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WIP: Exploring differences in student sense of belonging inside and outside the engineering classroom

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Introduction

Sense of belonging has become an important factor for creating inclusive and equitable learning environments in engineering education. By sense of belonging, Strayhorn [1] referred to the feeling of mattering to a community in consequence of the received support and the social ties created in a particular context. According to previous studies, this concept of sense of belonging is associated with student intrinsic motivation to learn and succeed, resulting in academic achievement and persistence in the engineering field [2], [3]. On the contrary, students who lack a sense of belonging are at a greater risk of suspending their studies, which has affected female and other underrepresented students to a greater degree [4].

To boost students' sense of belonging, different types of interventions have been designed and implemented in engineering education over the past few years. For example, Judson et al. [2] describes the incorporation of active classroom activities to promote peer interactions, in addition to undergraduate research projects to expose students to the work of faculty role models, and the creation of support groups to connect students with peers and undergraduate teaching assistants. Recent studies have also described the incorporation of specific interventions in cornerstone courses and other project-based learning opportunities across the engineering curriculum [5], [6], also promoting peer collaboration and further relationships with professors.

Despite the efforts that have been made both in engineering education and in higher education, few studies have accounted for the impact of these initiatives on student social ties [4]. Considering that most higher education institutions shifted to remote and hybrid environments since the outbreak of the COVID-19 pandemic, more research is needed to understand how student relationships have been affected by the current course formatting [7]. In these lines, this Work-In-Progress describes an effort to measure students' sense of belonging at an engineering school in a Latin American university. To meet this objective, an online survey was conducted during October 2021, which was voluntarily answered by 977 undergraduate students (out of 5,000 undergraduates). In the following sections, we describe our findings and discuss their implications for engineering education research and practice.

Methods

This paper is part of a large survey study to understand students' sense of belonging in engineering student subgroups. Due to the growing importance of social ties, we chose to focus on mattering to peers and institutional agents (faculty, administrators, student affairs professionals, and leadership). So far, the relationship between mattering and sense of belonging is recursive. According to different researchers [11], 12], students' sense of mattering is key to developing a sense of belonging, but at the same time enhanced feelings of mattering arise from social exchanges that promote a sense of belonging [8], such as peer collaborations or interactions with academic advisors. In this study, mattering and sense of belonging are treated

as two interrelated concepts that refer to the level of integration in a particular context [1], but we decided to focus on the subjective appraisal of mattering to different type of institutional agents.

In order to measure the latent construct of mattering, we used six items in which respondents were asked about the extent to which they agreed or disagreed with statements such as: “If I don't return to this University in the next month, my classmate(s) will miss me” (see items here: https://bit.ly/3H5bwn6). These survey items were developed for a prior survey instrument that examined the relationship between student experiences, integration variables (validation, belonging, and mattering), and educational outcomes for first-year students at three Latin American universities (Unpublished Dissertation Manuscript).

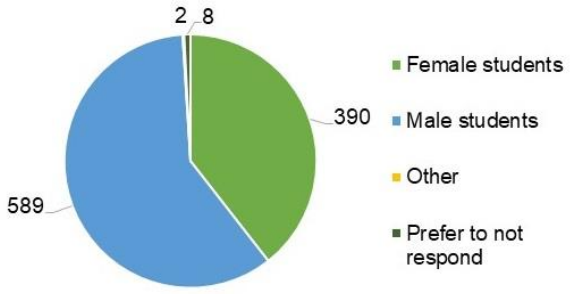
The development of the six items was preceded by the revision of theoretical literature about mattering. In particular, we revised Rosenberg and McCullough’s [9] seminal piece in which mattering was conceptualized as a multidimensional latent construct comprised by attention (called *awareness* later), importance, and dependence (called *reliance* later) [9], [10]. Then, we revised the literature that focuses on the use of mattering within the higher education context [11], [12]. According to the latter, college mattering is a multidimensional construct composed by general mattering, mattering v/s marginality, mattering to counselors, mattering to instructors, mattering to students, and perception of value. Finally, we revised specialized literature that focused on the psychometric properties of the diverse measure of mattering [12], [13]. Based on this revision, we selected the items that assessed social exchanges that promote a sense of belonging, identity, and commitment, and then adapt them to be consistent with the higher education system in Latin America.

In this adaptation process, a multidisciplinary group of three researchers with experience in higher education in Latin America worked in collaboration with the three institutional analysts. This team participated in an iterative process of revising the survey items to ensure the readability of the questions and response scales, besides optimizing the order of the questions, and testing the duration of the questionnaire. Then, two doctors in Hispanic Literature revised the questionnaire to eliminate incorrect and/or ambiguous uses of Spanish.

Finally, we included the revised version of these six items in an online survey that was applied in October 2021 at a large and selective engineering school in Latin America. This survey was voluntarily answered by a convenience sample of 977 undergraduate students (out of 5,000 undergraduates), who were affiliated with different engineering majors (e.g., engineering and research operations, software engineering, engineering design, among others). In this engineering school, the minority student subgroups that have been historically observed are women (~35%), students who came from outside the metropolitan region (~25%), and students who enter engineering degrees through alternative admission programs (~10%). To support these subgroups and the overall student population, this engineering school has different types of support strategies and extracurricular initiatives to connect students with peer, staff, and faculty, such as student tutors, school counselors, and faculty mentoring. Still, we decided to focus on gender differences in mattering due to the institutional interest to attract women students and faculty. In these lines, Figure 1 shows the cohort and gender distribution of survey responses, showing a slightly overrepresentation of freshmen and female students (39% instead of 35% at a school level).

Cohort	N=989
First-year students (freshmen)	22%
Second-year students (sophomores)	15%
Third-year students (junior)	16%
Fourth-year students (senior)	19%
Other (pursuing a professional or graduate degree)	28%

(a)



(b)

Figure 1. Cohort (a) and gender (b) distribution of survey responses

In line with the above, we performed an Exploratory Factor Analysis to measure the latent construct of mattering from observed responses to the final set of six items [14], using polychoric correlation techniques when working with ordinal items [15]. For factor extraction, we used the maximum likelihood procedure with varimax rotation. Then, we carried out a reliability analysis of the six items as a scale. Considering the problems that have been extensively discussed in the literature regarding Cronbach's Alpha [16], we also estimated G6 and Omega. Finally, we performed an ANOVA to estimate whether there are statistically significant gender differences in the latent factor of mattering.

Results

Table 1 presents the perceived levels of agreement with the six items regarding mattering. At a descriptive level, it is observed that friends (65% Agree + Strongly Agree) and classmates (39% Agree + Strongly Agree) are the most important social ties survey respondents. On the other hand, students' perceptions of mattering are much lower regarding institutional agents (i.e., student affairs professionals, program leadership, and other staff members), except for faculty members (17.8% Agree + Strongly Agree). Thus, the items on the scale tend to be grouped into two blocks of variables that are more strongly correlated with each other: (1) classmates, friends, and faculty members; and (2) faculty members, student affairs professionals, program leadership, and other staff members (see the polychoric correlations matrix in the following link: https://bit.ly/34oVK8g).

Table 1. Perceived agreement with the six items regarding mattering (*n*=989)

If I do not return to this college this month…	Strongly disagree	Disagree	Agree	Strongly agree
My **classmates** will miss me.	29%	32%	30%	9%
My **friends** from this college will miss me.	16%	19%	41%	24%
At least one **faculty member** will be worried about my situation.	54%	28%	15%	3%
At least one **student affairs professional** (social worker, counselor, etc.) will worry about my situation.	62%	27%	9%	2%
At least one member of my program's **leadership team** (chair, academic coordinator, etc.) will worry about my situation.	64%	27%	8%	1%
At least one **staff** member (such as secretaries) will worry about my situation.	68%	27%	4%	<1%

At the factorial analysis level (KMO=0.75), according to the Complexity, BIC and SRMR indicators (see details of the factor analysis here: https://bit.ly/3HijI3B), it is estimated that the most parsimonious solution is the one with two factors (which explain 75% of the total

variance). In the first factor extracted (which explains 47% of the variance), Table 2 shows that the institutional agents present factor loads (i.e., leadership team, staff member, student affairs, faculty members). For this reason, we named this factor as 'institutional mattering'. In the second factor (which explains 28% of the variance), Table 2 shows that the items that present high factor loads are 'friends', 'classmates', and 'faculty members.' Assuming that all these agents are present in the classroom, we called this second factor 'classroom mattering'. Then, Table 3 presents the reliability indicators of the two extracted factors, being acceptable in both cases.

Then, the extracted factors were incorporated as explained variables in ANOVA models to determine if there were statistically significant differences according to gender. The model corresponding to 'institutional mattering' does not present statistically significant differences according to gender, but statistically significant gender differences were found concerning 'classroom mattering' (F=5.2; p-value=0.02). Furthermore, students who identified themselves as female tend to score slightly higher than people who are male on the latent variable classroom mattering (Figure 2).

Table 2. Perceived agreement with the six items regarding mattering (n=989)

	First factor: Institutional mattering	Second factor: Classroom mattering
Leadership team	0.94	
Staff member	0.89	
Student affairs professional	0.87	
Faculty member	0.56	0.39
Friends		0.89
Classmates		0.81
SS loadings	2.81	1.67
Proportion Var	0.47	0.28
Cumulative Var	0.47	0.75
Proportion explained	0.63	0.37
Cumulative proportion	0.63	1.00

Table 3. Reliability indicators for institutional and classroom mattering

	Alpha	G.6	Omega hierarchical	Omega H asymptotic	Omega Total
Institutional mattering	0.88	0.84	0.01	0.01	0.89
Classroom mattering	0.70	0.65	0.02	0.03	0.73

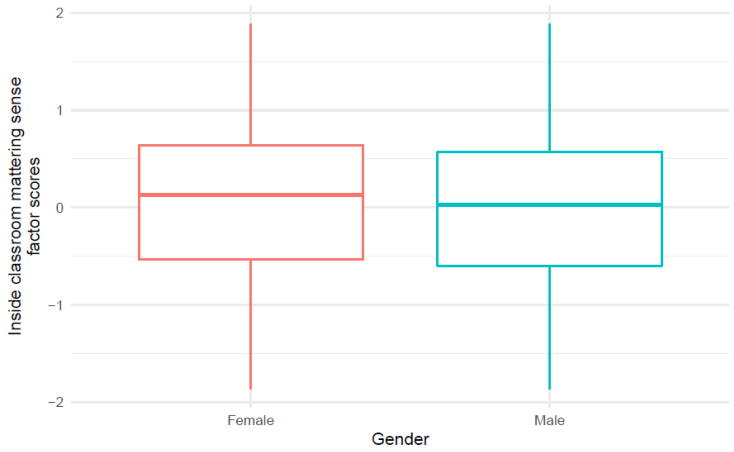


Figure 2. Distribution of the factor score regarding classroom mattering by gender

Discussion

This study presents a six-item scale for measuring mattering in an engineering education setting. The results obtained show validity and reliability indicators within an acceptable range, revealing the existence of two latent variables: one related to mattering to institutional agents ('institutional mattering'), and a second one related to mattering to classroom agents ('classroom mattering'). Assuming that mattering and sense of belonging are two social integration constructs that are interrelated [1], these findings have several implications for both research and practice.

First, the item regarding the perceived sense of mattering to faculty was present in both latent variables. Previous work highlights the importance of personal contact with faculty for student social integration both inside and outside the classroom [2]. In these lines, our findings indicate that teaching staff have a pivotal role on mattering. Thus, it is important to not only create spaces for interaction between students and teaching staff [2], but also to acknowledge faculty efforts to connect with students outside the classroom.

Second, results reveal that student respondents perceived lower levels of mattering to institutional agents. Although recent work have shown promising interventions at a classroom level [5], [6], more studies are needed to understand the role of institutional agents when students seek institutional support in critical situations, particularly underrepresented minorities. Although this concept of minorities might vary in each engineering education context and in response to evolving circumstances, our findings could imply the implementation of mechanisms to ensure that support reaches those who need it most, and not just those who know how to ask for help.

Third, we observed statistically significant differences among gender concerning classroom mattering, particularly favorable for students who identified themselves as female. Considering that prior studies have shown that female students could have a lower sense of belonging [4], further research is needed to understand the directionality of the relationship between mattering and sense of belonging. Besides, future work is required to explore the contextual nuances that might explain our finding, aiming to inform the design of further interventions to promote equitable academic experiences in engineering education programs.

Finally, this study is subject to limitations. Our survey was answered by a non-probabilistic sample, so its findings might not be generalizable for other student populations. Besides, further empirical analyses are needed to better understand the directionality of the relationship between mattering and sense of belonging. In these lines, we plan to apply the mattering items in other contexts, aiming to estimate validity and reliability indicators for the proposed scale in different educational settings.

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