Direct and Indirect Influence of Active Learning on Women's Sense of Belonging in Calculus

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Fewer women than men choose to major in STEM, and women leave STEM majors at a higher rate than men – especially after taking Calculus. Prior research identifies low sense of belonging (i.e., feeling like an accepted member of an academic community) as a key reason why women decide to leave STEM majors. Scholars have identified factors that contribute to one's sense of belonging, including students' perceived competence and social connectedness. This study explores ways in which engaging in active learning opportunities might support women's perceived competence and social connectedness, and in turn, their sense of belonging. Women's survey responses suggest that active learning supported their sense of belonging indirectly via their perceived competence and social connectedness, as well as directly.

Keywords: active learning, calculus, gender, sense of belonging

Women continue to be underrepresented in STEM fields (Bressoud, 2023; Seymour & Hunter, 2019), and this gender gap is due in part to women's decisions to (not) major in STEM (Carmichael, 2017; Chamberlain, 2017). Fewer women than men choose to major in STEM early in their college education (Eagan et al., 2016), and women leave STEM majors at a higher rate than men (Chen, 2013; Seymour & Hunter, 2019). Prior work has identified Calculus as a common exit point for women (Ellis et al., 2016; Rasmussen et al., 2019; Seymour & Hunter, 2019). Two key reasons women leave STEM majors are that they feel a low sense of belonging to the field and they perceive the instruction in their introductory STEM courses as "poor quality" (Ellis et al., 2013; Rasmussen & Ellis, 2013; Seymour & Hunter, 2019; Shapiro & Sax, 2011). This report aims to explore women's perspectives on the connections between their sense of belonging and the learning opportunities they experienced in their year-long active learning Calculus course.

Literature Review & Theoretical Foundations

Broadly, feeling a sense of belonging involves feeling connected to or accepted within a particular environment (Rosenberg & McCullough, 1981), rather than isolated or lonely (Hagerty, 2002; Solomon & Croft, 2016). Good et al. (2012) studied students' sense of belonging to an academic domain, which they define as "one's personal belief that one is an accepted member of an academic community whose presence and contributions are valued" (p. 701). This definition of sense of belonging (SB) is most relevant to the current study.

Researchers have found that students with a stronger SB in STEM are more likely to persist in STEM (Seymour & Hunter, 2019; Shapiro & Sax, 2011). However, research shows that women are less likely than men to develop a strong SB in STEM (Good et al., 2012; Rainey et al., 2018; Seymour & Hunter, 2019; Shapiro & Sax, 2011). Good et al. (2012) found that women's SB significantly predicted their intent to pursue math in the future, and that the presence of negative stereotypes about women's mathematical abilities hindered women's ability to develop a SB.

Components of and Contributors to Sense of Belonging

Good et al. (2012) developed the Mathematical Sense of Belonging scale, which measures students' SB specifically in the domain of mathematics. In their study, a factor analysis revealed five distinct components that comprise students' SB: *acceptance, affect, desire to fade, trust*, and *membership. Acceptance* refers to whether students feel included, valued, and respected in the community. *Affect* refers to whether students feel comfortable and calm or nervous and tense within the community. *Desire to fade* is the extent to which students feel like they want to be active participants or fade into the background and not be noticed. *Trust* refers to trusting the instructor to help them learn and believe in their potential, as well as trusting that they do not have to prove their worth. Finally, *membership* refers more generally to whether they feel like members of the community and like they belong.

Researchers have identified several factors that contribute to one's SB (Lahdenperä & Nieminen, 2020; Rainey et al., 2018; Rainey et al., 2019). For this study, I focus on students' social connectedness and their perceived competence.

Social connectedness refers to the extent to which one feels like they have made connections or relationships with the people in their class. Interacting with classmates and/or the instructor allows students to develop social connections (Hoffman et al., 2003). While both SB and social connectedness involve feelings of trust and acceptance among others, SB involves feeling that one is accepted into a larger community, whereas social connectedness can be felt with just a single person. Researchers have found that social connectedness is an important contributor to students' SB (Hoffman et al., 2003; Johnson, 2012; Lewis & Hodges, 2015; Rainey et al., 2018; Thacker et al., 2022; Tinto, 1975). For example, Thacker et al. (2022) found that opportunities to interact impacted students' social connectedness, which in turn influenced their feelings of belonging. And Rainey et al. (2018) found that women in particular were most likely to attribute their SB to feeling socially connected. Further, STEM leavers attributed their low SB to lacking social connections.

One's SB to a domain can also be influenced by their perceived competence in that domain. Perceived competence refers to students' perceptions of their performance and understanding of course-related material (Rainey et al., 2018), and is not necessarily correlated to their performance in that course (Cribbs et al., 2015; Carlone & Johnson, 2007). For example, one might feel competent but perform poorly on an exam due to other factors such as testing anxiety. Research indicates that students' perceived competence can impact their SB (Lewis & Hodges, 2015; Rainey et al., 2018). In Rainey et al.'s (2018) study, students reported feeling like they belonged in their major because they felt like they understood the major-related content. Further, many STEM leavers explained that their low SB stemmed from their low perceived competence. Lewis & Hodges (2015) found that ability uncertainty, or a lack of perceived competence, was associated with low SB. They suggested that perceived competence is tied to social comparison with peers. For example, if students notice that their peers have a better grasp on the material than they do, then they might feel like they are not "good enough" or do not belong in that class.

The Role of Active Learning

One aspect of students' experiences that might influence their SB is the instructor's pedagogical approach. In their follow-up study on why undergraduate students leave STEM, Seymour & Hunter (2019) report that students are less tolerant of "poor quality" instruction than they were 20 years prior. By "poor" they mean instruction that is boring and lacking engagement. More recently, there have been efforts toward supporting student engagement, performance, and retention by incorporating opportunities for students to engage in *active*

learning (Freeman et al., 2014; PCAST, 2012; Smith et al., 2020). While there are many definitions of active learning in the literature, there seems to be consensus on the students' role in the learning process – talking about or doing mathematics. One way we can characterize types of active learning opportunities is in terms of the extent to which the opportunity encourages interaction with others (Griffin, 2023), as shown in Figure 1. In this continuum, learning opportunities like individually working on problems and responding to clicker polls would be located near the individual end of the continuum, while opportunities like group work and whole-class discussion would be located near the interactive end.

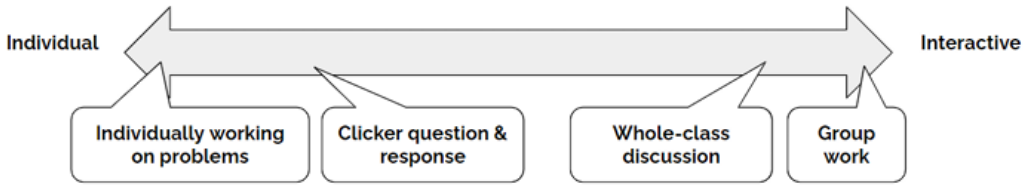

Figure 1. Active learning continuum.

I hypothesize that engaging students in active learning opportunities, especially more interactive learning opportunities, has the potential to strengthen women's SB in Calculus. First, the very nature of interactive learning opportunities enables students to form social connections with their classmates and instructor (Hoffman et al., 2003; MacMahon et al., 2020). Second, research indicates that active learning can support student achievement outcomes like performance, self-efficacy, engagement, and persistence (Freeman et al., 2014; Kogan & Laursen, 2014; Seymour & Hunter, 2019). Participating in group work or whole-class discussions presents opportunities for students to explain their thinking, which can reinforce and enhance their understanding of content, and also to form connections with their classmates. Therefore, active learning opportunities, particularly interactive learning opportunities offer promise as a way for instructors to support women's SB indirectly via their social connectedness and perceived competence.

Research Questions & Methods

The purpose of this report is to explore women's perspectives on the impact particular active learning opportunities had on their SB via their social connectedness and perceived competence. Specifically, I investigate: For women enrolled in a year-long active learning Calculus course, in what ways do they describe the impact of particular learning opportunities on their SB?

I employed a transformative (feminist) mixed methods research design (Creswell & Plano Clark, 2011) to conduct this study. I focus on women's experiences without comparing them to men's experiences because women's experiences are worthy of study in their own right (Du Bois, 1983; Kitzinger & Wilkinson, 1997), and I wanted to avoid comparisons that implicitly position the masculine perspective as "norm" and the feminine experience as "less than" (Gilligan, 1982). I administered surveys to collect data on women's perceptions of the impact of four main types of learning opportunities they experienced on their SB. The qualitative strand of this study aims to elevate women's perspectives, providing context and explanations for quantitative data.

Setting and Participants

This study was conducted at a midsized, mid-Atlantic R1 public university during the 2022-2023 academic year. The university offers a two-semester Integrated Calculus course as an

alternative to the university's standard one-semester Calculus course for STEM majors. The course and sample have been described in detail in prior work (Griffin, 2023; Griffin & Berk, 2023). Students enrolled in the course are typically first-year students who have declared or are considering a STEM major (i.e., as classified by the NSF ADVANCE Program; NSF, n.d.).

The course was designed to incorporate frequent opportunities for students to engage in active learning. During the time of the study, two sections of the course were offered, taught by two different instructors, both committed to active learning. There were 63 and 64 students enrolled in each section. The course is highly coordinated in that instructors teach from collaboratively developed lesson plans, which include recommended active learning opportunities. Specifically, instructors follow an instructional cycle of brief lecture, followed by students working on problems in groups or individually, followed by whole-class discussion. While the course was designed to incorporate opportunities for active learning, students do not know that upon enrolling in the course.

Students enrolled in the course were invited to complete a survey via email. The survey was distributed at Weeks 7, 14, and 21 of the year-long course (i.e., middle and end of fall and middle of spring). Response rates (and total number of enrolled students, N) were as follows: 90% (N=118) at Week 7, 85% (N=118) at Week 14, and 94% (N=108) at Week 21. For analysis, I include students who were first-year students and self-identified as women, which resulted in N=46 at Week 7, N=44 at Week 14, and N=39 at Week 21.

Data Collection & Analysis

To investigate my research question, I used Qualtrics, a web-based survey tool, to design and distribute an electronic survey. I administered the survey at Weeks 7, 14, and 21 of the semester. Within the survey was an item asking participants to select one of the four main learning opportunities they experienced during class (i.e., traditional lecture, interactive lecture, group work, and individual work) and describe how or why that activity has or has not impacted their SB in math. Note that the language "interactive lecture" was used in place of "whole-class discussions" because cognitive interviews with students enrolled in the course suggested that students were unclear on what was meant by "whole-class discussions" and would instead call that "interactive lecture."

At each time point, I calculated the frequencies and percentages of women's choices of activity. I analyzed their open-ended descriptions using theory-guided content analysis, anticipating the use of *social connectedness* and *perceived competence* as codes to identify times when active learning opportunities impacted women's SB indirectly via their social connectedness or perceived competence, though I also allowed for other themes to emerge. For example, I anticipated that the components of SB (i.e., *acceptance, affect, desire to fade, trust, membership*; Good et al., 2012) might emerge from women's responses, indicating more of a direct impact on their SB, so these were considered in the coding process as well. I first clustered responses by learning opportunity so that I could explore all the ways that, say, group work impacted women's SB throughout the year. Responses were not compared across time points; rather, I wanted to capture the scope of the ways in which women viewed the active learning opportunities as impactful toward their SB throughout the year.

Results

At Weeks 7, 14, and 21, participants were asked to select a learning opportunity from a list of four (i.e., traditional lecture, interactive lecture, group work, and individual work) and describe its impact on their SB. In their responses to this item, participants tended to do one of two things.

They either (1) described how the activity impacted their SB indirectly via their social connectedness or perceived competence, or (2) described how the activity they chose impacted their SB directly by invoking one of the components of SB (i.e., *acceptance, affect, desire to fade, trust, membership*; Good et al., 2012). Table 1 presents the percentages of women who chose each activity to describe its impact on their SB. Women were most likely to choose activities that fall more toward the interactive end of the active learning continuum (Figure 1). I present their responses by activity, beginning with the indirect impact it had on their SB via their social connectedness and/or perceived competence, followed by the direct impact it had on components of their SB. Given that so many women chose to discuss the impact of group work and interactive lecture on their SB, I will focus on these two activities after providing a brief synopsis of their perspectives on the impact of traditional lecture and individual work on their SB.

Table 1. Percentages of Women Who Chose Each Activity to Describe its Impact on their Sense of Belonging.

Activity	Week 7	Week 14	Week 21
Group Work	46%	52%	69%
Interactive Lecture	46%	32%	21%
Individual Work	4%	5%	5%
Traditional Work	4%	11%	5%

Note. At Week 7, N=46. At Week 14, N=44. At Week 21, N=39.

Not many women chose to discuss the impact of traditional lecture or individual work on their SB, though those who did commented on ways these activities positively impacted their SB. Those who chose traditional lecture (N=7), either discussed ways that traditional lecture impacted their SB indirectly via their perceived competence (e.g., "Traditional lecture affects how well I know the material and am able to apply it. If I feel I do not know the material well, I feel less of a sense of belonging."), or their response was vague. For those who chose individual work (N=6), responses reflected an indirect impact on their SB via their perceived competence. They either reported that they preferred to work alone or that they appreciated the opportunity to test their understanding.

Interactive Lecture

Across time, N=27 women chose to describe the impact of interactive lecture on their SB. Women's responses suggested both an indirect impact of interactive lecture on their SB via their perceived competence, as well as a direct impact on two components of SB – their feelings of acceptance and desire to fade.

Indirect impact via perceived competence. Some women (N=12, 44%) described interactive lecture as impacting their perceived competence, which in turn impacted their SB. In many cases, women explained that interactive lecture helped them understand the material. For example, one woman described, "When we have interactive lecture, we are able to discuss out all of the problems and share our ideas which helps me learn best." Others mentioned interactive lecture provided an opportunity for social comparison, which allowed them to compare their own level of understanding with that of their classmates. For example, one woman reported, "I would say interactive lecture is the most helpful because I get to hear what other people say and if they are struggling on the same things as me."

Direct impact on sense of belonging. Other women described interactive lecture as impacting one of the components of SB directly. Some women described ways it impacted their

feelings of *acceptance* (N=8, 30%). Some women described times they felt included and like they matter during interactive lecture. For example, one woman reported, "It allows my teacher to talk with us and engage us, so I feel like we are all included and listened to." Another said, "[Interactive lecture] makes me and other students feel like they matter and have a say in the class because it's encouraged for them to participate."

Many women (N=16, 59%) described how feeling involved, in contrast to fading into the background, contributed to their SB. These comments align with the *desire to fade* component of SB, though they reflect a positive view toward engagement. For example, one woman reported, "[Interactive lecture] helps with engagement and allows me to make sure I am learning which increases my sense of belonging." Others (N=2) reported that interactive lecture helped them pay attention during class, which made them feel engaged.

Group Work

Across time, N=39 women chose to describe the impact of group work on their SB. Women's responses suggested both an indirect impact of group work on their SB via their social connectedness and their perceived competence, as well as a direct impact on three components of SB – their feelings of acceptance, their desire to fade, and their affect (i.e., feeling comfortable versus anxious).

Indirect impact via social connectedness. When describing how group work impacted their SB, some women discussed how group work impacted their feelings of social connectedness, one of the contributors to SB. At times, women described group work as a means for them to feel socially connected to their classmates (N=23, 59%), which in turn supported their SB. In many cases, these were generic responses about being able to form relationships, make friends, and get to know their classmates. For example, one woman noted, "I get to know other classmates and create connections in the classroom. In a more specific example, one woman wrote:

> [Group work] has had the most positive impact on my sense of belonging in math because going over how we get an answer with my groupmates makes me feel like we're all in the same boat and I'm able to get to know my group a little better.

Indirect impact via perceived competence. Other women (N=17, 43%) reported ways that group work supported their perceived competence, which in turn supported their SB. Some simply reported that helping each other during group work supported their understanding of the material. Others were more specific and described how hearing multiple perspectives during group work supported their learning. One woman wrote, "It is helpful to get the perspectives of other students in your group and talk the problems through with them." Another wrote:

> I think talking the problems out helps me to understand the concept rather than copy answers form the professor or be confused on my own. I can also see new ways of explaining the concepts that are tricky by talking with peers.

Hearing others' perspectives also allowed students to see how well they understood the material compared to their classmates. For example, one woman wrote, "Group work is a chance for everyone to get together and share their ideas. This will allow one to get a sense of their and everyone else's understandings." Gauging others' levels of understanding made some participants feel less alone when they were struggling to understand something. One participant shared that group work allowed her to "realize that other people may also be struggling with some concepts," suggesting that she felt on-level with her classmates, which supported her SB.

Direct impact on sense of belonging. When describing the impact of group work on their SB, some women (N=9, 23%) described the ways group work impacted their feelings of *acceptance*. Some mentioned feeling valued and included. For example, one woman noted, "I

have a higher sense of belonging when working with others because it feels like I'm needed and not just there to be there." Others reported feeling like they were not alone. One said, "Group work helps with your sense of belonging because at times it's hard if you feel like you are the only one struggling. However, if you know that others are struggling too… it's a lot easier to feel like you belong,"

Other women (N=19, 49%) described group work impacting their engagement, which aligns with the *desire to fade* component of SB. Women mostly reported that engaging by getting to work together and help each other during group work supported their SB. Many women made generic statements connecting their engagement in group work with feeling like they belong. In more specific responses, women associated their level of engagement with their *affect* (e.g., feeling comfortable, calm, nervous, or anxious; N=6, 15%). In fact, all but one of the responses about affect also referenced engagement. One woman explained

> Group work makes me feel comfortable participating because I get anxious about answering questions in front of the whole class. I can share ideas with people I've grown to be comfortable and friendly with without having a fear of rejection.

Others echoed this idea that it was easier to engage when they felt comfortable. Another woman noted, "It is less intimidating to ask questions because asking in front of the whole class can be uncomfortable." Thus, participating in group work supported women's feelings of acceptance, as well as their engagement and their affect, all of which are components of their SB.

Discussion

The goal of this report was to explore women's perspectives about the impact of specific learning opportunities on their SB. The findings presented here build upon findings from Griffin (2023) by examining the impact of four learning opportunities rather than only two and providing women with a platform to describe ways their SB were impacted by these learning opportunities. When asked to select a learning opportunity and describe its impact on their SB, women were overwhelmingly likely to select group work and interactive lecture. This finding supports my hypothesis that *inter*active learning opportunities may offer more promise than solo-based active learning opportunities in supporting women's sense of belonging. In their descriptions, as hypothesized, women noted ways in which group work and interactive lecture supported their SB indirectly via their social connectedness and perceived competence. These activities supported women's ability to understand the material, as well as their ability to form relationships with their classmates, which in turn, supported their SB. In addition, women noted ways in which their SB was impacted directly as well, by invoking particular components of SB, namely, *acceptance*, *desire to fade*, and *affect,* in their responses. For example, both group work and interactive lecture supported women in feeling engaged and like their voices were valued. This is not to say that instructors should *only* employ group work and interactive lecture as women did report positive impacts of both traditional lecture and individual work on their SB. Specifically, they noted that these learning opportunities supported their perceived competence, which in turn supported their SB. However, this report provides support for employing at least some interactive learning opportunities as a way to support women's SB, which could in turn support their retention in STEM. Additionally, while other reports (Johnson et al., 2020; Reinholz et al., 2022) have noted negative impacts of active learning on women, interestingly the qualitative data in this study showed no indications of negative impacts of group work and interactive lecture on women's SB. These differences in findings could be due to several factors such as the sample, the instructors, or the enactment of the learning opportunities. More work is needed to explore aspects of enactment that are particularly important for women's SB.

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