

Research article

Understanding Student Sense of Belonging in Introductory STEM Courses

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Abstract: Women have been found to experience lower sense of belonging compared to men in STEM classrooms, which can lead to underperformance and withdrawal from STEM programs. Sense of belonging is believed to impact how students respond to challenges, which can subsequently affect whether students remain engaged in their coursework and how they perform in the course. Most research about sense of belonging has occurred in the United States, and other countries remain understudied. Scandinavia is an interesting context because there is high gender equality broadly, but the same gender differences found elsewhere are present at Scandinavian universities, where more men earn STEM degrees than women. We studied students' sense of belonging in four STEM courses at a university in Norway. We employed a mixed-methods study with a concurrent triangulation design and found that women had significantly lower sense of belonging compared to men, and that students with lower sense of belonging received lower course grades. We asked students an open-ended question about the challenges they faced in their courses and how they responded. We found that students with low sense of belonging disproportionately reported feeling overwhelmed and stressed. In their responses to the open-ended question, students shared desired changes to course structure and instruction. Based on those comments, we highlight evidence-based practices that instructors can use to improve their students' sense of belonging.

Keywords: sense of belonging, introductory STEM courses, attrition, STEM equity, gender equity

1 Introduction

1.1 Inequities in STEM education

Many science, technology, engineering, and mathematics (STEM) fields are characterized by different levels of persistence and performance depending on student attributes such as student gender (Salehi et al., 2019, Minelgaite et al., 2020; Schmader, 2023), socioeconomic status (Helland et al., 2024; Madsen et al., 2023), race/ethnicity (Costello et al., 2023, Riegler-Crumb et al., 2019), and whether one's parents pursued higher education (Costello et al. 2025; Gaudier-Diaz et al., 2019). This global inequity is the product of the exclusionary and oppressive systems that dominate in STEM (McGee et al., 2023), and results in a disparity between science workforce needs and individuals with necessary competence (Chen, 2013; McGrath, 2021; Ortiz-Martínez et al., 2023). One mediating factor shown to be involved in inequity in STEM is differences in students' sense of belonging in the classroom and in STEM in general (Rainey et al., 2018; Walton & Cohen, 2007). Understanding differences in sense of belonging can identify curricular modifications that instructors can employ in their STEM courses to reduce disparities.

1.2 Sense of belonging

Sense of belonging is “students' sense of being accepted, valued, included, and encouraged by others (teachers and peers) in the academic classroom setting and of feeling oneself to be an important part of the life and activity of the class” (Goodenow, 1993). Low sense of belonging is associated with lower grades (Cwik & Singh, 2022; Pittman & Richmond, 2007) and higher rates of leaving STEM (Fink et al., 2020; Höhne & Zander, 2019; Pedler et al., 2022; Rainey et al., 2018). Sense of belonging often differs between students of different demographic groups, with students from excluded groups (i.e., women, students of color, students with parents who have not attended university) having lower sense of belonging (Gillen-O'Neel, 2021; Johnson, 2012; Lewis et al., 2017). In an analysis of intersecting identities in the United States, Rainey et al. (2018) found that women of color had the lowest sense of belonging and highest rates of attrition, followed by white women. White men had the highest sense of belonging. Muenks et al. (2020) found that low sense of belonging is linked to lower course engagement, lower course interest, and lower course grades. Here, we focus on gender differences in sense of belonging and course performance in a Scandinavian context.

1.3 Gender Equality in Norway

Our work was conducted in Norway, a country noted for being among the most gender-equal, and as of 2024 rated as #3 on the World Economic Forum's Gender Gap Index (World Economic Forum, 2024). However, despite advances for women in terms of educational access, health care, and political representation, Norway mirrors many other countries in STEM attrition patterns that favor men (UNESCO Institute for Statistics). This phenomenon—of gender equality in many societal domains but not in STEM persistence—persists across the other Scandinavian countries and has been termed “The Gender-Equality Paradox” (Corneliussen, 2021; Minelgaite et al., 2020;

Stoet and Geary, 2018). While sense of belonging has been implicated in many studies of gender-biased performance and retention in STEM higher education in the United States, we are unaware of any work connecting sense of belonging to educational disparities in Norwegian STEM higher education.

1.4 Connection between sense of belonging, responses to challenges, and course performance

Sense of belonging is thought to be related to how students respond to challenges, such as receiving a low exam score (Figure 1; Binning et al., 2020; Hammarlund et al., 2022). If a student has a high sense of belonging, they are more likely to interpret a challenge as a normal experience that everyone faces at some point and not as a sign that they do not belong (a psychological response; Walton & Cohen, 2011). That reaction will likely promote sustained engagement in the course (a behavioral response; Gillen-O’Neel, 2021) and increased performance (an academic outcome; Tracy et al., 2022). If a student has a low sense of belonging, they may interpret the challenge as confirmation that they do not belong in STEM. This may lead to diminished engagement in the course and lower performance.

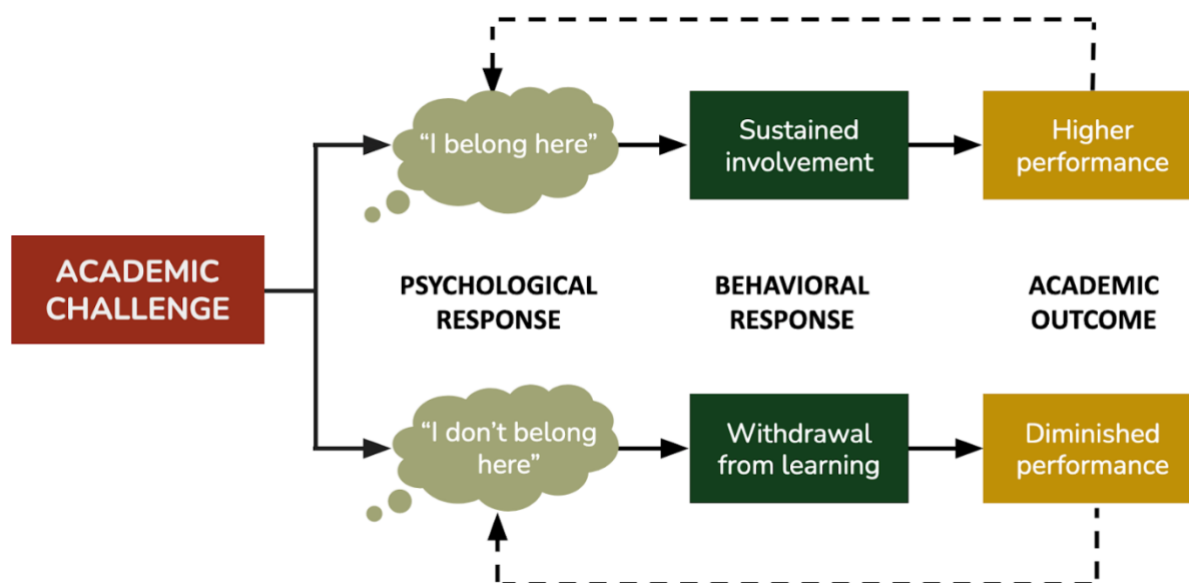


Figure 1. Hypothesized model for behavioral responses and academic outcomes to course challenges of students with different levels of sense of belonging. When faced with an academic challenge (e.g., a low test score or difficult course content), we expect students to respond in one of two ways. Students with high sense of belonging will continue to be engaged in their studies and perform well academically, reinforcing their high sense of belonging. Students with low sense of belonging, however, will withdraw from learning and follow a self-fulfilling cycle of low academic performance that further reinforces low sense of belonging.

Because of this hypothesized connection between belonging and responses to challenges, a recently developed “ecological belonging intervention” targets students’ beliefs and classroom norms about the universality of challenges and adversity. The goal of the intervention is to instill a shared classroom belief that challenges are universal, temporary, and surmountable. Binning et al. (2020) and Hammarlund et al. (2022) found

that the intervention reduced gaps between demographic categories (gender in Binning et al. 2020, race/ethnicity in Hammarlund et al. 2022). In both studies, belonging interventions were successful specifically when they were needed—that is, only in contexts where certain groups of students experienced low sense of belonging. Given that STEM as a field systematically marginalizes students who possess excluded identities, which can impact sense of belonging, understanding this aspect of students' experience can clarify whether an intervention is needed to support those students.

1.5 Research questions

Our study, conducted in four introductory STEM courses at an institution of higher education in Norway, involves four research questions. First, we aimed to document whether there are differences in sense of belonging among students on the basis of gender, and assess the relationship between sense of belonging and course performance. We asked:

Question 1: Does sense of belonging vary by student gender?

Question 2: What is the relationship between sense of belonging and course grades?

Next, we wanted to learn from students' responses to an open-ended question about challenges they face and connect their ideas to their sense of belonging. To our knowledge, this is the first study that asks students open-ended questions about their perceptions and ideas about challenges while also measuring sense of belonging. Students' psychological and behavioral responses to challenges is the hypothesized link between sense of belonging and course grades (Figure 1). Specifically, we asked:

Question 3: What challenges do students mention facing in their STEM courses, study program, and/or university? How do students describe their efforts to overcome these challenges?

Question 4: Does sense of belonging impact how students describe academic challenges and their behavioral responses?

In the four introductory STEM courses that we examined, we found that belonging does differ along gender lines, that belonging predicts course grades, and that students with different sense of belonging express different perceptions of and responses to challenges they encounter. Our research conducted at one university in Norway serves as an interesting case study, and we discuss how our findings fit into the developing literature about the connections between sense of belonging and performance inequities. We also make recommendations to instructors based on students' responses.

2 Methods

2.1 Mixed-methods approach

To better understand students' sense of belonging in STEM courses in Nordic higher education, we employed a mixed-methods approach by examining both quantitative and qualitative measures (Creswell & Clark, 2017; Warfa, 2016). Here, we used a concurrent triangulation mixed-method design, in which we simultaneously collected quantitative data about student sense of belonging and qualitative data about the challenges students face (described in more detail below) to provide a more holistic understanding (Warfa, 2016). Specifically, we supplemented quantitative analyses with qualitative analyses of responses to an open-response question to investigate potential mechanisms for the impact of sense of belonging on course performance (as proposed in Figure 1).

2.2 Data collection

We surveyed 236 students in four introductory-level science courses at the University of Bergen during the last two weeks of the Spring 2022 semester. The courses in this study included two Chemistry courses with 44 and 53 respondents (response rates of 32% and 29%, respectively), one Informatics course with 97 respondents (response rate of 30%), and one Geology course with 42 respondents (response rate of 67%).

As part of a larger survey, students were asked to rate their level of agreement with five sense of belonging items (Muenks et al., 2020; Murphy & Zirkel, 2015; Appendix 1):

1. How comfortable do you feel in this course?
2. To what extent do you feel like you can be yourself in this course?
3. To what extent do you feel accepted in this course?
4. To what extent do you feel alienated in this course?
5. To what extent do you feel that you "fit in" in this course?

Response options ranged from 0 (not at all) to 6 (extremely). We also asked students about the challenges they faced in their course and how they overcame those challenges via an open-ended prompt: *What specific challenges have you faced as a student – either in this course, in your study program, or at the university in general? What did you do to overcome these challenges? Try to be as specific as you can.* Lastly, our survey asked students to self-identify their gender. The survey was written in Norwegian, and most students responded in Norwegian. All responses were translated into English by a native Norwegian speaker (EMC).

In addition to our survey, we collected end-of-term grades from those students who consented to allow us to access their course grades. Course grades ranged from A to F. All courses in this study included final exams that constituted the majority of their course grade, ranging from 60% to 100% of the grade.

Our study was approved by The Norwegian Centre for Research Data (reference number 963610). We informed students about the general aims of the study and that the data would be treated confidentially and anonymized in any reporting. Participants could withdraw from the study at any time, and only those who consented to participate were included in our analyses.

2.3 Linear Mixed Models

We conducted a series of linear mixed models to analyze the relationships between sense of belonging, student gender, and course grade. We quantified sense of belonging by averaging the five sense of belonging items (Muenks et al., 2020; Murphy & Zirkel, 2015; Cronbach's alpha = 0.86), after first reverse-scoring item #4 (To what extent do you feel alienated in this course?). For analyses including gender, we only included students who self-identified as women and men. 58 respondents identified as men, and 132 identified as women. This distribution was not unexpected, as women strongly outnumbered men in three of the four courses included in this study, while in one course (Geology), there were equal numbers of men and women. We excluded two students who did not identify as either a man or woman and forty-four students who did not indicate their gender identity. We recognize that gender is a gradient, do not wish to minimize the voices of the students who do not identify with a gender binary, and included those students in our analyses of perceived course challenges. For analyses on course grades, we converted letter grades to numeric grades with A as the highest (6) and F as the lowest (1).

All of our mixed models included course as a random effect in all of our analyses. Using linear mixed models allows us to account for the nested structure of our data (i.e., students were nested within different STEM courses) and, by specifying course as a random effect, we can control for the variation that exists across these courses (Theobald, 2018). All models were built with the R package lme4 (Bates et al., 2015). The R package emmeans was used to calculate marginal means (Lenth, 2018). Figures were built in the R package ggplot2 (Wickham, 2016). All analyses were conducted in R version 4.2.2 (R Core Team, 2022).

2.4 Question 1: Does sense of belonging vary by student gender?

To evaluate whether sense of belonging varied by student gender, we ran a linear mixed model with gender as a fixed effect and sense of belonging as the dependent variable. Although 236 students consented to participate in the study, 190 students both filled out the sense of belonging survey items and provided gender demographic information and were included in this analysis.

2.5 Question 2: What is the relationship between sense of belonging and course grades?

We next quantified how students' sense of belonging affects course grade. We included an interaction between gender and sense of belonging to measure how gender affects the relationship between sense of belonging and course grade. We also ran a linear mixed model to analyze whether course grade differed between men and women. As only a subset of the 236 students consented to share their course grades, these analyses included 100 students.

2.6 Question 3: What challenges do students mention facing in their STEM courses, study program, and/or university? How do students describe their efforts to overcome these challenges?

91 students responded to the open-ended question about academic challenges. We used deductive coding (Saldaña, 2021) to match the student responses to categories that we assigned after an initial review of a subset of the data. 13 categories were initially developed by two coders (EMC and MKK). After the development of codes, these two coders worked independently to assign student responses to categories and then met to discuss these decisions and come to consensus. Student responses could be coded into multiple categories.

2.7 Question 4: Does sense of belonging impact how students describe academic challenges?

We ran five separate mixed effects logistic regressions to measure how sense of belonging impacted how students describe course challenges. Each model corresponded to one of the five most common categories identified in student responses about challenges. Models included sense of belonging as a fixed effect, course as a random effect, and specified a binomial distribution. We used a Bonferroni correction to account for multiple comparisons, which adjusted the significance threshold to $\alpha = 0.01$. To visualize differences in how students with different levels of belonging describe academic challenges, we describe our results for students with higher than average sense of belonging for this sample and for students with lower than average sense of belonging for this sample.

3 Results

3.1 Question 1: Does sense of belonging vary by student gender?

We found that students who identify as men had a higher sense of belonging than women (Figure 2; women: 4.15 ± 0.47 ; men: 4.57 ± 0.46 ; $p = 0.010$; $N = 190$ students, 132 women, 58 men; marginal means \pm 95% confidence intervals reported).

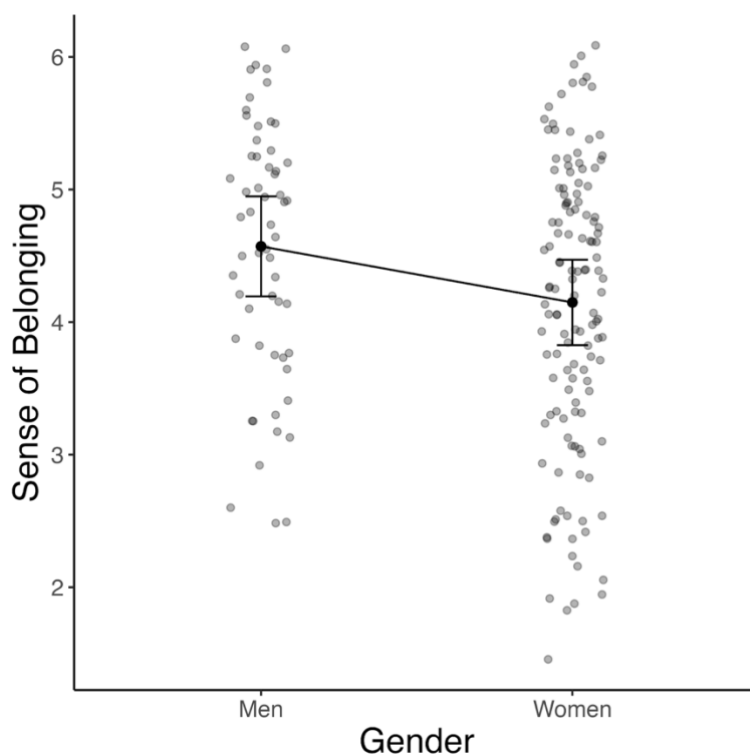


Figure 2. Sense of belonging varied across gender. Women reported lower sense of belonging than men ($p = 0.010$). Marginal means with 95% confidence error bars were extracted from a linear mixed model testing the effect of gender on sense of belonging, and points depict averages of individual student responses to five sense of belonging items. Each point shows a student and the points are jittered to visually represent all students.

3.2 Question 2: What is the relationship between sense of belonging and course grades?

We found that students with a higher sense of belonging performed better in their courses (Figure 3; $\beta = 0.83 \pm 0.27$ 95% CI; $p < 0.001$; $N = 100$). This positive relationship between sense of belonging and course grade was true for both women and men (i.e., the interaction between sense of belonging and gender was not significant, $p = 0.73$; $N = 67$ women, 33 men). Furthermore, course grade did not differ between men and women ($p = 0.34$, $N = 100$, 67 women, 33 men).

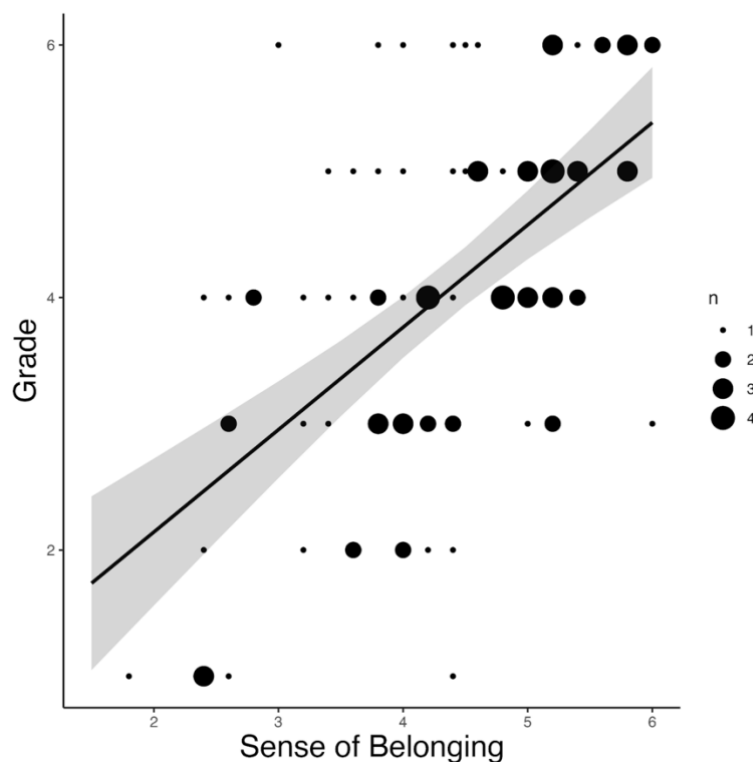


Figure 3. Relationship between sense of belonging and course grade. Students with a higher sense of belonging received higher course grades ($p < 0.001$). Datapoint size is scaled by number of students and ranges from one to four students.

3.3 Question 3: What challenges do students mention facing in their STEM courses, study program, and/or university? How do students describe their efforts to overcome these challenges?

Here, we report on the five most common categories identified in student responses about challenges (Table 1). The majority of student responses (52%) described experiencing challenges related to the course (Figure 4). These course-specific challenges included difficult course material, coverage of too much course content, ineffective course organization, and large course sizes (Table 1). Other commonly identified challenges with their STEM study program included difficulties with time management (20% of student responses), lack of motivation and trouble focusing (19% of student responses), and feelings of overwhelm and stress regarding courses and other aspects of student life (18% of student responses) (Table 1; Figure 4). In addition to mentioning challenges, 40% of student responses discussed the coping strategies that they employ to address course challenges (Figure 4).

Table 1. The five most common categories identified in open-ended responses about challenges.

Most Common Categories	Category Definition	Example Statements
Challenges related to the course	Participant states that the course material is too challenging, contains too much material or too many assessments, the material is too difficult to understand, the course isn't organized effectively, or that the introductory courses are too big. Can also include concerns about missing prerequisite information or courses.	<ul style="list-style-type: none"> • “That more of the courses (particularly the intro courses) are too big. For instance, I think that [courses redacted] should cover 15 study points each, instead of 10 sp.” • “Difficult curriculum, and many courses at a time. Stressful periods.”
Coping strategies	Participant discusses how they address a challenge using a specific strategy.	<ul style="list-style-type: none"> • “If I'm stuck, I ask friends at the same study program, who are also taking the course, for help.” • “Read a lot to be well prepared.”
Lack of motivation / Trouble focusing	Participant expresses a lack of motivation in performing any course related activities and/or participant is struggling with maintaining focus in relation to either the course or studying in general, affecting the quality of studying.	<ul style="list-style-type: none"> • “Have struggled a little with motivation, which naturally has affected this course a little bit as well.” • “Hard to sit down and actually focus on the subject.”
Time management	Participant reports that they are struggling to balance school, health, sleep, relationships, work, and social life, which may cause them to procrastinate and therefore perform poorly in school. Also includes issues relating to sleep, where the participant does not necessarily state an imbalance with other aspects of life. Participant reports having trouble sleeping, and/or waking up early in the morning and/or getting to bed at a reasonable time, affecting his/her focus when studying or participating in course-related activities and/or other mandatory activities at the University.	<ul style="list-style-type: none"> • “I work with school instead of relaxing, being social and active, during my spare time.” • “Often discovered that an assignment needed to be done the day before it was due.”
Overwhelmed, stressed	Participant reports feeling overwhelmed or stressed regarding either student work or other aspects of life.	<ul style="list-style-type: none"> • “Many of the courses feel overwhelming with many details and a large curriculum.” • “Difficult curriculum, and many courses at a time. Stressful periods.”

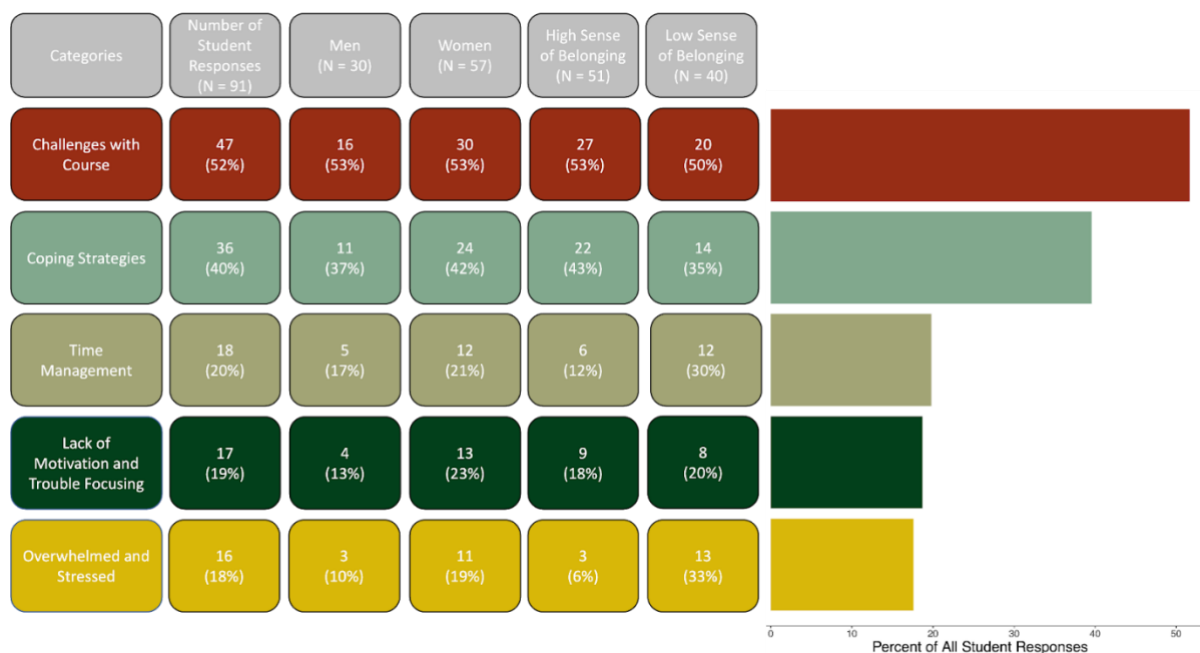


Figure 4. Number and percent of student responses in each of the five most common categories in response to the prompt, “What specific challenges have you faced as a student – either in this course, in your study program, or at the university in general? What did you do to overcome these challenges? Try to be as specific as you can.” We include student responses for each category and on the basis of student gender (men and women) and sense of belonging (high and low). Students with high sense of belonging had higher than average sense of belonging for this sample (N = 51), and students with low sense of belonging had lower than average sense of belonging for this sample (N = 40). The right-most panel displays the percent of student responses for each of the five categories (N = 91 students).

3.4 Question 4: Does sense of belonging impact how students describe academic challenges?

Sense of belonging impacted the likelihood that students mentioned feeling overwhelmed and stressed ($\chi^2_{1,91} = 10.21$; $p = 0.0014$) (Figure 5). However, sense of belonging did not affect the likelihood that students mentioned experiencing challenges with their STEM courses ($\chi^2_{1,91} < 0.001$; $p = 0.98$), coping strategies in response to academic challenges ($\chi^2_{1,91} = 3.70$; $p = 0.054$), experiencing challenges with time management ($\chi^2_{1,91} = 5.48$; $p = 0.019$), or lacking motivation in and struggling to maintain focus when performing course-related activities ($\chi^2_{1,91} = 0.014$; $p = 0.91$) (Figure 5).

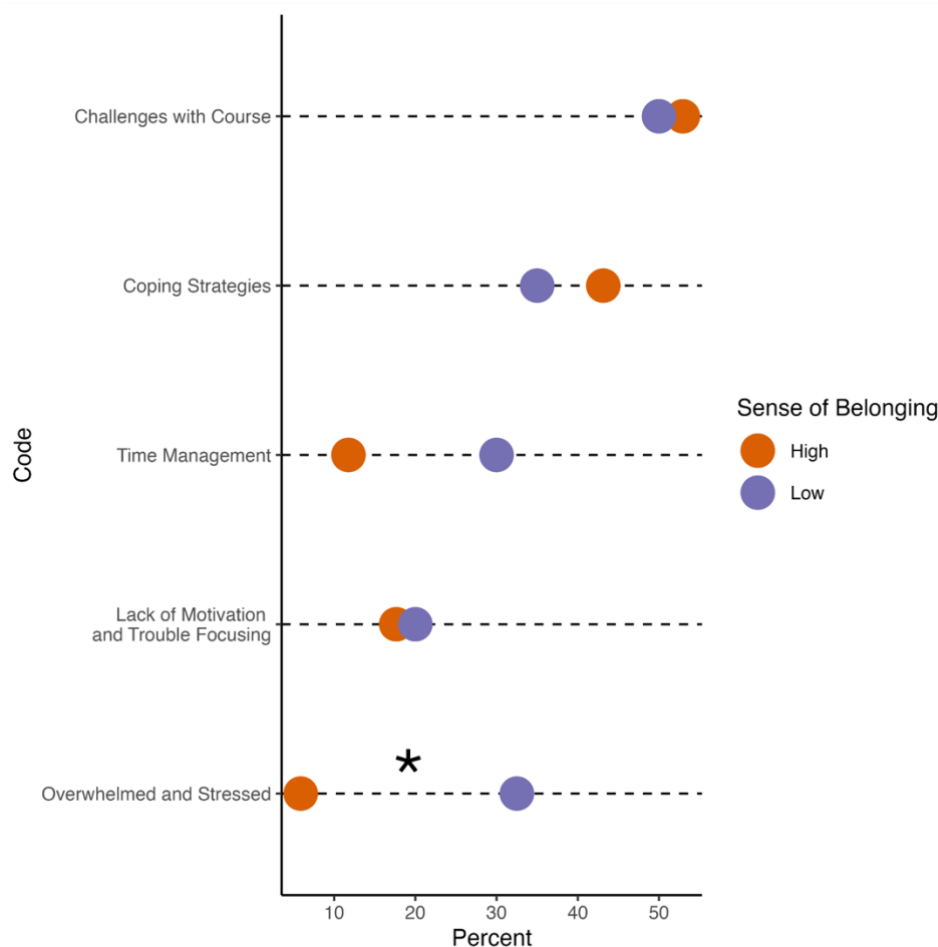


Figure 5. Percentage of students with high and low sense of belonging across the five most common categories for academic challenges. Students with high sense of belonging had higher than average sense of belonging for this sample ($N = 51$), and students with low sense of belonging had lower than average sense of belonging for this sample ($N = 40$). Students with low sense of belonging were more likely to report being overwhelmed and stressed ($p = 0.0014$). Asterisks indicate significant differences ($p < 0.01$) between students with high and low sense of belonging. The $p = 0.01$ alpha level is based on a Bonferroni correction for multiple comparisons.

Students with low sense of belonging discussed their experience with overwhelm and stress in response to academic challenges. One woman with a low sense of belonging expressed “stressing over deadlines and [the] many evaluations that overlap in time.” Another woman with a low sense of belonging mentioned, “There have been so many assignments..., which makes me feel like I’m working and working towards the next deadline, and I’m not able to work on the curriculum on my own, causing me to feel that I’m always behind.”

4 Discussion

4.1 Summary of results

We found that men reported higher sense of belonging than women (Figure 2), suggesting that the differences in belonging between men and women found in studies of institutions in the United States (e.g. Cwik & Singh, 2022; Edwards et al., 2022; Johnson, 2012) also exist in our Norwegian study population. Students with a high sense of belonging performed better in their courses (Figure 3), also consistent with studies of different contexts (e.g. Cwik & Singh, 2022; Edwards et al., 2022; Pittman & Richmond, 2007).

Based on past work suggesting that the link between sense of belonging and grades is mediated through students' responses to challenges (Figure 1; Binning et al., 2020; Gillen-O'Neel, 2021; Hammarlund et al., 2022), we analyzed students' responses to an open-ended question about their perceptions of and responses to challenges (Table 1, Figure 4). All students reported experiencing challenges, regardless of their sense of belonging (Figure 5). However, some of the reactions students had to those challenges differed among students with high vs. low sense of belonging. Students with low sense of belonging more frequently reported feeling stressed and overwhelmed. For example, a student with low sense of belonging wrote, "Oh, where to begin? There is just so much. I am never able to balance my courses and exercising + nutrition + sleep + friendship + relaxation... I feel that everyone I talk to is sailing through just fine and it's just me who is struggling." This aligns with the "I don't belong here" route shown in Figure 1, where low sense of belonging leads to withdrawal from learning and subsequent lower performance.

These findings are consistent with two previous studies that used quantitative scales to explore this link. Pedler et al. (2022) found that students with lower sense of belonging showed lower motivation and enjoyment of their courses compared to students with high sense of belonging. This suggests an emotional response that is concordant with the behavioral responses our students reported. Gillen-O'Neel (2021) tracked students' sense of belonging and emotional and behavioral engagement daily for one week and found that if students experienced high sense of belonging on a certain day, their behavioral and emotional engagement was higher. Paired with these studies, our findings highlight the importance of connecting sense of belonging with variables beyond grades in order to understand exactly how sense of belonging affects student performance and attrition. Doing so helps to identify targets for course improvements to change classroom environments so that students follow the path of high sense of belonging (Figure 1).

4.2 Belonging matters despite the lack of grade differences

Previous studies have found that when men's sense of belonging is higher than women's, men also perform better in the course (Cwik & Singh, 2022; Edwards et al., 2021; Li & Singh, 2023). In contrast, we did not observe differences in performance on the basis of binary gender despite observing differences in sense of belonging. One possible explanation is that because only a subset of students reported their course grades (see Methods), we had less power to detect grade differences than to detect sense of

belonging differences. Or, perhaps men and women did perform equally in the courses despite differences in sense of belonging. One might interpret that result as good news—if grades do not differ, perhaps men and women are equally prepared for future success in STEM. However, sense of belonging impacts whether students stay in STEM (Höhne & Zander, 2019; Lewis et al., 2017; Pedler et al., 2022). This difference in belonging, rather than a difference in aptitude or performance, may underlie gender disparities seen in STEM university graduation rates in Norway despite high gender equality according to other societal metrics (i.e., the Gender-Equality Paradox; Stoet & Geary, 2018; but see Richardson et al., 2020). In Norway, women experiencing low sense of belonging in their STEM programs may be pulled to other fields with equal earning opportunities and fewer barriers to belonging (Ballen & Holmegaard, 2019). Additionally, gender stereotypes around certain STEM fields being “for men” may exacerbate differences in sense of belonging (Corneliussen, 2021; Sund, 2015). Furthermore, an implicit assumption at the societal level that gender equality has already been achieved may hinder further progress (Minelgaite et al., 2020). To retain women in STEM fields, it is important to measure students’ sense of belonging and to not rely on academic performance as an indicator of student well-being.

4.3 Promise of belonging interventions

Because women show lower sense of belonging, an “ecological belonging intervention” may increase equity in these courses by fostering an environment in which women follow the high belonging path shown in Figure 1. Belonging interventions improve performance specifically of students with low sense of belonging, so in this case, women should benefit (Binning et al., 2020; Hammarlund et al., 2022). It will be interesting to determine whether ecological belonging interventions improve performance of women in this context—so far, there are no published studies of ecological belonging interventions performed outside of the United States. The impacts of interventions may be culturally-dependent, so it is important to measure whether ecological belonging interventions replicate in other countries.

4.4 Recommendations for instructors based on student responses

Many Norwegian universities have instituted programs for first-year students (e.g., “velkomstuken” at the University of Bergen) that focus on orienting students to the university’s resources and culture. These are often organized at the institution, faculty, or department level and led by administrative staff and fellow students. Typically, students are assigned to groups led by peer mentors, and groups engage in various academic and social programs for several days prior to the start of their first semester. These programs are typically well received (Myrtveit et al., 2017; Pinto et al., 2024). However, when students enter the classroom of one of their first-year courses (e.g., a 500-person introductory math class), they may get a shock. Students may feel disconnected from their peers, instructors, and study subjects. The traditional lecture environment can feel impersonal and alienating, and traditional high-stakes assessments can further reduce a student’s sense of belonging and ability to master the subject.

In their responses to our question about challenges, students made recommendations to improve classroom environments and assessments that were

insightful and consistent with evidence. We hope these insights can be useful for instructors to improve sense of belonging for all students. For example, students reported that they would prefer removal of high-stakes testing to reduce stress (Costello et al., 2025; Wang, 2024). Time management was another challenge. Instructors can provide students with strategies to reduce procrastination and improve student time management, like breaking tasks into smaller pieces, using positive self-talk, and structured studying (Hensley et al., 2021). Students also reported feelings of loneliness and desired more connection to other students. Instructors can foster students' connections with their peers through team-based learning (Møgelvang & Nyléhn, 2023; Møgelvang 2024). Finally, students reported a desire for more communication from their instructor. Recent work has shown that instructors' communication of their mindset about intelligence (i.e. whether they believe intelligence is fixed vs. or can grow with practice; Canning et al., 2022; Dweck, 2006) influences student experiences and performance (Canning et al., 2019). Instructors can directly respond to challenges through post-exam emails with growth mindset messages (Canning et al., 2024).

4.5 Limitations and future directions

Our study has some limitations that point to future research directions. First, in our qualitative prompt, we gave several examples of contexts in which students might experience challenges (“in this course, in your study program, or at the university”). While we included this wording to stimulate student responses, it limited our ability to identify the specific contexts students wrote about, and may have constrained student responses to only those options. Second, for three of the four courses, response rates were relatively low and we were unable to assess possible bias in response rates because we do not have access to demographic information about the students who did not respond to the survey. Next, we examined one term at one university and did not track students' behavior or performance during subsequent terms or at other institutions. Sense of belonging has been shown to be a predictor of both intention to persist in STEM (Lewis et al., 2017; Pedler et al., 2022) and actual persistence (Höhne & Zander, 2019). It would be interesting to follow the students in our study as they progress to future courses, change study programs, or decide to leave university before degree completion. It will also be important to replicate this study at other universities. Additionally, other demographic categories are also important, like race/ethnicity, transgender, non-binary, and gender-nonconforming students, and students with various forms of neurodivergence, and future work should explore how students with these identities respond to course challenges. Finally, there are other variables that would be useful to measure in addition to sense of belonging, such as students' perceptions of whether their instructors care about them (Rainey et al., 2019), and students' mindsets and imposter feelings (Muenks et al., 2020). Recent discussions critique sense of belonging as a measure of how well students can assimilate to an exclusionary and oppressive system (Ramos et al., 2024). Measuring additional variables may enrich our understanding of how to support students as they face and respond to academic challenges in STEM.

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Appendix

Survey Questions

Open field questions:

Student #

Course

Study program

Semesters studied at the University

Gender

Quantitative belonging scale:

The next questions deal with your experiences in this course, rated from 1 = not at all (*ikke i det hele tatt*) to 6 = extremely (*ekstremt*). Some elements may seem to overlap with previous questions, but these questions are meant to deal with different research questions.

- How comfortable do you feel in this course?
- To what extent do you feel like you can be yourself in this course?
- To what extent do you feel accepted in this course?
- To which extent do you feel alienated in this course?
- To which extent do you feel that you "fit in" in this course?

Open-ended question:

Norwegian:

Hvilke spesifikke utfordringer har du møtt som student – enten i dette emnet, i studiet ditt eller ved universitetet for øvrig? Hva gjorde du for å overvinne disse utfordringene? Prøv å være spesifikk hvis du kan.

English:

What specific challenges have you experienced as a student – either in this course, in your study program or at the university? What did you do to overcome these challenges? Try to be as specific as you can.