

# Communicating for Belonging in First-Year Engineering

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***Abstract - Engineering classrooms, norms, and the stereotypes about who becomes an engineer all communicate implicit, and sometimes explicit messages about who belongs. This research focuses on an ecological belonging intervention, customized to the institutional and course context, to create an environment within introductory engineering courses to support student belonging, particularly for Black, Latino/a/x, and Indigenous (BLI) students. This intervention normalizes discussions of adversity, struggle, and resolution within engineering courses through stories from prior students who have successfully completed the course. This brief paper describes the process of developing the customized intervention messages through focus groups and the training of faculty to support inclusive messaging to students within the classroom to combat the issues of stereotype threat and social belonging. Preliminary results show that treatment BLI students did not have a belonging decrease compared to their control peers, and that this belonging was comparable to White and Asian students in both treatment and control groups. Additionally, the intervention minimized the academic performance equity gap on individual assignments in the course.***

***Index Terms – Ecological belonging intervention, Focus groups, First-year engineering, Faculty training.***

## INTRODUCTION

Engineering is plagued by persistent underrepresentation of women and Black, Latino/a/x, and Indigenous (BLI) students and professionals [1]. One persistent area of inequity is in introductory engineering courses. Often, these courses demonstrate equity gaps in student academic performance by gender, race/ethnicity, or first-generation college student status, and the intersections of these identities can exacerbate disparate impacts of the

STEM curriculum on students' academic success and career pathways [2].

The research described in this brief paper starts with the premise that these inequitable outcomes are due to the structures and sociocultural context of engineering rather than the students (e.g., an asset-based approach). In examining the engineering context, we hypothesize that there are two key psychosocial mechanisms that are driving inequity: 1) social belonging, and 2) stereotype threat. The research team, the UBelong Collaborative, has developed a customizable ecological belonging intervention to address these two psychosocial mechanisms through stories [3]. This intervention uses stories as the central communication tool to convey the message that struggle is normal and surmountable to address social belonging and stereotype threat.

Stories are a powerful tool for communication and provide an opportunity for reflection and engagement [4]. They are humanity's oldest form of communication [5]. Using prior students' descriptions provides a contextualized and authentic framing of struggle that has the potential for students to "see themselves" within the storyline [6]. This work describes the process of developing these stories in an ecological belonging intervention in a first-year engineering course and training faculty to support the core message embedded in the intervention. Prior work has investigated the outcomes of similar interventions [3], [7], but little attention has been given to process of developing effective stories for belonging to shape the classroom ecology.

## THEORY OF ACTION

The theory of action that guides this work is guided by theory on social belonging and stereotype threat. Social belonging, "a sense of having positive relations with others" refers to feelings of being accepted, supported, connected, and is often negatively impacted by the experience of being one of a few in a particular context [8, p.

1447]. In engineering, BLI students also face racial stereotypes implying that they are less competent in subjects and skills pertinent to engineering, which in turn, can undermine their academic success and reduce their persistence in STEM fields [1], [9]–[12]. Together, these systemic issues contribute to higher cognitive burden and additional stress, which in turn, can lead to decreased academic performance.

## METHODS

We use a one-time classroom ecological-belonging intervention approach [3]. The intervention was developed from prior social belonging interventions [13], [14] and is designed to normalize struggle and to assist students in seeing that adversity is normal and surmountable. Rather than being delivered in a laboratory (divorced from the everyday classroom context), the intervention is delivered in a class in which there are demographic disparities in performance and “threats in the air” in which stereotype threat is likely activated [15]. Students work with their peers during the intervention. Thus, the intervention targets the belonging ecology of the classroom.

The intervention involves a discussion of struggle during a class period at the beginning of the semester. We hypothesize that this timing supports students’ internalization of the core intervention message that struggle is normal and surmountable to buffer against negative stereotypes and belonging threats. One of the key parts of the intervention is sharing stories from prior students about common struggles in the course, actions taken, and the psychological resolution.

### I. Study Context

This study was conducted at a large, Midwest public R1 institution. Students interested in pursuing engineering degrees are admitted generally to the first-year engineering program and after a year of common science, mathematics, and engineering courses, they select and matriculate into one of 16 engineering degree programs. The institution was predominately white (54%), and BLI students made up 7% of the engineering undergraduate engineering enrollment along with 16% Asian American, 4% multiracial, and 18% international students [16]. The project identified a required first-year engineering course focused on programming and data science skills with an average equity gap for BLI students of 0.44 GPA points on a 4.0 scale.

### II. Story Development

The stories used for this research were developed through focus groups with students. Focus groups were typically 4–6 students who had previously taken the course. Stratified sampling was used to create focus groups by gender and racial/ethnicity groupings. The focus groups were designed to have students discuss and share the

personal challenges they faced during the course and how they addressed the challenges and personally overcame them. For a fuller discussion of the story development process, see [17]. Using dialogic and arts-based methods, including the development of a journey map [18], [19] to represent their college experience, students moved from discussing challenges as complaints about the course to reframing challenges as experience from which they grew and developed.

After the focus groups, the stories were customized to target common experiences of struggle based on themes that emerged during the focus groups. Study team members with expertise on the course are involved in this process and faculty who teach the course may be consulted. The focus group artifacts and recorded audio were used to construct stories using students’ in vivo words for authenticity. All stories follow an arc from struggle to action used to address and overcome struggle, to reframing and psychological resolution.

### III. Developed Stories

A total of five stories were developed for this work around the themes of time management, teamwork on projects, unfamiliarity with programming, lack of motivation, and low scores on assessment. The unfamiliarity with programming story is provided as an example:

If you don’t know anything about coding—like me—you’re probably feeling like you did something wrong. You didn’t. The class is just tough sometimes. And that’s okay! You’re more than capable to get through this. Stack exchange is your friend. Don’t be afraid to ask other groups for help, and never think you’re not good enough. Have faith in yourself and your teammates. Learn to rely on yourself sometimes, but you gotta have a support system, both academically but more importantly emotionally. You got this! Signed, a fellow engineering idiot.

### IV. Pilot Study

A pilot study of the intervention was conducted in Spring 2022 with six sections of the introductory engineering course (three control,  $n = 331$ ; three treatment,  $n = 360$ ). The intervention was led by one research team member. Students’ sense of belonging was measured prior to the intervention and at the end of the semester. Full grade data and admissions records were also gathered. Changes in participants’ sense of belonging (3-item, 5-point Likert scale,  $\alpha = 0.82$ ) and grades (passing/failing) were compared across experimental groups (students who received the intervention and those who did not) and across race/ethnicity (BLI,  $n = 52$ , and White/Asian students,  $n = 589$ ) in a 2x2x2 repeated-measures ANOVA (RM-ANOVA) and logistic regression, respectively.

## VI. Faculty Training

In Spring 2023, another intervention study is ongoing with a larger sample size of 13 sections (six control,  $n = 717$ ; seven treatment,  $n = 765$ ) across seven instructors (three control, four treatment). In addition to collecting data from a larger number of BLI students to understand the effects of the ecological belonging intervention, and to replicate the small, but promising effects from the pilot study, the research team had questions about how faculty could be trained to authentically convey the core message of the intervention that struggle is normal and surmountable. Other research studies have found that faculty mindset can dramatically affect BLI student outcomes in STEM courses [20], [21], so the team hypothesized that faculty may be a key component of the intervention success or not.

The training materials were developed as two sets of resources: 1) asynchronous videos, and 2) synchronous case-based discussion. The asynchronous videos introduced the theory behind why the ecological belonging intervention works and the details on how to prepare for and effectively run the intervention in the classroom. The synchronous discussion session was held in the week before classes started, which was the week in which the intervention was implemented. This two-hour discussion focused on “what if” scenarios that might come up in small group discussion in the course and provided an opportunity for faculty to consider and plan for possible contexts that might disrupt the integrity of the implementation. These scenarios provided a rich discussion of ways to proactively and effectively disrupt peer-to-peer behaviors that might undermine the efficacy of the intervention and align faculty actions and behaviors with the message being communicated through student stories in the intervention.

### IN-PROGRESS RESULTS

#### I. Pilot Results

The results from the pilot study indicate that BLI and White/Asian students entered the semester with similar belonging scores, and that BLI students in the control group experienced a small, but statistically significant decrease in belonging over the semester compared to BLI students in the treatment group with small effect sizes even with very low power. This result indicates that the ecological belonging intervention is likely acting as a buffering effect against stereotype threat and social belonging uncertainty. Additionally, for BLI students in the treatment group, the odds of a passing grade on individual programming assignments increased by 80% (grades on average were 0.25 GPA points higher than the control group), while White/Asian students’ grades were similar across control and treatment groups. This result indicates that the ecological belonging intervention was effective in closing some of the academic equity gap in the

course. For a full discussion of this pilot study and results, refer to ref. [22].

#### II. Promising Faculty Training Outcomes

Data collection efforts with faculty for the Spring 2023 intervention are ongoing. Data collection includes pre- and post-semester surveys and interviews, for a discussion of the faculty training and results from the pre survey, refer to [23]. During the initial interview after implementation, all faculty reported that the intervention implementation went smoothly, although based on their own comfort levels some shared that they were nervous in sharing their own personal story of struggle within the intervention. All the implementing faculty also reported that the intervention is something they could see themselves implementing in the course in the future. Additionally, some of the faculty reported that they saw marked positive changes in the ways that students interacted with one another in the classroom and with them inside and outside the classroom, which they attributed to an increased sense of trust and belonging in the classroom. A couple of faculty reported that the intervention changed their understanding of and closeness with their students in ways that they were a beneficial to not only their own wellness as faculty, but to the potential for them to increase student thriving in their classrooms.

Faculty also had suggestions on ways to improve the logistics of the intervention implementation (e.g., reminder emails of upcoming events in addition to a detailed schedule), and some shared suggestions for how to include the intervention as part of the regular curricula for the course or to spread the intervention to other engineering courses, including course in the engineering disciplines.

### FUTURE WORK

This research is ongoing and future work will examine the effects of the second implementation of the ecological belonging intervention in this first-year engineering course to promote equity through stories. The larger effort is focused on institutional transformation. As these results provide insight into how the intervention can be effectively customized and delivered, the intervention will become a part of the course curriculum and be expanded to other disciplinary engineering courses in the second year with equity gaps. This future work will provide evidence-based ways to understand how the intervention provides ways to communicate through stories and shape and reshape course environments for equity.

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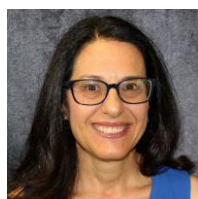
## REFERENCES

- [1] G. Lichtenstein, H. L. Chen, K. A. Smith, and T. A. Maldonado, "Retention and persistence of women and minorities along the engineering pathway in the United States," in *Cambridge Handbook of Engineering Education Research*, 1st ed., A. Johri and B. M. Olds, Eds. Cambridge University Press, 2014, pp. 311–334.
- [2] R. L. Matz *et al.*, "Patterns of Gendered Performance Differences in Large Introductory Courses at Five Research Universities," *AERA Open*, vol. 3, no. 4, p. 233285841774375, 2017.
- [3] K. R. Binning *et al.*, "Changing social contexts to foster equity in college science courses: An ecological-belonging intervention," *Psychol. Sci.*, vol. 31, no. 9, pp. 1059–1070, 2020.
- [4] R. T. Barker and K. Gower, "Strategic application of storytelling in organizations: Toward effective communication in a diverse world," *J. Bus. Commun.*, vol. 47, no. 3, pp. 295–312, 2010.
- [5] F. Polletta, P. C. B. Chen, B. G. Gardner, and A. Motes, "The sociology of storytelling," *Annu. Rev. Sociol.*, vol. 37, no. 1, pp. 109–130, 2011.
- [6] P. J. Lewis, "Storytelling as research/research as storytelling," *Qual. Inq.*, vol. 17, no. 6, pp. 505–510, 2011.
- [7] S. P. Hammarlund, C. Scott, K. R. Binning, and S. Cotner, "Context matters: How an ecological-belonging intervention can reduce inequities in STEM," *BioScience*, vol. 72, no. 4, pp. 387–396, 2022.
- [8] G. M. Walton and G. L. Cohen, "A brief social-belonging intervention improves academic and health outcomes of minority students," *Science*, vol. 331, no. 6023, pp. 1447–1451, 2011.
- [9] M. A. Beasley and M. J. Fischer, "Why they leave: the impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors," *Soc. Psychol. Educ.*, vol. 15, no. 4, pp. 427–448, 2012.
- [10] E. Seymour and A. Hunter, Eds., *Talking about leaving revisited: Persistence, relocation, and loss in undergraduate STEM education*. Cham: Springer International Publishing, 2019. doi: 10.1007/978-3-030-25304-2.
- [11] T. L. Strayhorn, L. Long, J. Kitchen, M. Williams, and M. Stentz, "Academic and Social Barriers to Black and Latino Male Collegians' Success in Engineering and Related STEM Fields," in *2013 ASEE Annual Conference & Exposition Proceedings*, Atlanta, GA, 2013, p. 23.132.1-23.132.14.
- [12] E. O. McGee, *Black, brown, bruised: how racialized STEM education stifles innovation*. Cambridge, Massachusetts: Harvard Education Press, 2020.
- [13] 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.
- [14] G. M. Walton, C. Logel, J. M. Peach, S. J. Spencer, and M. P. Zanna, "Two brief interventions to mitigate a 'chilly climate' transform women's experience, relationships, and achievement in engineering.," *J. Educ. Psychol.*, vol. 107, no. 2, pp. 468–485, 2015.
- [15] M. Inzlicht and T. Schmader, *Stereotype threat: Theory, process, and application*. Oxford University Press, 2011. doi: 10.1093/acprof:oso/9780199732449.001.0001.
- [16] American Society for Engineering Education, *Profiles of engineering and engineering technology*. <https://shinyapps.asee.org/apps/Profiles/> (accessed Mar. 13, 2023).
- [17] L. DeAngelo *et al.*, "Course-based adaptations of an ecological belonging intervention to transform engineering representation at scale," In *American Society for Engineering Education Annual Conference & Exposition*, Minneapolis, MN, 2022.
- [18] A. Brialias, "Using drawings in qualitative interviews: An introduction to the practice," *Qual. Rep.*, vol. 25, no. 12, pp. 4447–4460, 2020.
- [19] S. A. Annamma, "Disrupting cartographies of inequity: Education journey mapping as a qualitative methodology," in *Critical race spatial analysis: Mapping to understand and address educational inequity*, Stylus Publishing, LLC, 2017, pp. 35–50.
- [20] E. A. Canning, E. Ozier, H. E. Williams, R. AlRasheed, and M. C. Murphy, "Professors Who Signal a Fixed Mindset About Ability Undermine Women's Performance in STEM," *Soc. Psychol. Personal. Sci.*, vol. 13, no. 5, pp. 927–937, 2022.
- [21] E. A. Canning, K. Muenks, D. J. Green, and M. C. Murphy, "STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes," *Sci. Adv.*, vol. 5, no. 2, p. eaau4734, 2019.
- [22] A. Godwin *et al.*, "Belonging in engineering for black, latinx, and indigenous students: promising results from an educational intervention," Paper presented at *American Educational Research Association Annual Meeting*, Chicago, IL, Apr. 2023.
- [23] L. DeAngelo *et al.*, "The process of building faculty buy-in for course-based adaptations of an ecological belonging intervention to transform engineering representation at scale," In *American Society for Engineering Education Annual Conference & Exposition*, Baltimore MD, June 2023.

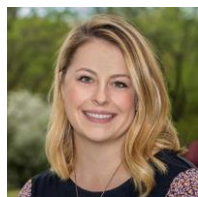
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