RESONATING FEEDBACK: THE IMPACT OF FEEDBACK CYCLES ON STUDENTS' SENSE OF BELONGING IN AN EIGHTH GRADE BIOLOGY CLASSROOM

by

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DEDICATION

"Dedication" is a perfect word for the many people behind this project. Deep thanks to my support committee – Marcie Reuer, Gregory Francis, Christine Primomo, and Hannah Chapin for their hours of reading, feedback, and analysis. Appreciation to Julia Rosenfeld, my partner in all things, including research, and to Fievel Jack Finley for hours of support, clarity, and comfort through the process of data-jousting. Most importantly, appreciation to my students for being the best teachers, editors, and curriculum-builders a researcher could ask for. This is for you.

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ABSTRACT

This classroom research project addresses the issue of middle school students' sense of belonging in their eighth-grade science classroom. Many students report a shift in relationship to science, technology, engineering, and mathematics in the middle grades. Regular feedback cycles about classroom procedures and assignments were implemented in two sections of my classes and compared to a third section who provided written feedback only. Differences in students' self-reported sense of belonging in my classroom before, during, and after two responsive feedback cycles showed no significant differences over the treatment cycle, but different individual classes of students had significant differences between them in their sense of belonging throughout the treatment. The relationship between students' sense of belonging was compared with vocal participation and relationship to grades and achievement. There was a positive, non-significant relationship between belonging and classroom participation and students' grade point average. Student responses indicate further research on the interactions between peers and teachers and teaching strategies to mitigate peer influence and disciplinary issues is one possible next step towards increasing students' sense of belonging in the science classroom.

INTRODUCTION AND BACKGROUND

Project Background

In November 2016, I was encouraged by a colleague to write my personal path to science – a map of the 'key events, people or things in your life that have contributed to your career as a science teacher.' She had encountered this at a National Science Teaching Association conference session that focused on equity in the science classroom and passed it along as a technique to use with my students and myself. When drawing out my own story and relationship to science, a pattern emerged. When I had a strong sense of connection to my teacher and co-creating the space I was in, I loved science. I was engaged, saw myself as capable, and was excited about future science courses. When I didn't feel included or connected to my teacher or the content we were studying, I detached myself from the task at hand and tried to dissociate with science. In fact, as I thought through the reasons why I chose to avoid science classes in college, I found myself thinking back to patterns established when I myself was a middle school student, struggling to find a place for myself in the science classroom. This is just one story, but it is not a coincidence. When interviewing other science faculty about their personal paths to becoming a science teacher, they also described moments from middle and high school that solidified (or dissolved) their relationships to their teachers, and to science, as a whole. Carlone, Scott, and Lowder (2014) found that the transition into middle school is a crucial time for identity development around being a "science person," or being able to succeed in science. Finding ways of connecting more readily with my students during their middle school years is an essential part of being an effective teacher and may also

lead some students to see themselves as effective scientists in a way that they would not have otherwise. Furthermore, this connection to scientific practice is one important piece of the puzzle of trying to increase representation of underrepresented groups in science fields, including women and girls, black and Latinx people, and people with disabilities.

The goal of this classroom research project was to use student feedback as one method of increasing students' sense of belonging in my science classroom. This would improve teaching effectiveness because students provided information about the systems within the class that are meeting or not meeting their needs and changes were made accordingly. I predicted that students would have an easier time learning because as we generated and implemented student feedback, improvements were made that removed barriers to engagement identified by the students themselves. I also predicted that my relationship with students would improve as students observed me taking steps to include them in important decision-making processes. I hoped this investment in student agency would translate into a sense of belonging and self-efficacy in academic work by demonstrating that student voices matter in the science classroom. I hoped to create a space in my classroom where students feel as though they can bring their full selves, whoever that was at the moment, and be met with respect, engagement, and positive paths to change that they believed would make the classroom better suit their needs.

Participants and Demographics

The study followed the 55 eighth grade students I taught during the Fall 2017 trimester. All were enrolled in an independent 6-12 school in Seattle, Washington. The total eighth-grade class was 94 students; the school has 817 students enrolled in the 2017-

18 school year. All data used for analysis had names removed and included a code to connect responses in different data collection tools to one another for analysis. I asked students to report their own demographic identity information. Thirty-nine of my students (71%) identified as white. Of the 29% of students that identified as people of color, six were Asian or Indian American (11%) and the remaining ten identified as a race or ethnic group that is underrepresented in science, technology, engineering, and mathematics (STEM) fields, such as black, mixed race, or Latinx (18.2%). Thirty-two students identified as boys (58.2%), 22 as girls (40%), and one as a nonbinary gender identity (1.8%). This is a close approximation of the demographics of the broader eighth-grade class at our school, which is 76% white and 62% boys. It is, however, more white than our local community, which is 65.7% white, 14.1% Asian, and 20.2% underrepresented racial/ethnic groups in STEM (U.S. Census Bureau, 2017). It is also important to note my position as an educator and my personal background. I identify as white and grew up in a predominantly middle-class white suburb in central Massachusetts. I am also a temporarily able-bodied transgender queer man. Having experiences that put me on the margin of STEM as well as in the center means that I am able to relate to both experiences. However, as a white educator in particular, it is important to recognize that I have never directly experienced racism, and my personal values are rarely challenged by my predominantly white institution. Keeping this demographic information in mind will be important for framing the work around identity and belonging happening in my classroom space, as specific groups overrepresented in

professional STEM are also present in disproportionate numbers in our school community.

Research Questions

In fall 2016, I tried a classroom assessment tool that involved gathering students' perspectives on class issues and then discussing and acting on their feedback as a larger group (Angelo & Cross, 1993). Though I had practiced collecting student feedback in the past, I had never "closed the loop" with my students to ensure that they saw how their feedback might affect the classroom's structure. I found the practice transformative. Students had many ideas about improving classroom procedures and assignments that had not come up in planning sessions with my co-teacher. Their collective wisdom was greater than their responses that I had collected individually, and students built off of one another and learned from one another while providing feedback about how to improve our classroom structures. Moreover, I observed that students' excitement about participating in classwork increased when they saw that they had more of a hand in designing the structure of that work and our classroom routines.

This experience led to the design of this classroom research project. By regularly practicing receiving feedback about classroom structures, discussing issues that arose, and identifying needs that students from underrepresented groups felt were missing in my classroom environment, I hoped to increase the overall sense of belonging of my students. The primary research question I asked was, "How does practicing regular feedback cycles in whole-class discussions impact students' sense of belonging in an eighth-grade human biology classroom?" The focus questions I explored were:

- How does participation in and response to feedback discussions change students' self-reported sense of belonging?
- How does students' sense of belonging affect participation in academic discussions and their perceptions of feedback and grades?
- What strategies will students identify to create a more welcoming classroom and increase their sense of belonging?

I was particularly interested in investigating the relationship between feedback cycles and students' sense of belonging. I extended my data collection and investigation into grades and participation because they are two highly valued measurements of student success. Teachers frequently reference a student's vocal participation and grades in conversations with other teachers about their performance overall, and it appears to be culturally significant at my school. I wanted to see if students' sense of belonging in my classroom interacted with these markers in significant ways worth investigating and if it could be possible to predict a student's sense of belonging through these easily measured external markers.

CONCEPTUAL FRAMEWORK

A persistent issue in professional STEM fields is the underrepresentation of certain identity groups compared with the general population (Corbett, 2010; National Science Foundation, 2017). In 2014, women earned less than 20% of the degrees earned in physics, engineering, or computer science, and less than 40% of the degrees earned in mathematics. In 2014, underrepresented racial groups (those who identify as a race other than White or Asian, including mixed-race individuals) make up 33% of the working-age

population, yet they make up only 12.7% of the STEM workforce (National Science Foundation, 2017).

Many factors contribute to this disparity. Women, people of color, and other underrepresented groups report many obstacles to feeling like they belong in the STEM classroom. Facing lower expectations, stereotype threat, lack of shared-identity role models, and feelings of isolation in predominantly white and male STEM programs adds stress to an already challenging academic path (Eddy & Brownell, 2016; Walton & Cohen, 2007). Even in fields where underrepresentation is no longer an issue of numbers, stereotypes about specific groups persist and create challenges for those who are not white and male (Eddy & Brownell, 2016). One example is biology, where women receive about 60% of undergraduate degrees, but continue to face obstacles to success and a sense of belonging (Eddy & Brownell, 2016; Moss-Rascusin, Dovidio, Brescoll, Graham, & Handelsman, 2012). Heteronormativity is also an issue in science classrooms, even though LGBTQ-identified students are not thought to be numerically underrepresented in STEM fields (Cooper & Brownell, 2016).

A sense of belonging in the STEM classroom, instilled as a young person and reinforced throughout a person's education, is crucial for persistence in STEM fields for underrepresented groups. Early adolescence is a critical time for science identity development in young people; the middle grades are a time when students' identity development is being directed towards or away from studying STEM topics at a high level (Carlone, Scott, & Lowder, 2014). As a middle school teacher, I carry an especially critical role as either inviting my students into the practice of science or disinviting their

participation. In this classroom research project, my aim was to evaluate how a feeling of participation in feedback processes within the classroom affected a student's sense of belonging in my classroom and in science more broadly. Using student surveys, classroom observations, and large-group feedback discussions, I hoped to uncover the relationship between vocal participation, grades and achievement, and feedback cycles on students' connectedness and sense of belonging on different groups of students in my classroom, and to have invited students to help co-create a more inclusive learning environment.

I was also interested to investigate the impact these conversations have on the cisgender[1] white boys in my classroom, whose experiences are often overlooked in literature related to belonging because there is no crisis of STEM underrepresentation for white boys. Some interventions aimed at including more women and people of color in STEM classrooms have been shown to negatively impact white cisgender men (e.g. Miyake et. al., 2010), but little discussion of this issue was present in the literature. It is crucial that classroom inclusion tactics welcome everyone into the conversation about belonging, connectedness, and creating a future where those who work in STEM represent the same diversity of identity and voice in the broader U.S. population.

[1] Cisgender is a term used to describe people who identify as the gender associated with the sex they were assigned at birth. For example, a cisgender boy is a boy who was assigned male at birth.

Theoretical framework: from margin to center

In her book *From Margin to Center* (2010), bell hooks[2] describes the experience of existing in societal institutions, such as schools and the workplace, from a position distant from the center of power.

> "To be in the margin is to be part of the whole but outside the main body. …Living as we did – on the edge – we developed a particular way of seeing reality. We looked both from the outside in and from the inside out. We focused our attention on the center as well as on the margin. We understood both" (p. xvii-xviii).

For centuries, those centered in American STEM classrooms have been overwhelmingly white, cisgender, outwardly straight, and male (Letts, 1999). To those outside those four central identity groups, finding a sense of belonging in the STEM classroom is challenging. The stories and work of women, people of color, LGBTQ people, and people with disabilities, when they are noted, are often literally marginalized – placed in boxes highlighted outside of the ongoing narrative of science textbooks rather than a part of the central story (Saunders, n.d.). Understanding and changing the dynamics of marginalization is crucial to dismantling its influence on underrepresentation in the STEM workforce.

Students from marginalized identity groups experience a variety of obstacles to learning that are not experienced by those whose cultures are reflected in the practices of teaching. One example is lower expectations held for students of color and female students compared with their white and male classmates (Delpit, 2013). Over 90% of science teachers grades 7-12 are white, leaving students of color with fewer role models

[2] The author bell hooks does not capitalize her name to focus on her work and words, not her personality (hooks, 1996). I follow that convention here to honor her choice.

than white students ("The K-12 Science Teaching Workforce," 2015). Students from marginalized groups also experience *stereotype threat*, the impact of stereotypes about a person's identity group that can have on their overall performance in an academic subject (Steele, 1997; Table 1).

Table 1
Key Terms Framing Belonging and Inclusion in STEM Education

Key term	Definition
Stereotype threat	Being in a situation where a negative stereotype about an identity group you are a part of is relevant (Steele, 1997)
Belonging	How well a student sees themselves fitting into the culture of practice in a particular subject (Eddy & Brownell, 2016)
Self-efficacy	A student's sense of being able to succeed in a subject (Eddy & Brownell, 2016)
Disciplinary identity	A student's sense of oneself as a practitioner of an academic discipline (Eddy & Brownell, 2016)
Interaction rituals	Regular practices that engage students in a shared sense of community (Olitsky, 2007)
Intersectionality	The experience of being a member of two or more oppressed groups is different than simply the sum of each oppression, i.e. being a woman of color means more than experiencing racism and sexism separately, but racialized misogyny (Crenshaw, 1988)

Students whose identities are in some ways marginalized in the science classroom know the world through two lenses – that of their home identity and that of the center of power. But what if science classrooms instead asked students to bring in their own expertise and knowledge in a way that centered their own understanding of the world? Freire (1970) describes this in his book *Pedagogy of the Oppressed*:

> The truth is, however, that the oppressed are not 'marginal,' are not people living 'outside' society. They have always been 'inside' – inside the structure which made them 'beings for others.' The solution is not to 'integrate' them into the structure of oppression, but to transform that structure so that they can become 'beings for themselves' (p. 74).

The basic theoretical framework of this classroom research was to flip the power dynamic to include students of presently marginalized identities within STEM to co-create a space that is more inclusive of their ideas in one middle school biology classroom. The goal of constructing a space where a broader range of students can access a sense of belonging was for students who otherwise felt they had to leave a part of themselves at the door can feel more embraced by our collectively created classroom culture.

Eddy and Brownell (2016) divide affective measures of student success into three main branches – self-efficacy, belonging, and disciplinary identity. *Self-efficacy* describes a student's sense of being able to succeed in a subject, *belonging* is how they see themselves fitting into the culture of the scientific practice, and *disciplinary identity* describes a student's sense of oneself being a practitioner of that form of science (Table 1). Of these three affective measures, I have chosen to hone in on belonging. Good, Rattan, and Dweck (2012) linked a greater sense of belonging in mathematics among female undergraduate calculus students to increased interest in pursuing higher-level coursework in mathematics, indicating that increasing overall sense of belonging can lead to improvements in representation for marginalized groups in STEM. Belonging in a community is also a persistent desire during adolescence, which I predict will compound

its importance on middle school students' overall sense of well-being, persistence, and success in the science classroom.

Constructing a sense of community: who "belongs" in science?

Studying students' sense of "belonging" begs the question – how can we think about belonging in a concrete, measurable way? Many researchers have approached this question, with a variety of research methods and frameworks that are helpful for framing this classroom research project. Previous research fed directly into the rationale for specific treatments used in this project and supports the reliability and validity of data collected.

Master, Cheryan, and Meltzoff (2016) focused on how a classroom's physical layout and design impacted students' sense of belonging in a future computer science class. They described a computer science class to groups of high school students, with some students shown a "stereotypical" computer science space (with Star Trek figurines, electronics equipment, and nerdy posters) and others a "neutral" classroom (with plants, water bottles, and art). When shown the first classroom, male students were more interested in the course and had a higher sense of belonging than female students, whereas the second classroom eliminated this difference between the two groups. The researchers termed this idea of seeing oneself reflected in a physical space "ambient belonging," with certain stereotypes about spaces intersecting with identity in determining whether or not a student is comfortable in a classroom.

Stout, Ito, Finkelstein, and Pollock (2013) measured the relationship between belief in gender stereotypes in physics and men and women's sense of belonging in the

physics classroom. They found that stereotypic beliefs about men being inherently better at physics than women led to a statistically significant difference in women's sense of belonging in physics. A questionnaire measured students' sense of belonging by asking three belonging-specific questions and one question about students' beliefs about a stereotype that men are inherently more capable in physics than women. This showed a measurable effect of stereotype threat on women's sense of belonging in the physics classroom, an effect which must be taken into consideration when constructing my own classroom research project.

Olitsky (2007) examined the relationship between *interaction rituals* in an eighth-grade science classroom and students' sense of engagement and belonging in that space (Table 1). Interaction rituals describe a wide range of activities that occur in the classroom that create a point of mutual focus, invoke a sense of community membership for students, co-construct a language specific to the individuals in the room, allow some side-talk and personal expression, and lead to physical or emotional entrainment as a group. The author used an ethnographic approach to work alongside students and the classroom teacher to evaluate how interaction rituals impacted the practice of science in their classroom. By working alongside the classroom members in creating a definition of a "community of practice," the research identified ways in which student-teacher exchanges increased students' sense of belonging and engagement in science practices.

Walton and Cohen (2007) coined the term "belonging uncertainty" to describe the experience of many marginalized groups feeling unsure if they belong in their STEM field of choice. They did two experiments to measure the impact of this effect on white

and black undergraduates on their perception of belonging uncertainty in computer science with a specific focus on peer influence on students' beliefs about STEM. They first asked students to name friends that they think would make a good fit for the computer science department at their university, with one experimental group asked to name two friends and one asked to name eight friends. Since the second number is most likely challenging for any participant in the study, the researchers assumed that this would activate the threat of belonging uncertainty. This treatment significantly impacted black students' sense of belonging and potential in computer science, whereas white students were not affected by this question.

The second experiment Walton and Cohen performed focused on students' idea that others in their age group experienced similar doubt about social belonging in college. Providing freshmen students with a statement from multiple upperclassmen about their experiences of feeling isolated or challenged by the transition to college early on significantly raised black students' sense of belonging and academic achievement compared with black students who were not given that reassurance. This suggests that including peer voices about challenges associated with social pressure and an ability to overcome those challenges has a positive impact on marginalized groups in the classroom.

Students' sense of belonging in the classroom is impacted by many factors, including relationships to physical space, peers, and stereotypes about their identity groups. Researchers have used a variety of methods to quantify the experience of belonging, an important methodological framework that built into the techniques used in

this classroom research project. Certain practices, including interaction rituals and creating neutral physical space, have been shown to reduce belonging gaps between demographic groups of students. Holding space for the experiences of many on the margin of visible practice in STEM creates an opening where centering those experiences may, in fact, reduce the impact they have on students' sense of centeredness and belonging in STEM fields.

Methodology for studying belonging

Many different techniques for study design and data collection have been used to analyze students' sense of belonging in the science classroom. I will highlight a few that I find useful when considering the scope of my classroom research project. Data collection techniques that I plan to use include feedback cycles, surveys, participation records, and academic achievement.

The feedback cycles used as a treatment are supported by several examples in the literature for attempting to boost students' sense of belonging in the science classroom. Walton and Cohen (2007) found that students at risk of stereotype threat and belonging uncertainty benefit from hearing about other students' challenges; those feedback discussions provided a place for students to hear about the ways other students have had a hard time with the way classes are structured and work evaluated. Feedback cycles are one example of an interactive ritual that can connect the community through emotional entrainment, creating a common language, and design a space specific to the people in the room. They also provide a basic group interviewing tool that can be used to elicit students' ideas about improving overall belonging in the classroom, helping to answer the

third focus question about what treatments they recommend to improve overall belonging.

Many researchers used surveys to measure students' sense of belonging and community. Townley et al. (2013) used a standardized instrument named the Sense of Community Index to measure students' feelings of belonging in the STEM field in their university community. Walton and Cohen (2007) and Murphy, Steele, and Gross (2007) both used surveys that focused on social fit within their chosen discipline. The short survey used by Stout et al. (2013) had only eight simple items that I adapted for use with my own students.

Measuring student participation in my classes is one way of measuring comfort and belonging with the culture of the classroom community. Townley et al. (2013) measured student participation in STEM-related coursework and extracurricular clubs. Instead of using solely self-reported data, which could be influenced by false perceptions of themselves or others, I used records from discussions tracked by students to look at whose voices are heard more than others in my classes. I was interested to see if there was a positive relationship between students' sense of belonging and the amount of their vocal participation in class discussions.

Finally, one measure used by many studies related to belonging and inclusion is student academic achievement and GPA (Cohen, Garcia, Apfel, & Master, 2006; Miyake et al., 2010; Townley et al., 2013). I included this as one measurement tool, but there are a few considerations when considering the reliability of this as data used to compute a student's sense of belonging in STEM. One complicating factor is that students' grades

in my class are largely dependent on their participation and engagement in classroom discussion, a different data set in this project. Another is that student grades are negatively impacted by missing assignments, which intersects with issues of executive functioning, cognitive processing, and learning disabilities. Finally, students' emotions around grades vary widely, with some students strongly self-identifying as a "Straight A" student and others who couldn't care less about their GPA in middle school science. I decided that instead of using GPA as a direct measure of students' belonging, I would investigate the relationship between GPA and belonging. I also used students to let me know what grade they felt they deserved and compared it to their actual grades in an attempt to measure discrepancies in student confidence and achievement, which may relate to impostor syndrome and stereotype threat.

METHODOLOGY

The primary question answered in this classroom research project was, "How does practicing regular feedback cycles in whole-class discussions impact students' sense of belonging in an eighth-grade human biology classroom?" The focus questions I explored were:

- How does participation in and response to feedback discussions change students' self-reported sense of belonging?
- How does students' sense of belonging affect participation in academic discussions and their perceptions of feedback and grades?
- What strategies will students identify to create a more welcoming classroom and increase their sense of belonging?

By identifying a potential low-input strategy for increasing students' sense of belonging, I hoped to improve students' continued participation and engagement in STEM subjects as well as increase my instructional effectiveness. The research methodology for this project received an exemption by Montana State University's Institutional Review Board, and compliance for working with human subjects was maintained (Appendix A).

Research Matrix

Analyzing the listed research questions requires triangulation of different data sources as evidence. Below, a triangulation matrix (Table 2) summarizes the major sources of data used as evidence in answering each focus question. They are a mix of quantitative and qualitative measurements.

Table 2
Data Triangulation Matrix

Focus question	Treatment data measurement tools		
1. How does participation in and response to feedback discussions change students' self-reported sense of belonging?	Large-group feedback discussions: data collection tool	Self-assessment of sense of belonging in the science classroom (pre-treatment)	Self-assessment of sense of belonging in the science classroom (post-treatment)
2. How does students' sense of belonging affect participation in academic discussions and their perceptions of feedback and grades?	Self-assessment of sense of belonging in the science classroom (pre-treatment)	Discussion tracking	Self-assessment of grade earned and actual achievement in science classes
3. What strategies will students identify to create a more welcoming classroom and increase their sense of belonging?	Large-group feedback discussions: data collection tool	Survey responses to open-response and checklist questions (pre-, mid-, and post-treatment)	Student quotes and teacher's observations

Treatment Description

Because my students change each trimester, I implemented my treatment in the fall trimester (August 31-November 22, 2017). I teach three sections of Human Biology, two that met in the morning (A and B blocks) and one that met in the afternoon (E block). All three classes completed the feedback survey given to students, but only the two morning classes completed large-group discussions as the experimental treatment.

For all data analysis, I assigned students a random alphanumeric code. When originally coding data, I found myself trying to identify students based on their class block and demographic information, so I also removed the class block for each participant for my major analyses to remove any implicit bias I have towards students and their responses. Class block information was used for data analysis related to how the feedback cycles impacted students' sense of belonging but not for other analyses.

Table 3 summarizes the timeline of treatment for each classroom. Baseline measurements included discussion tracking and a pre-assessment of students' self-reported sense of belonging. Mid-treatment measurements were discussion tracking, continued belonging surveys, focus group discussions, and a student assessment of academic performance. Post-treatment evaluation included a final belonging inventory and students' final grades and achievement.

Table 3
Treatment Timeline

Pre-treatment: September-October	During treatment: October-November	Post-treatment: November-December
• Discussion tracking • Sense of belonging survey (Pre-treatment)	• Feedback forms (2 iterations) • Feedback discussions (2 iterations, A and B blocks only) • Student assessment of performance • Sense of belonging survey (Mid-treatment) • Discussion tracking • Mid-trimester grades	• Sense of belonging survey (Post-treatment) • Discussion tracking • Teacher observations and one-on-one conversations

Below is a description of each data collection tool used with a brief description of its scope, rationale, and way it was analyzed.

Sense of Belonging Survey

A student's sense of belonging is defined as how they do or do not see themselves fitting into the culture of the scientific practice. An important instrument in measuring students' sense of belonging was a survey given to students three times during the trimester: before, during, and after treatment. I used the survey instrument used by Stout et. al. (2013) as a launching point for designing my Likert-style questions for this assessment (Table 4). Their work focused on identifying a gender gap in belonging connected to a gap in participation in physics classes. Since my students were not pursuing biology as a career and were required to take my class, I changed the questions to reflect their situation.

Table 4
Likert Survey Questions Inspired by Stout et. al. 2013

Original survey questions (Stout et. al. 2013)	My questions
1. According to my own personal beliefs, I expect men to generally do better in physics than women. 2. I feel like I belong in physics. 3. People in physics accept me. 4. I feel like an outsider in physics. 5. I think about the physics I experience in everyday life. 6. I study physics to learn knowledge that will be useful in my life outside of school. 7. Learning physics changes my ideas about how the world works. 8. Reasoning skills used to understand physics can be helpful to me in my everyday life.	1. Other students in this class have an easier time learning science than I do. 2. I feel like I belong in this classroom. 3. People in this classroom accept me for who I am. 4. I feel like an outsider in science class. 5. I think about how things I learn in biology relate to my experience of everyday life. 6. Omitted (not an elective) 7. Learning human biology changes my ideas about how the world works. 8. Omitted (more relevant to physics and more quantitative fields)

I also added questions that were specific to my students' experience of belonging in my classroom. In an attempt to include my students in every part of the process, I also asked a small group of students to look at the questions and help clarify any confusion that the questions presented, as well as contribute their own ideas. The final list of questions on the Likert-style scale is listed in Table 5.

Table 5
Final Likert Survey Questions After Student Input

My original question list	Final question list, with student input
1. I can be myself in science class.	1. I can be myself in science class.
2. Other students in this class have an easier time learning science than I do.	2. Other students have an easier time learning science than I do.
3. I feel like I belong in this classroom.	3. I feel like I am a part of making this classroom what it is.
4. People in this classroom accept me for who I am.	4. Most students in this classroom accept me for who I am.
5. I feel like an outsider in science class.	5. I have an easy time completing work for this class at a strong level.
6. The things we learn in class are important to me.	6. The things we learn in this class are important to me.
7. The things we learn in class are interesting to me.	7. The things we learn in this class are interesting to me.
8. I think about how things I learn in biology relate to my experience of everyday life.	8. When we learn about examples in this class, they are related to my life.
9. Lewis makes me feel welcome in the classroom space.	9. My teacher makes me feel comfortable in the classroom space.
10. Other students make me feel welcome in the classroom space.	10. Other students make me feel comfortable in the classroom space.
11. Learning human biology changes my ideas about how the world works.	11. The feedback and grades I receive match the effort I put into my assignments in this class.
	12. I am excited about studying science in high school and beyond.

In addition to these core questions, I added questions related to students' demographics and their willingness to participate in further, small-group interviews. These questions (Table 6) were only included in the pre-assessment. I opted to ask students for their own demographic information to ensure that they were comfortable with the way they were being represented, and because official records do not always capture the complexities of students' identities around race and gender, among other identity markers. I was also able to ask science-specific demographic information, such as students' relationships to people in STEM.

Table 6
Demographic Questions on Initial Survey with Rationale

Question	Rationale
A. What is your science block? (A, B, E) B. Did Lewis teach your science class in 6th grade? (Yes, No) C. Which of these best matches your gender identity? (Boy, Girl, Something else) D. What words describe your race and ethnic identity? (ex. Black, Latino, mixed race, White, etc.) [empty field]	A. Different classes have different cultures B. Students' preexisting relationship with me may impact their sense of belonging in my classroom C. Gender identity is shown to impact students' sense of belonging (Stout et. al. 2013, among many others) D. Nonwhite students experience stereotype threat around their performance in STEM (Steele, 1997)

I administered this Likert-style survey to my students to evaluate their sense of belonging and welcoming in my classroom. Data were collected on Monday, October 23, 2017 before doing the first feedback conversation as a large group. Scores were assigned based on whether the student said that they "Strongly agree" (5), "Agree" (4), "Neither agree nor disagree" (3), "Disagree" (2), or "Strongly disagree" (1) with each statement. One question was reverse-scored because it was phrased in the negative ("2. Other students have an easier time learning science than I do.").

Students' Likert scale responses were evaluated both by individual question and as a mean of the total responses for pre-, mid-, and post-treatment belonging scores. I compared different demographic groups to see if any trends emerged that matched expectations based on previous research, as well as comparing the pre- and post-treatment belonging scores for the experimental and control groups to answer the first focus question, "How does participation in and response to feedback discussions change students' self-reported sense of belonging?" I showed the means and distributions of overall Likert scores using a box-and-whisker plot and used a Mann-Whitney U test to

compare non-parametric distributions of the survey scores, and a *z*-score to estimate statistical significance based on the size of the samples.

Discussion tracking

A rotating student volunteer recorded each time students participated in class discussions week by week. Data were collected for six in-class reading seminars by student volunteers. Students recorded whether or not a student was absent, taking notes, or sick in order to account for illness and other responsibilities. This recorded the individual number of times a student spoke, but not the amount of time they took for each time they participated.

Though students recorded data for six different class discussions, these data were not as rich a source for analysis as I had originally hoped. Student absences and other responsibilities limited the scope of data, and the data were not collected frequently enough to provide a fine resolution on any trends that might have appeared with data collection on a daily or semiweekly basis. Students' vocal participation was compared with their Likert survey scores using linear regression to see if any significant relationship between students' self-reported sense of belonging and their participation in class discussions existed.

Student self-assessment of achievement in my classroom and feedback survey

Creating a survey that gathered student feedback about their own achievement and providing feedback about classroom procedures was essential groundwork needed to begin treatment. The survey questions for all three surveys fell into two categories: evaluation of current classroom procedures and suggestions for improvement in

classroom procedures. The initial survey, given around the mid-trimester grading period in October, also included a section on students' self-assessment of achievement in science class. Students in all three classes completed these surveys.

The first set of questions related to classroom procedures. Students ranked the usefulness of different readings, case studies, and in-class activities in preparation for feedback discussions. A full list of these questions can be found in Appendix B. This specific data-gathering allowed me as the teacher to present the concrete evidence of students' responses in preparation for feedback conversations around classroom routines. These large-group discussions helped answer the first focus question, "How does participation in feedback discussions impact students' sense of belonging?" and the third focus question, "What strategies will students identify to create a more welcoming classroom and increase their sense of belonging?"

The second set of questions asked students to consider interventions that they could identify that might make the classroom a more welcoming place for themselves. These questions were important to have at the end of the survey, since covering the major content of the class may activate parts of their thinking that have constructive feedback that can improve classroom culture and inclusion. These data also contributed to answering the third focus question.

Questions focused on students' ideas about improving classroom culture:

1. Give one or two specific examples of things that your teacher does that really help you learn human biology.

2. Give one or two specific examples of things that your teacher does that make it more difficult for you to learn human biology.

3. What specific changes can your teacher make to help your understanding and learning about human biology?

4. What specific changes can we make as a community to help you feel more comfortable in the human biology classroom?

These questions provided a space for students to ideate, leading to further questions during large-group discussions.

The first survey also included self-assessment of achievement, which provided quantitative data about students' perceived achievement compared with their actual achievement on in-class activities, participation, assessments, case studies, and lab work. This connects to focus question 2, "How does students' sense of belonging affect participation in academic discussions and their perceptions of feedback and grades?"

Self-assessment questions related to student achievement:

1. What grade do you think you are receiving in Human Biology right now?

2. Why do you believe that is the grade you are earning in Human Biology?

3. What grade do you think you deserve for your work in Human Biology so far?

4. Why do you believe you deserve the grade you listed above?

5. What have you done well so far in Human Biology class?

6. What could you have done better so far this year in Human Biology?

Student grades and achievement

Students' overall grades were used to compare with their sense of belonging and perceived achievement in science class. Students' mid-trimester grades were used as a baseline for comparing their perceived achievement on their mid-treatment feedback survey and compared with students' sense of belonging to look for a relationship between achievement, perceived achievement, and feeling of being welcomed in class. On a routine in-class survey, I asked students to estimate the grade they were receiving in my class and the grade they believed that they deserved. I then compared that to their actual overall percentage grade at the time that the survey was administered.

This was one question on a long survey later used for feedback conversations with my students. Students had 30 minutes to complete the survey in total; this question was early on in the survey, so students did a good job providing thorough feedback. Due to student absences or students not wanting to leave responses, I only have 47 students' responses to this question. Data were collected on Monday, October 9, 2017.

Students reported their perceived grade that they were receiving and that they deserved in either a letter or number format. For each letter grade, I assigned a number as follows; only letters listed by students are shown here - no students recorded a grade below "C+" as the grade they would give themselves/thought that they had earned up to that point (Table 7).

Table 7
Letter Grade Equivalents Used for Data Analysis

Letter grade	Number equivalent	Letter grade	Number equivalent
A	96 (because this is the lowest cutoff for an A grade in my class)	B	85
A-	92	B-	82
B+	88	C+	78

I used these data as an estimate of impostor syndrome, noticing what students underreported their scores compared with their actual achievement, and in comparison, with students' reported sense of belonging. I was interested to see if students who overreported their own grade would report a higher sense of belonging in my classroom, since that may be an indicator of confidence and comfort in science. I was also curious to see if a student's GPA was linearly correlated with their sense of belonging in the classroom, and used a linear regression to determine if there was a significant relationship.

Large-group feedback discussions

After surveys were given in all three classes, students in my morning classes participated in a 30-minute feedback discussion as an entire class. Participation in those discussions was tracked by a student volunteer and I took careful notes on the whiteboard to show students that their ideas were heard and recorded. Individual classes where students generated consensus on a new idea had those inventions implemented immediately. I used the data collected in these discussions to help answer the third focus question, "What strategies will students identify to create a more welcoming classroom and increase their sense of belonging?" I evaluated trends based on the number of

student responses and the frequency of agreement with different strategies to capture the experiences of students in the treatment groups.

Responses to student feedback and teacher observations

In addition to collecting data on students' reported sense of belonging, I was also implementing specific changes to my classroom rituals and routines to reflect the suggestions presented by students. These included suggestions that came from feedback surveys, large-group discussions, and spur-of-the-moment shifts that emerged outside of those spaces. Details on the changes made and how they impacted students' engagement in classroom community are detailed in the next section based on thematic analysis and include student quotes and trends in responses to surveys and in conversations with individuals and groups.

The list of tools above attempted to create a clear picture of students' sense of belonging and participation in creating a classroom that reflects their interests and identities. Measurements of belonging included the Likert scale generated based on Stout et. al. (2013) to cover a wide range of topics related to sense of belonging in the classroom. This was contrasted with student participation in classroom discussions, perceived and real academic achievement, feedback survey data, and teacher observations to assess the impact that feedback cycles had on students' sense of belonging over the course of a trimester together. This combined with student feedback and teacher observations created a fuller picture of students' sense of belonging and ways that they identified to improve overall belonging and comfort in the human biology classroom.

Validity, reliability, and trustworthiness

Data sources were triangulated to try and eliminate as much error as possible in summarizing trends observed and completing analysis. Though there are five sources of validity evidence that are used in evaluating research instruments, I will focus on content validity based on the small scope of this project (Mertler, 2017). The Likert scale on my survey instrument used has questions tied to specific aspects of belonging supported by research outlined in the conceptual framework. These relationships are listed in Table 8.

Table 8
Matrix of Likert-style Items By Issue Addressed

Teacher influence	Student influence	Ability/impostor syndrome	General belonging
8. When we learn about examples in this class, they are related to my life.	4. Most students in this classroom accept me for who I am.	2. Other students have an easier time learning science than I do.*	1. I can be myself in science class.
		5. I have an easy time completing work for this class at a strong level.	3. I feel like I am a part of making this classroom what it is.
9. My teacher makes me feel comfortable in the classroom space.	10. Other students make me feel comfortable in the classroom space.	11. The feedback and grades I receive match the effort I put into my assignments in this class.	6. The things we learn in this class are important to me.
			7. The things we learn in this class are interesting to me.
			12. I am excited about studying science in high school and beyond.

*Note. This question was reverse scored, i.e. "Strongly agree" = 1, "Strongly disagree" =5, etc.

Because this instrument was developed with foundations in others' research on belonging in science (Stout et. al., 2013), and because these items each contribute to the

same overarching concept of belonging in the science classroom, this instrument meets this criterion for content validity.

One possible source of error includes students feeling pressured to report positive feelings because of perceived judgment if they are not comfortable in my class. My relationship with my students is strong, so I do not believe that students would intentionally mislead me in their responses to questions asked in good faith that are not required and do not impact their grade. It is also possible that students' metacognition about their own participation in belonging in science class is not well-developed, either because they have not encountered many barriers to belonging or because they are developmentally not prepared to think critically about an abstract concept of this kind. I hope that by having conversations with my students about belonging, it activated enough of their own self-reflection that they were able to accurately reflect their own lived experience of being in my classroom.

Some possible limitations of the data collected include those listed above. My students' demographic makeup means that statistical analysis will not be as strong when looking at groups who make up a small portion of our student population such as students from underrepresented races and ethnicities in STEM. Indeed, the particularities of our student body and school culture mean that the research completed will be a solid analysis of our particular environment but may not be easily expandable to other environments beyond my classroom and our school community as a whole. This particular class of students also has a history of conflict and behavior issues, leading to specific challenges around classroom culture that I have not encountered in my previous years of teaching.

At the very beginning of the year, several students stopped to ask, “Are you going to leave at the end of the year just like the rest of our teachers?” It felt especially important to conduct this kind of research with a group of students who have received negative feedback in the past from adults in our community; this makes the work more critical to the current year, but possibly less generalizable to my future classes or other teachers’ classrooms.

Finally, trustworthiness is an important measure in a study that involves qualitative reporting and descriptions of students’ lived experience. As much as possible, I have recorded students’ responses verbatim and included quotations when relevant to making a claim to their views. I also normalized data carefully to not oversimplify or erase specific aspects of their responses in analyzing trends. Especially as someone who has taught these students as many as three years in a row, I have an established rapport that has provided a solid foundation for shining light on these students’ lived experiences of the science classroom.

The methodologies used in the treatment for this study include surveys, in-person discussions, participation tracking, students’ reported and actual grade point average, and a Likert-style survey that measures students’ sense of belonging. All instruments used are supported by other researchers’ work on the concept of belonging in science and related fields. The measured data will be analyzed using a variety of methods, including linear regression, t-test, Mann-Whitney U test, and emergent thematic analysis. These data together will provide evidence to support claims related to answering how feedback cycles impact students’ sense of belonging in the science classroom.

DATA AND ANALYSIS

Data presented here connect to each of the three focus questions of this classroom research project. In addition to general trends relating to these focus questions, a few trends specific to the instruments used will be analyzed to see if the instrument used reflects similar trends to those observed in previous research studies. Students' identity markers, including students with one or more identities that are marginalized in STEM fields, will be particularly considered given the importance of equitable representation and belonging for underrepresented groups in particular.

Sense of Belonging: Patterns and Trends

I administered the Likert pre-survey to my students before beginning the first feedback cycle for data collection. Table 9 shows trends in the initial values on the survey by group of survey questions.

Table 9

Average Scores by Demographic for Likert items, Grouped by Type of Question

	Teacher influence (8,9)	Student influence (4,10)	Ability/impostor Syndrome (2,5,11)	General belonging (1,3,6,7,12)	Overall
Boy	3.763	4.052	3.655	3.779	3.793
Girl	3.950	3.750	3.533	3.840	3.767
Difference	0.187	-0.302	-0.122	0.061	-0.026
White	3.943	4.057	3.667	3.886	3.869
POC	3.676	3.700	3.511	3.627	3.621
Difference	-0.267	-0.357	-0.156	-0.259	-0.248

Note. POC=Person of color. *N*=55.

The patterns to note in Table 7 are differences in the mean score for each question based on demographic group. Between boys and girls, the major differences don't

emerge in the overall averages, but rather in specific question categories. Girls scored lower than boys in the question about impostor syndrome ("Other students have an easier time learning science than I do") and the question specifically about other students' influence on their comfort ("Other students make me comfortable in the classroom space").

Students of color scored lower on average than white students on all parts of the survey except "Other students have an easier time learning science than I do" – on that item, the score was about the equal. This indicates that overall, students of color have a harder time fitting into my classroom culture, which is not surprising given how few nonwhite students they share that space with. The questions with the highest disparities are "I can be myself in science class," "I feel like I am a part of making the classroom space what it is," "Most students in this class accept me for who I am," "My teacher makes me feel comfortable in the classroom space," and "Other students make me feel comfortable in the classroom space." These questions seem to fit a general sense of not being able to be one's full self in the classroom.

When doing a test for statistical significance, differences between groups did not meet criteria to reject the null hypothesis with a significance level of $\alpha=0.05$ for a two-tailed *t*-test. The specific values of each test for significance are listed in Table 10.

Table 10
Calculated t-*values and* p-*values Comparing Likert Responses by Race and Gender*

	Teacher influence (8,9)	Student influence (4,10)	Ability/impostor Syndrome (2,5,11)	General belonging (1,3,6,7,12)	Overall
Gender *t*-value	-1.042	1.57	0.589	-0.302	0.164
Gender *p*-value	0.302	0.122	0.558	0.764	0.871
Race *t*-value	0.784	1.04	0.369	0.671	0.858
Race *p*-value	0.437	0.303	0.714	0.506	0.395

Note. N=55.

It is also important to note the way that *intersectionality* may impact students' sense of belonging in the classroom (Table 1). When considering different identities that are on the margin, the experiences of those who carry multiple identities and experience multiple oppressions are differently impacted by how power operates than those who experience fewer or a different combination of oppressions. One example is considering girls of color in my classroom, who may experience stereotype threat, racism, and sexism simultaneously and in ways that a white girl or a boy of color might not experience them. When looking at the five girls of color who are from underrepresented groups in my sample, I did not have enough data to draw any statistical conclusions. However, the average Likert scores for those five girls were consistently lower than the scores for all students of color and for white students (Table 11).

Table 11
Average Likert Score for Girls of Color Compared With Other Identities

	Pre-treatment	Mid-treatment	Post-treatment
Girls of color	3.50	3.58	3.35
All students of color	3.67	3.86	3.78
All girls	3.76	3.83	3.85
Overall average	3.79	3.86	3.78

Note. N=55.

How does participating in feedback cycles impact students' sense of belonging in the science classroom?

After gathering data on three occasions, I compared the mean scores on the Likert survey to see if the overall treatment was effective in improving students' sense of belonging in the classroom. I was interested to see if there were significant differences over time as well as between the experimental and control groups at the end of the experimental period.

Because I used a Likert scale with a smaller population size, I used a Mann-Whitney *U* test to compare treatment groups. This nonparametric analysis accounts for data without a normal distribution. In each test, at least one experimental group had $N>20$, allowing the use of a *Z* score for statistical significance. As shown in Table 12, there was no significant difference in students' reported sense of belonging over the course of the experimental treatment. I included a comparison of the mid-treatment scores because I wanted to ensure that no significant change happened after one feedback iteration. Students expressed some survey fatigue when taking the Likert survey a third time, so I wanted to reduce possible error introduced by less effort and attention given to the test. However, neither comparison showed significant results.

Table 12
Comparison of Students' Sense of Belonging Pre-, Mid-, and Post-Treatment Using Two-Tailed Mann-Whitney U *Test*

Date of survey	Mean Likert scale	*U* value compared with pre-survey	*Z* value	*P* value compared with pre-survey
Pre-survey (10/23/17)	3.886	N/A	N/A	N/A
Mid-treatment (11/7/17)	3.944	501	-0.34	0.36
Post-treatment (11/23/17)	3.869	504.5	-0.3	0.38

Note. N=55

There was also no recognizable statistically significant difference between the experimental and control groups' change in belonging over the experimental treatment (Table 13). This includes the mid-treatment and final survey results compared with the initial values. These were also compared using a two-tailed Mann-Whitney *U* Test; the distribution of these results is shown in Figure 1.

Table 13
Comparison of Change in Belonging for Treatment vs. Experimental Groups Using Two-Tailed Mann-Whitney U *Test*

Difference considered	Experimental mean difference	Control mean difference	*U* value compared with control	*Z* value compared with control	*P* value compared with control
Final-initial	-0.0486	0.0442	279.5	-0.798	0.211
Middle-initial	0.0935	0.101	250	-0.415	0.337

Note. N=55

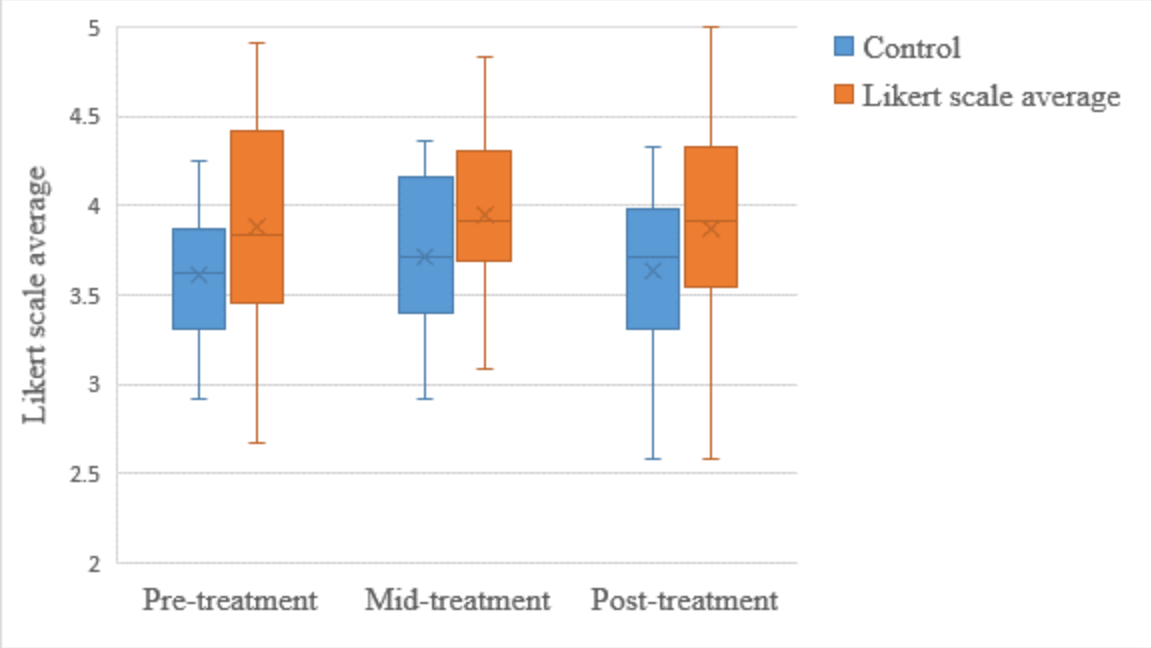


Figure 1. Box and whisker plot of Likert scores in control and experimental groups in pre-, mid-, and post-treatment surveys, (*N*=55).

Though my original prediction was to see an overall positive trend, the individual question categories and the survey as a whole had varied patterns over time. Teacher influence questions decreased over time, perhaps a manifestation of survey fatigue directed at me as the source of the persistent reporting. Ability/impostor syndrome questions increased overall, though very little. Overall, the Likert average actually decreased from the pre-treatment to the final iteration of the instrument.

As noted earlier, I removed the name of the students' block in an attempt to anonymize the data further and prevent implicit bias from influencing my analysis of verbal data. However, because one of the blocks served as a control group, I needed to separate the data into two categories. When the Likert averages are separated by all three blocks, the trends appear very different than the aggregated averages (Table 14).

Table 14.
Likert Survey Averages By Class Block

	10/23	11/7	11/21
Morning Class 1	3.82	3.95	3.7
Morning Class 2	3.99	3.94	4.15
Afternoon Class (Control)	3.61	3.71	3.63

Note. N=55

Students in the first morning class had the most negative change in their Likert averages over time, whereas the second morning class had a positive trend with each iteration and the afternoon class's scores were consistently the lowest. This reflects my observations as a teacher of each class – over the course of the trimester, my second morning class gelled as a group and created rituals and inside jokes that created a welcoming space for students, much like the interaction rituals described by Olitsky (2005). My first morning class always felt a little "off," no doubt influencing student scores. My afternoon class was a more chaotic space, with students frequently needing disciplinary action to stay on task and positive in class.

This observation of differences between classes led me to analyze the differences between the experimental and control groups as a whole for each survey. My afternoon class consistently had the lowest scores on the Likert survey. I performed a one-tailed Mann-Whitney U test to determine if the afternoon Likert average was significantly lower than the morning classes' average (Table 15).

Table 15.
Comparison of Belonging for Treatment vs. Experimental Groups Using One-Tailed Mann-Whitney U Test

Date of survey	Mean Likert scale Experimental Group	Mean Likert Scale Control Group	U value	Z value	P value (one-tailed)
Pre-survey 10/23/17	3.89	3.61	210	1.705	0.044
Mid-treatment 11/7/17	3.94	3.71	204.5	1.678	0.046
Post-treatment 11/21/17	3.87	3.63	197.5	1.819	0.034
Overall	3.92	3.62	217.5	1.919	0.027

Note. N=55.

It turns out that the differences between the afternoon class and the morning classes were clear enough to be statistically significant in every testing period (α=0.05). This gap between classes' experiences reduces the validity of the testing between groups to indicate the true nature of the treatment because of other variables which influenced each class to report different experiences of being in my classroom space.

Overall, the feedback cycles did not appear to have a significant impact on students' sense of belonging over the course of the trimester. Comparing my afternoon class to my morning classes showed that students in the experimental and control groups had significantly different experiences of belonging based on their class block. Other factors appeared to have a stronger effect on students' sense of belonging, including other students in the class, disciplinary issues, and when the class met during the day.

How does students' sense of belonging affect participation in academic discussions and their perceptions of feedback and grades?

Class discussions

The second focus question of this classroom research project involved investigating the relationship between students' sense of belonging in the science classroom and their participation in academic discussions. Belonging was assessed through responses to belonging Likert-style surveys given three times over the course of the term. Discussion participation was recorded by student volunteers during academic discussions throughout the term. The goal of investigating this question was to determine whether or not a correlation exists between students' vocal participation in the classroom and their perceived sense of belonging in their science class. Vocal participation is easily measurable and is frequently pointed to as a signifier of students' ability and comfort level at my school. It would follow that students who are more comfortable speaking in classroom discussions would also see themselves as belonging in the classroom space and in science more generally.

I was curious to see if any trends were observed between students' self-reported sense of belonging and the frequency of their participation in discussions. Though there was no statistically significant correlation, the trendline in Figure 2 shows a slight positive relationship overall ($R = 0.38$).

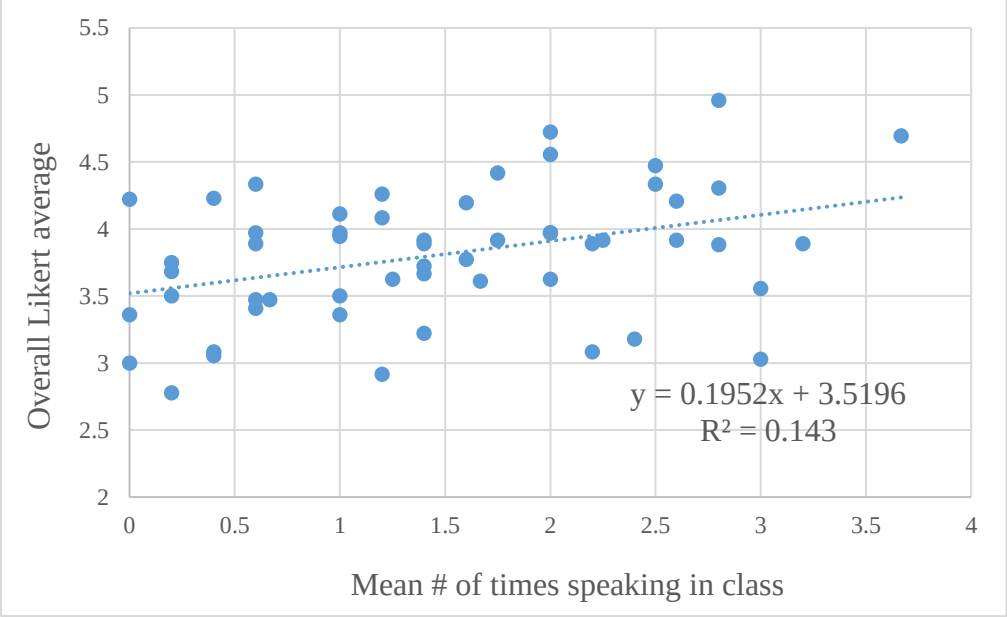


Figure 2. Overall Likert average score vs. mean number of times student participated in classroom discussions, (*N*=55).

Grades and achievement

I wanted to uncover any relationship between students' perception of their achievement and their sense of belonging in science class. I predicted that students who graded themselves higher than their actual grade percentage would have higher scores on the Likert scale than students who accurately or underestimated their own performance.

Students were asked in an in-class survey to share the grade they believe they are currently receiving as well as the grade they deserve for the work they have completed in my class up to this point. This relates to the second focus question of this classroom research project, "How does students' sense of belonging affect participation in academic discussions and their perceptions of feedback and grades?" Figure 3 shows the relationship between students' actual grades and the grade they would give themselves. The line x=y is included to aid with determining if the student overestimated, underestimated, or correctly estimated their grade.

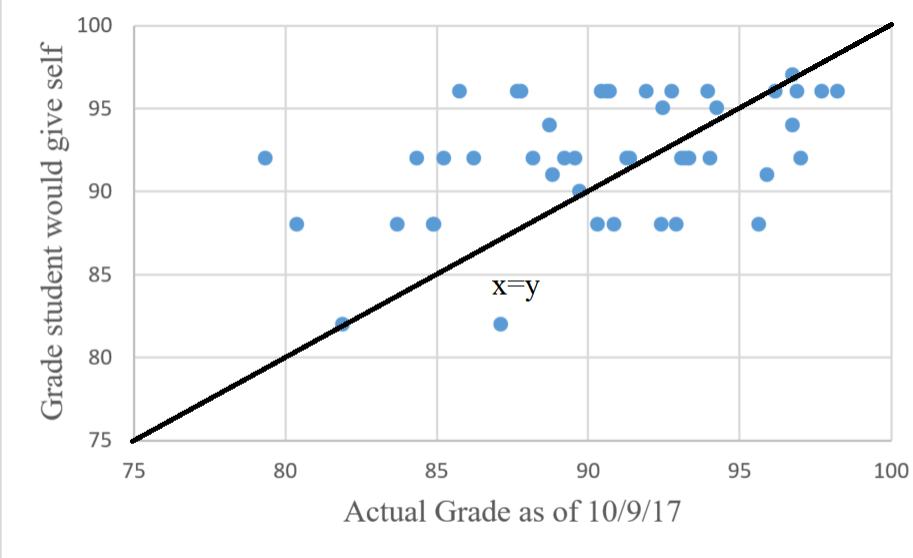


Figure 3. Students' grade they report earning vs. actual grade in 8th grade Human Biology, (*N*=47).

Overall, more students (*N*=28) believed that they were earning a higher score than their actual grade than believed their grade was lower than it actually was; this is especially true out of the "A" range. One issue at our school is overall grade inflation; this chart alone indicates the skewed distribution of grades above 80%. This most likely led many students to believe they were earning grades in that range even if that was not the case.

Figure 4 shows students' beliefs about the grade they are receiving vs. the grades they deserve.

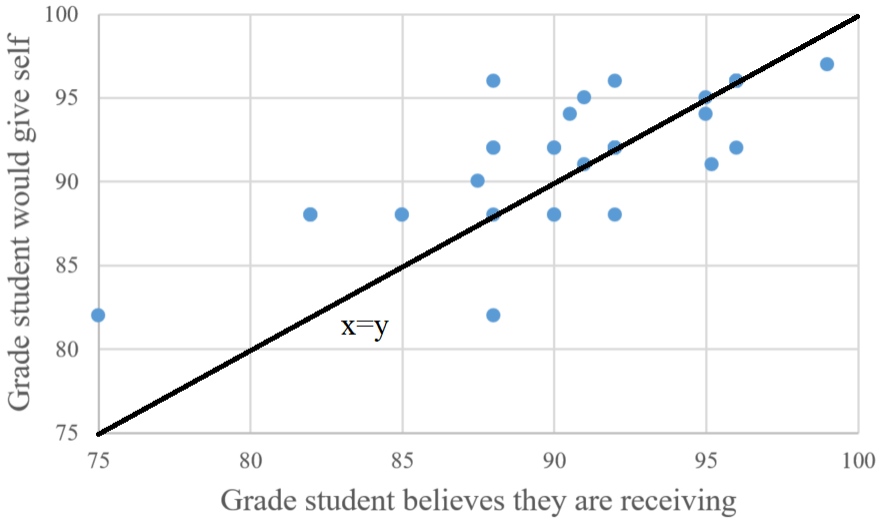


Figure 4. Students' beliefs about the grade they are receiving vs. the grade they deserve in 8th grade Human Biology, (*N*=47).

Interestingly, students mostly had scores that were the same (*N*=25) or higher (*N*=15) for the scores that they would give themselves compared with the score they believed they had earned up to that point in class. Of the eight students who believed they deserved a lower score than what they thought they were actually earning, no trends easily emerge demographically. Two are girls, five are boys, and one identifies as nonbinary. Four identify as white and four as people of color.

Did grade perceptions differ across demographic groups? Not in a statistically significant way. However, trends are striking, especially comparing white students with students of color (Table 16).

Table 16
Differences Between Perceived Grades and Grades Students Believe They Deserve, by Demographic

Group	Perceived score – deserved score	Standard deviation
Girls	-1.52	2.66
Boys	-0.58	2.98
Other genders	4	N/A
White	-1.19	2.61
Person of color	0.59	2.8

Overall, girls had a stronger tendency to believe that they deserve a grade higher than the one assigned to them in their own minds than boys did. However, the average for students of color was actually positive, meaning that the tendency in those students is to believe that they do not deserve the grades they are receiving, which may be an indicator of stereotype threat for those students.

To test this, I divided students into three test groups based on the difference between the grade they believed they deserved and the grade they were actually earning in my class. One group would have given themselves more than 2 percentage points higher than the grade they were earning, one group would have given themselves a grade 2 percentage points lower than the grade they were earning, and one group was within 2 percentage points of their actual course grade. I then compared the mean scores on the Likert scales on the pre-treatment survey to see if students had a significantly different mean Likert response based on their grade orientation (Table 17).

Table 17.
Students' Belonging Scores vs. Difference Between Perceived and Actual Grade

Student group	*N*	Mean Likert scale
Deserve higher grade	23	3.69
Within 2 points of grade	17	3.94
Deserve lower grade	12	3.89

Surprisingly, students who graded themselves higher than their current course grade had lower average scores overall on the Likert scale. This was not a statistically significant disparity (p=0.24) but may reflect that the measure I used to try and approximate self-confidence might have actually indicated students who did not feel that I saw their potential and achievements as valid, i.e. *not* experiencing a sense of belonging in the science classroom.

I was also curious to see if there was a correlation between a student's grade and their sense of belonging in the classroom. Simple regression analysis showed a positive relationship that was not statistically significant (R=0.378; Figure 5).

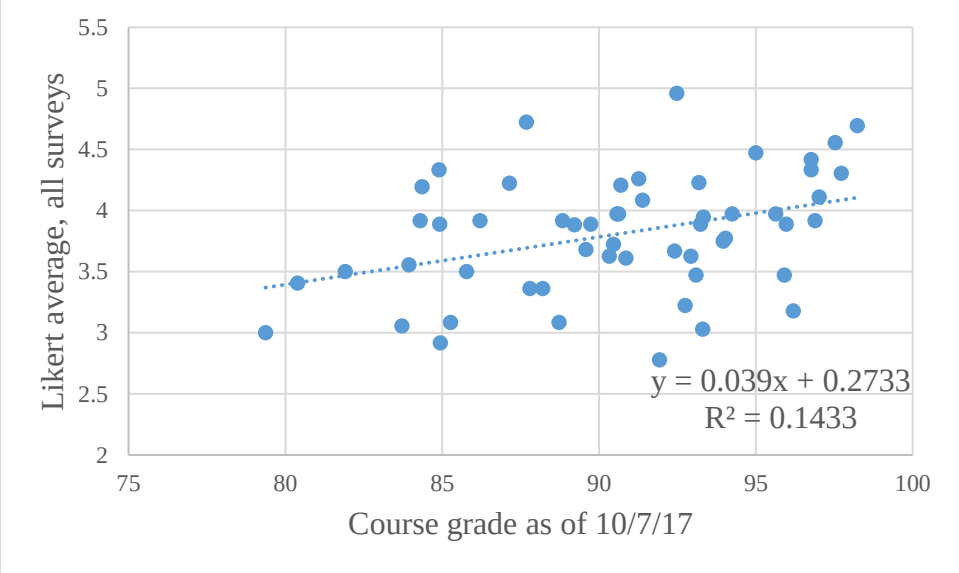


Figure 5. Likert average vs. course grade in pre-treatment survey, (N=47).

<u>What strategies will students identify to create a more welcoming classroom and increase their sense of belonging?</u>

The overall goal of this project was to practice gathering students' feedback about classroom procedures, assignments, and routines and create a classroom that better-reflected their desires in the classroom space. This section will summarize the major

steps taken to include more student voices, record their ideas, and implement them in the classroom. When possible, student responses are quoted or summarized by the number of times an answer appeared in their responses or in discussion.

Ideas generated via survey

During each survey given to students, I asked specific questions about what practices would make them feel more comfortable in the classroom. During the first survey, I asked students to list two specific examples of things that their teacher did that helps them learn science, two specific examples of things their teacher does that make it more difficult to learn science, specific changes that I could make to help understanding and learning about human biology, and specific changes we could make as a community to help them feel more comfortable in the science classroom. I was surprised to learn that the top-listed thing that students identified in my own behavior that helped them learn and feel comfortable was my willingness to answer their questions. Fourteen of the 50 student responses recorded on the first survey noted something about slowing down and answering any student questions that arose as being an important step in helping them feel like they belonged. The runner-up was having a lot of energy and enthusiasm for the subject matter (N=11), followed by detailed lessons (N=6), independence and hands-on learning (N=5), and interactive and engaging teaching practices (N=4).

When asked about specific tactics I used as a teacher that made it harder to learn, the most common response was that I speak too quickly (N=6) and that the homework load was too much (N=4). I also received three comments about emotional and sarcastic communication, which was not feedback that I found easy to digest. It led me to reflect

on ways that my intentions may not be conveyed in the ways I interact with students, especially when delivering discipline. Though I did not breach the trust of treating student responses anonymously, I found this challenging in this particular case as I wanted to clarify the ways that my communication style was inadvertently harming my relationship with students, something common in an intercultural setting.

The last two questions had a wide range of responses. Students' desires around learning were diverse, ranging from wanting no homework to wanting significantly more challenge with in-class and out-of-class work assignments. Three students commented on enjoying having hot cocoa in the classroom, something I implemented after students began coming to my room for tea and cocoa in a previous year. The last question – focused on community actions rather than specific teacher responses – had a number of comments about other students' distracting or disrespectful behavior (N=10). One response stood out in my mind: "We should be more respectful to one another cause sometimes I wanna answer but i'm scared i'm gonna get the answer wrong and I feel like some of the kids in class will make fun of me and I don't wanna answer." This is an ongoing issue in any middle school classroom, one that is beyond the scope of this particular research project. However, I wonder if intentional interventions and norm-setting could help alleviate some of the social pressure students experience in the public forum of classroom discussions and lessons.

One trend in the first survey overall was that students didn't provide a huge variety of ways to improve the classroom, which I suspected had to do with feeling limited by knowing that they would have me as their teacher for the rest of the school

year. During the second feedback survey, I asked students to imagine their ideal ninth grade science classroom and teacher. I hoped that this would encourage students to think outside the box and not simply replicate their current situation when describing a welcoming and exciting experience of science. The first question asked them to "imagine your 9th-grade science classroom. What do you hope the classroom looks like?" The most common responses were colorful and having state-of-the-art equipment (*N*=8). Seven students reported wanting a large space, and five students commented on wanting light, a precious commodity in cloudy Seattle. Other responses included a modern or new space, having friends in the classroom, and having productive classmates to make group work easier (*N*=3).

When asked about the characteristics they wanted in a teacher, most students were not very specific. Sixteen students said they hoped their teacher would be "fun" or "funny," and four students said they hoped they would be "like Lewis" (so much for helping them think beyond the current year!). Six students mentioned wanting a teacher with strong discipline skills, and five reported wanting a teacher who is supportive and understanding. One student specifically indicated that they would like to have a teacher of color. They also wrote that their ideal classroom would have more people of color in it in ninth grade, indicating a feeling of isolation in a school that is predominantly white.

In the last Likert-style survey given to students, I asked them to check boxes for each of the major strategies identified by students to create a more welcoming classroom environment (Figure 6). I also included a few categories of items either from previous research or informal conversations with students. I hoped that by surveying students with

a list of checkboxes, they would be honest about the full spectrum of their personal preferences for classroom changes and provide detail on what to focus on to have the highest impact.

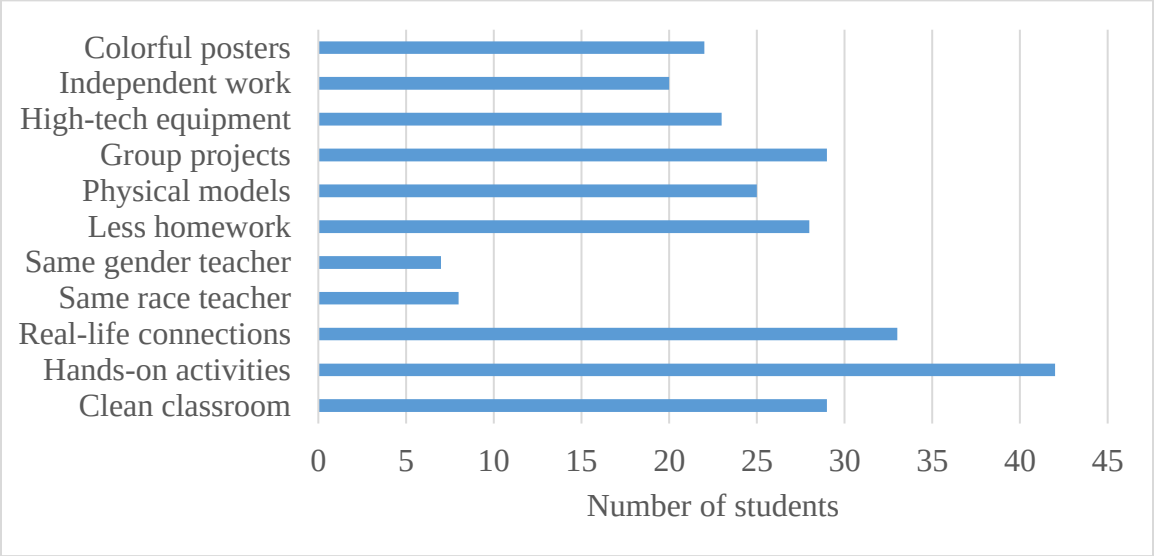


Figure 6. Number of students checking item indicating it would make them feel more comfortable in their science classroom, (*N*=51).

The top item listed was hands-on activities (*N*=42), with other categories having at least 20 people list them as ways that would help them feel more comfortable in their science classrooms except for same race and same gender teacher. Of the eight students who listed wanting to have a same race teacher, five were white and three were students of color. Of the seven students who listed wanting to have a same gender teacher, five were boys and two were girls. This did not match my expectations that students of color and students from underrepresented gender identities in STEM would have listed these as specific things that would have helped them feel more comfortable in the STEM classroom. However, it is interesting to note that the representation of students of color in the same-race question is higher than the overall student population (29% students of

color in general vs. 37.5% of respondents), while boys are overrepresented in the same-gender question compared to our eighth-grade class (62% boys overall vs. 71% of respondents).

Ideas generated in discussion

During large-group discussion, students and teacher engage together in building a community that centers students' experience of the work and how to improve their overall learning, achievement, and comfort. Collaborating with students to improve classroom norms and procedures was transformational in my first year of performing this classroom assessment tool with student groups, so I was eager to see what trends emerged from students' participation in these large-group discussions.

During the first discussion, both classes spent a lot of time processing weekly reading and video quizzes and lab procedures. My classroom has a weekly media quiz assignment that requires students to complete a reading passage or watch a video and answer 10 multiple choice questions. Videos were not universally loved; some students highly preferred them to readings whereas others strongly preferred readings because they can be annotated and self-paced. This was one instance where having the discussion as a class was a strength, as students who simply complete their own feedback forms don't benefit from seeing the wide diversity of learning styles in the classroom the way that teachers do. In both classes, we discussed this issue and decided that having a mix of both videos and readings would best meet the needs of the most students. A similar issue came up around dissections, though the class did not come to a conclusion quite as easily. Many students felt like the dissections we did in the fall trimester were an ideal hands-on

way of engaging in learning about the body. Others were disgusted by the activity and didn't find it helpful. Because of the sensitive nature of the topic, I let this rest and decided to reduce the number of dissections for the year based on the needs of students who had a distaste for the activity.

We discussed lab procedures at length during this first feedback cycle. Students commented that they needed clearer instructions to complete labs easily and in the time allotted. We brainstormed a number of strategies to address this issue, including more in-depth demonstrations of procedures, taping the procedure down in the relevant lab area, including more pictures in the lab procedure documents, and having a sample lab station set up in the back so that kids could emulate it. All of these were strategies I used in later labs; it was excellent feedback as I have not taught a class in the past that struggled this much with reading comprehension and following auditory and/or verbal instructions.

In the second feedback discussion, students focused more on weekly media quizzes and case studies. Students provided ideas for guidelines for writing clearer multiple-choice questions in the order they appear in the media being tested on. Students also noted that having multiple choice questions means that often, people would stop reading when they completed the final question rather than completing the entire reading or video for understanding. This was disheartening, as the quizzes were intended to ensure complete and thorough reading. Student suggestions led me to choose a mixed-format approach to future quizzes with some questions being multiple choice and others being open-response, requiring students to complete the reading and understand it fully. Students also provided insights into topics they were interested in studying further,

including diagnosing patients, genetic testing, harm reduction practices, and neuroscience.

Students gave a lot of positive feedback in the second discussion about improved lab procedures. Both classes reported a stronger understanding of expectations and instructions for each activity. Some students said that they wished there were only paper labs and not online documents, which I had been using for ease of grading and never losing worksheets. Students also asked for question-specific rubrics for lab assignments and case study assignments to clarify how long and detailed their responses should be.

Responses to student feedback

A major part of closing the loop with students isn't just talking about the feedback they provide, it involves taking action and demonstrating to students that their ideas have an impact on how the classroom is run. Though not all students' ideas could be implemented immediately, especially when considering conflicting needs, there were a few initiatives that came out of this process that improved the experience of the classroom for all students. These include Curiosity Question assignments, modifying homework quizzes, improving explanations of lab procedures, and holding students accountable for their actions during group work.

During the initial feedback survey, students were asked what specific ways that their teacher helped them learn in class. The highest response, by far, was answering student questions. I already had a practice of answering questions that students put in their weekly reflection assignments, something that makes grading those assignments more fun for me and reading my feedback more enjoyable for the students. I also

regularly held space for question and answer time in almost every lesson, and often we got into engaging discussions that incorporated students' ideas and curiosity about the topic we are studying. After seeing how much students were eager to have their questions answered in the classroom, I created an extra credit assignment for students called "Curiosity Questions" that allowed them to identify a question connected to our unit and answer it in a small-project format. The initial list of questions that they could choose from came from the book *Why Do Men Have Nipples?* (Leyner & Goldberg, 2006), a popular science book about the human body that is centered on light-hearted questions. This resulted in greater engagement – students had more of their questions answered in a public forum, kids who wanted more enrichment were able to do semi-guided independent research, and the overall sense that students had agency in choosing the course of their human biology learning increased.

We spent a large amount of time during our feedback discussions discussing weekly homework quizzes. Students reported feeling as though the quizzes were not testing their reading comprehension accurately and instead sent them on scavenger hunts for details that took away from their experience of the reading. I responded to specific feedback to have the quizzes be in the order they appear in the text, be less detail-oriented, and include some open-response questions to reduce pressure to find each detail and finish the reading before getting to the conclusion of a passage. This increased my grading load, but the feedback was urgent and persistent enough that it was clearly worth the shift.

Lab work improved after the student-led changes in delivering procedures. I also responded to students' feedback that it is challenging to hold people accountable for group work by implementing a weekly self and peer evaluation during longer collaborative projects. This weekly reporting of student accountability combined with my own observations as their weekly participation grade. This shift changed student behavior to be more accountable to their groupmates, including several students who spoke with me privately asking for clarification on how they could perform better in their research groups. It also relieved me of the duty of attempting to supervise ten lab groups simultaneously, an impossible task for any teacher.

INTERPRETATION AND CONCLUSION

This project attempted to answer the question, "How does practicing regular feedback cycles in whole-class discussions impact students' sense of belonging in an eighth-grade human biology classroom?" Though the major statistical findings were not significant, other trends and patterns show possible paths of future investigation. Classroom participation and students' sense of belonging did not have a strong correlative relationship. Feedback cycles do not appear to have a significant effect on students' sense of belonging in my science classroom. Grades and perceived achievement are not tied to a sense of belonging in my classroom in any apparent pattern. However, students reported a high level of belonging on their Likert surveys throughout the project (mean=3.78/5), and there are ways that the current classroom model appears to be supporting the majority of students well. Classroom culture is impacted by what students are in the room, and it is unclear how much teacher intervention can influence

that effect. A small minority of students identified major gaps in classroom culture for their own sense of belonging, prompting me to do further investigations to ensure that their voices are heard.

Major findings of the project

No statistically significant trends were uncovered during investigations of the first two focus questions of this project:

- How does participation in and response to feedback discussions change students' self-reported sense of belonging?
- How does students' sense of belonging affect participation in academic discussions and their perceptions of feedback and grades?

Students' participation in discussions varied widely, with some students who reported both the highest and lowest levels of belonging ranging in their participation from 0-15 times over the course of six classroom meetings. Feedback discussions appeared to have no measurable effect on students' sense of belonging over time. Students' perceived and actual grades also did not have a determinable relationship to students' sense of belonging, indicating that they were not a good indicator of students' comfort level and sense of connection to the work of science in my classroom.

Students reported a high level of belonging in my classroom, even at the beginning of the research period. This was reflected both in high Likert scores (mean= 3.8) and responses to questions asking about improvements in belonging that either asked for similar treatment or did not list possible changes. This indicates that current practices already create a space where the majority of students feel comfortable and centered when

entering my classroom, or that they have not encountered a better space yet in their careers as students. This may have reduced the impact of the chosen treatment on the population being studied.

The final major finding from the project is the impact that other students have on self-reported belonging in the classroom space. In each iteration of gathering student feedback, students indicated that their peers in the room played a part in their sense of belonging in the space. This particular phenomenon lies beyond the scope of this project but indicates a need for research into ways of creating positive classroom culture regardless of who is in the room. Collaboration with a diverse range of people increases students' empathy and is an important skill for use in future classes and the workplace (Cohen, 2015). It is possible that creating clear class norms, processing community behavior on a regular basis, and providing forums for students to give one another direct feedback may have had a more significant impact on students' sense of belonging than other kinds of teaching interventions.

Implications of the Project and Connections to Other Research

Though the feedback cycles did not have a significant impact on students' sense of belonging in my classroom, I will continue using feedback cycles as a way to improve overall classroom experiences and procedures. The wisdom in the room is too great to miss; no one knows how teaching impacts students better than the students themselves. However, I will continue investigating current literature about sense of belonging in the science classroom to ensure that I put other measures in place to improve ambient

belonging for all students, especially those from underrepresented groups in STEM fields.

High numbers of my students appear to be comfortable in my classroom space. However, the small number of students who indicated they do not feel comfortable or safe in my classroom asked for specific things to change. One student asked for a space with more students and faculty of color in science classes. Two students reported feeling uncomfortable when I used sarcasm in the classroom, and one student felt uncomfortable with the way that emotion came into play during disciplinary actions. These serious issues require reflection on my part as well as on an institutional level to meet these students' needs more completely.

Master, Cheryan, and Metzoff (2016) found experimentally that having a cleaner, less stereotypical, and lower clutter classroom increased students' sense of belonging in a computer science classroom. In this classroom research project, I asked students directly to indicate if having a clean, clutter-free and colorful science classroom was important to them. The majority of them said yes. Of 50 student responses, 29 students indicated that a clean classroom was important and 22 said that a colorful classroom helped them feel welcomed in a science space. This may indicate that these findings about computer science extend into other STEM fields where clutter and mess are unfortunately often a part of working in science for students and professionals.

Olitsky (2007) found that interaction rituals created an increased sense of belonging in one eighth-grade science classroom. I would argue that frequent large-group feedback cycles are an example of an interaction ritual that engages students' sense

of self and community. These sessions help create a common language in the classroom space and distinguish that group as unique, important, and collaborative. The class block that had the most improvement in their Likert scale responses had high levels of interaction rituals specific to that block, including inside jokes, a fun class name, and a special weekly routine set aside for "random question time." We often found ourselves laughing while completing lab assignments and lectures.

Past interaction rituals in my classroom have included discussion norm-setting and group norm-setting that meets students' specific needs. One example is a project group who decided that their way of resolving conflict would be occasional nerf gun battles (with permission, of course!) to settle disputes. Another was a class who wanted to say "turtle" as a way to remind students who are getting off topic to return to the current discussion focus. This kind of collective culture-building is an important part of forming a positive sense of belonging for students, as evidenced by my morning B block class.

It is also true that these kinds of interaction rituals are more challenging to build in student communities that do not trust each other and that have major disciplinary issues. It is significant that the primary issue raised by students in their desire to make the classroom a place where they experienced a higher sense of belonging was the behavior of other students, especially when they choose to be unkind towards one another. Building a community of trust is difficult work, and having major disciplinary issues got in the way of serious community building in my afternoon class and first morning class. Moreover, the kinds of practices that lead to a more welcoming space for

all students, hands-on activities, a clean lab space, and positive, energetic teachers, all rely on having a cooperative and positive student community with which to build those communities.

I had a number of bright moments over the course of the treatment that indicated to me that the treatment did have an impact, even small. One example was the way that certain students advocated for their needs, even when they were at risk of receiving negative feedback from adults in the community. In my class, we have a shared "Human Biology Bill of Rights" that students can review and edit each trimester. In the first trimester, before the treatment, students did not have many things to add or change to this document. However, after a trimester of providing feedback, we had several rich discussions about how to best suit the needs of our community when returning to the credo, and we made several changes including adding the need for students' accommodations to be met fully and allowing all students to feel safe sharing their opinions, even if they are unpopular. Having space for students to share their personal struggles and see the changes that are possible, similar to the treatment in Walton and Cohen (2007), may have led to an opening up of space for students to express more of their concerns after the treatment period was over.

Another example of a bright spot after the treatment was receiving a note from a student after class that shifted the way I thought about the language I was using. The student identified as asexual, and I had said "someday, when you have intercourse..." while describing safer sex practices for intercourse behavior. The student pointed out that not all students will have sexual intercourse, regardless of their personal identity and

sexuality, and that asexual students in particular deserve to have a sexual education that includes the wide range of desires and experiences unique to that community. I will always cherish that note, knowing that they provided me with key insights from an often-underserved community that allowed me to become a better and more inclusive teacher. I was able to close the loop while keeping the student's identity confidential, allowing students to also observe a person in power changing their lens based on feedback and showing them that their voices matter.

Finally, I'd like to connect back to the original theoretical framework for this research, the concept of moving from margin to center (hooks, 2010). This orientation towards power and research takes individuals – students, teachers, and others – who are often on the margins of a structure and placing their needs at the center of practice. It is true that the majority of students reported high levels of belonging in my classroom, but a few outliers gave responses that indicate that experience is not universal. Despite only having three students whose responses indicated feeling emotionally unsafe, these are the students who I must center my future steps on, as they are the ones most marginalized in my classroom space. This runs counter to conventional wisdom that what is best for the majority is best for all. Looking ahead to future classroom research, I aim to polish my own teaching practices to be more sensitive to the needs of students who do not easily connect with my communication style, humor, and energy as they are likely those who feel most outside the practice of science at our school.

VALUE

During the process of designing and implementing this classroom research project, it struck me frequently that the practice of teaching is the practice of research on a daily basis. As a teacher, I was often so busy that I overlooked opportunities for self-reflection and professional growth that have been underscored by the findings of this project. Completing this study forced me to really evaluate student feedback and address individuals' concerns in the public arena, a vulnerable process that helped remedy relationships with my students while also improving my teaching practice.

This research helped me address a number of assumptions and misconceptions I had about my students. One misconception was that there was a relationship between students' sense of belonging and their participation in academic discussions. I assumed that students who spoke more often would be those who feel most comfortable in my classroom space, but a statistically significant relationship did not exist. One cornerstone of my teaching is to allow for quieter and less-confident students to have avenues for expression that don't require speaking out loud in my classes, so it may be that those students both feel more comfortable in my classroom and still speak less frequently in a larger group. I also assumed that students who would grade themselves higher in my classes than the grade they were earning would feel comfortable in my classroom and in science more generally. This assumption was not correct, likely because those who would grade themselves higher than their actual score felt that I was not fairly treating them in my evaluation of their work. Finally, I was surprised to find that students who indicated they wanted a same-gender or same-race teacher were from groups who are

overrepresented in STEM: boys and white students. My assumption, based on my specific experiences of being on the margin and others' scholarship, was that the majority of those who wanted to share an identity with their teacher as a part of belonging would have been from underrepresented groups. This is useful information in thinking about future interventions with the population of students I work with, that is disproportionally white, male, and upper middle class.

Next steps

The major step I hope to take next in my teaching research is investigating strategies for increasing students' mutual accountability and decreasing or harnessing the impact of peer relationships on students' sense of belonging in the classroom. Increasing students' metacognition about their own impact on others' experience of belonging in science may mitigate the negative impact of peer behavior on creating a welcoming classroom. This could also include classroom interventions around discussion and group work norms, providing more avenues for students to give one another feedback, or allowing students who are from underrepresented groups to choose individuals that they want to have in the classroom space as a safe person to confide in and work with. I already do some of these practices now as a teacher and administrator; exploring the impacts of each intervention and making adjustments to the way I work with those students may have further repercussions on who feels welcomed into my science classroom.

After seeing that at least one student wishes they had more peers and teachers of color, I will continue to advocate for higher enrollment and employment of community

members of color to better-reflect our community's population. This is already happening in student enrollment for the coming year, and our employment committee is beginning to think critically about how we can be a more appealing school community for teachers of color in the future. It is clear that students need role models with a variety of identities, both shared and different from them, to have a complete picture of what science and teaching can look like. This includes students from groups overrepresented in STEM as well as those who come from underrepresented identity groups.

I also plan to continue implementing specific student feedback for improved teaching practices for the majority of students. Though I try to always use hands-on learning, it is not always apparent to students because they get caught up in the specific assessment tools I am using in that space, such as worksheets, lab reports, and quizzes. I plan to increase hands-on learning in a way that is visible to students in the coming year's curriculum, thinking about low-impact assessment tools and clearer rubrics for questions. I also must invest more time in decluttering my classroom, which is often full of partly-finished projects and lab equipment. Since having a cleaner classroom has been shown experimentally and in my own research to increase students' sense of ambient belonging, I will continue to improve my cleaning practices.

One question I was not able to address fully in my research was the way that treatments like these, aimed at increasing a sense of belonging among students who have identities on the margin in STEM practice, impact those most centered, especially white cisgender boys. Anecdotally, the white cisgender boys in my classes tended to complete my surveys quickly and provide shorter, less rich responses to questions about belonging

in the science classroom. I also saw that a number of white boys indicated that they wanted a same-gender teacher in the classroom and that they did not feel as well-supported by me as their teacher as students from other demographic groups. I have often struggled to make meaningful connections to the white cisgender boys in my classroom, which may be a result of homophobia, transphobia, or simple lack of common interests with many of those kids. In the same way that intersectionality can disproportionately impact students from multiple marginalized identities, I believe that identity work can overlook or exclude students for whom they hold many positions of power. I would like to keep this in mind moving forward when considering possible future work on inclusion, community-building, and access for all students, especially in such a predominantly white and boy-heavy environment.

It is also worth noting that I was teaching in a classroom where the primary science field studied is one where patterns of overrepresentation of specific groups are less-pronounced, especially for women (National Science Foundation, 2017). I would like to investigate the impact of this kind of treatment in a classroom where the content matter is in a field where disparities persist such as physics, chemistry, or computer science. I would imagine that the impact of this kind of treatment would be more significant given the increased barriers to a sense of belonging in those fields.

Finally, I hope to continue using the interaction ritual of mutual feedback in my classroom space and share it with my colleagues. I am especially hopeful to try sharing this ritual with other teachers at my school whose students may report lower amounts of belonging in their classroom space to see if more significant results are possible. I have

already shared the initial feedback activity with others on the eighth-grade team when leading a group exit interview for the rising class of eighth graders. Several teachers commented on how impressed they were by the students' level of engagement with the activity and said that they plan on using it in their own classrooms. This ripple effect of increasing students' voice in creating welcoming spaces will hopefully create a more positive and equitable school community for all students moving forward.

Doing inclusion and equity work around improving a sense of belonging for students on the margins of STEM practice is crucial in building a future in which specific groups are not underrepresented. Diverse perspectives add richness to scientific practice, and there is evidence that having a wide range of perspectives shared in space improves a group's ability to find creative solutions, work efficiently, and avoid errors (Phillips, 2014; Nielsen et. al., 2017). By adding to the research done on this topic, I hope to promote greater equity that may lead to higher rates of retention for students from underrepresented groups in STEM fields, improve the number of role models and mentors that are available to those students, and continue working against the status quo that continues to center particular experiences while excluding others. By promoting classroom techniques that center the voices of those most on the margin, middle-level teachers can be changemakers in the path to a more equitable and innovative future.

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APPENDICES

APPENDIX A

IRB EXEMPTION LETTER

MONTANA
STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Lewis Maday-Travis and Marcie Reuer

FROM: Mark Quinn Mark Quinn Chj
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: October 24, 2017

RE: *"The Impact of Feedback on Students' Belonging in an Eighth Grade Science Classroom"* [LM-T102417-EX]

The above research, described in your submission of October 24, 2017, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

STUDENT FEEDBACK SURVEY

Section 2 of 5

Readings and media quizzes

Description (optional)

In general, how useful have the assigned readings and videos been in helping you understand human biology? *

	1	2	3	4	5	
Not useful to me	○	○	○	○	○	Very useful to me

In general, how completely and carefully have you read or listened to the assigned media each week? *

- ○ Completely and carefully
- ○ Completely, but not carefully
- ○ Carefully, but not completely
- ○ Not completely or carefully

How do the media quizzes impact your careful reading and understanding of the assigned readings? *

- ○ I read more carefully and understand more because of the quizzes
- ○ I read more carefully, but don't necessarily understand more because of the quizzes
- ○ I would read just as carefully with or without the quizzes
- ○ I read less carefully and understand less because of the quizzes
- ○ Other...

How clear and understandable were the readings listed below? *

	Not clear at all	Somewhat clear	Meh	Clear	Very clear
Brain Rules "Introduction" (Evolution & the Brain)	○	○	○	○	○
Brain Rules "Exercise"	○	○	○	○	○
Article: "This is what happens to your brain when you exercise"	○	○	○	○	○
Brain Rules "Sleep"	○	○	○	○	○
Jim Olson "Tumor Paint"	○	○	○	○	○
Article: "Drugs and the Brain"	○	○	○	○	○
Brain Rules "Stress"	○	○	○	○	○
Article: Immune System	○	○	○	○	○

How much did the readings listed below help you learn? *

	Didn't learn anything	Helped a little bit	Meh	Helped me learn	Learned a ton
Brain Rules "Introduction" (Evolution & the Brain)	○	○	○	○	○
Brain Rules "Exercise"	○	○	○	○	○
Article: "This is what happens to your brain when you exercise"	○	○	○	○	○
Brain Rules "Sleep"	○	○	○	○	○
Jim Olson "Tumor Paint"	○	○	○	○	○
Article: "Drugs and the Brain"	○	○	○	○	○
Brain Rules "Stress"	○	○	○	○	○
Article: Immune System	○	○	○	○	○

How much did you enjoy the readings listed below? *

	Hated it	Not my thing	Meh	It was enjoyable	Loved this
Brain Rules "Introduction" (Evolution & the Brain)	○	○	○	○	○
Brain Rules "Exercise"	○	○	○	○	○
Article: "This is what happens to your brain when you exercise"	○	○	○	○	○
Brain Rules "Sleep"	○	○	○	○	○
Jim Olson "Tumor Paint"	○	○	○	○	○
Article: "Drugs and the Brain"	○	○	○	○	○
Brain Rules "Stress"	○	○	○	○	○
Article: Immune System	○	○	○	○	○

What other comments or suggestions do you have about our readings and media quizzes?

Long answer text

In-class activities

Description (optional)

In general, how useful have the case studies been in helping you learn? *

	1	2	3	4	5	
Not helpful at all	○	○	○	○	○	Super helpful

In general, how useful have the in-class labs been in helping you learn? *

	1	2	3	4	5	
Not helpful at all	○	○	○	○	○	Super helpful

In general, how useful have the Friday in-class reading discussions been in helping you learn? *

	1	2	3	4	5	
Not helpful at all	○	○	○	○	○	Super helpful

How active and engaged do you feel when doing the following in-class activities? *

	Not engaged at all	Somewhat engaged	Meh	Active and engaged	Super active and engaged
Case studies	○	○	○	○	○
In-class labs	○	○	○	○	○
Reading discussions	○	○	○	○	○
Lectures	○	○	○	○	○
Guest speakers	○	○	○	○	○

What other comments or suggestions do you have about the activities we do in class?

Long answer text

Weekly Reflections

Description (optional)

How useful have the weekly reflections been in helping you understand and remember our current topics? *

	1	2	3	4	5	
Not helpful at all	○	○	○	○	○	Super helpful

How much time do you typically spend writing your weekly reflection? *

- ○ Less than 10 minutes
- ○ 10-20 minutes
- ○ 20-30 minutes
- ○ 30-45 minutes
- ○ More than 45 minutes

What other comments or suggestions do you have about our weekly reflections?

Long answer text