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Work-In-Progress: Exploring Student Growth in Engagement, Belonging, and Engineering Identity in a Large-Enrollment Statics Course

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Abstract

This methods/theory work-in-progress mixed-methods study examines students' engagement, sense of belonging, and developing engineering identity within a transformed foundational course (Statics) over a semester. While these constructs have been studied in early engineering courses, less is known about how they evolve in large-enrollment, interactive settings, such as courses where students attend lectures of up to 275 peers and discussion sections of up to 140 students, collaborating in small groups on whiteboards and using engineering software. The study examines how features of the redesign relate to students' engagement, belonging, and engineering identity over time and how these experiences are associated with academic outcomes such as performance and persistence. A mixed-methods approach integrates pre-, mid-, and post-course surveys, a structured reflection activity, and course performance data to examine both patterns across students and contextualized accounts of experience. As a work-in-progress, this paper presents the study's conceptual framing and research design.

Introduction

Foundational engineering courses such as Statics serve as pivotal experiences that shape students' early engagement with engineering practices, collaboration, and professional identity [1] - [3]. Students' initial experiences with problem-solving, instructional support, and engineering modeling software can influence their sense of belonging, confidence, and persistence in engineering pathways [4] - [7]. However, large-enrollment engineering courses often struggle to support these dimensions due to limited opportunities for interaction and individualized support [3], [8], [9]. To support student learning at scale, the redesigned Statics course integrates collaborative problem-solving, engineering modeling software, and structured reflection activities. The course currently serves up to 770 students with multiple lecture sections of up to 275 students and discussion sections of up to 140 students. In discussion, students work in groups of three on whiteboards before building an engineering model in a software program. This work employs a mixed-methods approach to examine how students experience the redesigned course with respect to engagement, belonging, and engineering identity. Findings will be interpreted through a multidimensional theoretical lens drawing on self-determination, belongingness, and identity frameworks [5], [10] - [12].

Research Questions

The study will address the following research questions:

1. How do specific aspects of the redesigned course relate to students' engagement, sense of belonging, and engineering identity in a large-enrollment, early engineering course?
2. How do students' engagement, sense of belonging, and engineering identity evolve over the course of the semester within this large-enrollment, collaborative learning environment?

3. How are these constructs related to academic outcomes such as performance and persistence?

Theoretical Background

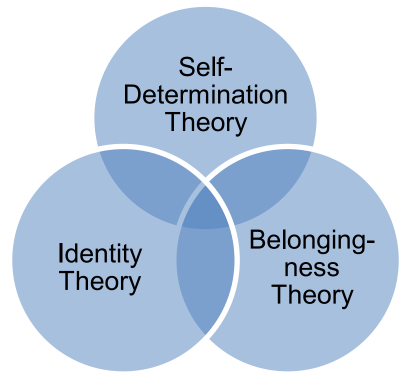

Figure 1. Multidimensional approach involving three frameworks.

Examining growth in engagement, belonging, and engineering identity within a large-enrollment, early engineering course calls for multiple, intersecting frameworks. Accordingly, this study integrates Deci and Ryan's Self-Determination Theory, belongingness theory adapted from Strayhorn, and sociocultural identity theory articulated into concrete dimensions by Carlone and Johnson to support a holistic interpretation [5], [10] - [12].

Engagement is understood as a multidimensional construct encompassing behavioral, cognitive, and emotional participation in learning, supported by instructional practices that promote active involvement and metacognitive reflection [10], [11], [13], [14]. Self-Determination Theory emphasizes that engagement is shaped by the extent to which learning environments support students' basic psychological needs for autonomy, competence, and relatedness [10], [11]. From this perspective, instructional structures that provide meaningful choice, opportunities for mastery, and social connection are more likely to foster sustained engagement. Drawing on Self-Determination Theory, the study uses survey responses and a structured reflection activity to examine how course structures and collaborative practices relate to students' engagement across the semester.

Sense of belonging reflects students' perceived inclusion, connection, and fit within an academic learning environment and has been strongly linked to persistence and motivation in STEM contexts [4] - [6], [15], [16]. Belongingness theory emphasizes the role of social relationships, perceptions of institutional support, and broader campus context in shaping students' sense of inclusion within academic settings [5]. The theory complements self-determination theory as it posits that students' perceptions of belonging are closely tied to their engagement, motivation, and persistence. Informed by belongingness theory, the study examines how students' survey responses and reflections illuminate the role of social interaction and perceived institutional support in shaping students' sense of belonging.

Engineering identity refers to how students perceive themselves in relation to the engineering profession, including feelings of competence, recognition, and interest [7], [12], [17]. Drawing on sociocultural identity theory, Carlone and Johnson propose an analytic framework in which identity develops through opportunities to demonstrate competence, engage in disciplinary practices, and be recognized by others [12]. From this perspective, identity is constructed through participation rather than possessed as a fixed trait. Guided by this framework, the present study examines how collaborative problem solving and engineering modeling assignments provide contexts in which students can enact engineering practices and begin to see themselves as engineers.

Rather than treating these constructs as independent outcomes, this work conceptualizes identity, belonging, and engagement as mutually reinforcing processes shaped through social interaction and participation in authentic engineering practices. Together, this approach will allow the research to explore the intersections of these frameworks, providing deeper insights into how pedagogical structures relate to students' developing sense of themselves as engineers.

Research Design

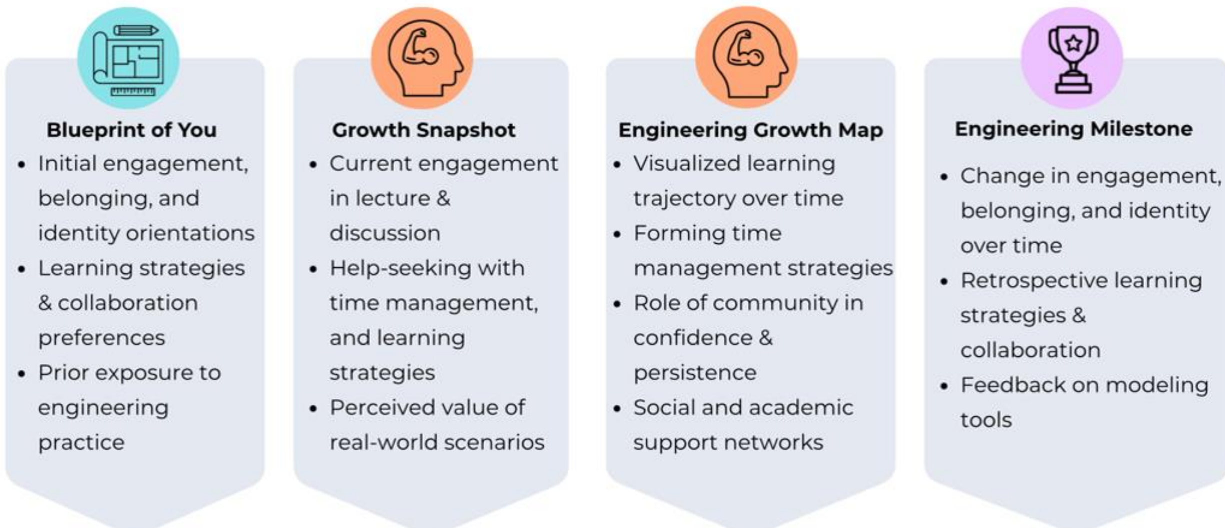

Figure 2. Overview of coordinated survey and reflection instruments

The study proceeds through a coordinated, semester-long sequence of surveys, a structured reflection activity, and course performance outcomes, enabling examination of student experiences across time. Figure 2 summarizes the coordinated survey and reflection instruments used in the study and the types of questions or activities included at each data collection point.

Administered at the beginning of the semester, The Blueprint of You survey is designed as a baseline instrument that captures students' backgrounds, interests, learning strategies, and orientations toward engineering. Survey items draw on established measures of sense of belonging and perceived group membership [4], [15], [18], engineering identity [7], [12], [17], and learning-related constructs such as perceived knowledge transferability and problem-solving confidence [13], with adaptations to maintain relevance to the Statics course context. This approach supports interpretability and construct validity while remaining closely connected to students' lived experiences.

At mid-semester, students complete a brief Growth Snapshot survey centered on self-reported engagement and learning practices and an in-discussion Engineering Growth Map activity to capture experiences to date. The Engineering Growth Map is a structured, in-discussion reflection activity in which students record moments of challenge and support on sticky notes and place them along a shared timeline to represent their learning trajectory and how collaboration and course components shape their engagement, belonging, and engineering identity. Together, these instruments provide broader quantitative data on students' engagement and learning practices through the survey, while also offering complementary qualitative insight into students' interpretations of challenge, support, and collaboration through the Engineering Growth Map activity.

The Engineering Milestone survey, administered at the end of the course, is designed as a complementary end-of-semester instrument that mirrors the structure and constructs of the Blueprint of You survey, supporting pre–post comparison of engagement, belonging, and engineering identity across the semester. When examined alongside course performance data, these measures will enable exploratory analysis of how students' self-reported experiences align with course performance outcomes. To account for known limitations of pre–post designs (e.g., response shift and sensitization), the study incorporates multiple data sources to support triangulation. Initial implementation of the data collection instruments during the spring and fall 2025 course offerings demonstrated practical implementation of the coordinated surveys and structured reflection activity and informed instrument refinement and planned expansion to larger cohorts of students.

Expected Significance

This work is expected to have broader impact by providing research-informed approaches and tools for understanding students' engagement, sense of belonging, and engineering identity within large-enrollment foundational engineering courses. Over time, insights from this research will support more informed interpretation of students' social and motivational experiences in courses where scale often limits visibility into how students experience participation and learning. By examining these constructs together in the context of a collaboratively structured Statics course, the study offers a lens for considering how engagement, belonging, and identity develop through interaction with peers, instructional structures, and engineering practices. The coordinated instruments introduced in this work offer a practical, scalable infrastructure that can be adapted across courses and institutions to support continued research.

Conclusions & Future Work

This work-in-progress presents a mixed-methods design for examining student engagement, sense of belonging, and engineering identity within a redesigned, large-enrollment Statics course. By integrating a coordinated sequence of surveys, a reflection activity, and course performance data, this study establishes a methodological foundation for capturing both patterns across students and contextualized insight into student experiences. Expansion to larger cohorts of students will support larger-scale quantitative analyses, examination of internal consistency, and further refinement of the data collection instruments. This ongoing work aims to strengthen understanding of how to support student engagement, belonging, and engineering identity growth in large-enrollment, early engineering courses.

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References

[1] B. D. Coller, "An experiment in hands-on learning in engineering mechanics: Statics," *Int. J. Eng. Educ.*, vol. 24, no. 3, pp. 545–557, 2008.

[2] P. S. Steif and A. Dollár, "A new approach to teaching and learning statics," in *Proc. ASEE Annu. Conf.*, 2005.

[3] R. A. Streveler, T. A. Litzinger, R. L. Miller, and P. S. Steif, "Learning conceptual knowledge in the engineering sciences: Overview and future research directions," *J. Eng. Educ.*, vol. 97, no. 3, pp. 279–294, 2008.

[4] C. Goodenow, "Classroom belonging among early adolescent students: Relationships to motivation and achievement," *J. Early Adolescence*, vol. 13, no. 1, pp. 21–43, 1993.

[5] T. L. Strayhorn, *College Students' Sense of Belonging: A Key to Educational Success for All Students*, 2nd ed. New York, NY, USA: Routledge, 2018.

[6] G. M. Walton and G. L. Cohen, "A question of belonging: Race, social fit, and achievement," *J. Pers. Soc. Psychol.*, vol. 92, no. 1, pp. 82–96, 2007.

[7] A. Godwin, "The development of a measure of engineering identity," in *Proc. ASEE Annu. Conf.*, 2016.

[8] M. Prince, "Does active learning work? A review of the research," *J. Eng. Educ.*, vol. 93, no. 3, pp. 223–231, 2004.

[9] M. Prince and R. M. Felder, "Inductive teaching and learning methods: Definitions, comparisons, and research bases," *J. Eng. Educ.*, vol. 95, no. 2, pp. 123–138, 2006.

[10] E. L. Deci and R. M. Ryan, *Intrinsic Motivation and Self-Determination in Human Behavior*. New York, NY, USA: Plenum, 1985.

[11] R. M. Ryan and E. L. Deci, *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. New York, NY, USA: Guilford Press, 2017.

[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, 2007.

[13] C. Wang, Y. Zhang, J. D. Moss, E. M. Bonem, and C. Levesque-Bristol, "Multilevel factors affecting college students' perceived knowledge transferability: From the perspective of self-determination theory," *Res. Higher Educ.*, vol. 61, no. 8, pp. 1002–1026, 2020.

[14] M. T. H. Chi and R. Wylie, "The ICAP framework: Linking cognitive engagement to active learning outcomes," *Educ. Psychol.*, vol. 49, no. 4, pp. 219–243, 2014.

[15] 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," *J. STEM Educ. Res.*, vol. 7, no. 1, pp. 155–180, 2024.

[16] S. D. Museus and S. J. Quaye, "Toward an intercultural perspective of racial and ethnic minority college student persistence," *Rev. Higher Educ.*, vol. 33, no. 1, pp. 67–94, 2009.

[17] Z. Hazari, G. Sonnert, P. M. Sadler, and M.-C. Shanahan, "Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice," *J. Res. Sci. Teach.*, vol. 47, no. 8, pp. 978–1003, 2010.

[18] K. A. Bollen and R. H. Hoyle, "Perceived cohesion: A conceptual and empirical examination," *Social Forces*, vol. 69, no. 2, pp. 479–504, 1990.