Paper Title Targeted Curricular and Co-Curricular Activities and Identity Development Across Two Projects Supporting Diverse STEM Undergraduates

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Purpose / Objective

Prior research indicates that STEM undergraduate students' perceptions including self-efficacy, sense of belonging, and identity are important to their retention and success, especially for individuals belonging to historically underrepresented groups, e.g., females, students of color, students from low socioeconomic status backgrounds (Carlone & Johnson, 2007; Chang, Sharkness, Hurtado, & Newman, 2014; Hausmann, Schofield, & Woods, 2007; Johnson, Alvarez, Longerbeam, Soldner, Inkelas, Leonard, & Rowan-Kenyon, 2007; Pantic & Clark-Midura, 2019; Walton & Cohen, 2011). University projects supported by programs like the National Science Foundation's Scholarships in STEM (S-STEM) effort seek to recruit and retain students from these underrepresented backgrounds and, as such, typically incorporate curricular and co-curricular support activities tailored toward fostering positive STEM affect among their participants. Common activities in these sorts of projects, included due to their demonstrated positive impacts on undergraduates, are summer bridge programs, cohort structures, redesigned introductory level courses, and peer mentoring programs (Lisberg & Woods, 2018, Martin-Hansen, 2018).

Previous studies conducted as part of two S-STEM projects at a university in the Northwestern United States have confirmed the utility of these types of supports for developing self-efficacy, sense of belonging, and identity among undergraduates studying mathematics, computer science, and engineering (Authors, 2019; Authors, 2020; Authors, 2021; Authors, 2022). The present study sought to expand upon these findings by investigating how conceptually aligned but structurally different activities across these projects served to support students' identity development. The specific research question that guided the study was: To what extent do curricular and co-curricular activities, focused on social applications of STEM, support undergraduate mathematics, computer science, and engineering students' identity development?

Theoretical Perspective

This study utilized the Dynamic Systems Model of Role Identity (DMSRI; Kaplan & Garner, 2017), which views the role identities that individuals develop in particular contexts as constructed from a complex and dynamic combination of self-perceptions, purposes and goals, beliefs, and perceived action possibilities. Development of each of these facets of an individual's role identity is influenced both by the subject domain(s) related to that role as well as the social context surrounding that role. In this case, the subject areas in question are STEM domains (specifically mathematics, computer science, engineering) and the social context consists of undergraduate students' experiences as a participant in one of the two S-STEM projects. Thus, the focus is on students' identity development in the roles of undergraduate STEM student / future STEM professional. The DSMRI has been applied successfully in prior work examining undergraduate engineering students' learning and professional growth (Garner, Haas, Alley, & Kaplan 2018), as well as a study of the influence of mentoring experiences on students' identity development in mathematics and computer science within one of the S-STEM projects underlying the present study (Authors, 2021).

Methods

Study Context

The data analyzed for this study were collected as part of educational research and external evaluation components of two separate NSF S-STEM projects hosted by the same institution. One project, MC (project acronyms are pseudonyms), draws students interested in majoring in math and/or computer science while the other, 3E, draws students interested in majoring in electrical, manufacturing, or plastics/composites engineering. Both projects utilize a cohort model where first-year students enroll as a group in specially focused introductory courses, attend themed program events, and participate in peer mentoring relationships. The 3E program also includes a math-focused summer bridge program, designed to help students achieve math placement exam scores that allow them to take calculus in their first academic quarter, putting them on track for a 4-year time to graduation. Intentional advising by project faculty are also hallmarks of both projects. While the project PIs and Co-PIs differ, the same educational researcher (1st author) and external evaluator (2nd author) work on both and co-manage data collection activities.

Among the activities described above, this study sought to understand the particular identity-related impacts of two experiences (one from each project) that focused on social applications of STEM. Students in the MC project attended a panel discussion including three female mathematicians / computer scientists who are currently using mathematical and computational models in their work across a range of socially benevolent applications including early cancer detection, immune system characterization, detection of deceptive news articles, and predictive epidemiology. Students in the 3E project enrolled as a cohort in a first-year course focused on the relationships among engineering, design, technology, and society, which explored topics including societal impacts of technology and the role of social justice in engineering and design. Though the scope and duration of these experiences was quite different, they shared a common conceptual focus of exposing students to elements of STEM outside of the traditional, commercially focused applications and related career pathways often associated with computing and engineering.

Data source and analytical approach

The data source for this study consisted of transcripts from six focus group interviews conducted in the spring of the 2021-22 academic year with N=27 students across both projects. Three focus groups were held with students from MC (n=13): first-year participants (4 females, 1 male), second-year participants (4 females), and subsequent year participants (1 female, 3 males). Since 3E's interventions are focused on students' first two years and it has the added math-focused summer bridge program element, its' focus groups were arranged as follows (n=14): first-year students who had to pass math placement assessment (2 females, 3 males), first-year students who did not have to pass math placement assessment (2 females, 2 males), second-year students (2 females, 3 males).

Focus groups lasted approximately 1 hour each, with protocols asking students about their experiences and satisfaction with curricular and co-curricular activities associated with their respective S-STEM project, including the extent to which their experiences with these activities

influenced their perceptions or affect. Focus groups were co-facilitated via Zoom by the projects' educational researcher and external evaluator and were video recorded and transcribed verbatim. Student responses typed into the Zoom chat box were read aloud by the facilitators so that these data could also be captured in the transcripts. All research and evaluation data collection activities in both projects were approved by an Institutional Review Board and focus group participants completed appropriate informed consent documentation.

Using QSR NVivo 12 software focus group transcripts were coded first for a priori themes including references to specific project components or activities, as well as responses that were generally indicative of students' developing role identity as a STEM undergraduate/future STEM professional. Then, a second round of coding was applied identifying aspects of the DSMRI (i.e., self-perceptions, beliefs, purposes & goals, perceived action possibilities) evident in identity-focused responses. NVivo matrix coding queries were conducted to explore how students' discussion of project activities (panel event for MC, introductory engineering course for 3E) provided evidence of their identity development across components of the DSMRI. Representative quotes were selected to provide examples of these intersections.

Results

Project Activities and Students' Identity Development: Big Picture

Figure 1 shows the number of words coded across MC focus groups at the intersection of panel event discussions and each respective DSMRI component. MC students' identity-related comments in reference to the panel event were overwhelmingly focused on action possibilities, followed by some discussion of beliefs and only a short discussion of self-perceptions. None of the identity-related comments about the panel event were coded as making references to students' purposes and goals.

Figure 2 shows the number of words coded across 3E focus groups at the intersection of the introductory engineering course and each respective DSMRI component. 3E Students' identity-related comments in reference to the introductory engineering course mostly related to their beliefs, followed by some discussion of self-perceptions and action possibilities and only a short reference to purposes and goals.

Project Activities and Students' Identity Development: In Their Own Words

Below are representative quotes reflecting students' discussion of project components in terms that aligned with aspects of the DSMRI. Additional examples will be provided in the conference presentation / final paper.

MC Students

Action Possibilities: *"What kind of stuck out to me is that you…go into computer science and you think, oh, I'll get my degree and then I'll go get a job at Microsoft or go work at Google or get a generic sort of software engineering job, but it kind of stuck out…none of the people that they had at that event were like that. They were all*

doing different interesting stuff that you might not initially think of when you think of computer science, but it's still really interesting applications to different fields that are helping people." – MC Student 1 (Female, White)

Beliefs: *"Knowing computer science doesn't mean that you just only know how to code and look at data. You can learn with other people and share your knowledge with other people and we're all learning together."* – MC Student 2 (Female, Asian)

Self-perceptions: *"I think motivation is a really big part because when I feel unmotivated because of stress like…Seeing people who have persevered through that and are in successful careers gives you the motivation to keep going in school."* – MC Student 3 (Female, Asian)

3E Students

Beliefs: "*Having that class was like a break where you got to think outside of the box and see what there is to engineering other than just the math behind it. And while that's a big part, it's not the only part."* – 3E Student 1 (Male, Asian)

Self-perceptions: "*I was really worried about getting like imposter syndrome and being like, oh man, all these people around me are so much smarter. But having that intro level class, where everybody is just as curious as you are and not knowing as much as anybody else, I thought that was really nice, because there's people just like me everywhere and we're all doing the same thing."* – 3E Student 2 (Male, Pacific Islander)

Action possibilities: "*I think one of the things that we got out of it was insight into the actual career. We got to go over not only some of the different projects and different things that are going on in the world and engineers are being a part of, but we also got to...go through the mindsets of engineers and things that we can expect in the future."* – 3E Student 3 (Female, White)

Conclusions, Limitations, and Significance / Implications

The findings described above are encouraging in that they suggest even short, one-time experiences like the MC panel discussion can have meaningful impacts on individuals' role identity development as undergraduate STEM students / future STEM professionals. It is perhaps not surprising that this development centered on action possibilities given the focus of the event on varied career pathways. At the same time, it is encouraging that other dimensions of identity development were at least partially evident in students' reflections on this experience. Findings

related to the 3E introductory engineering course suggest that a more sustained experience like a full course may be necessary to have a wider ranging impact on students' identity development, and/or to significantly influence identity along the generally more well-defined and stable dimension of beliefs. These findings are likely to be of interest to other individuals conducting research in the STEM identity space, as well as program designers / facilitators who are interested in supporting undergraduate students' STEM identity development across multiple dimensions and using a variety of support structures / intervention strategies.

It is important to acknowledge that this study has limitations, as the findings are drawn from a small sample of students at a single university site and represent a snapshot of students' views at a particular timepoint. Though students were encouraged to be open and honest during focus groups and informed that their responses would only be shared with project faculty anonymously or using pseudonyms, it is possible that they may have been hesitant to communicate negative feedback on their experiences. It is also worth noting that both of the projects described here have been ongoing for multiple years (with MC already in its second iteration) and so they are already fairly refined in their design and high functioning in their execution.

Figures

Figure 1: Matrix Coding for MC Panel Event References by DSMRI Components

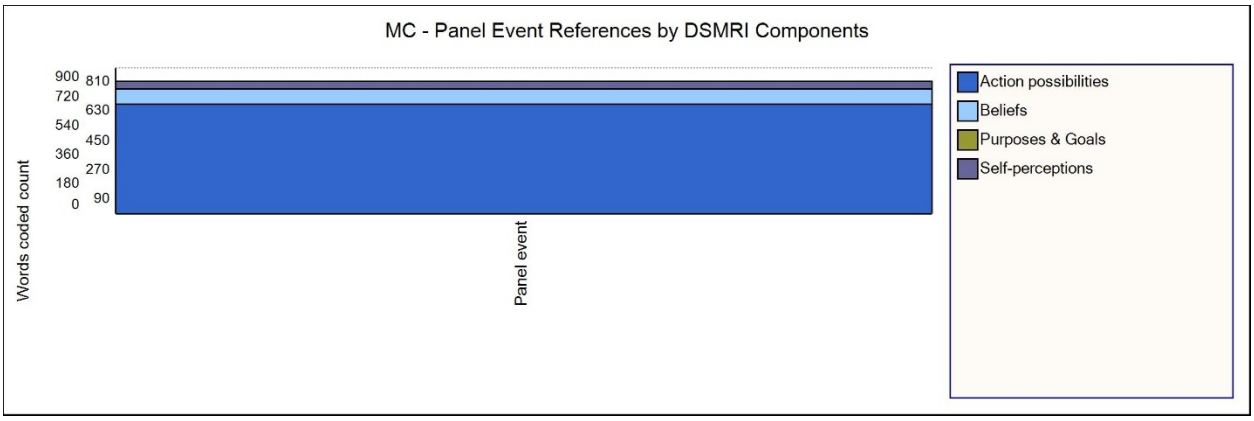
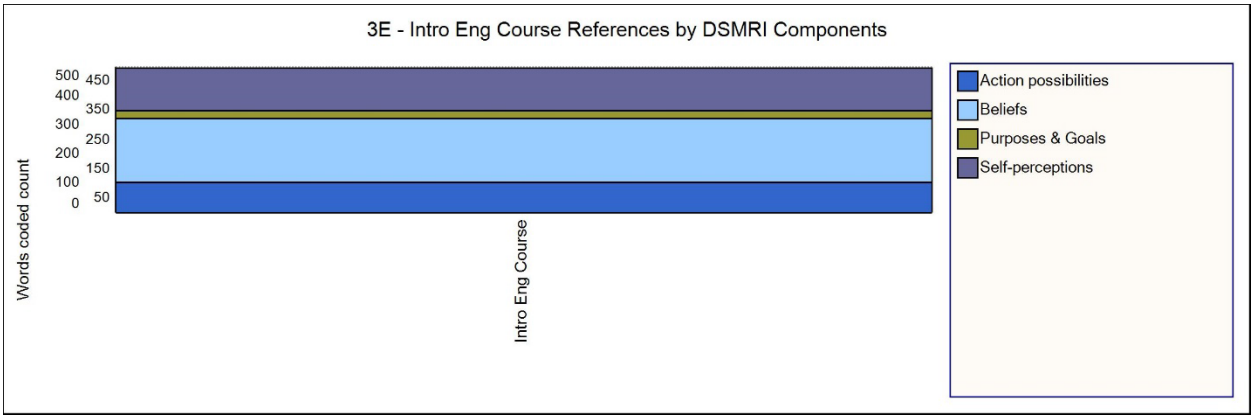


Figure 2: Matrix Coding for 3E Introductory Engineering Course References by DSMRI Components



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