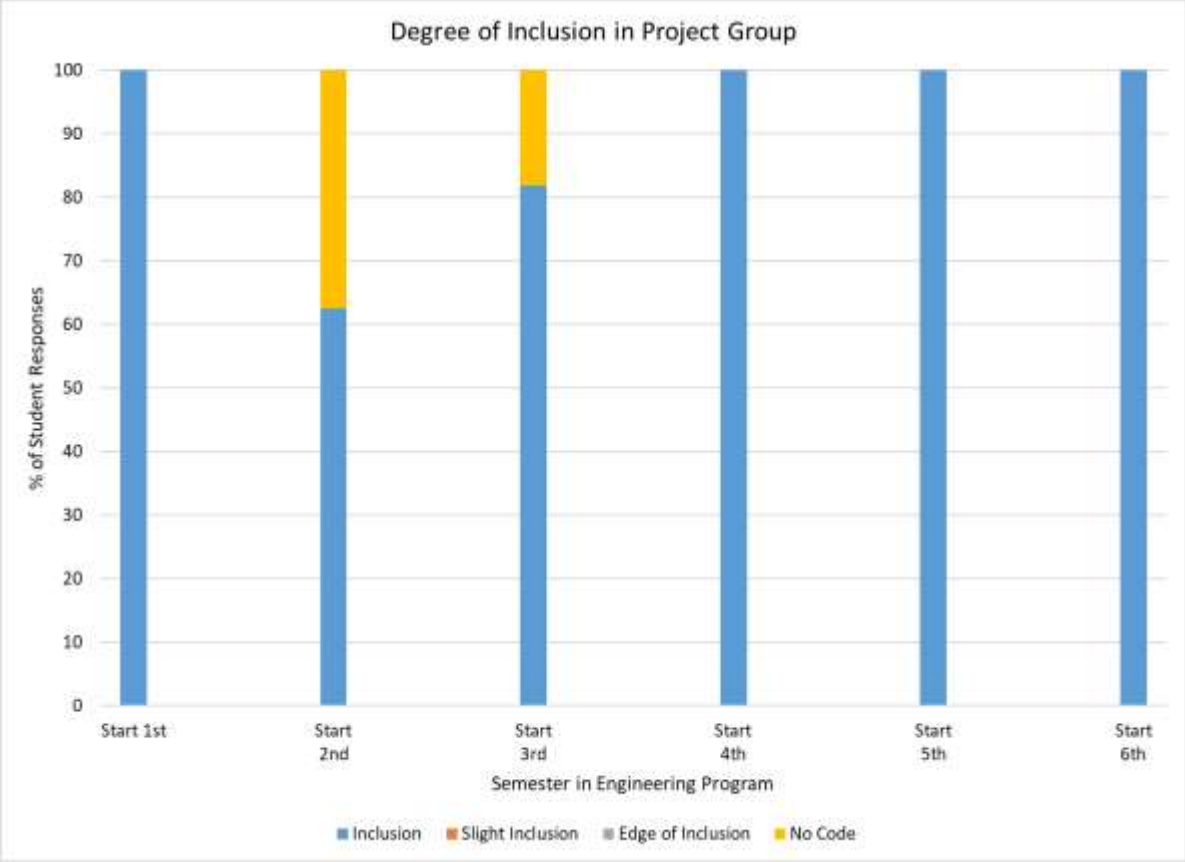

Figure 3.1 Reported Degree of Inclusion Regarding Project Teams in Engineering Courses

It should be noted that the AcES participants complete two group projects as part of the first semester professional development course. In the second and third semesters, the percentage of students who reported feeling included in their engineering project groups were 62.5% and 81.8%, respectively. Table 3.2 displays samples of student responses indicating feelings of inclusion in response to how students feel when working on projects in their engineering courses.

Table 3.2: Samples of Student Responses Indicating Inclusion in Engineering Project Teams

Student Response	Degree of Inclusion
"Yeah I do I usually like to be the team leader and get involved as much as everyone else because I like being able to coordinate stuff and help them out."	Feelings of Inclusion
"Yeah I feel like I am part of the group. Every project I worked on so far with a group I feel like I have given good input and I feel that my ideas were implemented in some way like I wasn't just standing by and watching them do all the work."	Feelings of Inclusion

Additionally students were asked "Do you consider yourself a member of the scientific and engineering community here at WVU? Why or why not?" Figure 3.2 displays the degree of

inclusion indicated by students with respect to the scientific and engineering community at their institution. Students were asked this questions at the start, middle, and end of each semester. No code indicates the student response did not include any information that was coded as inclusion, slight inclusion, or edge of inclusion. The data shows the degree of reported inclusion in the scientific and engineering community at the institution increases from the start to middle of the first semester, but by the start of the second semester the lowest average degree of inclusion occurs. The students participating in this study participated in a one-week summer bridge program and a first semester professional development class. The summer bridge program has a strong focus on cohort formation and supporting the transition to college, which may explain why these students start their first semester with a majority feeling included in the engineering community at their institution.

At the end of the second semester all student responses indicated that the students felt included in the scientific and engineering community at the institution. Between the start of the fourth semester and the end of the fifth semester in the program the percentage of students feeling included in the scientific and engineering community at the institution is less than 70%. For the entirety of the sixth semester all students reported feeling included in the scientific and engineering community at WVU. It is of interest to note that two students left engineering at the end of the fifth semester and therefore are not included in the sixth semester data. These two students who did not matriculate into their sixth semester consistently reported feeling a lower level of inclusion than their peers. Two students cited the AcES program as contributing to their feeling of inclusion at the start of their first semester, and one of which reported feelings of inclusion consistently throughout their six semesters. Table 3.3 displays samples of student responses expressing their degree of inclusion in the scientific and engineering community at the institution.

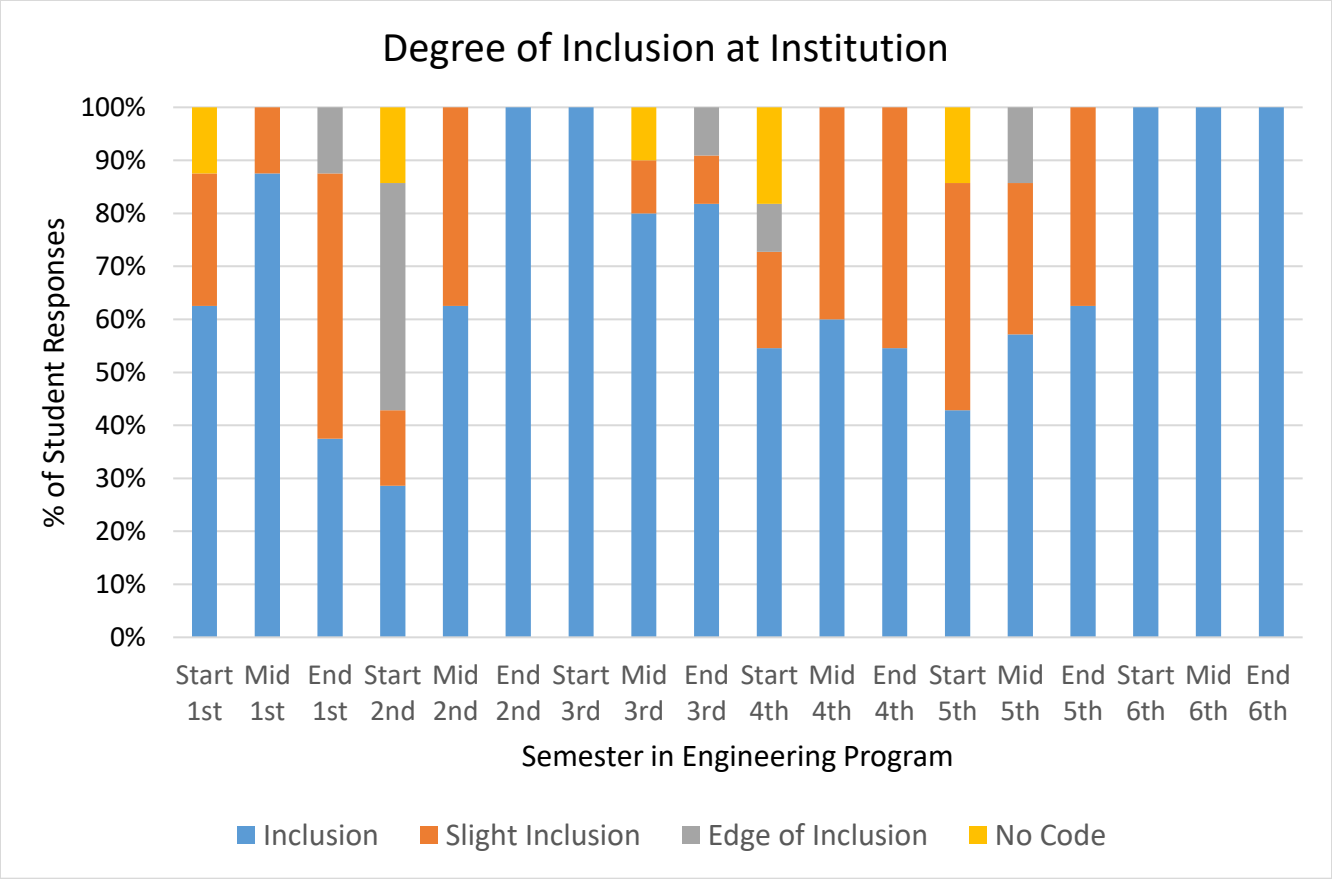

Figure 3.2: Degree of Inclusion in the Engineering Community at WVU

Table 3.3: Student Responses and Reported Degree of Inclusion in the Scientific and Engineering Community at the Institution

Student Response	Degree of Inclusion
"I would say I am. I've been pretty successful in my classes this semester and I've made a lot of friends in engineering in the clubs and stuff so I think I've connected pretty well with it."	Feelings of Inclusion
"Yeah we've already started taking engineering classes or getting out and getting used to the people we're going to see the next few years so."	Feelings of Inclusion
"I completely agree, we are in engineering majors but I feel like I'm still just at the beginning of my major I don't think I've progressed that far into it even though I am making progress I just feel like I am still in the beginning steps."	Slight Inclusion
"I would say a small part of it because we are still learning and we're kind of like just getting into that basics of engineering."	Slight Inclusion
"I think once we declare our majors then we will be in it but right now we're just kind of on the wall."	Edge of Inclusion
"I would say here at WVU I would say we are pretty close and since when we finally declare a major we will really be into something."	Edge of Inclusion

As a follow up question, students were asked "Do you consider yourself a member of the broader scientific and engineering community?" Figure 3.3 displays the degree of inclusion students reported in the broader scientific and engineering community. At the start of the first semester one student indicated feeling on the edge of inclusion and all other students made no indications of feeling any degree of inclusion. As the students' time in the engineering program increases, the average degree of inclusion moves towards a higher percentage of students reporting slight inclusion and ultimately inclusion in the broader scientific and engineering community. It should be noted that the two students who left engineering prior to the start of the sixth semester consistently reported low or no levels of inclusion.

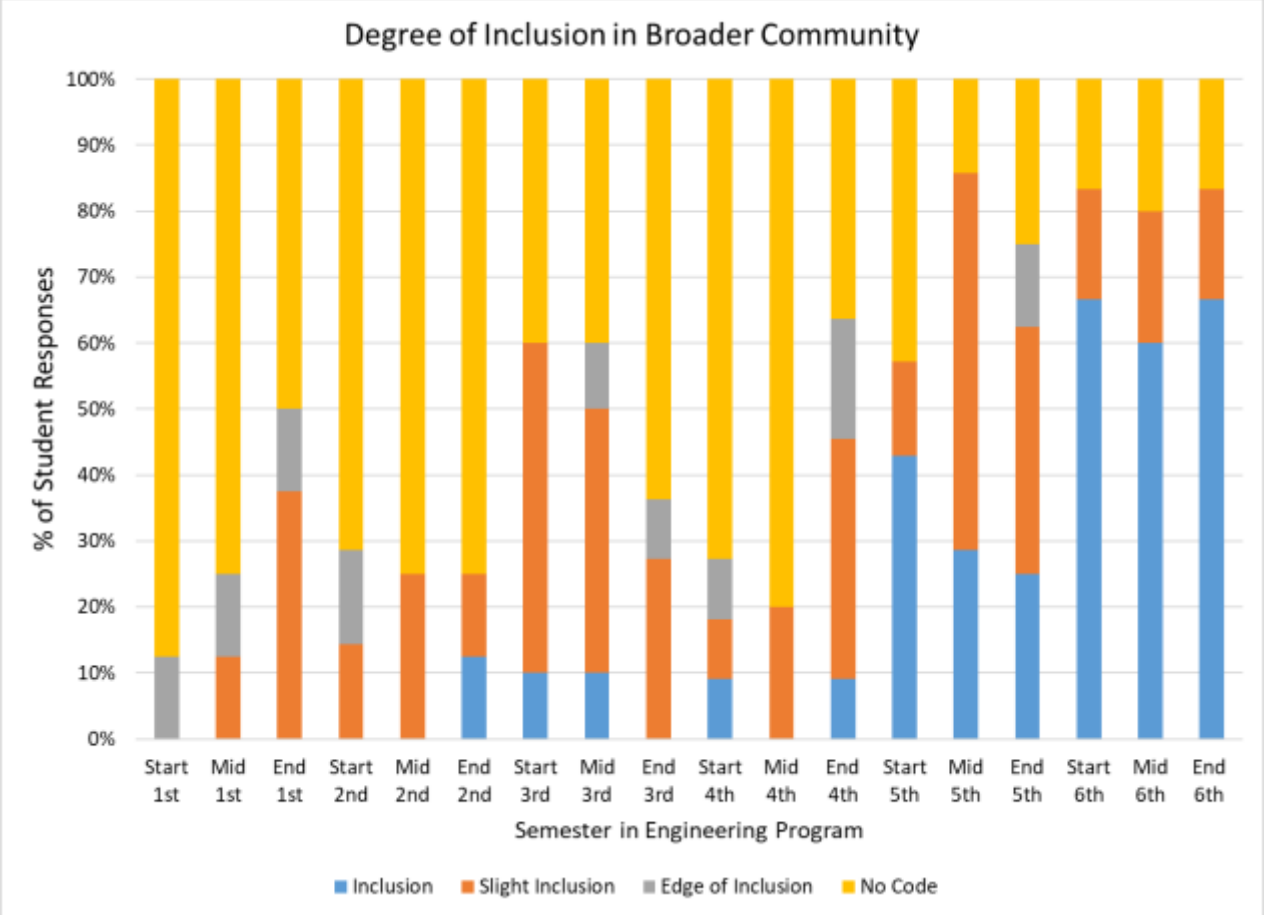

Figure 3.3: Degree of Inclusion in the Broader Scientific and Engineering Community

Analysis of the student interview responses showed that participating in an internship or co-op experience increased their degree of inclusion in the broader scientific and engineering community. Two students repeatedly cited their internship as a source of their feelings of inclusion in subsequent interviews. Table 3.4 displays samples of student responses expressing their degree of inclusion in the broader scientific and engineering community.

Table 3.4 Student Responses and Reported Degree of Inclusion in the Broader Scientific and Engineering Community

Student Response	Degree of Inclusion
"For once on this question I actually do starting this summer I will be doing the co-op position for an engineering company so I actually feel accepted in the engineering community because I'll be working under professionals and be able to go out in the field and work."	Feelings of Inclusion
"I would say so I have had a lot of experiences with different companies and I feel like I am really learning engineering stuff."	Feelings of Inclusion
"I would say yes to but just a very small part of it. I don't feel very involved I guess but I guess indirectly."	Slight Inclusion
"I would say 75 to 25% for the most part I do I feel like if I tell someone I am majoring in engineering people respect that and stuff like that but I wouldn't say completely because I haven't really had any field experience yet. I feel like I definitely fit into it I just haven't really gotten myself in it yet. I just feel like I am one step away."	Slight Inclusion
"I kind of agree with them. I wouldn't go around saying oh I'm an engineer but I would say I'm a student though. So I kind of think we're in kind of like that gray area between being a part of the bigger picture and being outside of it."	Edge of Inclusion
"I would say no but maybe just a slight bit yes. Mostly no because I'm still in college and just a freshman but partly yes because I am an engineer, like I declared mechanical engineering and that's what I want to do."	Edge of Inclusion

4.0 Conclusion

Students' feelings of inclusion in both the broader scientific and engineering community and the scientific and engineering community at the institution cover a range over the spectrum of inclusion. With respect to feeling included in engineering project teams, however, students either felt included or not; they did not express a spectrum of inclusion.

While the Engineering in History class contributed to the students' sense of belonging in engineering it was not cited as a source of feelings of inclusion. A decrease in the students' average feeling of inclusion is seen in the second semester, the same semester the Engineering in History course is taken. Currently the history course is taught in an asynchronous online modality, and several students mentioned the modality as a reason it did not contribute to their feelings of inclusion at the institution. Further study is needed to determine if and how the teaching modality of this course affects students' feelings of inclusion.

A decrease in the average degree of inclusion occurred after the students' first semester, prior to increasing in later semesters. Multiple students indicated that the AcES contributed to their feelings of inclusion in the scientific and engineering community at the institution. These responses support the researchers' belief that the emphasis on cohort formation, career exploration, and planned co-curricular activities during the first semester in the AcES program bolstered the initial feelings of inclusion.

The degree of inclusion a student feels in the broader engineering and scientific community is dependent on student engagement beyond the classroom. Students cited internship and co-op experiences as contributing factors to feeling included in the broader engineering and scientific community. This finding suggested that university resources should be allocated to preparing students for and helping students apply for internships and co-ops. Faculty and academic advisors should strongly encourage internships as early as possible in an undergraduate's academic career.

5.0 Future Work

The 2016, 2017, 2018, and 2019 scholarship cohorts will continue to participate in one-on-one interviews, focus groups, and surveys until graduation. This data will contribute to the longitudinal analysis of feelings of inclusion in engineering and the profession. The researchers also recommend that the data collection be expanded beyond the small S-STEM funded scholarship students to determine if the trends become statistically significant. Findings from the LAESE, MSLQ, and Grit survey analysis will continue to be disseminated in publications.

It is recommended resources be allocated to curricular and co-curricular activities that contribute to students feeling included in the engineering college and the engineering profession. Recommendations include focusing on cohort formation, designating space and times for study groups and encouraging use of campus career resources. Additional focus should be put towards assisting students in applying for and obtaining internships, co-ops, and undergraduate research experiences early in their academic careers.

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