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More Than Numbers: The Relationship Between Belonging and Engagement in an Introductory Statistics Course

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Abstract

More college students from diverse backgrounds and disciplines are enrolling in introductory statistics courses. In these courses, active learning, collaborative projects, and relatable content can help to support student learning, belonging, and engagement. In this study, we examined the effect of student-perceived peer, faculty, and classroom belonging on three dimensions of student engagement in a music-themed introductory statistics course. We identified significant models for each dimension of engagement: absorption (conditional R^2 = .76, marginal R^2 = .26), dedication (conditional R^2 = .81, marginal R^2 = .28), and vigor (conditional R^2 = .79, marginal R^2 = .25). We found significant associations between (a) classroom belonging and dedication, vigor, and absorption, and (b) faculty belonging and absorption. The absorption model demonstrated a significant interaction, with students' sense of faculty belonging declining over time. Qualitatively, students perceived the course theme, instructors, and peer collaboration as supportive. Implications suggest that instructors can take creative, high-impact approaches to teaching introductory statistics. Fostering students' engagement and belonging may help to offset students' anxiety or disinterest and help them to become more autonomous learners.

Keywords: sense of belonging, engagement, general education, statistics pedagogy, mixed methods

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Many institutions offer general education introductory statistics classes, as the statistical literacy and data analysis skills taught in these courses have broad, practical, and cross-disciplinary applications that can benefit today's college students. Consequently, a growing number of students from diverse educational programs have enrolled in such courses (Ben-Zvi et al., 2018; GAISE College Report ASA Revision Committee [GAISE], 2016). However, mathematics and statistics anxiety (Onwuegbuzie & Wilson, 2003; Zieffler et al., 2018), a lack of perceived content relevancy (Bromage et al., 2022; Lalayants, 2012), and limited prior knowledge (Baloğlu, 2003; Bromage et al., 2022) present challenges for student success in introductory statistics classes. To meet the needs of today's learners, the revised Guidelines for Assessment and Instruction in Statistics Education College Report (GAISE, 2016) recommended several strategies for effective statistics courses, including the use of real, contextualized data; formative and summative assessment; and active learning strategies. Research has also emphasized the importance of educational environments designed to support statistical learning (Ben-Zvi et al., 2018).

Prior research has highlighted innovative pedagogical approaches that make statistics accessible to students from diverse personal and professional experiences, including full or partially flipped classes, project-based learning, and other active and collaborative learning techniques (Bromage et al., 2022; Kuiper et al., 2015; Zieffler et al., 2018). Studies have emphasized the importance of creating fun and relatable opportunities for students in introductory statistics courses (Lesser et al., 2019; Meng, 2009). These approaches suggest that students' attitudes toward statistics play important roles in their learning (Bateiha et al., 2020; Griffith et al., 2012; Schau & Emmioğlu, 2012) and that students' perceptions of their own classroom engagement may have implications for learning outcomes (Lawton & Taylor, 2020). Research focusing on attitudes and engagement as well as other noncognitive constructs like self-efficacy reflects an important development in statistics education scholarship (Spencer et al., 2023). However, understanding the role of other noncognitive variables may further contextualize our understanding of how teachers and students engage in the process of statistics education within the college classroom. To our knowledge, no research has yet examined college students' sense of belonging—feeling connected to, valued in, and supported by college environments (Strayhorn, 2019)—in statistics classrooms, although prior research has found that belonging is associated with student engagement and learning outcomes (Gillen-O'Neel, 2021; Hausmann et al., 2007).

Additionally, much of the existing literature on statistics education has been conducted in smaller classes (Lawton & Taylor, 2020; Spencer et al., 2023) or has focused on specific instructional approaches (Lesser et al., 2019; Neumann et al., 2013), although recent research has started to consider how large class sizes can support student learning and engagement in statistics courses (Schneiter et al., 2023). Such approaches present valuable insights into effective statistics education. However, as Ben-Zvi et al. (2018)

noted, more research is needed that engages with the complex dimensions of statistics learning environments. A better understanding of whether students feel a sense of belonging in statistics classrooms—and what students perceive enhances or interferes with that belonging—may inform continued development of statistics pedagogy (Freeman et al., 2007; Kirby & Thomas, 2022; Zumbrunn et al., 2014).

To examine students' perceptions of engagement and belonging in an intentionally designed statistics learning environment, we examine Albums & Algorithms, a general education course open to students from all majors. In the course, we introduced students to fundamental statistical concepts and analyses through music, active learning, and a semester-long group project in which students collected and analyzed data to answer a research question they devised. The course was co-designed with another faculty member by Benjamin Torsney, and both authors taught the course, Torsney as the instructor of record and Catherine Pressimone Beckowski as a teaching assistant [TA]. We assessed the extent to which students perceived their own engagement, belonging, and learning in Albums & Algorithms across a semester and what aspects of the course contributed to or detracted from these dimensions of their experience. We also examined how students' sense of belonging influenced student engagement, defined as an individual's perceived absorption, dedication, and vigor when participating in a task or activity (Schaufeli & Bakker, 2004).

We employed a convergent mixed methods-case study design (MM-CS; Creswell & Plano Clark, 2018; Guetterman & Fetters, 2018) to examine the following research questions:

1) How do students' self-perceived course engagement, sense of belonging, and learning vary over the course of a semester in an introductory general education statistics course?
2) What course components do students perceive as valuable to their course engagement, sense of belonging, and learning in an introductory general education statistics course?

Literature Review

Engaging Statistics Pedagogy

Scholars and practitioners have advocated for innovative introductory statistics pedagogy (Bromage et al., 2022; Kuiper et al., 2015). Some empirical research has suggested that project-based statistics courses are beneficial to student learning and outcomes (Dierker et al., 2018). Engaging approaches may help to create supportive classroom environments and opportunities for real-world examples and projects, potentially alleviating statistics anxiety (Lalayants, 2012), which has been found to negatively predict academic engagement and learning (González et al., 2016; Onwuegbuzie & Wilson, 2003). Additionally, researchers have emphasized the importance of improving students' motivation in statistics courses by encouraging students' personal engagement with course concepts and making statistics fun, relevant, and applicable, particularly in general education courses (Meng, 2009). According to Zumbrunn et al. (2014), a supportive classroom, belonging, motivation, and engagement are necessary parts of the learning experience and relate to student outcomes. However, prior research has suggested that student engagement can vary over the course of a semester and that the extent to which students feel engaged can reflect perceptions of different active learning and engagement strategies used in statistics classes (Lawton & Taylor, 2020).

Efforts to reform statistics education have been guided by the notion that "learning statistics is not about passively acquiring a set of facts and procedures but rather about actively constructing meanings and understandings of big ideas, ways of reasoning, and articulating arguments, dispositions, and perspectives" (Ben-Zvi et al., 2018, p. 475). To this end, Ben-Zvi et al. (2018) elaborated six dimensions that interconnect and inform an effective statistics learning environment: use of real and engaging data, well-designed learning tasks, focus on core statistical concepts, assessments that monitor students' developing understanding (formative) and determine students' content mastery (summative), integration of appropriate technology for statistical analyses, and the creation of a classroom culture where students feel they can openly discuss statistical concepts.

Research has advocated different approaches to achieve these aims, reflecting the GAISE (2016) acknowledgement that all introductory statistics courses need not share a single set of objectives. The proliferation of publicly available datasets (Coughlan, 2020) has allowed instructors to incorporate analyses of real and contextualized data in their classrooms (Bromage et al., 2022). Readily available technology and analytic tools have made it possible for students to engage in instructor-facilitated active and collaborative learning in the classroom (Bromage et al., 2022; Park et al., 2022) and has made formative, continuous assessment more manageable for instructors in large classes (Hadfield, 2023). Dierker et al. (2018) found that students enrolled in a project-based statistics course—where students developed an inquiry and tested it through analysis of real data—reported greater understanding of content, increased confidence in some areas, and more interest in continued statistical work than students enrolled in a traditional course. Beyond course design and structure, statistics educators and scholars have recommended the use of course content that students find engaging, either because it connects to their field of study or because it brings an element of fun that piques students' interest, can make content accessible, and can reduce anxiety (Lesser et al., 2019; Meng, 2009).

Thanks to its universal appeal (Khachatryan, 2023), music has been integrated into some statistics courses and pedagogical tools. For example, Khachatryan (2023) developed the *Playmeans* app to facilitate student-directed quantitative analysis of music by a selected artist; other studies have shown that listening to and working with statistical songs can promote students' perceptions of engagement and learning (Lawton & Taylor, 2020; Lesser et al., 2019). Scholars have proposed that using music in introductory statistics classes can reduce statistics anxiety (Lesser et al., 2019) and promote active learning opportunities accessible to students regardless of their educational, socioeconomic, or cultural backgrounds (Khachatryan, 2023). Existing research has thus explored the contributions of specific pedagogical approaches to music-based statistics instruction. However, although Lawton and Taylor (2020) examined students' engagement over the course of the semester and considered statistics-based music as one engagement tool, the class they studied was not exclusively music-themed and did not consider students' sense of belonging. Consequently, our study extends the research on music-based statistics pedagogy by offering a distinct approach from those in existing studies and by considering additional dimensions of students' learning experiences. More specifically, this study investigates a course that primarily incorporated hip-hop, which has been used to engage students in learning by helping them make personal, real-world connections and engage with instructors in and beyond STEM contexts (Adjapong & Emdin, 2015; Hains et al., 2021).

College Students' Sense of Belonging and Engagement in Statistics Classrooms

College student belonging is positively associated with such outcomes as persistence and attainment (Gopalan & Brady, 2019; Hausmann et al., 2007). Although belonging is fundamental to college students' success (Strayhorn, 2019), only limited research has considered college student belonging in classroom contexts (Zumbrunn et al., 2014) and specific instructional practices that foster belonging (Taff & Clifton, 2022). Students' perceptions of and interactions with faculty have also been positively associated with classroom sense of belonging (Freeman et al., 2007; Means & Pyne, 2017), which may promote student motivation and achievement (Zumbrunn et al., 2014). Thus, we were interested in understanding how students experience belonging and what factors contribute to sense of belonging in a general education statistics course.

Following Hoffman et al. (2002) and other literature on statistics education and classroom belonging, we considered three dimensions of belonging in this study. *Classroom belonging*—the extent to which students feel comfortable within the classroom itself—has been associated with higher self-efficacy (Freeman et al., 2007), motivation (Zumbrunn et al., 2014), and engagement (Wilson et al., 2015). However, despite these apparent benefits, research has tended to focus on institutional, rather than classroom, belonging (Kirby & Thomas, 2022). We define *peer belonging* as the extent to which students feel comfortable engaging with, or feel supported or accepted by, their classmates (Zumbrunn et al., 2014). Zumbrunn et al. (2014) found that students reporting a higher sense of classroom belonging felt accepted by their peers, and peer collaboration has played a key role in statistics instructional approaches (Garfield & Ben-Zvi, 2008). Finally, *faculty belonging* reflects the extent to which students feel academically and socially supported by their instructors (Zumbrunn et al., 2014). Although prior research has not specifically examined faculty belonging in statistics classrooms, studies have suggested that students' perceptions of faculty improve in active learning environments such as flipped classrooms (Kuiper et al., 2015), and that student perceptions of engagement may be strongly correlated with faculty perceptions of engagement (Lawton & Taylor, 2020). Additionally, Trassi et al. (2022) found that instructors' personalities and behaviors could have an effect on the presentation of statistics anxiety and posited that teaching methods could help to reduce anxiety. Other research has found that instructors' attitudes were associated with changes in students' statistics attitudes (Bateiha et al., 2020; Xu et al., 2020). Together, these findings suggest that classroom, peer, and faculty belonging may play important roles in helping students to navigate challenges and master concepts in an introductory statistics course.

We also examined students' course engagement, as engagement has been identified as an outcome of student motivation and a predictor of academic performance and success (Gonzáles et al., 2016; Zumbrunn et al., 2014), and as prior research has examined various approaches to engaging students in introductory statistics courses, including through music (Lawton & Taylor, 2020). However, Gonzáles et al. (2016) found that statistics anxiety negatively predicted dimensions of academic engagement. Cognitive (i.e., strategy and skill use), behavioral (i.e., observable effort and involvement in learning), and emotional (i.e., feelings while working on a task) engagement can be enhanced by supportive teachers, instructional styles, and learning environments (Acosta-Gonzaga & Ramirez-Arellano, 2022; Lalayants, 2012). Thus, we were interested in the associations between engagement and belonging.

Theoretical Framework

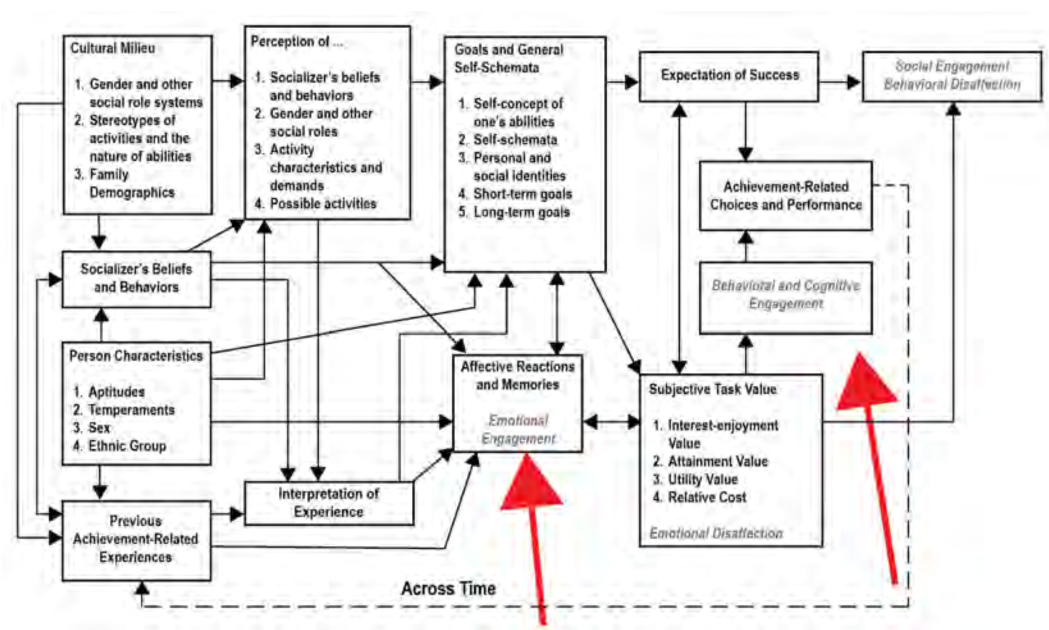
Our theoretical approach to this study is guided by Situated Expectancy-Value Theory (SEVT; Eccles & Wigfield, 2002, 2020). SEVT is a developmental model of achievement motivation that considers the relationship between a person's expectation for success at a task or activity and the extent to which they value completing or succeeding at that task (i.e., subjective task value; STV). STV is comprised of four components: attainment value (task value related to a person's identity), interest-enjoyment value (inherent interest or value gained from engaging in that task), utility value (perceived usefulness of a task for future goals), and cost (perceived negative outcomes of engaging in a task in comparison to other, more personally relevant tasks). Importantly, SEVT acknowledges that individuals may value the same task differently and that motivation to succeed is not linear or static, but rather develops over time and in response to a host of contextual factors (Eccles & Wigfield, 2020).

Take, for example, a college student enrolled in an introductory statistics course. Prior experiences—such as struggling to pass math classes in high school or being told that, as a female, they are not "good" at math (i.e., self-concepts of one's ability)—may decrease the student's value for taking statistics and lower their expectations of success. However, if the class makes the content relevant and enjoyable and helps the student understand why the course will benefit them, the student may become more inclined to complete course activities and ultimately achieve course outcomes.

Thus, in the context of this study, SEVT provides a useful framework for understanding the contextual factors that lead to a student's motivation. We consider students' perceived sense of belonging as a contextual factor that may influence motivation and subsequent engagement. Following Zumbrunn et al.'s (2014) model of classroom support for motivation—which demonstrated that a supportive classroom predicted belonging and subsequently predicted engagement—we are interested in whether and how dimensions of sense of belonging (classroom, peer, and faculty) foster dimensions of student engagement (dedication, vigor, and absorption) in statistics.

As posited by Gladstone et al. (2022), we view different dimensions of engagement as subcomponents of the SEVT achievement motivation system (see Figure 1). *Dedication*—feeling enthusiasm for and valuing the significance and challenge of class work (Schaufeli & Bakker, 2004; Schaufeli et al., 2002)—is linked to emotional engagement (Wong & Liem, 2022) and situated within the "Affective Reactions and Memories" component of the SEVT system (Gladstone et al., 2022). This suggests that students' prior associations with tasks or activities can inform their affect toward related contexts, interests, values, and costs; i.e., a student who had prior negative experiences with math or statistics may be less likely to dedicate themselves to a statistics course. *Vigor*—an energetic willingness and ability to engage in a task (Schaufeli & Bakker, 2004; Schaufeli et al., 2002)—reflects students' behavioral engagement in class math activities (Gladstone et al., 2022). *Absorption*—feeling fully immersed in and satisfied

Figure 1. SEVT Engagement Integration



Note. Adapted from Gladstone et al. (2022).

by one's work (Schaufeli & Bakker, 2004; Schaufeli et al., 2002)—reflects students' cognitive engagement as they seek to fully understand math concepts (Gladstone et al., 2022). Within the SEVT model, both behavioral and cognitive engagement serve as mediators between STV and course outcomes (Gladstone et al., 2022). Together, this model suggests that dimensions of engagement shape students' values. In this study, we are interested in how sense of belonging might factor into fostering different types of student engagement.

Previous research has linked STV and belonging, with student belonging emerging within the STV component (Freeman et al., 2007). However, more insight is needed to determine how a classroom environment can foster belonging, which can in turn foster engagement (Zumbrunn et al., 2014). Although prior research has demonstrated that different instructor behaviors and class activities can inform engagement (Lawton & Taylor, 2020), less is known about learning environments and teaching attitudes and styles that can reduce anxiety, foster social support, and promote statistical learning (Ben-Zvi et al., 2018; Trassi et al., 2022; Zumbrunn et al., 2014). Thus, in this study, we adopt a MM-CS approach (Creswell & Plano Clark, 2018; Guetterman & Fetters, 2018) to investigate the relationship between dimensions of belonging and engagement over the course of a semester in a specific statistical learning environment. Below, we describe the case context, which details some of the characteristics of the statistics course in question.

Method

Case Description

We conducted this research in a music-themed undergraduate general education statistics class at a research university during the Spring 2023 semester. The course was one of 11 non-honors courses designated under the Quantitative Literacy General Educational curriculum (Quant Lit). All students at the university were required to take a Quant Lit class for graduation.

Students met twice a week: once in a large lecture for all students and once in smaller recitation cohorts of approximately 20–30 students. During lectures, the full-time faculty instructor introduced statistical concepts, illustrating them through music-related, publicly available datasets such as "The Language of Hip-Hop" (Daniels, 2019) along with supplemental data visualizations and activities (see Appendix for sample course materials). During recitations, TAs reviewed core concepts through additional music-themed examples and activities, and students applied concepts through the development of a semester-long research project involving the design, administration, and analysis of a survey. To ensure that students could readily access and utilize data collection and analysis tools, we trained students to conduct all aspects of the project using Google Sheets, Google Forms, and Excel (Park et al., 2022).

The use of hip-hop and other music—coupled with engaged, collaborative pedagogy in both the lecture and lab sessions—was intended to help students find a connection with challenging course material and feel that they were in a welcoming, supportive environment. For example, students were regularly invited to choose songs during "DJ breaks" before class and during in-class work sessions. During lectures, the instructor regularly played song or video clips that served as the basis for conceptual discussions. The lecture instructor also regularly conducted whole-class, dialogue-driven exercises using fun, low-stakes examples to build content mastery. For the semester-long collaborative project, students could develop topics that interested them; many, though not all, groups developed music-themed research questions and surveys. In recitations, TAs provided whole group and individualized support. Assignments included formatively assessed weekly labs and homework, quizzes, scaffolded group project components, and individual presentations and papers using project data.

Researcher Positionality

Catherine Pressimone Beckowski—a scholar of higher education and student success—was in her third semester as a TA for this course when she helped to develop and conduct this study. Prior to serving as TA, she had worked for over a decade in academic support and as a general education instructor; in these roles, she developed a deep commitment to promoting student success by recognizing students' strengths and fostering belonging in and beyond the classroom. As a White, female doctoral student in her late 30s, she reflected on how her own statistics anxiety had stemmed from gendered assumptions about her ability to succeed at math and quantitative research; consequently, she approached this course and study with an interest in understanding students' perceptions of statistics and a desire to challenge underlying biases that could impede some students' success.

Benjamin Torsney, who holds a PhD in educational psychology, co-designed the class for this study. Drawing from his experience teaching a course on the psychology of hip-hop, he used hip-hop as an entry point to connect students' prior knowledge with class material, making learning statistics more relevant. This approach builds on his previous work exploring the intersection of race, racism, and psychology. As a White male in his mid-30s, Torsney has reflected on the cultural implications and potential biases of using hip-hop as a teaching tool.

Participants

Participants were undergraduates enrolled in the course (N = 74, N = 162 observations). Fifty-eight percent of the sample identified as female, 35% as male, and 7% as non-binary. Fifty-nine percent identified as White, 27% Black, 4% Latine, 7% multiracial, and 3% Asian.

Participants self-selected into this Quant Lit course for various reasons (e.g., course topic, schedule availability, peer recommendation, etc.). Therefore, although participants were not a representative sample of the students at the university, they did come from a range of colleges and majors, reflecting the more diverse enrollment in Quant Lit courses noted elsewhere (e.g., Ben-Zvi et al., 2018).

Measures

We sought to examine factors that would impact a student's engagement in an introductory statistics class, understanding engagement as an outcome of motivation, time, and supportive factors (e.g., student-perceived belonging in an academic context; Gladstone et al., 2022; Zumbrunn et al., 2014). We therefore chose a combination of measures that would best help us describe student engagement across the semester.

To measure engagement, we used an adapted version of the shortform Utrecht Work Engagement Scale (Schaufeli et al., 2006). All scales were anchored 1 to 6. The work engagement scale consisted of three subscales: absorption, dedication, and vigor. A sample item measuring absorption included *I am immersed in the material related to this class.*

The belonging scale (Hoffman et al., 2002) consisted of three subscales related to peer-to-peer belonging, a sense of belonging in the class, and a sense of belonging from the instructor. A sample item measuring belonging in the class included *I feel comfortable volunteering ideas or opinions during class.*

Individual subscales were created in composite variables. All subscales had reliability >.70 (see Table 1).

Students were also invited to respond to two open-ended prompts during each survey administration: *What aspects of the course are supporting your engagement and learning? How?* and *What aspects of the course are challenging your engagement and learning? How?*

Design and Procedure

The study employed a convergent MM-CS design (Creswell & Plano Clark, 2018; Guetterman & Fetters, 2018). Students took a survey with Likert scale and open-ended responses at three points during the semester: Weeks 3, 9, and 14. By Week 3, students had been introduced to functions in Google Sheets and Excel, concepts like research questions and operationalization, and the semester-long data collection and analysis project. By Week 9, students had learned more statistical concepts including measures of central tendency, reliability and validity, and correlations; in their project groups, they had developed research questions, designed surveys, and initiated data collection. By Week 14, student had been introduced to all course content including z-score calculation, t-tests, and ANOVA; at this point, student groups were working on data analysis and interpretation of their survey findings and beginning to develop their presentations and draft their final papers. Observation notes and course materials were collected throughout the semester.

Table 1. Descriptive Statistics

Variable	*Mean*	*SD*	a
Absorb_t1	3.23	1.10	0.83
Absorb_t2	3.09	1.12	0.85
Absorb_t3	2.99	0.94	0.78
Dedication_t1	3.95	1.04	0.81
Dedication_t2	3.62	1.14	0.84
Dedication_t3	3.43	1.06	0.83
Vigor_t1	3.08	1.05	0.86
Vigor_t2	2.85	1.10	0.89
Vigor_t3	2.89	0.98	0.76
BelongC_t1	4.06	1.42	0.94
BelongC_t2	4.28	1.33	0.95
BelongC_t3	4.64	1.25	0.94
BelongF_t1	5.06	1.13	0.78
BelongF_t2	5.21	1.07	0.76
BelongF_t3	5.22	0.98	0.73
BelongS_t1	2.85	1.41	0.81
BelongS_t2	3.41	1.17	0.74
BelongS_t3	3.77	1.29	0.79

Data Analysis

We analyzed quantitative data through linear mixed modeling using student ID number (level 2) as the cluster variable and covariates of belonging and time at level 1. We conducted hierarchical models for each engagement subscale. We used conditional (variance related to random and fixed factors, e.g., individual and time) and marginal R^2 (fixed factors alone, e.g., time) as indicators of model fit (i.e., proportion of variance accounted for in each model). Hierarchical models are particularly useful when dealing with nested data structures, such as repeated measures on the same subjects, like those in this study.

Hierarchical models also require long-form data input, meaning that each case has multiple rows for each time point. Having data formatted in this way allows individual cases to be estimated implicitly, even with missing data (Vongkulluksn & Xie, 2022). In analyses like repeated measures ANOVA, one missing value would result in that case being dropped (i.e., listwise deletion), unless a missing data estimation technique, such as multiple imputation, was performed. Having data in a long format does not require a missing data technique.

Table 2. Bivariate Correlations

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Absorb_t1	1																	
2	Absorb_t2	.73**	1																
3	Absorb_t3	.68**	.68**	1															
4	Dedication_t1	.84**	.75**	.72**	1														
5	Dedication_t2	.67**	.88**	.67**	.79**	1													
6	Dedication_t3	.66**	.66**	.86**	.72**	.73**	1												
7	Vigor_t1	.78**	.76**	.71**	.78**	.76**	.68**	1											
8	Vigor_t2	.68**	.86**	.60**	.70**	.84**	.67**	.83**	1										
9	Vigor_t3	.63**	.80**	.82**	.69**	.73**	.82**	.72**	.81**	1									
10	BelongC_t1	.49**	.52**	.34*	.52**	.56**	.43**	.63**	.50**	.34*	1								
11	BelongC_t2	.38*	.53**	.40*	.52**	.59**	.45**	.45**	.47**	.50**	.75**	1							
12	BelongC_t3	.30	.58**	.38**	.35*	.52**	.43**	.47**	.49**	.42**	.70**	.83**	1						
13	BelongF_t1	.39**	.35*	.25	.30*	.38*	.26	.33**	.22	.22	.44**	.55**	.62**	1					
14	BelongF_t2	.39*	.39**	.17	.34*	.41**	.32	.32*	.29*	.28	.37*	.44**	.47**	.77**	1				
15	BelongF_t3	.31	.27	.09	.31	.27	.21	.33*	.17	.16	.43**	.42*	.80**	.73**	.90**	1			
16	BelongS_t1	.22	.38*	.10	.15	.32*	.04	.06	.24	.13	.16	.30	-.04	-.02	.15	.18	1		
17	BelongS_t2	.31*	.22	.13	.33*	.23	.17	.32*	.26	.44**	.16	.27*	.12	.13	.24	.51**	.71**	1	
18	BelongS_t3	.14	.29	.05	.13	.29	-.02	.19	.19	.12	.06	.12	.17	.31	.42**	.46**	.66**	.73**	1

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

We computed interactions to account for changes in perceptions of student belonging at three time points over the course of the semester. That is, interactions allowed us to understand if changes in belonging and engagement were dependent on time. All analyses were completed using Jamovi 2.3 (The Jamovi Project, 2022), a free statistical analysis software program similar to SPSS. Results describe the final model (see Tables 3–5).

We open-coded qualitative data from each time point, then grouped related ideas using axial coding (Corbin & Strauss, 2015). Initially, we examined responses to each open-ended question separately; however, after open and axial coding were completed, we reexamined responses to both questions by respondent to gain a more nuanced understanding of how students perceived supports and challenges. We conferred to agree on code applications. We triangulated our findings through analysis of observation notes and other course materials, which supported our interpretation of findings (Creswell & Plano Clark, 2018). Finally, we compared our codes to existing theoretical and conceptual frameworks (Ben-Zvi et al., 2018; Zumbrunn et al., 2014) and found alignments that lent further support to our emergent themes (Cresswell & Plano Clark, 2018).

Limitations

Our study has several limitations. First, findings should be interpreted with care due to our limited sample size. We also aimed to study general belonging as related to three components of engagement over time, and therefore did not include demographic information in our analysis. Second, for the purposes of this study, we wanted to focus on the relationship between classroom context, belonging, and engagement and thus did not include a course outcome measure (e.g., final course grades). Finally, in the semester of data collection, the participating university's TAs went on strike, which delayed the first survey administration by one class period and required some redistribution of students' recitation sections for the remainder of the course. Since the strike began before the initial data collection and the course ultimately proceeded as planned, we argue that our results accurately reflect students' experiences of the course of a typical semester. However, replication of the study in other semesters could help to confirm or extend findings.

Results

Quantitative Results

Descriptive statistics and correlations can be seen in Tables 1 and 2. Mean values for each component of belonging increased over time. All models were significant and met the assumptions of regression.

For the *dedication* model, we identified a conditional R^2 = .81, marginal R^2 = .28. We also identified one significant main effect for perceived sense of belonging in class

Table 3. Dedication Model

	Model 1 Dedication			Model 2 Dedication			Model 3 Dedication			Model 4 Dedication		
Predictor	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*
Intercept	3.67	3.44–3.89	< .001	3.66	3.43–3.88	< .001	2.23	1.40–3.07	< .001	1.94	0.98–2.90	< .001
Time				−0.30	−0.41–−0.19	< .001	−0.36	−0.48–−0.25	< .001	−0.11	−0.67–0.45	.709
Belonging-C							0.37	0.25–0.49	< .001	0.32	0.18–0.46	< .001
Belonging-F							0.07	−0.08–0.21	.39	0.12	−0.05–0.29	.16
Belonging-S							−0.05	−0.16–0.06	.39	0.02	−0.11–0.14	.78
Time × Belonging-C										0.08	−0.02–0.17	.134
Time × Belonging-F										−0.06	−0.20–0.07	.347
Time × Belonging-S										−0.08	−0.16–0.01	.072
Random effects												
σ2	0.40			0.30			0.25			0.24		
τ00	0.79			0.84			0.64			0.66		
ICC	0.67			0.74			0.72			0.73		
N	74			74			74			74		
Observations	162			162			162			162		
Conditional R^2/ Marginal R^2	.67/.00			.75/.05			.79/.26			.81/.28		

Note. $Dedication_{ij} = \beta_0 + \beta_1 Time_{ij} + \beta_2 Belonging\_Class_{ij} + \beta_3 Belonging\_Faculty_{ij} + \beta 4 Belonging\_Peers_{ij} + \beta_5 Time_{ij} * Belonging\_Class_{ij} + \beta_6 Time_{ij} * Belonging\_Faculty_{ij} + \beta_7 Time_{ij} * Belonging\_Peers_{ij} + u_{0j}(ID) + e_{ij}$

Table 4. Vigor Model

	Model 1 Vigor			Model 2 Vigor			Model 3 Vigor			Model 4		
Predictor	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*
Intercept	2.94	2.72–3.16	< .001	3.07	2.83–3.31	< .001	1.51	0.71–2.31	< .001	1.15	0.23–2.17	.015
Time				−0.15	−0.26–−0.04	.007	−0.2	−0.31–0.09	< .001	0.25	−0.30–0.79	.376
Belonging-C							0.36	0.24–0.47	< .001	0.36	0.23–0.49	< .001
Belonging-F							0.07	−0.08–0.21	.371	0.13	−0.03–0.29	.119
Belonging-S							−0.08	−0.18–0.03	.161	−0.07	−0.20–0.04	.201
Time × Belonging-C										0.01	−0.09–0.10	.891
Time × Belonging-F										−0.11	−0.24–0.02	.086
Time × Belonging-S										0.03	−0.05–0.11	.425
Random Effects												
σ2	0.30			0.27			0.23			0.22		
τ00	0.77			0.79			0.59			0.58		
ICC	0.72			0.75			0.72			0.72		
N	74			74			74			74		
Observations	162			162			162			162		
Conditional R^2/ Marginal R^2	.72/.00			.75/.01			.79/.24			.79/.25		

Note. $\text{Vigor}_{ij} = \beta_0 + \beta_1\text{Time}_{ij} + \beta_2\text{Belonging\_Class}_{ij} + \beta_3\text{Belonging\_Faculty}_{ij} + \beta 4\text{Belonging\_Peers}_{ij} + \beta_5\text{Time}_{ij} * \text{Belonging\_Class}_{ij} + \beta_6\text{Time}_{ij} * \text{Belonging\_Faculty}_{ij} + \beta_7\text{Time}_{ij} * \text{Belonging\_Peers}_{ij} + u_{0j}(\text{ID}) + e_{ij}$

Table 5. Absorption Model

	Model 1 Absorption			Model 2 Absorption			Model 3 Absorption			Model 4		
Predictor	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*	*Estimate*	*CI 95%*	*p*
Intercept	3.12	2.90–3.34	< .001	3.29	3.04–3.54	< .001	1.36	0.51–2.21	.002	0.70	−0.28–1.69	.165
Time				−0.19	−0.31–0.07	.002	−0.28	−0.40–−0.15	< .001	0.43	−0.17–1.03	.165
Belonging-C							0.32	0.19–0.44	< .001	0.28	0.14–0.42	< .001
Belonging-F							0.12	−0.04–0.27	.134	0.25	0.07–0.42	.007
Belonging-S							0.01	−0.10–0.13	.818	0.07	−0.06–0.20	.306
Time × Belonging-C										0.08	−0.03–0.18	.146
Time × Belonging-F										−0.18	−0.33–−0.04	.012
Time × Belonging-S										−0.03	−0.12–0.06	.475
Random Effects												
σ2	0.38			0.34			0.30			0.28		
τ00	0.73			0.78			0.59			0.59		
ICC	0.66			0.7			0.67			0.68		
N	74			74			74			74		
Observations	162			162			162			162		
Conditional R^2/ Marginal R^2	.66/.00			.70/.02			.74/.23			.76/.26		

**Note*. $Absorption_{ij} = \beta_0 + \beta_1 Time_{ij} + \beta_2 Belonging\_Class_{ij} + \beta_3 Belonging\_Faculty_{ij} + \beta 4 Belonging\_Peers_{ij} + \beta_5 Time_{ij} * Belonging\_Class_{ij} + \beta_6 Time_{ij} * Belonging\_Faculty_{ij} + \beta_7 Time_{ij} * Belonging\_Peers_{ij} + u_{0j}(ID) + e_{ij}$

(β = .32, p < .001). This finding indicated that students' perceived sense of belonging in the class was positively related to their dedication for the class, as indicated in the final model. That is, students who felt a sense of belonging in the classroom reported higher levels of dedication—i.e., enthusiasm for coursework—as they engaged in class.

For the *vigor* model, we identified a conditional R^2 = .79, marginal R^2 = .25. We also identified a significant main effect for perceived sense of belonging in class (β = .36, p < .001). This finding indicated that students who perceived more classroom belonging felt more vigorously engaged—i.e., energetic and motivated to work hard—in class.

For *absorption*, we identified a conditional R^2 = .76, marginal R^2 = .26. We identified a significant main effect for perceived sense of belonging from faculty (β = .25, p = .007). We also identified a significant main effect for perceived sense of belonging from the class (β = .28, p < .001). This finding indicates that students' absorption—i.e., deep engagement in their work over the course of the semester—was a function of their perception of faculty's level of care as well as their comfort level in the classroom.

Notably, each dimension of engagement declined over time. For Model 3, the models with all covariates but no interactions, time negatively predicted absorption (β = –.28, p < .001), dedication (β = –.36, p < .001), and vigor (β = –.20, p < .001).

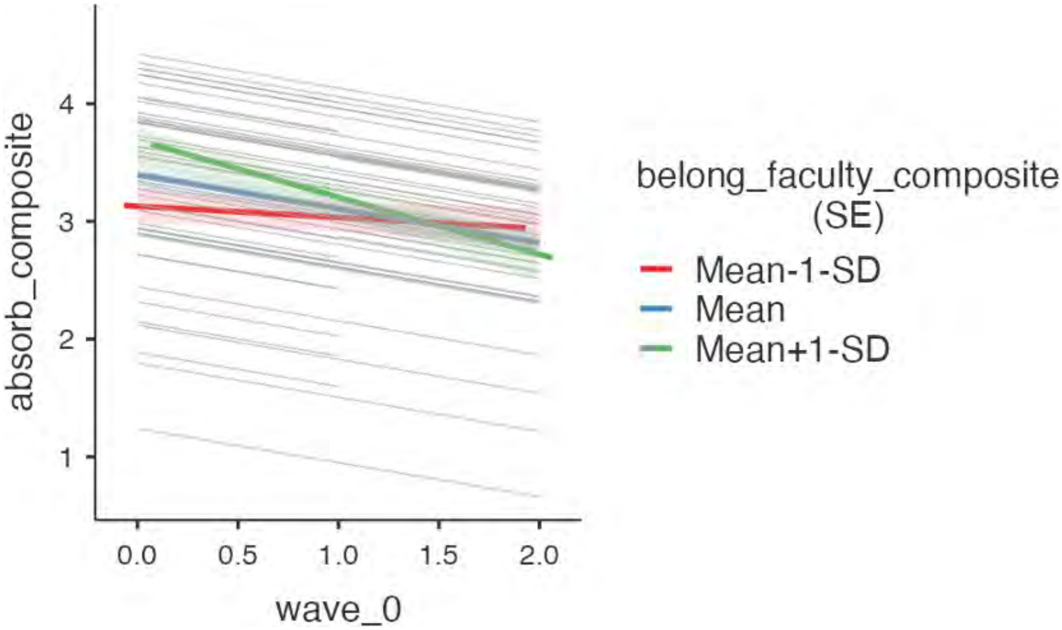
We identified a significant interaction between time and a sense of faculty belonging (β = –.18, p = .012). A follow up simple effects analysis showed that students' sense of faculty belonging showed significant slopes for faculty belonging at the mean (β = –.29, p < .001) and +1 SD above the mean (β = –.48, p < .001). In relation to students' absorption, sense of belonging ultimately decreased over the course of the semester for students who, at Week 3, perceived faculty belonging at or above the mean. In other words, students whose faculty belonging decreased also became less absorbed in the work. However, no similar interaction was found for faculty belonging and dedication or vigor (see Figure 2).

Qualitative Results

Qualitative data provided insights into changes in students' perceptions of engagement, belonging, and learning during the course. For the open-ended prompt *What aspects of the course are supporting your engagement and learning? How?*, we organized our codes into six primary themes. From most to least frequently, students identified supportive aspects of the course content, instructors, pedagogy, course structure, support, and classroom environment (see Table 6 for theme definitions and code counts across survey administrations).

For the open-ended prompt *What aspects of the course are challenging your engagement and learning? How?*, we organized our codes into seven primary themes. From most to least frequently, students described challenges related to course concepts, coursework, course structure, personal challenges, or the whole course. However, students also used this prompt to state that they were experiencing no challenge with the course, or that

Figure 2. Absorption Moderation



Note. Significant slopes for Mean (β = –.29, $p < .001$) and Mean +1 SD (β = –.48, $p < .001$).

they perceived existing challenges as positive (see Table 7 for theme definitions and code counts).

Across the semester, some students shared that they found the quantitative subject matter difficult, uninteresting, or stressful; students also felt that aspects of the course design—such as the large lecture sessions and the high number of assignments—challenged their learning and engagement. However, students frequently identified the course's music theme as supportive of their learning and engagement. As one student wrote, "I love music so the fact that the class kind of revolves around music is intriguing to me and motivates me to want to learn." Additionally, across all time points, students perceived instructors as "enthusiastic," "engaged," "passionate," and "fun," and frequently noted that the lecturer and TAs supported their learning and engagement in the class. As we describe throughout the following sections, students' perceptions of course-related supports and challenges shifted at each data collection time point.

Time One

Students' responses from time one illustrated the ways that supportive and engaging approaches in the classroom helped to offset course challenges early in the semester, as students were being introduced to key vocabulary, foundational concepts, and spreadsheet functions and formulas. One student shared that "just getting myself to want to do any kind of math honestly" was a challenge, but also that

> The music aspect of the class is absolutely keeping me interested and supporting my learning. It is one of the most important things to me and I

> always enjoy working with it. It works as a balance for me with this class that almost cancels out the actual work.

Table 6. Support of Learning and Engagement: Open-Ended Themes and Parent Code Applications

Theme	Time 1	Time 2	Time 3	Total
Course Concepts: Specific concepts including math and statistics concepts and tools (e.g., spreadsheet formulas) or the general education curriculum that challenged student engagement/learning	28	19	21	68
Coursework: Aspects of the course content that challenged engagement/learning, including homework, labs, the group project, or the overall workload	11	17	12	40
Course Structure: The structure of the lecture, lab, or both, including comments about course size and duration	13	11	10	34
Personal Challenges: Challenges students described as personal or as extending beyond the scope of the course, such as busy schedules creating course conflicts, different learning preferences, or disinterest in the course	12	11	4	27
No Challenge: Comments that no aspects of the course were challenging	10	7	4	21
Positive: Acknowledgments that existing challenges were opportunities for growth and other positive comments about the course	7	9	4	20
No Response/NA	1	3	9	13
Whole Course: Broad descriptions of the whole course as challenging	1	0	2	3
Total	83	77	66	226

Note. Responses could contain multiple code applications, so totals exceed number of qualitative comments (n = 154).

Another student shared that "The course is challenging to me because I've never taken a stats class and have no experience using google sheets. That being said, I feel like I've already learned a great amount only three weeks into the class." However, the same student felt that "The class is set up very easily and is easy to get started in. My TA and the professor both do a good job explaining topics and presenting them to the class."

Time Two

Student responses from time two suggested that as students encountered more statistical content (e.g., correlations) and advanced through the survey design and data collection phases of their semester project, engaging pedagogy and faculty support helped them to remain confident that they could succeed. One student shared that the

Table 7. Challenges to Learning and Engagement: Open-Ended Themes and Parent Code Applications

Theme	Time 1	Time 2	Time 3	Total
Course Concepts: Specific concepts including math and statistics concepts and tools (e.g., spreadsheet formulas) or the general education curriculum that challenged student engagement/learning	28	19	21	68
Coursework: Aspects of the course content that challenged engagement/learning, including homework, labs, the group project, or the overall workload	11	17	12	40
Course Structure: The structure of the lecture, lab, or both, including comments about course size and duration	13	11	10	34
Personal Challenges: Challenges students described as personal or as extending beyond the scope of the course, such as busy schedules creating course conflicts, different learning preferences, or disinterest in the course	12	11	4	27
No Challenge: Comments that no aspects of the course were challenging	10	7	4	21
Positive: Acknowledgments that existing challenges were opportunities for growth and other positive comments about the course	7	9	4	20
No Response/NA	1	3	9	13
Whole Course: Broad descriptions of the whole course as challenging	1	0	2	3
Total	83	77	66	226

Note. Responses could contain multiple code applications, so totals exceed number of qualitative comments (n = 155).

course was “not really challenging” and that “My TA has helped me if I was confused on something specific. I really enjoy working in groups, it has helped a lot.” Another student admitted that

> Sometimes I’m just not in the mood for this, but that can [be] any class. The spreadsheet stuff can be a bit complicated and it can make things tedious, but once you get the hang it’s pretty easy. Some of the work just feel[s repetitive] and tedious, but I understand because it’ll help us understand and absorb it more. I just have a hard time focusing sometimes.

However, the same student shared, “I definitely feel comfortable communicating with teachers about class related things. I feel supported and valued. The teachers try to make class fun which is nice.” A third student explained that “Trying to understand what the data means and interpreting it is a challenging aspect for me because it’s strange to convert numbers in words and ideas,” but also shared, “I enjoy the musical component of the class. It helps me look forward to going to class each week. And I enjoy learning how to make surveys/use google forms; I think it will be very helpful to me in the future."

Time Three

By time three, students had learned all statistical content for the course and were focused on interpreting and reporting their research project data. Some students found that the large lecture was less supportive of their learning and engagement as they completed this more independent work. One student described "being uncomfortable participating in larger lecture halls," but noted that "The recitation helps a lot with questions as it can be nerve-racking to ask questions in a large lecture hall." Another student described challenges related to the semester-long project as they prepared their final paper and presentation, explaining that "It's been difficult having to translate numbers into ideas and then connect, explain, and use those ideas when answering my research question." However, the student felt that "Recitation is helpful because it is a smaller setting and I feel more comfortable asking questions and working with others." Thus, qualitative data suggest that students valued a smaller classroom environment where they could more comfortably interact with peers and faculty as they completed their semester requirements.

Discussion

In this study, we investigated how, in a general education introductory statistics course, students' self-perceived course engagement, sense of belonging, and learning varied over the course of a semester and which course components informed their experiences. Quantitatively, we found the different dimensions of engagement were related positively to students' perceptions of belonging during class time and connection with the instructors. Students' qualitative responses supported and illustrated these findings. We also identified that engagement dropped over time in the aggregate. These results indicate that (a) students' perceptions of the class and experiences with instructors were positive and impacted engagement on different dimensions, and (b) absorption (i.e., the cognitive dimensions of engagement) declined when accounting for time and faculty belonging. Our findings are consistent with Lawton and Taylor's (2020) description of declining engagement, in general, over the course of a semester in an introductory statistics course. However, we extend those findings to show how students' perceived sense of belonging can impact student engagement. Through our case study approach, we also qualitatively demonstrate that many aspects of the course (e.g., music, engaging activities) contributed to a learning environment that supported students' learning and engagement even as they navigated content- and coursework-related challenges.

Implications for Theory and Practice

Our study makes several contributions to literature and practice. First, our case study offers one illustration of how an intentionally designed learning environment can support students in a general education introductory statistics course (Ben-Zvi et al., 2018). Albums & Algorithms brings together course design and teaching practices to support students from a range of disciplinary backgrounds. As described in this manuscript, the course reflects GAISE (2016) recommendations through the dimensions described by Ben-Zvi et al. (2018):

- *Real or realistic data*: The course's music theme and datasets help to engage students and connect statistics to their experiences.
- *Technological tools*: The course uses accessible programs like Excel and Google Sheets to reduce barriers to working with data.
- *Well-designed tasks*: Students develop, conduct, and analyze their own study on a topic that interests them; they also participate in engaging in-class activities and hands-on practice in lectures and recitations.
- *Assessment to monitor and evaluate*: Student receive formative assessment and feedback throughout the semester on labs and components of their class projects. Instructors are also highly accessible in class and through email to support students' learning.
- *Focus on central ideas*: The course takes a scaffolded approach, beginning with fundamentals of quantitative literacy (e.g., understanding an empirical question) and progressing through foundational analyses (e.g., t-tests, ANOVA), with an emphasis on interpreting and applying findings.
- *Classroom culture*: Instructors take an intentional approach to engaging with students, speaking transparently about their own challenges with statistics, inviting collaboration and participation, and encouraging fun.

These dimensions reflect Zumbrunn et al.'s (2014) model, which demonstrates that a supportive classroom environment can serve as a precursor to student belonging and engagement. Reflecting SEVT, these dimensions may support student motivation, values, and ultimately course outcomes (Gladstone et al., 2022). Our findings suggest that cultivating classroom, peer, and faculty belonging can support absorption, dedication, and vigor in an introductory statistics course and suggest the continued need for research that examines the role of noncognitive constructs in statistics education (Spencer et al., 2023).

The positive associations between classroom belonging and engagement and students' positive feedback about the course's music theme suggest that using accessible topics may encourage students' enthusiasm for and willingness to work on challenging material. Adjapong & Emdin (2015) and Emdin et al. (2016) used hip-hop as a means of engaging historically marginalized students in high school STEM subjects, suggesting that hip-hop can serve as an entry point for teaching unfamiliar or challenging content. By integrating hip-hop and other music into the curriculum, we sought to connect statistical content to students' personal interests and to build upon their prior musical knowledge, helping us create and sustain a dynamic and engaging class (Lovett et al., 2023).

For example, to teach normal distribution, we used a dataset illustrating rappers' use of unique words (i.e., nonrepeating words used in lyrics; Daniels, 2019). The dataset contained a histogram demonstrating that, across the sample of artists, use of unique words reflected a near-perfect normal distribution. During lecture, students would listen to examples of songs by artists across the distribution, which resulted in a lively discussion of how popular rap songs tend to have fewer unique words compared to more artistic or underground rap songs. Exercises like this not only created an engaged classroom environment and fostered a connection between students and the lecture, but also provided a fun, real-world application for a core statistical concept (GAISE, 2016; Meng, 2009). These kinds of activities—which were conducted throughout the semester, but particularly during the first two thirds of the course—offer another way that music can be used to help students engage in statistical thinking (Khachatryan, 2023; Lawton & Taylor, 2020; Lesser et al., 2019). Our approach, along with those studied elsewhere, suggests that music offers many pathways by which instructors can help students invest in statistical reasoning.

Additionally, the association between faculty belonging and absorption may suggest that effective statistics teaching requires more than just expert content delivery that promotes mastery of statistical concepts. Rather, teaching can be enhanced by instructors' willingness to acknowledge challenges presented by complex concepts, empathize with students as they cope with anxiety or uncertainty related to those challenges, and model how to work through difficulties (Trassi et al., 2022). Feeling a strong sense of belonging from faculty early in the semester may have supported students' initial engagement with course content. As the semester progressed, this foundation of faculty belonging may have empowered some students to become more autonomous in their work. As these students worked independently on their projects, they may have required less faculty support (reflected in a negative association with faculty belonging). Conversely, students who felt less absorbed may have continued to rely on faculty belonging for reassurance as they worked toward successfully completing the course. Notably, faculty belonging was the highest rated subscale across all inventories in this study at all three time points, suggesting that participating students generally did feel supported by instructors (a finding echoed by qualitative comments). As autonomy-supportive teaching has been associated with students' perceptions of achievement (Yoon et al., 2020), these findings suggest that cultivating strong faculty belonging at the beginning of the semester can play a key role in fostering independent learning and ensuring that less confident students feel supported for the duration of the course. Future research should explore the complicated relationship between absorption and faculty belonging.

Our qualitative data also support these findings. As noted, students appreciated how the music theme made statistics material more approachable (Hains et al., 2021). Other students felt comfortable discussing class-related matters with the instructor and TAs, which they reported helped them feel supported and valued. Students' qualitative data highlight the class's success in fostering an environment of belonging where students enjoy the material and feel at ease communicating with the instructors. These findings support the idea that belonging in class can positively impact the emergence and development of motivation and subsequent engagement (Freeman et al., 2007; Gladstone et al., 2022; Zumbrunn et al., 2014). Instructors may find that intentionally cultivating a supportive, engaging classroom environment can help to offset challenges related to difficult content or student disinterest. Our findings also suggest that faculty belonging may help to offset challenges to engagement and learning that might be beyond faculty's control, such as a large lecture format.

We also recommend reexamining how engagement is conceptualized in the work engagement theory and scale. The Schoolwork Engagement Inventory (Salmela-Aro & Upadaya, 2012) adapted the dimensions of Schaufeli et al.'s (2006) Utrecht Work Engagement Scale. In Salmela-Aro and Upadaya's (2012) theorization, energy, or vigor, is aligned with emotional engagement; dedication is aligned with cognitive engagement; and absorption is aligned with behavioral engagement. However, in our conceptualization of work engagement, we view absorption as cognitive, dedication as emotional, and vigor as behavioral. We arrived at this understanding through a careful interpretation of Schaufeli and Bakker's (2003) conceptualization:

> Vigor is characterized by high levels of energy and mental resilience while working, the willingness to invest *effort* in one's work, and *persistence* even in the face of difficulties [our emphases]. Dedication refers to being strongly involved in one's work and experiencing a sense of significance, *enthusiasm*, *inspiration, pride*, and *challenge* [our emphases]. Absorption is characterized by being *fully concentrated* and *happily engrossed* in one's work, whereby time passes quickly and one has difficulties with detaching oneself from work [our emphases] (p. 5).

In the engagement literature, persistence and effort correspond to behavioral dimensions; enthusiasm, pride, and inspiration are indicative of emotional connection to a task; and being fully immersed and concentrating greatly on a task is indictive of cognitive engagement (Fredricks et al., 2004; Torsney et al., 2022). The distinctions and nuances of the dimensions of engagement, however, continue to be murky (Sinatra et al., 2015) and are not easily observed, hence the need for different conceptualizations (Symonds et al., 2021). Thus, while the application of engagement measures in school contexts is important, additional alignment between theory and practice can help to ensure that engagement constructs are consistently understood and appropriately supported.

Implications for Future Research

Only limited research has been conducted on the connection between teaching practices, psychological attributes, and classroom belonging (Kirby & Thomas, 2022), and little to no research has looked at how students' classroom belonging varies over a semester. Our study suggests that how and how much students belong may vary over time—future research should examine why that belonging changes and how to best foster belonging to ensure students successfully persist in and complete courses. Additionally, future research should examine how classroom belonging varies for students from underrepresented and minoritized backgrounds, as prior research has shown such students are less likely to feel they belong in college contexts (Gopalan & Brady, 2019). Future research should also consider how belonging relates to students' anticipated and actual course outcomes.

Conclusion

By investigating the relationship between dimensions of belonging and engagement in a large, music-themed general education introductory statistics course, we found that dimensions of the learning environment—especially the use of music and the instructors—supported students' learning and engagement even when they found the statistical content challenging or anxiety-inducing. Our study suggests that instructors of statistics—and potentially other classes that students find challenging or disinteresting—can shape their classroom environment through their course design and pedagogy. A creative, student-centered approach to complex content may help to promote belonging, engagement, and ultimately student success.

Author Note

Both authors contributed equally to this manuscript and share first-author status.

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Appendix: Course Overview and Selected Materials

Course Description and Outcomes (from Syllabus):

Music is a constant, from hip-hop to country to gospel. We can play it on our phones, computers, and turntables. You have access to music from the 1700s, 1920s and 2021. In this class we will explore lyrics, beats, music history, and the health and wealth of artists and the music industry using tools from statistics and data analysis. This course helps students explore and consider potential explanations for different phenomena they might observe while learning about music, such as how hip-hop record sales have changed throughout the last 25 years. The purpose of this course is to: (a) show how statistics and data analysis are inherently creative and visual, (b) expose students to how statistics and data function in their everyday lives, (c) explore how research questions are formed, and (d) explain how data are collected/managed, analyzed, and presented visually and in written form. By exploring changes in lyrics over time we can describe how rap's language has evolved, or by looking at artists' royalties from various media we can better understand the chances of a new artist being able to survive. This course will provide a basic overview of quantitative measurement and associated quantitative concepts and will explore the ways in which certain data analytic techniques and associated quantitative models could be used to explore problems in the music industry. Finally, and most importantly, this course will help students to become more fluent in their understanding of and communication about data by moving away from data and statistics as content that is highly theoretical and moving toward content that has real-world applications.

At the end of this course, you will be able to:

- Describe and explain how research questions lead to different forms of measurement, which then lead to quantitative models that describe real world phenomena.
- Recognize the limitations of mathematical models (e.g., linear models in regression when the data suggests diminishing returns).
- Perform simple mathematical computations (i.e., means, standard deviations, correlations) in different data analysis programs (such as Google Sheets), and by hand as appropriate, associated with quantitative models, and make conclusions based on the results.
- Recognize, use, and appreciate mathematical thinking for solving problems that are a part of everyday life.
- Describe and explain the various sources of uncertainty, error, and limitations in empirical data.
- Retrieve, organize/manage, and analyze data associated with a quantitative model.
- Communicate logical arguments and their conclusions.

*Note: Each student learning outcome is reflective of the GenEd Quantitative Literacy Learning Goals, especially information literacy that emphasizes the importance of identifying reliable models and sources of knowledge.

Table A1. Course Project Overview

Project Component & Requirements	Week Due
Research Question This question will establish precisely what you want to learn through your study. The data you collect and analyze should enable your group to answer your research question.	Week 3
Survey Instrument You will design a study to answer your research question using Google Forms. Your survey must include the following components: 1) a minimum of 4 demographic questions (e.g., class year, race/ethnicity, gender, etc.) 2) a minimum of 6 Likert-scale items that use a 5-, 6-, or 7-point scale. 3) A minimum of one open-ended item	Week 6
Data Collection and Cleaning You will launch your survey by sharing it with your target population for responses (e.g., other students). To run analyses, you need to obtain a minimum of 60 responses by the completion deadline. You will also need to clean the data—make sure there are no uninterpretable responses and convert any non-numeric scales to numbers so that you can conduct analyses.	Week 8
Descriptive Analyses Using your collected data, conduct the following analyses: 1) *n*'s, mean, median, mode, and standard deviation for each item (present in a table) 2) Correlations between all items (provide a correlation matrix and at least 3 scatterplots) 3) Provide pie/bar graphs to illustrate your demographic data	Week 9
Inferential Analysis #1: T-tests Using your collected data, conduct at least 2 dependent sample and 2 independent sample t-tests and calculate effect sizes (Cohen's *d*). (Provide tables with the *p*-value, *t*, and Cohen's *d* for at least 2 t-tests.)	Week 12
Inferential Analysis #2: ANOVA Using your collected data, conduct at least 3 ANOVAs and post-hoc tests. Be sure to determine the effect size. Provide tables with groups, means, standard deviations, *n*'s, and F-statistic; bar graphs showing between-group differences; and Tukey post-hoc test p-values.	Week 13

Project Component & Requirements	Week Due
Final Presentation See separate assignment description; should include all data visualizations and complete description of research question, methods, and findings. (Complete individually)	Finals Week
Final Paper See separate assignment description; should include all data visualizations and complete description of research question, methods, and findings. (Complete individually)	Finals Week

Selected Course Resources/Readings for Integrating Music and Quantitative Literacy

The following sources provide data sets and visualizations used to guide conversations about and practice with fundamentals of quantitative analysis, including understanding empirical vs. philosophical questions, operational definitions, measures of central tendency, distribution, and data visualization, as well as analyses like ANOVA.

Daniels, M. (2017, September). *The language of hip hop*. [Blog Post]. https://pudding.cool/2017/09/hip-hop-words/

Daniels, M. (2018, August 30). *Emo rap vs. Dashboard Confessional*. https://pudding.cool/2018/08/emo-rap/

Daniels, M. (2019, January 21). *Rappers, sorted by the size of their vocabulary*. https://pudding.cool/projects/vocabulary/

Wilber, J. (2018, June 5). *The good, the bad, and the gnarly: An exploration into the music of skateboarding*. https://pudding.cool/2018/06/skate-music/

The following video is used to facilitate an introductory conversation about how data and data visualization can be used to tell a story. Students discuss stories that grab their attention and discuss how the information used as the criteria for "best-selling" changes throughout history.

Data is Beautiful. (2019, November 2). *Best-selling music artists 1969–2019*. YouTube. https://www.youtube.com/watch?v=a3w8I8boc_I