Examining the Relationship between Local Sense of Belonging and Students' Development of Socio-Academic Relationships in Introductory STEM Classes

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Introduction

Sense of belonging, here defined as students' perceived social support, and feelings of connectedness, mattering, acceptance, and respect in socio-academic communities, is widely considered an important antecedent to students' socio-academic success in college [1]. We use the term *socio-academic* to draw attention to the ways that students' experiences outside of the classroom can shape their academic lives in college, as well as to draw attention to the ways that complex social interactions shape students' academic experiences and outcomes [2]. Indeed, decades of research has documented the ways that college students' sense of belonging shape important socio-academic outcomes, such as major choice, involvement, retention, graduation, and even post-graduation outcomes [3-4]. These studies have explored sense of belonging both as an antecedent to important socio-academic outcomes, as well as an outcome of students' socio-academic experiences within the college community [5-7].

Existing research often examines college students' sense of belonging as a global construct, positioning students to respond about their sense of belonging to institutions, disciplines, or departments [8-9]**.** However, recent research suggests that students' development of sense of belonging may differ across contexts in the university community [7, 10]. Thus, how one's sense of belonging in one space on campus (e.g. a classroom) may not be indicative of their sense of belonging in a different space (e.g., a residence hall). Wilson and colleagues [11] examined students' sense of belonging within multiple levels spanning from classrooms to whole institutions. Their multi-institutional study found that students' sense of belonging in classrooms, as opposed to other contexts, was most significantly and consistently linked to positive emotional engagement [11]. These findings suggest a need to study students' belonging across the smaller communities that make up the larger institutional context [12]. This conceptual change from examining belonging at the global (i.e., institutional) level to local (e.g., classroom, residence hall, club/organization) level may also require the development of new analytical frameworks and instruments for studying local sense of belonging (LSOB) in college [12].

This research focuses on students' sense of belonging in an introductory STEM class, herein referred to as classroom belonging. Prior research has demonstrated the role of disciplinary contexts, as well as the influence of demographic characteristics, on students' sense of belonging. For example, Good and colleagues [13] examined how gendered stereotypes of women's mathematical abilities decreased their sense of belonging within the field and curtailed their future interest in mathematics. Similarly, researchers have examined how engineering students' sense of belonging in the discipline is related to persistence, retention, and their development of important socio-academic relationships with peers, faculty and the discipline [15-16].

Other research has examined demographic differences in college students' sense of belonging [e.g., 16-20]. In STEM, research has consistently documented how students from historically excluded racial/ethnic and gender backgrounds, such as women or Black and Latinx students, disproportionately experience lower levels of sense of belonging than students from majority

backgrounds [e.g., 14, 16, 19]. Still, while research frequently describes how historically excluded students experience STEM as hostile, chilly, and exclusionary, others have documented how historically excluded students find community and belonging in other, smaller spaces and communities on campus [21].

Taken collectively, research must examine how students' sense of belonging across contexts may differ in ways that shape their socio-academic success across contexts in the collegiate community. This research began from the premise that different learning opportunity structures in college may shape students' sense of belonging. How a student experiences a large lecture classroom may differ from how they experience a team-based design course or a residence hall in college. As such, this research examines sense of belonging in a specific academic context–an introductory large lecture course. We sought to answer the following research questions:

RQ1: What is the relationship between students' LSOB and their development of socio-academic relationships in the classroom?

RQ2: What is the relationship between students' LSOB and other socio-cognitive outcomes?

RQ3: How do demographic characteristics, such as race/ethnicity, gender, and international student status, inform students' LSOB?

Methods

Research Setting and Sample

Data for this study comes from a larger study examining how students develop important socio-academic relationships that support their academic and social success across contexts in college. Recognizing that students' social relationships in one classroom (e.g., a large lecture course) might differ in the nature and structure from those in other classrooms (e.g., a team-based engineering design course), we sought to measure the nature and structure of students' socio-academic relationships across contexts in the collegiate community. Thus, the setting for this study was an introductory, large lecture course–Calculus II–at a small, Northeastern private university.

The research team worked closely with the course instructor to recruit participants from the classroom, including by developing a course-specific incentive structure to encourage participation. In full, 233 of the 247 students in the course are included in the analysis.

Measures

Socio-academic Relationships. The outcome of interest in this study was students' self-reported socio-academic relationships in the context of an introductory, large lecture course. Specifically, we asked students to report their study relationships with peers and instructional staff (e.g., tutors, teaching assistants). First, we asked students about their study tendencies and whether they study for the class (a) alone, (b) with classmates in the course or in another section of the course, (c) with members of the instructional team such as the instructor of record or TAs, or (d) with other peers in the collegiate community who had taken the course in the past. For this study,

the outcome of interest was dichotomous, where 1 represented those students who reported study relationships with other students either enrolled in the course, another section of the course, or who had enrolled in the course in the past, while 0 represented those students who reported that they studied alone.

Demographic Characteristics. Additionally, given existing research examining sense of belonging for students from underrepresented backgrounds in STEM disciplines [16-20], we asked students to report key demographic characteristics, such as race/ethnicity, gender, and international student status. For example, existing research suggests that dimensions of social identity, such as race/ethnicity and gender, inform students' sense of belonging, with implications for students' desires to pursue STEM careers, retention in secondary and postsecondary education, and post-graduation career pursuits [13-20]. As such, we measured demographic characteristics using a battery of items capturing racial/ethnic identity (1 = historically excluded student, 0 = non-historically excluded student), gender identity (1 = man, 0 = non-man), international student status (1 = international student, 0 = domestic student).

Local Sense of Belonging. Finally, we measured a student's classroom sense of belonging using an instrument developed by Mosyjowski and colleagues [22]. The classroom belonging instrument consisted of 11 items (e.g., "I feel like my peers in this course respect me." and "I feel like I am a valued member of this classroom community."), which were measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Cronbach's alpha for the scale was .86, indicating good internal consistency. However, we also used structural equation modeling to establish construct validity, which we return to in later sections.

Analytical Procedure. Data analysis proceeded in four stages. First, we conducted an exploratory factor analysis using principal axis factoring and promax oblique rotation to establish the underlying factor structure of the classroom belonging instrument. Second, we established construct validity using structural equation modeling. Specifically, we fit an initial measurement model to examine the factor loadings of the four measured items on the classroom belonging construct. Since each measured variable was continuous, we used the maximum likelihood with robust standard error estimator to fit the measurement model. Third, we examined demographic differences in classroom belonging by estimating a set of multiple indicators and multiple causes (MIMIC) models by regressing the classroom belonging subscale on the demographic variables (i.e., race/ethnicity, gender, international student status). Finally, we estimated a logit model to understand the relationship between demographic characteristics and classroom belonging in the large lecture classroom.

Findings

First, we established construct validity for the classroom belonging subscale by observing factor loadings and model fit indices in the measurement model. Model fit indices for the classroom belonging all the cutoff criteria recommended by Hu and Bentler [23] (CFI = .995, TLI = .984, RMSEA = .054, SRMR = .017), indicated the model was an excellent fit to the data.

Second, we examined the MIMIC model to explore demographic differences in classroom belonging. The model fit indices for the MIMIC model (CFI = .956, TLI = .931, RMSEA = .068,

SRMR = .044) were worse than those of the measurement model, though most met the cutoff criteria recommended by Hu and Bentler [23]. Still, while standardized coefficients for the international student (β = -.063, p = .525), Asian student (β = -.034, p = .693), and URM student (β = -.091, p = .271) variables were all negative, and the standardized coefficient comparing men to non-men was positive (β = .080, p = .273), we found no statistically significant demographic differences in classroom belonging.

Finally, we examined the logit model to examine demographic differences in students' reported study relationships, as well as the role of classroom belonging in students' development of study relationships in the course. Since the outcome of interest was dichotomous, we report results in terms of odds ratios, where odds ratios greater than 1 indicate an increase in the odds that a student will report study relationships with other students, and odds ratios less than 1 represent a decrease in the odds that students will report study relationships with other peers. Like the results of the MIMIC model, we found no statistically significant demographic differences in students' self-reported study relationships. However, we found that classroom belonging (odds ratio = 1.565, p = .030) was a statistically significant predictor. Full model results can be found in Figure 1 (Appendix A).

Discussion

Decades of research have consistently pointed to the experiences of women and underrepresented minority students in STEM disciplines, pointing directly to the relationship between students' social identities, their socio-academic experiences, and their resulting sense of belonging in STEM [e.g., 16-20]. Researchers consistently find that women, students of color, and women of color students' socio-academic experiences negatively influence their sense of belonging in STEM, thereby undermining their socio-academic outcomes [5, 11, 14, 19]. However, we suggest that such research might miss the nuances of belonging in specific socio-academic communities in college.

While our findings appear to be in conflict with existing research, many scholars have documented the socio-academic strategies historically underrepresented students adopt when navigating hostile climates in STEM, such as joining identity-based organizations (e.g. National Society of Black Engineers, Society of Women Engineers, Society of Hispanic Professional Engineers) or cultivating socio-academic relationships with faculty, staff, and peers [24]. Still, these studies tend to examine how students navigate larger academic environments, such as universities or departments, which may not explain how students navigate the smaller communities in which they operate in their day-to-day lives. This research suggests students' LSOB may shape how they develop the day-to-day relationships that shape their socio-academic experiences and success in STEM.

This research also joins scholarship that suggests context-specific, or local, belonging may be a stronger predictor of socio-academic outcomes than general or global belonging. For example, Hansen and colleagues' [5] longitudinal study of STEM students' sense of belonging found that STEM-specific belonging (i.e., students' sense of belonging to a major or program) was a stronger predictor of students' persistence in STEM than general belonging (i.e., students' sense of belonging to the campus or university community). These findings underscore the need to

examine sense of belonging to smaller, local communities in college, rather than to institutions or larger socio-academic environments [12, 22]. Understanding students' socio-academic experiences in smaller, local communities may be the key to supporting their broader success in STEM education.

Future Directions

One might interpret our findings as cause for celebration. After all, the idea that there are no statistically significant demographic differences in students' self-reported sense of belonging in a large lecture course undermines decades of research on underrepresented students' experiences in STEM. However, we argue that simply examining mean differences in the classroom belonging instrument may miss nuances of students' socio-academic relationships, interactions, and broader experiences in STEM. As such, our future work will examine the nature, structure, and functioning of students' socio-academic relationships.

The research represents a preliminary analysis of data examining the role of students' socio-academic relationships in their learning in undergraduate science and engineering education. The broader study also examines sociocognitive influences, such as self-efficacy beliefs and academic adjustment, in students' socio-academic experiences. While findings from this preliminary analysis appear to undermine research that has consistently documented underrepresented minorities (URM) students' negative experiences in STEM classrooms broadly, and within engineering classrooms specifically, we intend to analyze these and additional data using social network analysis, which we believe may be better suited for understanding students' socio-academic experiences [25]. For example, we hypothesize that one reason we did not find statistically significant demographic differences might be due to homophily effects in the classroom—the tendency for individuals to create and maintain social connections with others who share characteristics [26]. As such, our future research will analyze the specific socio-academic relationships students report with others using name matching techniques and social network analysis (SNA). We posit that SNA as a methodological framework may bring additional insights from these data to the fore.

References

[1] T. L. Strayhorn, *College students' sense of belonging: A key to educational success for all students*. Routledge, 2018.

[2] R. Deil-Amen, "Socio-academic integrative moments: Rethinking academic and social integration among two-year college students in career-related programs," *The Journal of Higher Education*, vol. 82, no. 1, pp. 54–91, 2011.

[3] A. W. Astin, "Student involvement: A developmental theory for higher education," in *College student development and academic life*. Routledge, 2014, pp. 251–262.

[4] V. Tinto, *Leaving college: Rethinking the causes and cures of student attrition*. University of Chicago Press, 2012.

[5] M. J. Hansen, M. J. Palakal, and L. White, "The importance of stem sense of belonging and academic hope in enhancing persistence for low-income, underrepresented stem students," *Journal for STEM Education Research*, pp. 1–26, 2023.

[6] R. A. Smith, "Magnets and seekers: A network perspective on academic integration inside two residential communities," *The Journal of Higher Education*, vol. 86, no. 6, pp. 893–922, 2015.

[7] C. Zabriskie, R. Henderson, and J. Stewart, "The importance of belonging and self-efficacy in engineering identity," *AERA Open*, 2018. [Online]. Available: https://par.nsf.gov/biblio/10058182-importance-belonging-self-efficacy-engineering-identity

[8] T. L. Drew and G. G. Work, "Gender-based differences in perception of experiences in higher education: Gaining a broader perspective," *The Journal of Higher Education*, vol. 69, no. 5, pp. 542–555, 1998.

[9] X. Ma, "Sense of belonging to school: Can schools make a difference?" *The Journal of Educational Research*, vol. 96, no. 6, pp. 340–349, 2003.

[10] S. Hurtado and D. F. Carter, "Effects of college transition and perceptions of the campus racial climate on latino college students' sense of belonging," *Sociology of education*, pp. 324–345, 1997.

[11] D. Wilson, D. Jones, F. Bocell, J. Crawford, M. J. Kim, N. Veilleux, T. Floyd-Smith, R. Bates, and M. Plett, "Belonging and academic engagement among undergraduate stem students: A multi-institutional study," *Research in Higher Education*, vol. 56, pp. 750–776, 2015.

[12] J. Pollard, M. Randolph, E. Mosyjowski, M. Brown, and L. Lattuca, "Conceptualizing a local sense of belonging," in *American Educational Research Association*, 2016.

[13] C. Good, A. Rattan, and C. S. Dweck, "Why do women opt out? sense of belonging and women's representation in mathematics." *Journal of personality and social psychology*, vol. 102, no. 4, p. 700, 2012.

[14] 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, pp. 1–14, 2018.

[15] R. M. Marra, K. A. Rodgers, D. Shen, and B. Bogue, "Leaving engineering: A multi-year single institution study," *Journal of Engineering Education*, vol. 101, no. 1, pp. 6–27, 2012.

[16] A. Rainey, D. Verdín, and J. Smith, "Classroom practices that support minoritized engineering students' sense of belonging," in *Proceedings of the American Society for Engineering Education*, 2021.

[17] R. M. Johnson, "A socio-ecological perspective on sense of belonging among racially/ethnically minoritized college students: Implications for equity-minded practice and policy," *New Directions for Higher Education*, vol. 2022, no. 197, pp. 59–68, 2022.

[18] M. Hussain and J. M. Jones, "Discrimination, diversity, and sense of belonging: Experiences of students of color." *Journal of Diversity in Higher Education*, vol. 14, no. 1, p. 63, 2021.

[19] D. Dortch and C. Patel, "Black undergraduate women and their sense of belonging in stem at predominantly white institutions," *NASPA Journal About Women in Higher Education*, vol. 10, no. 2, pp. 202–215, 2017.

[20] D. R. Johnson, M. Soldner, J. B. Leonard, P. Alvarez, K. K. Inkelas, H. T. Rowan-Kenyon, and S. D. Longerbeam, "Examining sense of

belonging among first-year undergraduates from different racial/ethnic groups," *Journal of College Student Development*, vol. 48, no. 5, pp. 525–542, 2007.

[21] W. E. Cross Jr, "The enactment of race and other social identities during everyday transactions," *New perspectives on racial identity development: Integrating emerging frameworks*, pp. 192–215, 2012.

[22] E. Mosyjowski, K. Shoemaker, M. Randolph, J. Pollard, and L. Lattuca, "Using item response theory to develop and assess the michigan local sense of belonging (milsob) scale," in *Association for the Study of Higher Education*, 2017.

[23] L.-t. Hu and P. M. Bentler, "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives," *Structural equation modeling: a multidisciplinary journal*, vol. 6, no. 1, pp. 1–55, 1999.

[24] S. L. Rodriguez and J. M. Blaney, ""we're the unicorns in stem": Understanding how academic and social experiences influence sense of belonging for latina undergraduate students." *Journal of Diversity in Higher Education*, vol. 14, no. 3, p. 441, 2021.

[25] D. Z. Grunspan, B. L. Wiggins, and S. M. Goodreau, "Understanding classrooms through social network analysis: A primer for social network analysis in education research," *CBE—Life Sciences Education*, vol. 13, no. 2, pp. 167–178, 2014.

[26] M. McPherson, L. Smith-Lovin, and J. M. Cook, "Birds of a feather: Homophily in social networks," *Annual review of sociology*, vol. 27, no. 1, pp. 415–444, 2001.

Appendix:

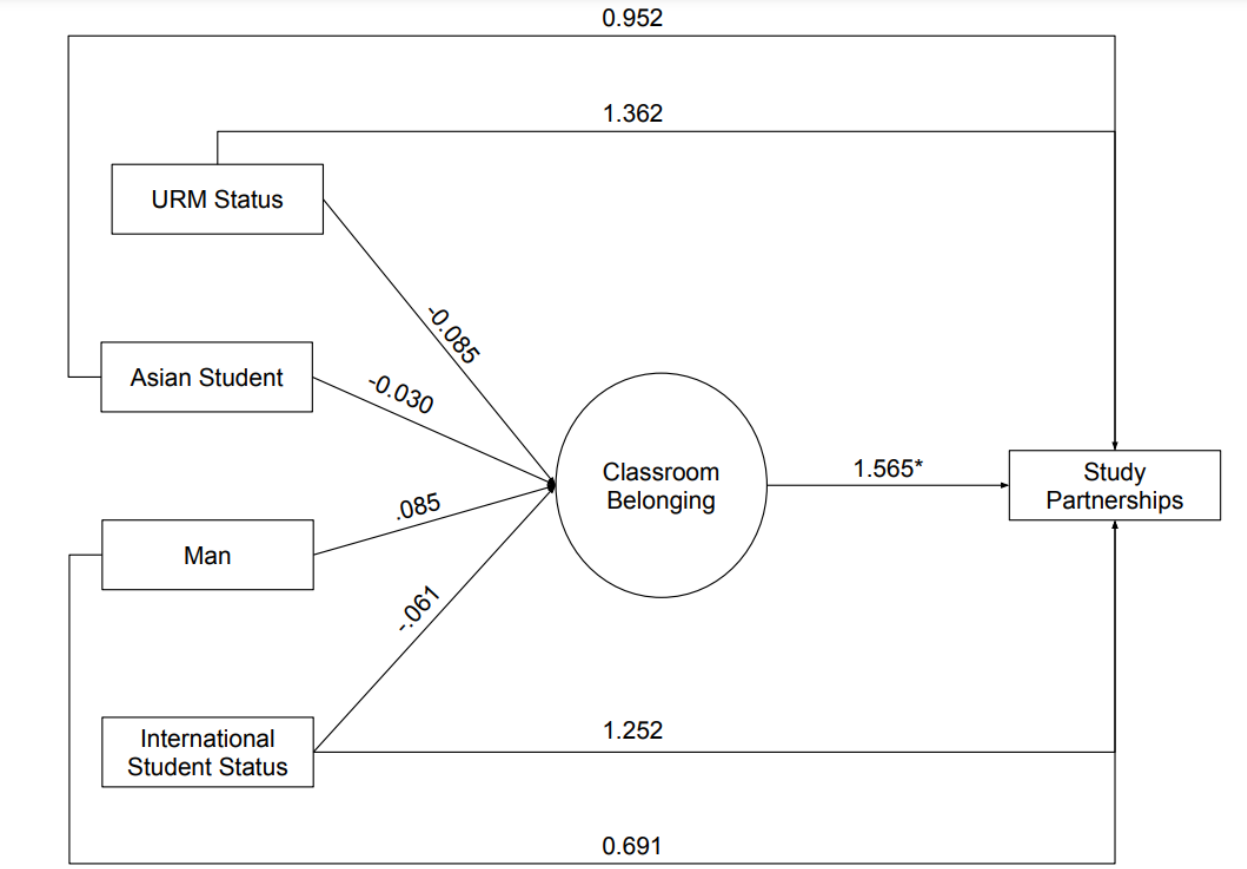

Figure 1: Full model results for logit model examining the role of classroom belonging and demographic differences in students' reported study relationships