Journal for STEM Education Research
https://doi.org/10.1007/s41979-020-00041-z

RESEARCH ARTICLE

Limited Support for Use of a Social-Belonging Intervention with First-Year Engineering Students

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Published online: 23 July 2020

Abstract

First-year STEM students often interpret academic challenges as diagnostic of belonging. Studies demonstrate that a social-belonging intervention helps undergraduates reframe belonging uncertainty as temporary and universal. We implemented this intervention with first-year engineering majors. In Study 1 ($N = 284$), we analyzed data from engineering mathematics students. Underrepresented students in the belonging intervention reported increased belonging over the semester but did not report significantly higher belonging post-intervention than peers in a control condition. The intervention did not impact achievement. In Study 2 ($N = 87$), we analyzed data from pre-calculus mathematics students, not replicating the intervention findings of Study 1. In both studies, perceived belonging at beginning-of-semester was positively associated with engineering mathematics grades at semester's end. In Study 2, use of campus supports mediated the relationship between belonging and achievement over students' first semester. These findings demonstrate a relationship between perceived belonging and gateway engineering course outcomes but limited support for a social-belonging intervention.

Keywords Belonging · Engineering education · Mathematics · Social-psychological intervention · Underrepresented students

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s41979-020-00041-z) contains supplementary material, which is available to authorized users.

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Introduction

The college transition can be daunting even to the most prepared, qualified, and capable students. For many, college means encountering more challenging coursework, receiving poorer grades, and learning from new instructors and with unfamiliar classmates. These circumstances can rattle students who worry about fitting into this social and academic environment. Research demonstrates that these students may interpret daily adversities as indicating they do not belong (Walton and Cohen 2007, 2011).

Social belonging, a feeling of acceptance and membership in a group (Good et al. 2012), is associated with success in college (Weaver et al. 2016). Indeed, the need for relatedness is a fundamental human motivation (Baumeister and Leary 1995; Ryan and Deci 2000; Walton et al. 2012). *Belonging uncertainty* occurs when students feel insecure about the quality of social bonds in an academic or professional setting (Walton and Cohen 2007). Historically disadvantaged minorities (Walton and Cohen 2011; Yeager et al. 2016), first-generation college students (Harackiewicz et al. 2014), and women in male-dominated engineering majors (Walton et al. 2015) are particularly susceptible to belonging uncertainty in college. These worries can interfere with success in college, leading to lowered grade point average (Walton and Cohen 2011; Walton et al. 2015), decreased engagement (Wilson et al. 2015), and decreased enrollment (Yeager et al. 2016).

Our research investigates the impact of a brief social-psychological intervention on students' perceptions of belonging and academic performance over the course of their first semester in engineering school.

Belonging Uncertainty Impacts STEM Undergraduates' Engagement and Perceptions

A sense of belonging can be felt for a specific domain, such as computer science (Cheryan et al. 2009; Walton and Cohen 2007), mathematics (Good et al. 2012), and engineering (Walton et al. 2015). Belonging uncertainty may be particularly salient for students in science, technology, engineering, and mathematics (STEM) fields. A sense of belonging is associated with patterns of behavioral and emotional engagement among STEM undergraduates (Wilson et al. 2015). Feelings of acceptance and fit in STEM classes have been found to be directly related to self-reported effort and participation in these classes and inversely related to feelings of discouragement or worry about academic performance (Wilson et al. 2015).

STEM bachelor's programs in the United States have retention rates between 50 and 60%; about half of these students switch majors to non-STEM disciplines, and the other half drop out of college—a rate comparable to that of other fields (Chen 2013). This pattern is present at our university as well. However, there is national interest in increasing the graduation rate of STEM majors to meet the needs of the workforce – in America and abroad (e.g., The Netherlands; Van den Hurk et al. 2019). The President's Council of Advisors on Science and Technology found that approximately one million more graduates with STEM degrees than are currently expected to be produced will be required to meet the nation's need for STEM professionals (President's Council of Advisors on Science and Technology (PCAST 2012). The PCAST executive report notes that reaching the "underrepresented majority"—women and members of minority groups who do not receive a proportionate number of STEM degrees—is critical for increasing the STEM workforce. One recommendation is to improve the undergraduate experience during students' first two years, when introductory-level courses deter students from continuing in their STEM majors (President's Council of Advisors on Science and Technology [PCAST] 2012). Of particular note are the challenges of first-year engineering mathematics classes, for which many students are academically underprepared (Eagan et al. 2011; Hieb et al. 2014).

There are differences at the national level among students who persist in STEM fields. According to the National Center for Education Statistics (NCES) 2016–2017 data, undergraduate institutions conferred bachelor's degrees in STEM fields to U.S. citizens and permanent residents who identified as White (63.5%), as Asian or Pacific Islander (13.8%), as Hispanic (11.6%), as Black (7%), as multi-racial (3.8%), and as American Indian or Alaska Native (.4%; U.S. Department of Education n.d.).[1] Rates of attrition from STEM are higher for students who are female, first-generation college students, or from underrepresented minority groups or low-income backgrounds (Griffith 2010; Kokkelenberg and Sinha 2010; Shaw and Barbuti 2010). Women and students from minority groups are also initially underrepresented in engineering undergraduate programs (National Science Foundation [NSF] 2019), likely due to difficulty recruiting them (Tyson 2011). In 2014, Black and African American students earned 3.83% of the degrees awarded in engineering; Hispanic students earned 9.56%, and Native American or Alaska Native students about 1%. These rates contrast with the rates of representation in the young adult population of the United States (14% Black and 22% Hispanic; NSF 2019).

When students perceive that their group is underrepresented in their major of choice, they may interpret this perception to mean that they do not belong or have a reduced likelihood of success (Good et al. 2012). Underrepresented minority students in engineering may experience more doubt about belonging in their classes than their white classmates (Harackiewicz et al. 2014; Hurtado et al. 2007; Jordan 2014). Engineering undergraduates, generally, report the perception that first-year gateway courses are intended to weed out students (Suresh 2006). President's Council of Advisors on Science and Technology (2012) cited "an unwelcoming atmosphere from faculty in STEM courses" as a reason STEM majors explained attrition from their field. Engineering departments have attempted retention initiatives, such as academic interventions, with mixed success (Hieb et al. 2014; May and Chubin 2003). Other factors, specifically social and psychological experiences, may explain some of the variance in achievement and retention in engineering. The aim of this study is to evaluate the efficacy of a social-psychological intervention on perceptions of belonging, achievement, and retention in STEM.

Social-Psychological Interventions Targeting Belonging Uncertainty

Previous research has shown that a brief social-psychological intervention can help students reframe belonging uncertainty as a passing phase that all college students face. In a seminal study, Walton and Cohen (2011) implemented an intervention promoting a message that all students worry about belonging in college, but that these feelings

[1] Race/ethnicity categories are those used in survey's data collection.

dissipate over time. First-year students randomly assigned to either a belonging-treatment or control condition came to a lab and read qualitative summaries of survey data ostensibly collected from more senior students at their college. In the belonging-treatment condition, the survey summaries demonstrated that worries about belonging were common to all students at first, regardless of gender or ethnicity, but that they lessened over time. In the control condition, the message was unrelated to belonging. Next, participants wrote a personal essay echoing the message on the basis of their own experience. Participants then recorded their essays in video format and were told these would be used with future students. This intervention led to an increase in 3-year grade point average (GPA) for African American first-year students. This effect was mediated by a change in participants' reported construal of daily adversities on campus, from personal threats to commonly-faced challenges.

In three double-blind experiments, Yeager et al. (2016) delivered a similar social-belonging intervention to more than 9500 students before they matriculated to college. The intervention improved full-time continuous enrollment for socially and economically disadvantaged students in their first year at a public university. The intervention also raised cumulative first-year GPA for disadvantaged students at a selective private university. These results were mediated by measures of social and academic integration on campus.

In addition to such large-scale evidence of the effectiveness of social-belonging interventions, Walton et al. (2015) provided evidence that these interventions can help in STEM settings. First-year engineering students ($N = 228$, 92 women) participated in a lab session held in an engineering classroom. This session was described as benefiting participants because they would learn about other students' experiences with the college transition and share their own experiences with future incoming students. The intervention materials were based off of Walton and Cohen's (2011) but revised to incorporate themes that emerged from focus groups with female engineering students, pertaining to being treated with respect and sharing similar interests with male students. Most students in the sample self-identified as White, East Asian, South Asian, or Middle Eastern, typical of the school's student body. Women in male-dominated engineering majors, defined as those undergraduate programs with fewer than 20% female students (i.e., computer, electrical, mechanical, mechatronics, nanotechnology, and software engineering), had lower GPAs on average than their male peers, if they were in a control condition. If they received the belonging intervention, women closed the GPA gap with their male classmates. No differences in GPA were found between women and men in gender-diverse majors (i.e., chemical, civil, environmental, geological, management, and systems design engineering). Social integration and reported attitudes towards academics and daily adversity improved for those in the intervention condition, compared with the control.

Mechanisms that Explain the Effect of Social-Psychological Interventions

These interventions work by subtly influencing the way students interpret their own experiences (Yeager et al. 2013). In the initial phase of the typical social-belonging intervention, participants read, view, or hear messages that they are told come from more advanced students in their academic program. These messages discuss how common it is to feel worried about fitting in at first, but that these feelings recede over time. Often, these stories are accompanied by summaries of data, which are portrayed as results from surveys of previous students about their experiences with social belonging. These summaries reflect the message that perceptions of belonging begin low but gradually increase.

An important feature of the interventions is a writing exercise that asks students to compose a letter to a future student describing the intervention message in their own words. Students are encouraged to consider aspects of their own experiences that were echoed in the survey results they read about. This step puts students in the role of communicating the message they just received, as if it were of their own creation. Moreover, writing the message for the benefit of another, future, recipient removes from the writer any potential stigma of being targeted by an intervention (Yeager et al. 2013). The content of the writing exercise is as critical as its delivery. For example, the more college women wrote about social belonging, as opposed to other topics, before taking an extremely difficult math test, the more their math scores improved (Shnabel et al. 2013).

However, like other interventions that aim to change students' beliefs, only the lowest achieving students or select minorities benefit from the intervention (Lin-Siegler et al. 2016; Schwartz et al. 2016; Yeager et al. 2016). Some argue that belonging uncertainty is activated by reminders of one's group membership when that group is stereotyped as likely to underachieve (i.e., stereotype threat; Steele and Aronson 1995). Heightened attention to one's minority status would therefore make students from underrepresented groups more sensitive to the social-belonging intervention (Shnabel et al. 2013; Stephens et al. 2014).

Current Studies

To evaluate persistence in STEM, a relevant theoretical model proposes that interventions should consider the impact of malleable student characteristics on educational outcomes (Van den Hurk et al. 2019). We implemented a social-belonging intervention with first-year engineering students, compared to an active control condition, to examine the impact on perceived belonging, course achievement, and retention in the engineering major. Previous work with this population has demonstrated a significant positive relationship between engineering students' perceived social belonging and first-year calculus course grades (Weaver et al. 2016). In the current studies, we implemented the social belonging intervention shown in prior studies to reduce belonging uncertainty and increase college GPA (Walton and Cohen 2011; Walton et al. 2015; Yeager et al. 2016) and full-time continuous enrollment (Yeager et al. 2016) among historically disadvantaged students. Unlike the only other published intervention with first-year engineering students, a lab-based study (Walton et al. 2015), our participants took part in the study as part of their regular classroom instruction in the required introductory course to the engineering major. Therefore, our sample was likely more representative of first-year engineering students than previous studies.

Context

Our research also differed from previous studies by examining course performance in the school's gateway engineering mathematics course, in addition to overall university grades and enrollment status. This course is a comprehensive and thorough calculus course for engineering majors. The semester is divided into 13 units, and students have a unit exam roughly each week. Performance is graded on a predefined scale with a larger C range than A, B or D, but the scale may be adjusted slightly (always downward) to accommodate test variance. Performance determines progression in the engineering major as this is the first course in a four-course required sequence. Many students find the pace and rigor of the course very different from and more challenging than their high school mathematics courses. Some find it difficult to accept a C grade on a test and become discouraged, despite faculty assuring them that this is normal, and a very solid grade. Thus, performance in this course may present students with a particularly salient message about whether they belong in engineering. Learning environments like this may have a disproportionate negative influence on underrepresented students (Hurtado et al. 2007).

The version of the course taken by the majority of first-year students accepted to the engineering school, *Engineering Analysis I*, is a calculus course designed for engineering students. The school of engineering also offers another first course, *Introductory Calculus for Engineers (Intro Calculus),* for students who are accepted into engineering, but whose algebra and other pre-calculus skills need additional reinforcement before proceeding to *Engineering Analysis I*. *Intro Calculus* is taken by students who score below a 27 on their Math-ACT or who perform poorly on the first two exams in *Engineering Analysis I*. *Intro Calculus* is primarily a pre-calculus course and will be referred to as such in the rest of this paper.

Course Differences

Study 1 examined the impact of a social-belonging intervention on students in *Engineering Analysis I*. Study 2 examined the impact of the intervention on students in *Intro Calculus.* All students, across both studies, participated in the social-belonging intervention during the same semester as part of a separate course, *Introduction to Engineering*. We examined the impact of the social-belonging intervention separately for students in *Engineering Analysis I* and *Intro Calculus*, because of several key differences between the samples. First, each of the courses consisted of a different proportion of students who might be considered underrepresented students. Underrepresented students comprised approximately 23% of the *Engineering Analysis I* group and 34% of the *Intro Calculus* group. Moreover, all the students in *Intro Calculus* can be characterized as at greater risk of dropping out of the engineering major, based on previous data (Bego et al. 2019; Hieb et al. 2014). These students begin less academically prepared and one semester behind in their coursework.

Second, the exam performance outcome variable was different in the two courses, as content (i.e., calculus versus pre-calculus) and grading procedures were not equivalent. Finally, the instructional method between the courses was different. *Engineering Analysis I* was taught in a traditional, large-lecture format. *Intro Calculus* was taught using active learning methods (i.e., the Emporium Model), including collaborative learning and a flipped classroom, making class time an opportunity for students to problem-solve in groups (The National Center for Academic Transformation 2013). Collaborative learning is associated with increased feelings of belonging (Johnson et al. 2014) and increased academic achievement (Springer et al. 1999; Weaver et al. 2016).

Thus, the instructional setting, as well as other course differences, may have a different impact in conjunction with the belonging intervention between the two courses. By examining the impact of the belonging intervention in these two courses separately, we are better able to determine whether the intervention has a differential impact on underrepresented students who are on track (Study 1) versus those who are a semester behind (Study 2), learning calculus (Study 1) versus pre-calculus (Study 2), and in a traditional lecture class (Study 1) versus active learning-based course (Study 2).

Research Questions

Prior research has demonstrated that student perceptions of belonging are directly related to achievement in both the regular and pre-calculus engineering mathematics courses (Weaver et al. 2016). However, the causal direction of this relationship has not been established—students may obtain better course achievement due to greater perceptions of belonging or perceive greater belonging due to better course achievement. In the current studies, we examined whether a short experimental intervention presented early in the first semester of engineering school helps increase underrepresented students' perceptions of belonging.

We focused on three key research questions:

1. Will underrepresented students in the belonging group report higher perceived belonging at the end of the semester compared to underrepresented students in the control group?
2. Will underrepresented students in the belonging condition obtain higher course exam scores, GPA, and retention rate compared to underrepresented students in the control condition?
3. Will students in the belonging condition report greater use of campus supports over the course of the semester, as compared to the control group?

Based on previous belonging intervention studies (e.g., Walton et al. 2015), we hypothesized that underrepresented students in both the belonging and control groups would report lower belonging at the beginning of the semester relative to majority students. We predicted that underrepresented students in the belonging intervention would exceed those in the control group in belonging and achievement at the end of the semester.

We also analyzed students' use of campus supports, to help clarify the relationship between social belonging and academic achievement over the first year in college. Previous research has identified the prosocial behaviors of students on campus as an important mechanism in their academic success (Walton and Cohen 2011; Yeager et al. 2016), and this finding is supported by Student Involvement Theory (Astin 1999). At the end of the semester, we asked students to identify their use of academic support services from a list of five choices. We predicted that students in the belonging condition would be more motivated to seek help when needed, contributing to a greater use of campus supports when compared to students in the control group.

Study 1

Method

Participants

Approval for this study was received from the ethical review board at the university where it was conducted. A statement on the course syllabus for the required *Introduction to Engineering* course informed enrolled students that their course information could be used for research purposes, and that they could contact the study director to remove their information at any time. They also received a debriefing letter at the conclusion of the study. Participants ($N = 284$; 74% of students enrolled in the course, 13% female) were full-time first-year students at a large, urban, public university in the U.S. Midwest. Participants were included in the study if they had ACT or SAT scores available, completed both pre- and post-intervention surveys, the intervention, and the final exam in the engineering school's gateway mathematics course, *Engineering Analysis I. Engineering Analysis I* is the first course in the math sequence for students accepted to the engineering major and is a calculus class designed for engineering students.[2] Two additional participants were excluded when the students dropped the course and their data was deleted from the learning management system.

Materials

Intervention

Participants were randomly assigned to the belonging intervention ($n = 141$) or control condition ($n = 143$) using the groups function in Blackboard, which has the option to randomly assign individuals to groups and show them different materials online. These conditions have been described in detail by Walton et al. (2015) and Yeager et al. (2016). Our intervention was closely adapted from these studies with slight modifications for our sample to create a context that was specific to engineering school. These modifications included using photographs of students at the engineering school alongside the text (including both underrepresented and majority group students), changing the name of the school to our own, and referring to specific places on our campus. Our presentation of the stories also differed from Walton and colleagues in that we delivered them visually, instead of presenting the messages by audio-recording in conjunction with the visual aid.

As in the previous studies, each condition was described as a College Transition Assignment, containing three parts (see Supplemental Material). The first part summarized results from a survey that students were told had been taken by juniors and seniors. A sample statement from the belonging condition was: "Most upperclassmen reported that, during their freshman year, they 'sometimes' or 'frequently' felt intimidated by professors." Next, students viewed a slideshow of quotations said to be

[2] Preliminary analyses examined whether the belonging intervention reduced the number of students who dropped from *Engineering Analysis I* to the pre-calculus version after the first two course exams. No effects of condition were found.

"illustrative of the major findings of the survey." The six slides in the belonging condition included stories from junior and senior students about how their worries about belonging subsided over time, coupled with photographs of students involved in various scenarios around the engineering campus. In one slide from the belonging condition, students read:

> I always had really small, close-knit classrooms in high school, and I really appreciated that. My first calculus class at Speed School was a huge contrast. It was in a huge lecture hall, and to be honest, I felt a lot like a number at first. It took me a long time to get used to it, and to realize that just because there were a lot of people in the class, it didn't mean that my professor and TAs cared any less about me. Once I figured this out, I started to take a lot more initiative in talking with my classmates and meeting with my TAs. When I made the effort, I found that people really were invested in me and in my doing well. After a while, I got involved in an exciting research project where I got to work more closely with my classmates. It's great to actually participate in research with a group of people.

Last, students completed a writing activity in which they were instructed to compose a personal letter to a future student. This "saying-is-believing" exercise was intended to reinforce the message from the survey and stories. Students read that excerpts of their letters would be given, anonymously, to a future student of the same program and gender as themselves, so they ought to imagine the recipient to be a student like themselves. An excerpt from the directions stated:

> In an effort to further understand how the transition to college takes place, we would like to ask you to describe why you think this would be so – that is, why students might feel initially unsure about their acceptance but ultimately overcome these fears. Please be sure to <u>illustrate your essay with examples from your own experiences</u> in classes, study groups, and recitations. Consider especially any aspects of your experience that are echoed in the survey results you read about.

The message of the control condition was focused on study skills rather than belonging, but the format was identical: students read a survey summary, viewed nine slides of stories from students ahead of them in the program (total word count was equivalent between the two conditions), and wrote a letter to a future student. A sample survey summary statement from the control condition was: "Most upperclassmen reported that, during their freshman year, they: "sometimes" or "frequently" felt overwhelmed by the workload." An example story from the control condition read:

> There can be a lot of work in college, especially in engineering. When I got to campus, I realized I didn't know how to study properly. I signed up for a Student Success seminar through [campus tutoring center]. The best suggestion they had was to review your lecture notes at the end of each day. That helps you learn them, and then you can tell if there is something you missed, or something you don't understand, and you can ask about it. I'm glad I took the time to do that.

An excerpt of the directions for the letter to a student stated:

> In an effort to further understand how the transition to college takes place, we would like to ask you to describe why you think this would be so – that is, why students might feel initially that they cannot keep up with their work but ultimately learn to be savvier students. Please be sure to illustrate your essay with examples from your own experiences in classes, study groups, and recitations. Consider especially any aspects of your experience that are echoed in the survey results you read about.

Pre- and Post-Surveys

Prospective belonging uncertainty was measured with the four-item Prospective Belonging Uncertainty scale (Walton and Cohen 2011; sample Cronbach's α: pre-survey = .86, post-survey = .84). This scale assesses students' perceptions of belonging in college. A sample item reads, "When I face difficulties in college, I wonder if I will really fit in" (see Appendix). Each item was answered on a five-point Likert scale (*Not at all true* = 1 to *Completely true* = 5). After reverse coding one item, items were averaged to form a composite measure of belonging uncertainty. For ease of interpretation, the score was reflected so that higher scores reflect greater perceived belonging.

Demographic data was collected at the end of the pre-survey. To determine whether participants were first-generation college students, they were asked if they were the first member of their immediate family to attend college (*yes* or *no*). Students were asked to identify their gender and their race/ethnicity, choosing from the NCES list of descriptors. Students also identified the engineering field in which they planned to major.

A dummy variable to indicate historic underrepresentation in engineering undergraduate education was created (1 = *yes*; 0 = *no*). As in previous belonging intervention studies (Walton and Cohen 2011; Walton et al. 2015; Yeager et al. 2016), students were categorized as historically underrepresented (UR) if they were first-generation college students, or reported that they were Black, Hispanic, Native American, or female. Females constituted fewer than 20% of students across all engineering majors at our university; thus, all of our engineering majors are considered to be male-dominated. Table 1 shows the frequencies of UR students in our sample.

Table 1 Frequencies of Historically Underrepresented Students in Studies 1 and 2

Sociodemographic characteristic	Number (%) in Study 1 *Engineering Analysis I* (*n* = 284)	Number (%) in Study 2 *Intro Calculus* (*n* = 87)
Female	38 (13.38%)	18 (20.45%)
First-Generation[a]	25 (8.80%)	10 (11.36%)
Black, Hispanic, Native American	8 (2.82%)	9 (10.23%)
Total Underrepresented	65 (22.89%)	30 (34.09%)

Note. Numbers in each category do not add up to total because of overlap

[a] Many students did not respond to this question. Only those who affirmatively identified themselves as first in their immediate family to attend college were counted

Campus support was measured at the end of the semester by asking, "When you need help with academic, social, or life challenges, where do you seek help? Check all that apply: On-campus support offices, Professor, TA, Upperclassmen, Peers."

Procedure

Surveys

All participants completed the survey measures as part of a larger survey study administered by the department. Students completed pre- and post-surveys online during weeks 1 and 13 of the 16-week semester, as part of their regular instruction in a required first-year course for the engineering major, *Introduction to Engineering*. Students were informed that completing each survey was voluntary and were allowed to decline to participate with no penalty.

Intervention

During Week 2 of the semester, participants were randomly assigned to the belonging or control condition using the Blackboard groups function, as part of their regular instruction in their *Introduction to Engineering* course. This course introduces students to the major and profession of engineering, including content such as the various engineering disciplines, critical thinking, the design process, professionalism, ethics, diversity, communication, time management skills, team building skills, and computer applications. As such, it was deemed an appropriate context for professors to authentically communicate the belonging or control condition information. The three course instructors assigned the study materials as homework to be completed online, outside of class, at any time during a three-day window. The professors were blind to students' conditions and were not involved in the research in any other way.

The assignment was designed to take 45–60 min and timed to be given after the pre-survey and first exam in the math course. This timing was chosen so that students would have already received some information about their course performance (from an exam), which could inform their perceptions of belonging early in the course (Yeager and Walton 2011). All students were given course credit for completing the assignment and were not evaluated on their work. The researchers read and coded the intervention data. Though a manipulation check was performed, all students were included in analysis as intent to treat (Yeager et al. 2016).

Exam Average, GPA, and Retention

Fall-to-fall retention and cumulative GPA for all students who completed the surveys were obtained from the university office of Institutional Research (IR) one year after the intervention. Institutional data was de-identified by the office of IR and participants were assigned research identification numbers (RIDs). Course grades were collected at the end of the semester from the instructors. Exam average was calculated by averaging all 15 exams and substituting final exam score for the lowest exam grade, consistent with the course grading procedures. The grades were sent to the office of IR to be matched to the RIDs, anonymizing the dataset.

Results and Discussion

Preliminary Analyses

In every case where we report significance, we have used a threshold of alpha < .05, unless otherwise noted. This threshold is standard in social science and allows for the probability of a Type I error to be less than 5%, granting confidence that our results are not due to chance, but rather due to the effect of the intervention. We first examined the data for outliers and for conformity with a normal distribution. Math-ACT scores, exam average, belonging at post-survey, and social support were negatively skewed. All analyses were run with log-transformed scores and results did not differ from those computed using raw data. Therefore, results are reported using the raw data. We controlled for Math-ACT scores ($M = 29.88$, $SD = 3.10$) in all analyses, to examine findings beyond any influence of prior math performance. Means, standard deviations, and partial correlations between all variables are shown in Table 2.

Descriptive Statistics

Higher belonging ratings were weakly, positively associated with higher exam scores, using belonging ratings at both pre-survey (Pearson's $r = .14$, $p = .020$) and post-survey ($r = .25$, $p < .001$). These findings demonstrate a link between perceived belonging and course performance, consistent with previous studies (e.g., Good et al. 2012; Weaver et al. 2016). Higher belonging ratings were also significantly correlated with the number of campus supports used, at both pre-survey ($r = .17$, $p = .004$) and post-survey ($r = .23$, $p < .001$). This finding supports the idea that students who perceive greater belonging also connect to support systems in the university, such as peers, instructors, and tutoring programs.

Qualitative research with college seniors in STEM has found that students who feel they belong in STEM also tend to believe that their professors care about them (Rainey

Table 2 Partial Correlations and Means (Standard Deviations) for All Variables in Engineering Analysis I and Intro Calculus

Variable	Course	1	2	3	4
1. Exam Average	Engineering Analysis I	.72 (.13)	.14*	.25***	−.02
	Intro Calculus	.72 (.11)	.27*	.29**	.31**
2. Pre-belonging	Engineering Analysis I		3.93 (0.95)	.53***	.17**
	Intro Calculus		3.99 (1.05)	.60***	.22*
3. Post-belonging	Engineering Analysis I			4.06 (0.89)	.23***
	Intro Calculus			3.91 (1.05)	.27*
4. Campus Supports	Engineering Analysis I				2.30 (1.27)
	Intro Calculus				2.25 (1.38)

Note. Engineering Analysis I $N = 284$. Intro Calculus $N = 87$

Correlations while controlling for Math-ACT score. Means (standard deviations) are shown on the diagonal

*$p < .05$. **$p < .01$. ***$p < .001$

et al. 2019), which might make them more likely to reach out for support. Among college engineering students, relatedness (i.e., belonging) was the most important factor in fostering situational intrinsic motivation in learning in engineering courses (Trenshaw et al. 2016). Motivation to learn may also explain the pattern of help-seeking behavior we observed in our data. However, there was no relationship between exam average and use of campus supports. This finding may indicate that students who needed academic resources were not seeking them out.

These correlational analyses demonstrate a link between perceived belonging and exam performance as well as use of campus supports but cannot tell us whether belonging caused these changes. The experimental intervention targeting belonging was designed to determine the causal impact of belonging.

Intervention and Perceptions of Belonging

To examine changes in perceptions of belonging as a result of the intervention, we conducted a 2 (time of survey: pre, post) × 2 (intervention condition: belonging, control) × 2 (underrepresentation status: UR, majority) mixed-factorial ANCOVA, with time of survey as a within-subjects factor and intervention condition and underrepresentation status as between-subjects factors. There was no main effect of intervention condition, $F < 1$. A main effect was found for time of survey, $F(1, 279) = 6.29$, $p = .013$, $\eta_p^2 = .02$, with average scores increasing over the course of the semester (pre-survey $M = 3.86$, $SD = 0.95$; post-survey $M = 4.02$, $SD = 0.89$). The main effect of underrepresentation status was not significant, $F(1, 279) = 3.04$, $p = .083$, $\eta_p^2 = .01$ (UR $M = 3.76$, $SD = 0.96$; majority $M = 4.01$, $SD = 0.94$). A significant time of survey × intervention condition interaction was found, $F(1, 279) = 4.25$, $p = .040$, $\eta_p^2 = .02$. This effect was qualified by a significant interaction between time of survey, intervention condition, and underrepresentation status, $F(1, 279) = 5.73$, $p = .017$, $\eta_p^2 = .02$ (Fig. 1; all other Fs < 1).

As shown in Fig. 1, UR students in the belonging condition reported greater perceived belonging over the course of the semester (pre-survey $M = 3.56$, $SD = 1.05$, 95% CI [3.23, 3.90]; post-survey $M = 4.04$, $SD = 0.76$, 95% CI [3.72, 4.35]), *Hedges'* $g_{av} = 0.53$. Thus, we found a medium effect of the belonging intervention on changes to belonging ratings over the course of the semester for UR students (Lakens 2013). In contrast, UR students in the control group showed no increase from pre-survey ($M = 3.92$, $SD = 0.85$, 95% CI [3.60, 4.25]) to post-survey ($M = 3.84$, $SD = 1.12$, 95% CI [3.53, 4.14]), *Hedges'* $g_{av} = 0.08$. Majority groups showed no changes in belonging from pre-survey ($M = 3.98$, $SD = 0.94$, 95% CI [3.85, 4.10]) to post-survey ($M = 4.10$, $SD = 0.87$, 95% CI [3.98, 4.22]), *Hedges'* $g_{av} = 0.13$. These findings are consistent with our hypotheses, demonstrating an increase in perceived belonging for UR students in the belonging intervention condition, while ratings for the other groups remained unchanged over the course of the semester.

Also as hypothesized, at pre-survey, UR students in the control condition reported comparable belonging ratings ($M = 3.92$, $SD = 0.85$, 95% CI [3.60, 4.25]) as UR students in the belonging condition ($M = 3.56$, $SD = 1.05$, 95% CI [3.23, 3.90]), *Hedges'* $g_{av} = 0.38$. However, the UR groups also did not significantly differ at post-survey (control $M = 3.84$, $SD = 1.12$, 95% CI [3.53, 4.14]; belonging $M = 4.04$, $SD = 0.76$, 95% CI [3.72, 4.35], *Hedge's* $g_{av} = 0.21$). We had hypothesized that UR students

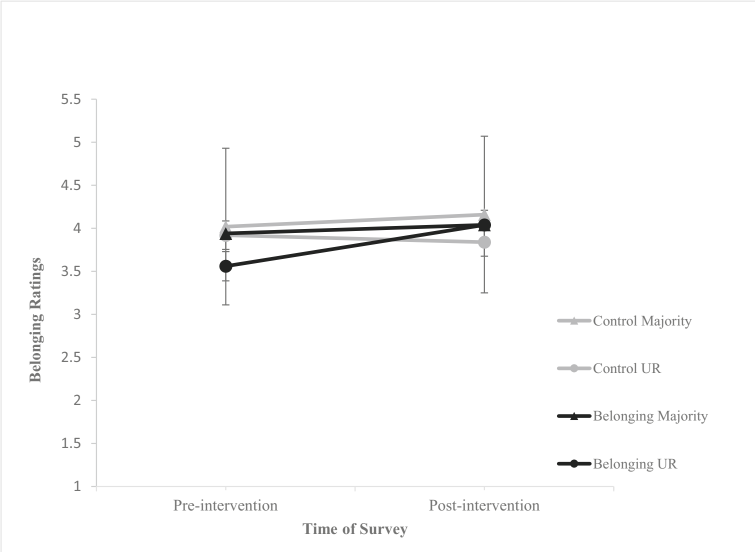

Fig. 1 *Mean Changes in Belonging as a Function of Intervention Condition and Underrepresentation Status in Study 1*
Note. $N = 284$. UR = historically underrepresented. Error bars represent standard error of the mean

in the belonging intervention would demonstrate significantly higher perceived belonging than UR students in the control condition. Also in contrast to hypotheses, UR students in the control condition did not rate their belonging as significantly lower relative to majority students at either pre-survey (UR $M = 3.92$, $SD = 0.85$, 95% CI [3.60, 4.23]; majority $M = 4.02$, $SD = 0.95$, 95% CI [3.84, 4.20]; *Hedges'* $g_{av} = 0.11$), or post-survey (UR $M = 3.84$, $SD = 1.12$, 95% CI [3.53, 4.14]; majority $M = 4.16$, $SD =$ 0.86, 95% CI [3.99, 4.33]; *Hedges'* $g_{av} = 0.32$). Similarly, UR students in the belonging condition did not rate their belonging significantly lower than majority students at pre-survey (UR $M = 3.56$, $SD = 1.05$, 95% CI [3.23, 3.90]; majority $M = 3.94$, $SD = 0.93$, 95% CI [3.76, 4.12]); *Hedges'* $g_{av} = 0.38$), or post-survey (UR $M = 4.04$, $SD = 0.76$, 95% CI [3.72, 4.53]; majority $M = 4.04$, $SD = 0.88$, 95% CI [3.88, 4.21]; *Hedges'* $g_{av} = 0.00$).

These findings limit our ability to conclude that the belonging intervention had a beneficial effect on perceived belonging. As predicted, belonging ratings for UR students in the control condition were unchanged, but they also began and ended no lower than majority students in both conditions. It remains possible that the increase in perceived belonging demonstrated by the UR students in the intervention condition was driven simply by regression to the mean, and not the intervention.

Exam Average, GPA, and Retention

We next conducted separate 2 (intervention condition) × 2 (underrepresentation status) ANCOVAs, to examine exam average and GPA. For exam average, a main effect of Math-ACT scores was found, $F(1, 279) = 34.44$, $p < .001$, $\eta_p^2 = .11$. For GPA, a main effect of Math-ACT score, $F(1, 277) = 8.87$, $p = .003$, $\eta_p^2 = .03$, and an intervention condition × underrepresentation status interaction were found, $F(1, 277) = 4.02$,

Table 3 Estimated Marginal Means for Exam Average, GPA, and Retention in Engineering by Underrepresentation Status and Condition in Engineering Analysis I and by Condition for Intro Calculus

				Exam Average			GPA[a, b]			Retention	
	Condition	Underrepresentation Status	*n*	*M*	*SD*	95% CI	*M*	*SD*	95% CI	%	*SD*
Engineering Analysis I	Control	Majority	109	.72	.13	[.70, .74]	2.95	.62	[2.83, 3.08]	83	38
		UR	34	.71	.14	[.65, .76]	3.15	.54	[2.92, 3.38]	85	36
	Belonging	Majority	110	.74	.13	[.71, .76]	3.10	.51	[2.98, 3.23]	86	35
		UR	31	.69	.15	[.64, .75]	2.93	.46	[2.70, 3.16]	84	37
Intro Calculus	Control		45	.74	.12	[.71, .77]	2.72	.38	[2.58, 2.87]	64	48
	Belonging		42	.71	.11	[.68, .74]	2.65	.46	[2.51, 2.79]	69	47

Note. CI = confidence interval. All analyses control for Math-ACT score

[a] GPA and retention data were missing for 2 students in Engineering Analysis I

[b] GPA was missing for 9 students from the Control condition and 7 from the Belonging condition in Intro Calculus

$p = .046$, $\eta_p^2 = .01$, all other Fs < 1. However, planned comparisons showed no significant simple effects. Majority students in the belonging condition had non-significantly higher GPAs one year after the intervention than majority students in the control condition, $F(1, 218) = 3.07$, $p = .083$. Similarly, UR students showed no condition differences, $F(1, 64) = 1.30$, $p = .258$ (see Table 3).

A hierarchical logistic regression analysis of retention on Math-ACT, intervention condition, and UR status was conducted to assess retention in the engineering major. Overall, 241 students were retained in engineering and 43 dropped out of school or changed their major (i.e., 85% of our sample was retained). Neither the inclusion of Math-ACT, intervention condition, nor UR status improved the model's predictive power for retention, $\chi^2(3) = 1.40$, $p = .706$, Nagelkerke $R^2 = .01$. Thus, the belonging intervention had no significant impact on any of the performance or retention outcome variables for UR students.

Campus Supports Used by Students

A 2 (intervention condition) × 2 (underrepresentation status) ANCOVA on campus supports used by students also showed no significant effects, Fs < 1. Students in the control and belonging intervention conditions did not differ in terms of the number of campus supports they reported to use in their first semester of college, nor did UR status have an effect.

Summary

In summary, these findings demonstrated that perceived belonging at both the beginning and end of the semester was positively associated with engineering mathematics course grades at the end of the semester. However, support for a causal benefit of a social-belonging intervention for UR students was limited, and only for perceived belonging. The intervention did not improve GPA or retention for UR students. In addition, UR students did not demonstrate lower perceived belonging than majority students at either the beginning or end of the semester, limiting our ability to make strong claims about the effectiveness of the belonging intervention for UR students.

Study 2

Study 2 was designed to examine the impact of the belonging intervention with a different sample of engineering students—those placed in a pre-calculus engineering calculus course before being accepted into the credit-earning track of introductory coursework. This sample consists of a greater proportion of UR students than the sample in Study 2 (see Table 1). This sample is also less academically prepared and begins the major a semester behind on their mathematics track. For these reasons, these students are at a greater risk of dropping out of the engineering major than the students in Study 1, and historically do so. Therefore, we considered the whole sample to be at-risk, and hypothesized that the belonging intervention would improve outcome measures for these students compared to the active control condition.

Method

Participants

All full-time first-year students enrolled in *Intro Calculus* who completed the course's final exam, had ACT or SAT scores available, and completed the belonging intervention or control condition and survey measures were included in analyses ($N = 87$, 60% of students enrolled in the course, 21% female).[3] Twenty to 35% of students who are accepted into the first-year class at the school of engineering each year begin in this course.

Materials and Procedure

All materials and procedures were the same as in Study 1. Participants were randomly assigned to the belonging intervention ($n = 42$) or control condition ($n = 45$). The surveys included the Prospective Belonging Uncertainty scale (sample Cronbach's α: pre-survey = .91, post-survey = .92), demographic items, and campus support item. Course grades were computed by averaging the six unit exams and counting the final exam grade twice, consistent with grading procedures outlined in the course syllabus. Students received a debriefing letter from the engineering department after the study's conclusion.

Results and Discussion

Achievement Gap between Courses

To confirm that students in *Intro Calculus* were less likely, in this cohort as in the past, to perform well or to be retained in the engineering major, we conducted a univariate ANCOVA on GPA and a hierarchical logistic regression of retention on course assignment (dummy-coded as *Intro Calculus* = 1 and *Engineering Analysis I* = 0) with Math-ACT as the covariate. The Bonferroni correction was applied to control for inflated alpha due to running multiple tests, so the alpha required to find significance in each analysis was $p < .025$. Students in *Intro Calculus* had significantly lower GPAs than students in *Engineering Analysis I*, $F(2{,}328) = 23.80$, $p < .001$, $\eta_p^2 = .07$, a medium effect (Lakens 2013). The inclusion of course assignment in the model predicting retention in engineering significantly improved prediction accuracy, $\chi^2(2) = 14.56$, $p = .001$. Even so, the proportion of variance in retention that course assignment explained was small Nagelkerke $R^2 = .06$. The odds ratio confirmed that being a student in *Intro Calculus* decreased the odds of retention, $Exp(\beta) = .42$, Wald $\chi^2(1) = 8.02$, $p = .005$. After controlling for Math-ACT, the odds of retention for those in *Intro Calculus* was 58% less than for students in *Engineering Analysis I*.

[3] Preliminary analyses examined whether the belonging intervention reduced the number of withdrawals from the course or zeros on the final exam. No effects of condition were found.

Descriptive Statistics

Means and partial correlations between all variables are shown in Table 2. We controlled for Math-ACT scores in all analyses. Perceived belonging was weakly, positively correlated with both exam average and number of campus supports used, at both pre-survey and post-survey (Pearson's $r = .29$, $p = .007$). Exam average was significantly associated with use of peers as support ($r = .22$, $p = .041$) and use of on-campus support offices ($r = .27$, $p = .012$), above and beyond the variance accounted for in these factors by Math-ACT and ratings of social belonging at pre-survey. The number of campus supports students used was significantly positively correlated with belonging at the beginning and end of the semester, as shown in Table 2. Use of campus resources was also significantly correlated with math exam average (see Table 2): more resources used was associated with higher grades. This relationship was not found in Study 1.

Perceptions of Belonging

To examine changes in belonging, we conducted a 2 (time of survey: pre, post) × 2 (intervention condition: belonging, control) mixed-factorial ANCOVA, with time of survey as a within-subjects factor and intervention condition as a between-subjects factor. No significant main effects or interactions were found, $F\text{s} < 1$. Table 4 reports mean belonging ratings at beginning and end of semester by condition.

Exam Average, GPA, and Retention

We conducted an ANCOVA to examine the effect of intervention condition on exam average in *Intro Calculus* and GPA. Math-ACT scores were significantly related to student exam average, $F(1, 84) = 5.67$, $p = .019$, $\eta_p^2 = .06$. For exam average, there was no significant effect of intervention condition, $F(2, 84) = 1.54$, $p = .219$, $\eta_p^2 = .02$. Similarly, no significant effects were found for GPA, $F\text{s} < 1$.

We conducted a hierarchical logistic regression to examine retention in the engineering major. Overall, 29 students dropped out or changed their major and 58 were retained in engineering (i.e., 67% of our sample was retained). No effect of Math-ACT or intervention condition was found, $\chi^2(2) = .642$, $p = .726$, Nagelkerke $R^2 = .01$. Thus, the belonging intervention had no significant impact on any of the performance or retention outcome variables for students in *Intro Calculus*.

Table 4 Mean Belonging Ratings at Beginning and End of Semester by Condition for Intro Calculus

		Pre-intervention belonging			Post-intervention belonging		
Condition	*n*	*M*	*SD*	95% CI	*M*	*SD*	95% CI
Control	45	3.97	1.15	[3.66, 4.28]	3.85	1.13	[3.54, 4.17]
Belonging	42	3.99	0.95	[3.67, 4.31]	4.00	0.98	[3.67, 4.33]

Note. CI = confidence interval

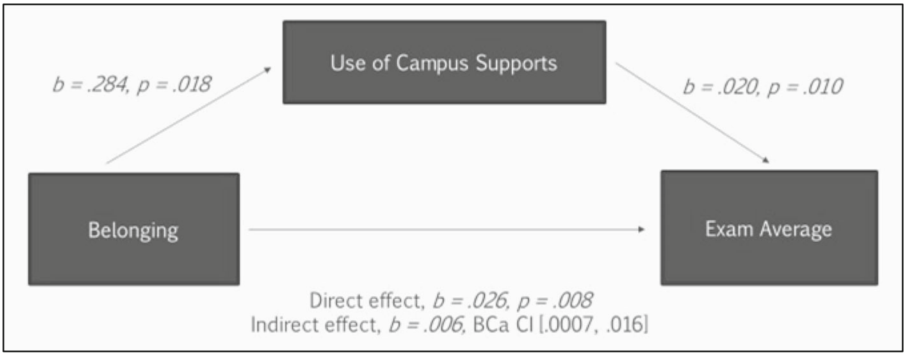

Fig. 2 *Mediation Model Examining Impact of Perceived Belonging on Exam Average in Study 2*
Note. This mediation model predicts exam average in Intro Calculus using social belonging ratings, as mediated by use of campus supports. Campus support is operationalized as the number of supports a student reported using during the first semester of their first year (0–5). All analyses control for Math-ACT scores

Use of Campus Supports as a Mediator

Although the intervention manipulation had no effect in this sample, we followed up on the significant partial correlations between perceived belonging, exam average, and use of campus supports. Based on previous research (Walton and Cohen 2011; Yeager et al. 2016), we examined whether the relationship between perceived belonging and exam performance is explained by students' use of campus supports.

In a multiple regression analysis, we found that belonging at the beginning of the semester significantly predicted achievement at the end of the semester, while controlling for math ability, accounting for 12.8% of the variance in math course grade (adj. $R^2 = .11$, $F(2, 85) = 6.23$, $p = .003$). A mediation analysis was tested in the PROCESS macro (Hayes 2012) to determine whether use of campus supports mediated the relationship between belonging and exam average. As shown in Fig. 2, we found a significant indirect effect of perceived belonging on exam average; students' use of campus supports fully mediated the relationship, $b = .006$, BCa CI [.001, .016]. Thus, perceived belonging appears to have had a beneficial effect on exam grades by increasing students' use of social supports offered on campus.

General Discussion

In two sub-samples of first-year engineering students, we did not find a significant effect of a social-belonging intervention on academic outcomes in the major's gateway or pre-calculus math courses. The gateway course is the first in the major's regular sequence of calculus courses; the other course is a pre-calculus version for students who are less prepared for the regular calculus sequence, based on Math-ACT scores or low scores on the first two exams in the gateway course. We also found no impact of the intervention on fall-to-fall retention in the engineering major. However, in Study 1, we found a significant interaction between time of survey, intervention condition, and underrepresentation status, such that perceived belonging increased for UR students in the belonging condition over the semester. A recent review of interventions aimed at preventing STEM dropout found that small effects are the norm in this research area (Van den Hurk et al. 2019). This positive result was not found in Study 2.

Research Question 1 (R1): Changes in Belonging over the Semester

The results for the belonging condition in Study 1 demonstrate some support for the use of a social-belonging intervention with UR first-year engineering students. However, these findings must be interpreted with caution. Ours was the first study that we know of that directly tested a change in perceived belonging over the course of the first semester in a STEM undergraduate program. We hypothesized that UR students in both conditions would demonstrate lower perceived belonging than majority students at the beginning of the semester, as being underrepresented might invoke negative stereotypes about their group's ability to succeed in their chosen major. However, belonging ratings for UR students did not differ from majority students, at either the beginning or end of the semester.

Thus, it remains possible that perceived belonging between UR and majority students simply was not different in this sample, even though this factor has often been theorized as a cause of difference in college achievement (e.g., Aronson et al. 2002; Murphy et al. 2007; Steele 1997). If this were the case, then the increase in perceived belonging for UR students in the belonging condition could be simply explained as a statistical artifact, such as regression to the mean. This possibility seems theoretically unlikely, given the numerous studies in the research literature demonstrating lower perceived belonging for UR students in STEM (e.g., Good et al. 2012; Jordan 2014; Walton and Cohen 2007). The ratings for UR students in the control condition may instead have simply been numerically higher at the beginning of the semester due to a failure of random assignment. Importantly, the only group to increase in perceived belonging was the UR students in the intervention condition, whereas the other three groups showed no differences from the beginning to end of the semester. This overall pattern is consistent with hypotheses. Nonetheless, the unexpected differential in initial belonging ratings make it difficult to interpret the findings in Study 1 with respect to R1.

In Study 2, we treated all students as at-risk because they were considered to be unprepared to enroll in the gateway course to their chosen major and because the alternative course has historically been a leak in the pipeline to retention in engineering. However, the intervention did not lead to differences in perceptions of belonging among this group. It is possible that the instructional methods in *Intro Calculus* were sufficient to boost sense of belonging among these students. For example, collaborative learning methods have been found to increase belongingness in college students (Johnson et al. 2014), a relationship we have previously identified in our engineering students (Weaver et al. 2016). STEM students, specifically, report heightened belonging when they perceive that their professors care about them, and professors who use active teaching are perceived as more caring (Rainey et al. 2019). Furthermore, in STEM fields, collaborative learning is associated with greater retention of minority students (Springer et al. 1999) and benefiting women, minorities, adult and reentry students, commuters and international students, specifically (Barkley et al. 2014). However, even at pre-survey, these students' belonging ratings were not lower than their peers in *Engineering Analysis I*. Perhaps the designation of these students as "at-risk" obscured important differences between them, making a mean belonging rating too blunt a measurement, and again, making it difficult to answer R1 using the data from Study 2.

Research Question 2 (R2): Differences in Achievement Due to the Intervention

Therefore, we turn to consider why there was not a difference in achievement between intervention and control groups in these courses. In *Intro Calculus*, collaborative learning was employed; active learning methods such as this are associated with increased engagement and achievement (Prince 2004; Ruiz-Primo et al. 2011). If all students in the course benefited from these methods equally across intervention conditions, those benefits may have obscured any differences hypothesized to exist between groups on the performance and retention outcomes in Study 2.

We also did not demonstrate an achievement gap between UR and majority students in Study 1 on exam performance, GPA, or retention. Taken together, these results provide only limited support for the benefit of the intervention, as the benefit (a) was only found for one of the dependent measures (perceived belonging), (b) was not found when comparing UR students in the intervention versus active control conditions, and (c) was not replicated in Study 2.

Despite the general lack of condition effects, we found a positive relationship between perceived belonging and exam average in both studies. After controlling for Math-ACT scores, perceived belonging at the start of the semester predicted 13.1 and 12.8% of the variance in exam scores in Studies 1 and 2, respectively.

Research Question 3 (R3): Differences in Use of Campus Supports

We further examined whether use of campus supports (i.e., support offices, professors, TAs, upperclassmen, or peers) was correlated with belonging or achievement, as a long tradition of research in higher education suggests that perceived belonging is associated with greater social integration on campus (e.g., Hausmann et al. 2007; Hurtado et al. 2007; Wilson et al. 2015; Yeager et al. 2016). In Study 2, use of campus supports by students fully mediated the relationship between their perceived belonging and exam average; the greater their sense of belonging, the more supports they used, and the higher their exam average. One mechanism thought to explain the impact of belonging uncertainty on achievement is the downstream recursive processes that threaten academic success (Cohen and Garcia 2008). Students who are placed in the pre-calculus math course are academically less prepared for engineering mathematics. Therefore, these students have the most room for improvement and reason to believe that they need to seek help. Perhaps this is why this relationship was not present in Study 1.

Limitations

Several limitations may help to explain the limited support we found for the intervention. First, the level at which we measured feelings of belonging may have influenced the results. Our survey measured belonging at the college level, whereas others have found a more specific measure of belonging to STEM classes (Wilson et al. 2015) or domains (Good et al. 2012; Walton et al. 2015; Weaver et al. 2016) to be a correlate of behavioral, emotional, or academic outcomes. Thus, the effects of the intervention on engineering-related measures, namely exam average, might have been stronger with a closer correlate of students' perceived belonging in mathematics specifically.

Similarly, it is possible that students in our sample did not have much room to improve due to the intervention. Mean belonging scores ranged from 3.56 to 4.10 on a 5-point scale, suggesting that average scores were above the midpoint in our sample. Alternatively, a restricted range on this measure may have limited our ability to detect any effects of the intervention.

It is also plausible that our active control condition brought about academic improvements similar to those expected from the belonging intervention. The "saying-is-believing" exercise might have impacted the motivation of the control group. The message of how to become a more effective student may have helped students in this condition improve study habits, time management, or use of campus resources. However, both intervention conditions were modeled closely after Walton et al. (2015), who did find differences in women's academic attitudes, social integration into engineering, and engineering GPA as a result of the belonging intervention.

Although our manipulations were nearly identical to those of Walton et al. (2015), our presentation of the stories differed from theirs. We delivered the intervention messages visually, whereas Walton and colleagues presented the messages by using audio-recording in conjunction with the visual aid. It is possible that hearing the voices of real students made a stronger impact on students in the intervention condition than in the control condition. Perhaps eliminating the voice recording reduced some of the power of the intervention.

It is also important to keep in mind that our findings are limited to the specific classroom contexts in our samples. More specifically, our research context differed from that of Walton et al. in a number of ways. In contrast to Walton et al. (2015), our samples were drawn from a large, public U.S. university with large courses. In addition, all students who completed the assignments were included in the studies, as opposed to a volunteer sample. These courses are likely representative of other large, public institutions, with similar pressures and climates. Walton et al. specifically studied women in certain engineering fields; we studied UR students as defined by Yeager et al. (2016), which included women, underrepresented racial/ethnic minority students, and first-generation college students. However, we acknowledge that this intervention may have a greater effect in a different context or even over a longer time course.

Conclusion

Social-psychological interventions to improve factors such as belonging are becoming increasingly popular, and large-scale studies in high-impact publication outlets lend exciting support for their use. Of course, enthusiasm for reproducing or scaling up social-psychological interventions to enhance academic achievement has been tempered by concern for precise implementation (Paunesku et al. 2015; Walton 2014; Yeager and Walton 2011). We closely adapted both our intervention and control conditions from previous studies that demonstrated benefits of the belonging intervention for underrepresented students (Walton and Cohen 2011; Walton et al. 2015; Yeager et al. 2016). We also closely followed procedures outlined by Walton et al.

(2017) for social-psychological interventions. Yet, we found only limited support for the intervention with our first-year engineering sample. Like others (e.g., Jordan 2014), we were unable to replicate previous published results in our sample of first-year engineering students despite utmost attention to "wise" delivery, timing, tailored messaging, and affordances for academic improvement. Our results suggest that these interventions may not always have the intended effect and that careful research on their effectiveness must continue before taking the time and effort to implement them across student groups.

Acknowledgements We thank Kate E. Snyder for her guidance and feedback and the professors who helped to implement this study: Jeff Hieb, James Lewis, Jacqueline C. McNeil, Brian Robinson, and Angela K. Thompson.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Appendix

Belonging Uncertainty Scale

1. Sometimes I worry that I do not belong in college.
2. I am anxious about whether I fit in at college.
3. I feel confident that I belong in college. (reverse-coded)
4. When I face difficulties in college, I wonder if I will really fit in.

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