Journal of University Teaching & Learning Practice

Assessing the motivational climate in a university course: Considerations for motivating all students

Brett D. Jones, Margaret O. Ellis, Hande Fenerci, Frances A. McCarty, and Jennifer A. Gallagher
Virginia Tech, United States of America

Abstract

The motivational climate in a course reflects the degree to which students feel empowered, successful, interested, that the coursework is useful, and that instructors care about their learning and well-being. It is important because it is related to students' motivation and engagement in a course. Yet, little is known about how motivational climate changes over time within large university courses or how these changes affect different groups of students. We examined dynamic changes in motivational climate across four time points during a large gateway computer science course, with particular attention to differences by gender and prior computer science experience, as well as relationships with final course grades. We analyzed quantitative and qualitative survey data that measured motivational climate with the eMpowerment, Usefulness, Success, Interest, and Caring scales from the MUSIC Model of Academic Motivation Inventory. Empowerment and success decreased throughout the semester for all students. Success expectancies and grades were significantly lower for women and for students without high school computer science experience. Women also reported declines in their perceptions of usefulness, success, and caring across the semester. These findings demonstrate that motivational climate is dynamic and not experienced equally by all students, which could contribute to persistent equity gaps in computer science. Regular monitoring of motivational climate could enable instructors to identify when and for whom the course is less supportive, which could allow them to make timely instructional adjustments. This study illustrates a method by which instructors and research can assess motivational climate in a large course.

Editors

Section: Student Experience
Editor-in-Chief: Dr Joseph Crawford
Senior Editor: Dr Sally Ashton-Hay
Associate Editor: Dr Collins Fleischner

Publication

Submission: 12 February 2025
Revised: 7 September 2025
Accepted: 10 September 2025
Published: 16 September 2025

Practitioner Notes

1. Instructors can assess motivational climate perceptions to consider how student groups may differ.
2. Computer science instructors need to be aware of how their teaching approaches affect women's perceptions of success, usefulness, and caring.
3. Women and students without high school computer science experience may have lower perceptions of success in computer science courses.

Keywords

motivational climate, MUSIC model, self-efficacy, motivating students, computer science

Citation:

Jones, B. D., Ellis, M. O., Fenerci, H., McCarty, F. A., & Gallagher, J. (2025). Assessing the motivational climate in a university course: Considerations for motivating all students. *Journal of University Teaching and Learning Practice, 22*(4). https://doi.org/10.53761/a9rk7d25

Introduction

To provide a learning environment in which all students can succeed, it can be helpful for instructors to understand how the motivational climate in a course is affecting students' motivation and learning. Motivational climate has been defined as "the aspects of the psychological environment that affect students' motivation and engagement within a course" (Jones, Miyazaki, et al., 2022, p. 1). Students' perceptions of the motivational climate are important because these perceptions have been shown to affect their engagement (Jones, Khajavy, et al., 2023), their ratings of the course and instructor (Wilkins et al., 2021), their identity (Jones et al., 2016), and their major and career goals (Jones et al., 2016).

Researchers have found that students' perceptions of the motivational climate can vary across students (Jones, Fenerci-Soysal, & Wilkins, 2022); therefore, it could be important for instructors to consider whether the motivational climate is having disproportionately negative effects on some groups of students over others. In the present study, we investigated this phenomenon within a large introductory computer science course because research has identified some differences between groups within computer science. Specifically, researchers have noted some gender differences (e.g., Pirttinen et al., 2020) and differences by prior computer science experience (e.g., Alvarado et al., 2018).

The purpose of this study was to examine the extent to which university students' perceptions of the motivational climate varied during a computer science course. In addition to documenting overall patterns, we investigated whether these changes differed by gender or students' high school computer science experience. We also examined how students' perceptions of motivational climate related to their course performance to document how these perceptions were associated with tangible academic outcomes. This study is important because identifying how and when motivational climates disadvantage particular groups of students can help teachers to identify and implement instructional strategies that foster the motivation and engagement of all students.

Because student motivation in computer science can decline across the semester, strategies are needed for sustaining it (Peteranetz et al. 2021). Examining the student experience throughout a course, instead of only with pre- and post-course surveys, can provide additional insight (Lishinski, 2023). The aim of this study was to investigate whether students' perceptions of the motivational climate varied during a computer science course and whether these changes were moderated by student gender or previous high school computer science experience. Our research questions were:

> **Research Question 1**. To what extent do students' perceptions of the motivational climate vary during an introductory computer science course?
>
> **Research Question 2.** To what extent do women's perceptions of motivational climate vary relative to men's during an introductory computer science course?
>
> **Research Question 3.** To what extent do the perceptions of motivational climate of students without high school computer science experience vary during an introductory computer science course relative to those with high school computer science experience?
>
> **Research Question 4.** Are the students' course grades in an introductory computer science course moderated by gender or high school computer science experience?

Research Question 5. What aspects of an introductory computer science course may affect changes in students' perceptions of the motivational climate?

Literature

Motivational Climate

The motivational climate has been assessed in courses using the five components of the MUSIC Model of Motivation (Jones, 2009, 2018): eMpowerment, Usefulness, Success, Interest, and Caring (MUSIC is an acronym). When students are *empowered*, they perceive that they are in control over some aspects of the course, often by having choices in the course. Students perceive courses to be *useful* when the learning activities relate to their short- or long-term goals. In the MUSIC model, *success* refers to the extent to which students believe that they can succeed at the activities within the course. *Interest* refers to the extent to which students pay attention to, are interested in, and enjoy the instructional activities. Finally, students perceive high levels of *caring* when others in the course (the instructor and/or other students) care about their learning and well-being.

The MUSIC components have most often been assessed using the MUSIC Model of Academic Motivation Inventory (Jones, 2012/2024), which measures the motivational climate in a learning environment with an assessment scale for each MUSIC perception. There are several versions of the MUSIC Inventories and validation evidence is cited in Jones (2012/2024). For example, the college student version of the MUSIC Inventory has been used to assess students' perceptions of the motivational climate in college courses (Ang & Ng, 2022; Reash & Larwin, 2021; Zwanch & Cribbs, 2021). It has also been shown to produce valid scores with college and university students in a variety of different types of courses and contexts (Gladman et al., 2020; Jones & Wilkins, 2023; Vaziri et al., 2022; Wilkins et al., 2021) and in countries with different cultures (e.g., Iran, Mexico, China, Egypt, Colombia; Jones et al., 2023; Jones et al., 2017).

In the MUSIC model, students' MUSIC perceptions are influenced by variables external to students (e.g., teaching strategies, family, culture, society) and internal to students (e.g., cognition, emotions, needs, identity beliefs, abilities). Students' MUSIC perceptions then affect their motivation and engagement in a course, which can affect their learning and performance, which cycles back to affect the external and internal variables through feedback loops. Teachers play an important role in students' motivations because they can influence students' MUSIC perceptions with the types of teaching strategies that they employ (Anderson, 2020; McGinley & Jones, 2014). Therefore, if teachers can identify which MUSIC perceptions are lowest, it is possible for teachers to address their lowest scores on the MUSIC Inventory (see Jones, 2018) and create a more positive motivational climate for students.

Student Motivation in Computer Science Courses

To improve student motivation in introductory computer science courses, some computer science educators have implemented course improvements (Bellino et al., 2021; Nikula et al., 2011). Researchers have found that students' success beliefs (a.k.a., self-efficacy) can predict their achievement and persistence in computer science and other STEM domains (Beyer et al., 2003; Hutchinson et al., 2006; Lent et al., 1986). However, women and men can differ in how they perceive the motivational climate in a course. Women's self-efficacy beliefs in STEM domains, university-level computer science, engineering, and math courses are often lower than those of men (Ojha et al., 2024; Pirttinen et al., 2020; Zeldin & Pajares, 2000). Several studies also found that although female students' self-efficacy in engineering, math activities, perceived engineering skills, and problem-solving abilities are much lower than male students, their course grades, GPAs, or skill levels were equal to or higher than those of male students (Pirttinen et al., 2020; Rayman & Brett, 1995).

Students come to university computer science courses with a broad range of computing experience outside of class and from high school (Ellis et al., 2020), which can also affect their performance in computer science courses. For example, Alvarado et al. (2018) found that students with AP (Advanced Placement) credits tended to have higher grades across computer science courses. In addition, prior computing experience such as internships, co-curricular activities, or high school programming courses can significantly impact a student's experience in a computer science course (Peters et al., 2014).

Method

Participants

The computer science course was a 3-credit, introductory, 2000-level intensive computer programming course offered through the computer science department, which was within the College of Engineering. Of the 426 students enrolled in the course, approximately 58% were either computer science or Engineering majors, and 209 students (49.1%) were included in the analysis. Some of the students were not included because they did not consent to participate in the study or did not complete all four surveys (n = 143), they responded rapidly (n = 26), or they reported a gender other than male or female (n = 3; which did not allow us to include them in the gender analysis). Students self-identified their race/ethnicity as 42.1 % Asian or Pacific Islander, 41.4% White or Caucasian, 6.2% more than one race/ethnicity, 4.3% Black of African American, 2.4% Hispanic, 1.0% as a race/ethnicity not provided on the survey, and 0.4% Native American. Of the 209 students, 74.1% self-reported as male and 25.8% self-reported as female. Many students (72.3%) indicated that they had high school computer science experience, with 63% of women and 75% of men reporting that they had high school computer science experience.

Computer Science Course

Many first-year, transfer, and non-major students are enrolled in this course, and this course is considered the gateway to ongoing computer science enrollment. This course was taught in java with three lecture sections and 14 lab sections. It was taught in a flipped format using one shared learning management system (Canvas) with ungraded checkpoint questions integrated within instructional content and graded section quizzes. The course also contained graded learning activities for small programming practice, ethics discussion questions, and object-oriented design activities. There were tests in Weeks 5 and 12, and a final exam.

Students had 10 lab assignments and five programming projects, with the fifth one being a team project introduced in Week 11. The four individual projects were distinct, and each was worth the same percentage of the course grade but increased in size and complexity. The course content was cumulative with the first two weeks serving as a review of computer science Java topics before introducing data structures and working through bags, stacks, queues, lists, and trees.

Additional topics such as generics, efficiency, and recursion were introduced throughout the semester.

Procedure

The study was approved by the IRB at our institution (IRB #17-057 and #22-808) and students provided consent to participate in the study. Students were surveyed in Weeks 5, 8, 12 and 15 of the 15-week semester. The survey consisted of closed- and open-ended items related to their perceptions of the motivational climate in the course.

Instruments

We measured students' perceptions of the motivational climate using the MUSIC® Model of Academic Motivation Inventory (20-item College Student version; available at Jones, 2012/2024, which includes 20 items that form five MUSIC scales with four items each: an empowerment scale (e.g., "I have control over how I learn the course content"), a usefulness scale (e.g., "In general, the coursework is useful to me"), a success scale (e.g., "I am confident that I can succeed in the coursework", an interest scale ("The coursework is interesting to me"), and a caring scale ("The instructor cares about how well I do in this course"). Students responded to all items on a six-point Likert-format scale ranging from 1 (*Strongly disagree)* to 6 (*Strongly agree*) labeled at each point.

On the Week 15 survey, students were asked one open-ended question for each of the five MUSIC model components: "What aspects of this course give you control/choices and/or no control/choices within this course?" (eMpowerment), "What do you find useful and/or not useful about this course?" (Usefulness), "What makes you feel successful and/or that you cannot be successful in this course?" (Success), "What do you find interesting/enjoyable and/or boring about this course?" (Interest), and "What do the instructors do and/or not do to make you feel that they care about your learning and well-being?" (Caring).

Analyses

SAS version 9.4 was used to conduct all quantitative analyses. All dependent variables were assessed for normality by examining normal quantile plots and skewness and kurtosis values for each time point assessed. Boxplots were also used to assess the distributions of dependent variables by week and gender and high school computer science experience. The five MUSIC variables were found to be somewhat negatively skewed with a few outliers at the lower end of the scale. Prior to conducting the main analyses, these variables were winsorized by setting more extreme values to the fifth percentile value based on week and gender, and on week and high school computer science experience. The maximum number of observations with winsorized values for any time point was 28 out of 209.

To examine the effect of gender and previous high school computer science course experience on final course grade, the GLM procedure was used to conduct a two-way ANOVA. To assess whether students' perceptions changed over time and whether these changes were moderated by student gender or previous high school computer science course, the MIXED procedure using a repeated statement was implemented. Two separate analyses were conducted for the MUSIC variables, one for gender and week, and another for high school computer science course and week. Course section was included as a covariate in all models. For those effects found to be statistically significant, appropriate pairwise comparisons were conducted. We set the alpha value at .05.

We conducted a content analysis (Strauss & Corbin, 1998) of the responses to the five open-ended items by creating coding categories. Codes were developed inductively by one researcher who documented analytic memos during the coding process. A codebook was iteratively refined to ensure clarity and consistency. After coding 200 responses, it was determined that "saturation" was reached in that no new codes were being identified; therefore, it was unnecessary to code more responses to meet the goals of the study (Strauss & Corbin, 1998). Because the purpose of the content analysis was simply to identify aspects of the course that could affect the motivational climate, it was not necessary to code the remainder of the responses once we reached saturation. The codes and results were spot-checked by a second researcher and then reviewed by the course leader.

Delimitations

One of the delimitations of this study is that the statistical findings may not be generalizable to other courses. The sample of students is a non-probability sample from a course at a single university. However, the aim of the study was not to be able to generalize to all courses. Students' perceptions of the motivational climate can vary across courses (Jones et al., 2023; Wilkins et al., 2021); therefore, we do not expect the findings from this one course to necessarily generalize to other courses taught by different instructors. Instead, the aim was to provide an initial examination of how students' MUSIC perceptions can vary over time in one course. Hopefully, other instructors will add to this literature by conducting similar studies, and a corpus of studies can be examined for patterns. Finally, we included course section as a covariate, but we did not account for the many other factors at the class or student level that could impact students' MUSIC perceptions.

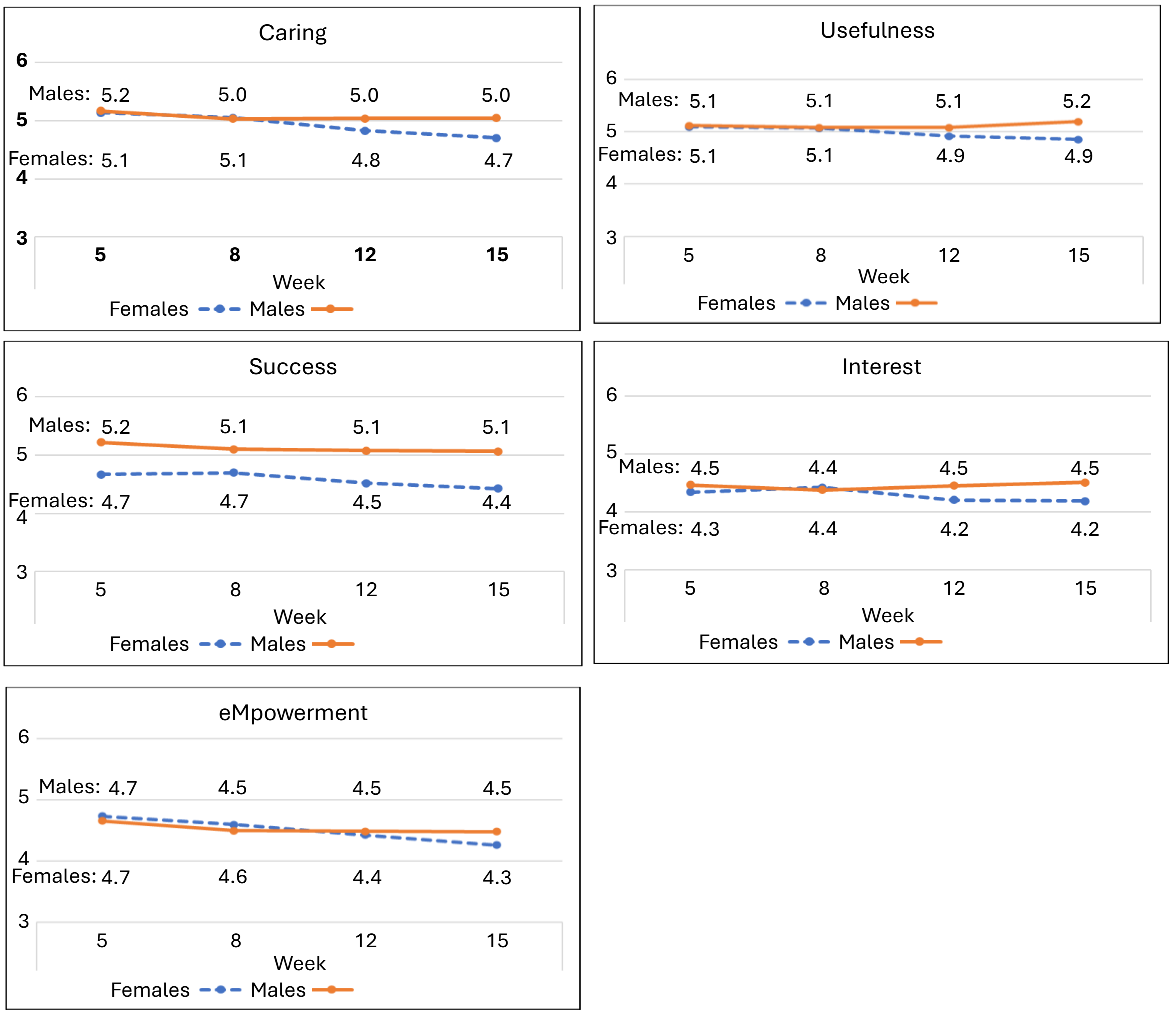
Results

Week by Gender Results

Our first research question was to determine the extent to which students' perceptions of the motivational climate varied during the computer science course, and the second question was to examine these variations by gender. We answered these questions by comparing the means for each MUSIC component by week and gender, as shown in Figure 1. In this section, we report statistically significant results for each MUSIC component.

Figure 1

Means by Week and Gender for Each MUSIC Variable



For the main effect, students' empowerment perceptions decreased by week (F[3, 615] = 5.96, p = .001). The means for Week 12 (t = 2.97, p = .003) and 15 (t = 4.04, p < .001) were lower than the mean at Week 5. The mean at Week 15 (t = 2.19, p = .029) was lower than the mean at Week 8. There were no interaction effects for week by gender. For students' perceptions of usefulness across the semester, there was an interaction effect for week by gender (F[3, 615] = 5.17, p = .002). The means differed by week for women but not for males. For women, the means for Week 12 (t = 2.09, p = .037) and 15 (t = 2.82, p = .005) were lower than the means for Week 5, and the mean at Week 15 (t = 2.58, p = .010) was also lower than the mean at Week 8.

For students' success perceptions, there was a main effect for both weeks (F[3,615] = 5.13, p = .002) and gender (F(1, 205) = 33.91, p < .001). The means for Week 12 (t = 2.59, p = .001) and 15 (t = 3.49, p = .001) were lower than mean at Week 5. The mean at Week 15 was also lower than the mean at Week 8 (t = 2.7, p = .007). For the main effect for gender, the overall mean for women (4.58) was lower than the overall mean for men (5.11). For Interest, there was an interaction effect for week by gender (F[3,615] = 3.48, p = .016). For women, there was a difference in means for Week 8 and 15 (p = .031) and for Week 8 and 12 (p = .051). Tests of effect slices by week indicated that the means for women (4.19) were lower than those for men (4.51) at Week 15 (F[1, 615] = 4.90, p = .027). For Caring, there was an interaction effect for week (F(3,615) = 7.88, p < .001) and for week by gender (F[3,615] = 5.05, p = .002). There was an effect of week for women (F[3, 615] = 9.17, p < .001) but not for men (F[3, 615] = 1.93, p = .124), whereby the means for women for Week 12 (t = 3.32, p = .001) and 15 (t = 4.66, p < .001) were lower than the mean for Week 5. The means for Week 12 (t = 2.39, p = .017) and 15 (t = 3.73, p < .001) were also lower than the means at Week 8 for women. These results address the first and second research questions and demonstrate that students' perceptions of empowerment and success decreased throughout the semester for all students. A summary of the key findings is presented in Table 1.

Table 1

Summary of Key Findings

MUSIC perception	Key findings
Empowerment	• Decreased during the course for all students
Usefulness	• Decreased during the course for women only
Success	• Decreased during the course for all students • Success was lower for women than men regardless of time point • Success was lower for those without high school computer science experience regardless of time point
Interest	• Decreased during the course for women only • Was lower for women than men in Week 15
Caring	• Decreased during the course for women only

Week by High School Computer Science Experience

The third research question examined the extent to which the perceptions of motivational climate of students without high school computer science experience vary across weeks in the course relative to those with high school computer science experience. There were no statistically significant effects based on week or high school computer science experience for students' perceptions of usefulness or interest. However, there was a main effect for week for empowerment, success, and caring, such that overall average perceptions were highest at Week 5 and lowest at Week 15.

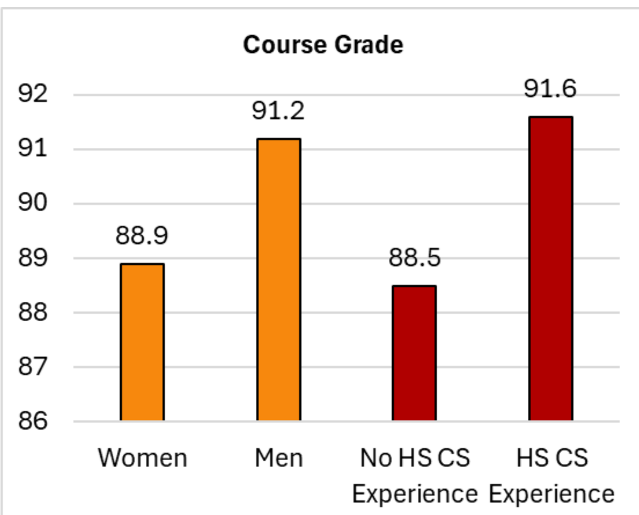
For students' perceptions of success, there was a main effect for week (F[3,615] = 3.23, p = .022) and a main effect for high school computer science experience (F[1, 205] = 4.34, p = .039). The success means for Week 12 (t = 2.28, p = .023) and 15 (t = 2.7, p = .007) were lower than the means at Week 5. The adjusted means for Weeks 5, 8, 12, and 15 were 5.02, 4.98, 4.89, and 4.87, respectively. The adjusted mean for those without high school computer science experience (4.84) was lower than the adjusted mean for those with high school computer science experience

(5.04). Success was the only MUSIC component that was affected by students' high school computer science experience.

Grades by Gender and High School Computer Science Experience

The fourth research question was: Are the students' grades in an introductory computer science course moderated by gender or high school computer science experience? The association between gender and having high school computer science experience was not statistically significant ($\chi^2[1] = 3.13$, $p = 0.077$). The mean final course grade for all students ($n = 209$) was 90.4 ($SD = 5.97$). The main effects for gender ($F[1,203] = 5.58$, $p = .019$) and high school computer science experience ($F[1,203] = 8.98$, $p = 0.003$) were found to be statistically significant. The interaction effect was not statistically significant. The adjusted mean grade for women was 88.9 (SE = 0.84), with a mean grade of 91.2 ($SE = 0.62$) for men. The adjusted mean grade for students who did not have a high school computer science course was 88.5 ($SE = 0.81$), and for those who did, the mean was 91.6 ($SE = 0.69$) (see Figure 2). Therefore, gender and high school computer science experience each had a distinct effect on final course performance.

Figure 2
Mean Course Grade by Gender and High School Computer Science Experience



Qualitative Analysis

Research Question 5 asked: What aspects of an introductory computer science course may affect changes in students' perceptions of the motivational climate? The codes and themes identified for each open-ended question are presented in Table 2.

Table 2

Percentage and Number of Responses for Each Code

Codes	No.	%
Empowerment: What aspects of this course give you control/choices?		
Specific assignments	42	21%
The modality/instructional methods	32	16%
Flexibility in the pace of the course	27	14%
Flexibility in how to code and complete assignments	23	12%
Instructor/TA support	4	2%
The overall course gave control/choices (no specifics provided)	2	1%
Empowerment: What aspects of this course did not give you control/choices?		
Specific assignments	38	19%
No or not as much flexibility in how to code and complete assignments	27	14%
The overall course gave no significant control/choices (no specifics provided)	13	7%
The modality/instructional methods	12	6%
The timing/pace of the course	10	5%
Usefulness: What do you find useful about this course?		
Specific course content	51	26%
Specific assignments	48	24%
The modality/instructional methods	36	18%
Support opportunities (e.g., office hours, class discussion, discussion boards)	20	10%
The course is generally useful (no specifics provided)	7	4%
Freedom to solve problems in various ways	1	1%
Usefulness: What do you find not useful about this course?		
Specific assignments	32	16%
The modality/instructional methods	26	13%
The timing/pace of the course	6	3%
Not enough freedom in how to solve problems	5	3%
The course is generally not useful (no specifics provided)	3	2%
The quality of instructional/TA support	2	1%
Specific course content	1	1%
Success: What makes you feel successful in this course?		
Successful performance (e.g., good grades and ability to complete assignments)	48	24%
Personal characteristics (e.g., perseverance, hard-working, likes learning, understands the content)	25	13%
Specific assignments	20	10%
Instructor/TA support	18	9%
Course resources (e.g., videos, software)	12	6%
Course policies	11	6%
Ability to manage the coursework and keep up with the pace	7	4%

Generally feels can be successful (no specifics provided)	2	1%
Success: What makes you feel you cannot be successful in this course?		
The coursework (e.g., difficulty, amount, and lectures not helpful)	18	9%
Trouble keeping up/managing time	13	7%
Specific assignments	11	6%
Insufficient support from instructors/TAs	7	4%
Lack of resources	4	2%
Don’t feel confident with the content/lack prior experience	2	1%
Poor grades	1	1%
Interest: What do you find interesting/enjoyable about this course?		
Specific assignments	88	44%
Specific content from the course	57	29%
Course resources (e.g., videos, class sessions)	8	4%
Getting code to work/solving problems	8	4%
The course is overall interesting/enjoyable (no specifics provided)	5	3%
Interest: What do you find boring about this course?		
Course resources (e.g., videos, lectures, readings)	30	15%
Specific assignments	25	13%
The course is overall uninteresting/unenjoyable (no specifics provided)	4	2%
The course content	2	1%
Caring: What do the instructors do to make you feel that they care about your learning and well-being?		
Provide support (e.g., answer questions, hold office hours, etc.)	117	59%
Exhibit caring attributes (e.g., good communication, warmth, friendliness, etc.)	15	8%
Teach well	15	8%
Has course policies that support success (e.g., organizes the course well, provides numerous ways to be successful, offers leniency on assignments/attendance)	11	6%
Overall feel like the instructor cares (no specifics given)	8	4%
Caring: What do the instructors do to make you feel that they do not care about your learning and well-being?		
Do not offer sufficient support	18	9%
Do not teach well	10	5%
Do not exhibit caring attributes	6	3%
Did not interact with students	6	3%
Do not offer leniency on assignments/attendance	5	3%

For empowerment, the most frequent code was “specific assignments,” both for the aspects of the course that provided students with control/choices and for those that did not. This finding clearly demonstrated that students who experience the same course can have different empowerment perceptions. For example, one student reported that “the projects and labs gave me full control,” whereas another student wrote, “I mean the only control I really had was WHEN I would read the course material. No real freedom other than that.” Although not all students were as extreme as these two, they show the range of perceptions that students held. The other empowerment codes in Table 2 also demonstrate that some students perceived there to be flexibility in the course (e.g., pace of instruction, how to code and complete assignments) and others did not (e.g., not much flexibility in how to code and complete assignments, no significant control/choices). Some students perceived certain parts of the course as providing more empowerment than others, as illustrated by one student, “The labs did not give me very much control but the projects were more free for me to code how I wanted to.”

Students gave more responses indicating that the course was useful than not useful, although a variety of responses were provided in both cases. Some students cited specific aspects of the course that were useful or not (e.g., “I did not find the section quizzes useful at all,” “the online resources were very useful”) and others were more general in their response (e.g., “I thought the content was useful.”). The code titled “Not enough freedom in how to solve problems” demonstrates how empowerment can affect usefulness. That is, by not having enough empowerment/autonomy in how to solve problems, some students found the course less useful.

Students reported that they felt successful in the course when they were able to complete the assignments and receive good grades. They also pointed to other aspects of the course as helping them to feel successful, such as instructor/TA support, course resources and policies, the timing and pace of the course, and specific assignments. Some noted that they felt successful due to personal characteristics such as their general ability to persevere and work hard, or that they enjoyed it, factors which were less within the control of the instructors and more related to their abilities and dispositions. One student explained, “I feel like when I am presented with a problem I am always able to solve it if I put in enough work.” Other students had trouble keeping up with the coursework or completing specific assignments and found there was a lack of resources and insufficient support from the instructors/TAs.

Students listed more aspects of the course that were interesting/enjoyable than boring, yet there were some of each. Some students found specific assignments and content interesting, as well as the course more generally. Others reported the opposite and that these aspects of the course were uninteresting. A few students reported some of each: “Algorithms and efficiency are interesting. Watching slow videos can be boring. Needs energy.” The projects and labs were frequently praised, especially larger programming projects because they were challenging and practical. Here we see how students’ perceptions of usefulness can affect how interesting/enjoyable students perceive the course. The lecture videos were often seen as boring if they were too long or too slow.

Students provided many more comments related to how the instructors cared about them than about how they did not care about them. Students felt supported during the course when teachers answered questions, provided good communication, were friendly, taught well, had supportive course policies, among other things. As one student summarized, “they are quick to respond to questions and are very helpful and kind.” Although few in number, some students had complaints such as “Not answer any of my emails, like any of them or failing to show up to their own office hours.”

Discussion

Motivational Climate During the Course

Our first research question asked broadly about the stability of the motivational climate during a computer science course: To what extent do students’ perceptions of the motivational climate vary during an introductory computer science course? We found that all five MUSIC perceptions changed throughout the course for at least one subgroup (e.g., females) of students. This finding indicates that motivational climate is not a stable characteristic of the course, at least for some students. The fact that it can change during a course is consistent with findings from other researchers (e.g., Jones, Fenerci-Soysal, & Wilkins, 2022). Nonetheless, the changes in the class-level means were rather minimal. For example, empowerment and success were the only two MUSIC components that decreased for the entire class and decreases were in the range of 0.2 to 0.3 on a 6-point scale. These changes were statistically significant, but we wondered whether they were practically significant. In other words, do these small decreases significantly affect students' motivation and engagement in the course? Future research should seek to understand the extent to which small changes in students' MUSIC perceptions affect their motivation and engagement.

Motivational Climate by Gender

Our second research question asked about differences in motivational climate perceptions by gender: To what extent do women's perceptions of motivational climate vary relative to men's during an introductory computer science course? One of the main findings of this study was that motivational climate perceptions decreased more for women than for men. Women's perceptions decreased for all of the MUSIC components over time, while men only reported decreases in empowerment and success. This finding indicates that, on average, women experience a different microclimate than men. Here, *microclimate* refers to the perceptions of the motivational climate held by a subgroup that differ from the perceptions of the entire group (Robinson, 2023). This result is important because women remain underrepresented in computer science majors and professions (Meiksins & Layne, 2022; National Center for Science & Engineering Statistics, 2021). This finding suggests that the motivational climate may contribute to women's lower persistence in computer science majors. Specifically, if women's MUSIC perceptions continue to decrease over time, particularly across multiple courses, it could increase the likelihood that they leave the major.

Motivational Climate by High School Computer Science Experience

Because high school computer science experience can affect students' experiences in college courses, our third research question was: To what extent do the perceptions of motivational climate of students without high school computer science experience vary during an introductory computer science course relative to those with high school computer science experience? We found that prior high school experience only affected students' success perceptions, not their other motivational climate perceptions. As anticipated, success perceptions were lower for students who did not have high school computer science experience. This finding is logical because based on self-efficacy theory (Bandura, 1997) successful past experiences in computer science (e.g., during high school) should increase students' success perceptions in the current computer science course.

Despite their lower success perceptions, we consider it a positive finding that students without prior high school computer science experience did not report lower empowerment, usefulness, interest, or caring perceptions than the other students. The main negative effect of the lower success perceptions was lower grades, as explained in the next section.

Grades Moderated by Gender and High School Computer Science Experience

The answer to our fourth research question was yes, students' course grades in an introductory computer science course were moderated by gender and high school computer science experience. Women earned a significantly lower final grade in the course than men (88.9% vs. 91.2%). This difference of about 2% could have some practical implications for students' overall GPA, as it is the difference between a B+ final grade for the women and an A- grade for the men. A similar result was obtained when comparing the statistically significant difference between students with no high school computer science experience and those with experience (88.5% vs. 91.6%).

This study was not designed to determine why women and students with no high school computer science experience earned lower grades than men and those with high school computer science experience; therefore, this is a question for future research. A plausible explanation is that both of the lower-scoring groups had less computer science knowledge and skills at the beginning of the course, which kept them behind their peers in terms of their computer science knowledge and skills. Future studies should assess students' computer science abilities at the beginning of the course to determine its effects on their motivational climate perceptions and grades. Another possible explanation is that the motivational climate had a negative effect on their motivation, engagement, and learning during the course. Future research could investigate how women and students with no high school computer science preparation experience the course.

Course Features that Affect Changes in Motivational Climate

Our final research question was: What aspects of an introductory computer science course may affect changes in students' perceptions of the motivational climate? We addressed this question by analyzing students' responses to the open-ended items and identified many different possible aspects of the course that affected students' perceptions (as summarized in Table 2). Specific assignments and course content were cited by students most often as aspects of the course that affected their perceptions of the motivational climate. Assignments and course content affected their perceptions of how much empowerment/autonomy they had, how useful they perceived the course to be, whether or not they could be successful, and whether they were interested in and enjoyed the course. The role of the instructor and TAs influenced students' caring perceptions, but the instructor and TAs also affected students' perceptions of empowerment (control/choices), usefulness, and success.

What we found striking was the extent to which students' perceptions of the same aspects of the course could differ. For example, some students perceived that they were empowered with control over projects and labs, while other students reported that they had no control in the class. We found a similar pattern in the responses to the other MUSIC components, with disagreements about how different assignments were perceived. Such results can be frustrating for instructors, as they suggest that no matter what instructional strategies are used, some students will report lower MUSIC perceptions. Similar differences among students have also been documented by other researchers (e.g., Jones, Fenerci-Soysal, & Wilkins, 2022). Yet, the only way to address these concerns is to listen to students to determine why they have both positive and negative perceptions and try to address them. Other ways to minimize the negative perceptions are to vary assignment types throughout the semester. Doing so can alleviate some concerns that students have about specific assignments. It may not be possible to satisfy all students all the time, but instructors can try to satisfy most students at least some of the time.

Another interesting finding was that aspects of the course that affected one MUSIC component could have effects on other MUSIC components as well. For example, a lack of empowerment in solving problems led to lower usefulness perceptions. Another example was that increased perceptions of usefulness could lead to increased interest/enjoyment. These examples are consistent with the MUSIC model, which states that although the MUSIC perceptions are distinct, they can influence one another (Jones, 2018). These examples demonstrate that by addressing one of the MUSIC components, instructors may also enhance students' perceptions of other components, thereby positively influencing the overall motivational climate.

Practical Implications

Students' success perceptions decreased across the semester for both male and female students. In addition, success perceptions were significantly lower for both female students and students without high school computer science experience. Consequently, success perceptions is an obvious target for improvement in this course. These findings also align with previous studies on self-efficacy in computer science that have documented lower self-efficacy perceptions for women (Beyer, 2014; Krause-Levy et al., 2021; Nguyen & Lewis, 2020).

The correlation between students' self-efficacy and their achievement in a course is well documented in computer science education (Wilson & Shrock, 2001). According to Bandura (1997), students' self-efficacy perceptions (i.e. Success expectancies) are affected by four factors: past performance, observing others, feedback from others or social persuasion, and physical and emotional states. The computer science course has many aspects that address these four factors, and these could lead to higher self-efficacy. For example, the responses to the open-ended success question indicate that students found that their ability to complete assignments bolstered their success expectancies (self-efficacy) perceptions, which is consistent with Bandura's "past performance" factor. Students also noted that instructor/TA support helped make them feel successful, which could be considered "feedback from others" in Bandura's model.

However, some students also responded that some aspects of the course made them feel that they could not be successful, such as the difficulty and amount of coursework/assignments and their ability to keep up with the pace of the course and manage their time. Although the course included small practice, scaffolding, milestones, and a flexible pace of work, it may be possible to improve these aspects of the course design. For example, allowing students to redo assignments may have an impact on their perceptions of their past performances by providing them with the opportunity to overcome perceived failures. To address the "observing others" factor in Bandura's (1997) model, students could be provided with more opportunities to work together in structured teams, and thus, observe others' successes and strategies to achieve success. Providing more project milestones may also help to improve success perceptions. All these considerations for improving the course may be especially important for female students because they reported lower success perceptions than the male students.

It is unclear why women reported slightly lower usefulness and interest over time, and the men did not report changes in these variables. The responses to the open-ended items suggest that specific assignments, course resources, and instructional methods made students perceive the course to be less useful and interesting. Yet, students also reported that some assignments were useful and interesting. Future studies could examine which assignments were deemed to be less useful and interesting, and the instructor could attempt to modify these assignments and their presentation to make them more useful and interesting. Most students' responses to the open-ended item were not detailed enough to identify specific assignments that could be improved. Future research could ask more detailed questions about specific aspects of the course in open-ended survey items or during interviews of students.

To increase usefulness perceptions, some students may prefer more concrete examples of how a skill is useful in future careers (Peteranetz et al., 2021). On average, however, students agreed that the course content was useful and rated their interest between "somewhat agree" and "agree." These findings indicate that, overall, the course is perceived as rather useful and interesting, but that the instructor could consider some minor changes to improve it even further.

Another possible reason for female students' decreased usefulness perceptions over time could be associated with their decreased success perceptions over time. If women begin to feel less successful, they may not believe that they will pursue a career in computer science, which could then lead to a decreased sense of usefulness for the coursework. Future research could examine this speculation. Furthermore, researchers could attempt to improve the success perceptions of women and students without high school experience in order to increase their course engagement and grades, which could lead to higher perceptions of usefulness.

Perceptions of caring also decreased slightly across the weeks for women. Students reported in the open-ended caring question that they did not feel cared for when the instructors did not offer sufficient support or did not teach well, and conversely, that they did feel cared for when they were supported, taught well, were caring (e.g., communicated well, were warm and friendly), and the course policies supported success. Based on suggestions by others (see Jones, 2018), it may be possible to increase students' perceptions of caring by making the entire teaching staff (instructors and TAs) more accessible and approachable, by communicating with students frequently, by sending prompt email responses to student inquiries, encouraging students to ask questions, checking on students or reminding them of deadlines, and accommodating students' needs. Ensuring that students feel cared for is important because researchers have noted the association between caring relationships/belonging and student success in computer science (Krause-Levy et al., 2021; Lewis & Conrad, 2020).

Conclusion

This study demonstrates that students' perceptions of the motivational climate of a course can shift during a semester, which can have important implications for students. We found that while perceptions of empowerment and success decreased for all students, women reported declines across every component of the MUSIC model. Women and students without prior high school computer science experience reported lower success perceptions and earned lower final grades in the course. These differences matter because they signal that some groups of students experience microclimates that are disproportionally affected by course design in ways that can decrease motivation and widen performance gaps.

From a practical standpoint, the results provide instructors with evidence that they should regularly monitor motivational climate to identify how different groups of students are experiencing the course as a means to identify negative microclimates. By doing so, they can intervene by strengthening students' perceptions of empowerment, usefulness, success, interest, and caring. For example, course design elements that increase students' success perceptions or caring may not only improve students' experiences in the course, but they may also contribute to longer-term retention in computer science.

More broadly, this study demonstrates the value of treating motivational climate as an essential part of course quality across higher education. Although our results were based on a single computer science course, the patterns we observed are relevant to many STEM (Science, Technology, Engineering, and Mathematics) disciplines and introductory and gateway courses. Ultimately, fostering a positive motivational climate is not only about making improvements to a single class, but also about creating learning environments across courses and students' higher education experiences so that students are motivated to engage deeply in their learning.

Acknowledgements

The authors disclose that they have no actual or perceived conflicts of interest. The authors disclose that they have not received any funding for this manuscript beyond resourcing for academic time at their respective universities. The authors have not used artificial intelligence in the ideation, design, or write-up of this research as per Crawford et al. (2023). The authors confirm that they have met the ethical standards expected as per Purvis & Crawford (2024). The authors list the following CRediT contributions: **Jones:** Conceptualization, methodology, data collection, writing - initial draft, writing - review and editing; **Ellis:** conceptualization, data collection, and writing - initial draft; **Fenerci:** conceptualization, data collection, analysis, writing - initial draft; **McCarty:** conceptualization, data analysis, writing - review and editing; **Gallagher:** data analysis, writing - review and editing.

References

Alvarado, C., Umbelino, G., & Minnes, M. (2018). The persistent effect of pre-college computing experience on college CS course grades. In Proceedings of the 49th ACM Technical Symposium on Computer Science Education (SIGCSE '18). Association for Computing Machinery, New York, NY, USA, 876–881. https://doi.org/10.1145/3159450.3159508

Anderson, A. S. (2020). One small step in the lecture hall, one big step for student motivation: Short bursts of in-class small group work. *Pedagogy in Health Promotion, 7*(2), 135-143. https://doi.org/10.1177/2373379920963706

Ang, J. W. J., & Ng, Y. N. (2022). Effect of research-based blended learning with scrum methodology on learners' perception and motivation in a laboratory course. *Journal of Chemical Education, 99*(12), 4102-4108. https://doi.org/10.1021/acs.jchemed.2c00002

Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman.

Bellino, A., Herskovic, V., Hund, M., & Munoz-Gama, J. (2021). A real-world approach to motivate students on the first class of a computer science course. *ACM Transactions on Computing Education, 21*(3), Article 22, 1-23. https://doi.org/10.1145/3445982

Beyer, S. (2014). Why are women underrepresented in Computer Science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS coursetaking and grades. *Computer Science Education, 24*(2-3), 153-192. doi:10.1080/08993408.2014.963363

Beyer, S., Rynes, K., Perrault, J., Hay, K., & Haller, S. (2003). Gender differences in computer science students. *SIGCSE Bulletin, 35*(1), 49–53. https://doi.org/10.1145/792548.611930

Crawford, J., Cowling, M., Ashton-Hay, S., Kelder, J. A., Middleton, R., & Wilson, G. S. (2023). Artificial intelligence and authorship editor policy: ChatGPT, Bard Bing AI, and beyond. *Journal of University Teaching and Learning Practice, 20*(5). https://doi.org/10.53761/1.20.5.01

Ellis, M., Edwards, S. H., Shaffer, C. A., & Amelink, C. T. (2020). Incorporating Practical computing skills into a supplemental CS2 problem solving course. *Journal of Higher Education Theory and Practice, 20*(11), 150-162. https://doi.org/10.33423/jhetp.v20i11.3771

Gladman, T., Gallagher, S., & Ali, A. (2020). MUSIC for medical students: Confirming the reliability and validity of a multi-factorial measure of academic motivation for medical education, *Teaching and Learning in Medicine, 32*(5), 494-507. https://doi.org/10.1080/10401334.2020.1758704

Hutchison, M. A., Follman, D. K., Sumpter, M., & Bodner, G. M. (2006). Factors influencing the self-efficacy beliefs of first-year engineering students. *Journal of Engineering Education, 95*(1), 39-47. https://doi.org/10.1002/j.2168-9830.2006.tb00876.x

Jones, B. D. (2009). Motivating students to engage in learning: The MUSIC Model of Academic Motivation. *International Journal of Teaching and Learning in Higher Education, 21*(2), 272-285. https://www.isetl.org/ijtlhe/ijtlhe-article-view.php?mid=774

Jones, B. D. (2012/2024). *User guide for assessing the components of the MUSIC® Model of Motivation*. Retrieved from http://www.theMUSICmodel.com

Jones, B. D. (2018). *Motivating students by design: Practical strategies for professors* (2nd ed.). CreateSpace. https://vtechworks.lib.vt.edu/handle/10919/102728

Jones, B. D., Fenerci-Soysal, H., & Wilkins, J. L. M. (2022). Measuring the motivational climate in an online course: A case study using an online survey tool to promote data-driven decisions. *Project Leadership & Society, 3,* Article 100046. https://doi.org/10.1016/j.plas.2022.100046

Jones, B. D., Khajavy, G. H., Li, M., Mohamed, H. E., & Reilly, P. (2023). Examining the cross-cultural validity of the MUSIC Model of Academic Motivation Inventory in English language courses. *SAGE Open, 13*(1), 1-16. https://journals.sagepub.com/doi/full/10.1177/21582440231156583

Jones, B. D., Li, M., & Cruz, J. M. (2017). A cross-cultural validation of the MUSIC® Model of Academic Motivation Inventory: Evidence from Chinese- and Spanish-speaking university students. *International Journal of Educational Psychology*, *6*(1), 366-385. https://doi.org/10.17583/ijep.2017.2357

Jones, B. D., Miyazaki, Y., Li, M., & Biscotte, S. (2022). Motivational climate predicts student evaluations of teaching: Relationships between students' course perceptions, ease of course, and evaluations of teaching. *AERA Open, 8*(1), 1-17. https://journals.sagepub.com/doi/10.1177/23328584211073167

Jones, B. D., Tendhar, C., & Paretti, M. C. (2016). The effects of students' course perceptions on their domain identification, motivational beliefs, and goals. *Journal of Career Development, 43*(5), 383-397. https://doi.org/10.1177/0894845315603821

Jones, B. D., & Wilkins, J. L. M. (2023). Validating the MUSIC Model of Academic Motivation Inventory: Evidence for the short forms of the college student version. *Journal of Psychoeducational Assessment, 41*(1), 22-35. https://doi.org/10.1177/07342829221121695

Krause-Levy, S., Griswold, W. G., Porter, L., & Alvarado, C. (2021). The relationship between sense of belonging and student outcomes in CS1 and beyond. In Proceedings of the 17th ACM Conference on International Computing Education Research (Virtual Event, USA) (ICER 2021). Association for Computing Machinery, New York, NY, USA, 29–41. https://doi.org/10.1145/3446871.3469748

Lent, R. W., Brown, S. D., & Larkin, K. C. (1986). Self-efficacy in the prediction of academic performance and perceived career options. *Journal of Counseling Psychology*, *33*(3), 265. https://doi.org/10.1037/0022-0167.33.3.265

Lewis, C. M., & Conrad, P. (2020). Teaching practices game: Interactive resources for training teaching assistants. In Proceedings of the 51st ACM Technical Symposium on Computer Science Education, 1110-1111. https://doi.org/10.1145/3328778.3366989

Lishinski, A. (2023). Self-efficacy feedback loops and learning experiences in CS1. In Proceedings of the 2023 Conference on Innovation and Technology in Computer Science Education V. 2. https://dl.acm.org/doi/proceedings/10.1145/3587103

McGinley, J. J., & Jones, B. D. (2014). A brief instructional intervention to increase students' motivation on the first day of class. *Teaching of Psychology, 41*(2), 158-162. https://doi.org/10.1177/0098628314530350

Meiksins, P., & Layne, P. (2022). Women in engineering: Analyzing 20 years of social science literature. *SWE Magazine, 68*(3). https://magazine.swe.org/lit- review- 22/

National Center for Science and Engineering Statistics. (2021). *Women, minorities, and persons with disabilities in science and engineering: 2021* (Special Report NSF 21–321). National Science Foundation. https://ncses.nsf.gov/wmpd

Nikula, U., Gotel, O., & Kasurinen, J. (2011). A motivation guided holistic rehabilitation of the first programming course. *ACM Transactions on Computing Education, 11*(4), Article 24, 1-38. https://doi.org/10.1145/2048931.2048935

Nguyen, A., & Lewis, C. M. (2020). Competitive enrollment policies in computing departments negatively predict first-year students' sense of belonging, self-efficacy and perception of department. Proceedings of the 51st ACM Technical Symposium on Computer Science Education. ACM. https://doi.org/10.1145/3328778.3366805

Ojha, V., West, L., & Lewis, C. M. (2024). Computing self-efficacy in undergraduate students: A multi-institutional and intersectional analysis. Proceedings of the 55th ACM Technical Symposium on Computer Science Education. 993-999. https://doi.org/10.1145/3626252.3630811

Peteranetz, M. S., Soh, L.-K., Shell, D. F., & Flanigan, A. E. (2021). Motivation and self-regulated learning in computer science: lessons learned from a multiyear program of classroom research. *IEEE Transactions on Education 6*4(3), 317-326. https://doi.org/10.1109/TE.2021.3049721

Peters, A.-K., Berglund, A., Eckerdal, A., & Pears, A. (2014). First year computer science and IT students' experience of participation in the discipline. In 2014 International Conference on Teaching and Learning in Computing and Engineering. 1–8. https://doi.org/10.1109/LaTiCE.2014.9

Pirttinen, N., Hellas, A., Haaranen, L., & Duran, R. (2020). Study major, gender, and confidence gap: Effects on experience, performance, and self-efficacy in introductory programming. 2020 IEEE Frontiers in Education Conference (FIE), 1-7. https://doi.org/10.1109/FIE44824.2020.9273884

Purvis, A. J. & Crawford, J. (2024). Ethical Standards in Educational Research and Publication. *Journal of University Teaching and Learning Practice, 21*(9). https://doi.org/10.53761/hqnqr710

Reash, C., & Larwin, K. H. (2021). Factors of motivation in education: Perspectives of college students and their professors. *Journal of Organizational & Educational Leadership, 7*(1), Article 2. https://digitalcommons.gardner-webb.edu/joel/vol7/iss1/2

Kristy A. Robinson (2023) Motivational climate theory: Disentangling definitions and roles of classroom motivational support, climate, and microclimates. *Educational Psychologist, 58*(2), 92-110. https://doi.org/10.1080/00461520.2023.2198011

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Sage.

Vaziri, S., Vaziri, B., Novoa, L. J., & Torabi, E. (2022). Academic motivation in introductory business analytics courses: A Bayesian approach. *INFORMS Transactions on Education*, *22*(2), 121-129. https://doi.org/10.1287/ited.2021.0247

Wilkins, J. L. M., Jones, B. D., & Rakes, L. (2021). Students' class perceptions and ratings of instruction: Variability across undergraduate mathematics courses. *Frontiers in Psychology, 12,* Article 576282. https://doi.org/10.3389/fpsyg.2021.576282

Wilson, B. C., & Shrock, S. (2001). Contributing to success in an introductory computer science course: a study of twelve factors. *ACM SIGCSE Bulletin 33*(1), 184–188. https://doi.org/10.1145/364447.364581

Zeldin, A., L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*(1), 215–246. https://doi.org/10.2307/1163477

Zwanch, K., & Cribbs, J. (2021). A study of motivation and engagement in teacher education: Students' perceptions of moving to online instruction in response to a pandemic. *Journal of Technology and Teacher Education, 29*(1), 91-119. https://doi.org/10.70725/080785hcyxxj