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HOW WE TEACH | *Generalizable Education Research*

Who perceives they are smarter? Exploring the influence of student characteristics on student academic self-concept in physiology

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Cooper KM, Krieg A, Brownell SE. Who perceives they are smarter? Exploring the influence of student characteristics on student academic self-concept in physiology. *Adv Physiol Educ* 42: 200–208, 2018; doi:10.1152/advan.00085.2017.—Academic self-concept is one's perception of his or her ability in an academic domain and is formed by comparing oneself to other students. As college biology classrooms transition from lecturing to active learning, students interact more with each other and are likely comparing themselves more to other students in the class. Student characteristics can impact students' academic self-concept; however, this has been unexplored in the context of undergraduate biology. In this study, we explored whether student characteristics can affect academic self-concept in the context of an active learning college physiology course. Using a survey, students self-reported how smart they perceived themselves to be in the context of physiology relative to the whole class and relative to their groupmate, the student with whom they worked most closely in class. Using linear regression, we found that men and native English speakers had significantly higher academic self-concept relative to the whole class compared with women and nonnative English speakers. Using logistic regression, we found that men had significantly higher academic self-concept relative to their groupmate compared with women. Using constant comparison methods, we identified nine factors that students reported influenced how they determined whether they were more or less smart than their groupmate. Finally, we found that students were more likely to report participating more than their groupmate if they had a higher academic self-concept. These findings suggest that student characteristics can influence students' academic self-concept, which in turn may influence their participation in small-group discussion and their academic achievement in active learning classes.

academic self-concept; gender; identity; physiology; undergraduate

INTRODUCTION

While numerous factors have been shown to influence student learning and retention in undergraduate biology, an understudied area is the importance of affective components of learning (36, 37, 41, 43). Recently, biology education researchers have increasingly turned their attention to exploring student affective constructs, including sense of belonging (3, 14, 26, 34, 38, 41), self-efficacy (2, 3, 11, 41, 42), comfort (16), and science identity (7, 14, 41). One affective construct that has not been explored in the context of college biology classrooms is student academic self-concept.

Academic self-concept is one's perception of one's own ability in a specific academic domain (e.g., statistics, ecology, physiology) and is developed by one's experiences within a learning environment, including academic interactions with peers and instructors (5, 31, 35). Academic self-concept is strongly influenced by one's perceptions of the academic abilities of other students and can be measured by assessing a student's perception of his/her academic ability in a domain compared with a group of peers in that domain (31).

Prior research on academic self-concept has shown that it can influence other affective constructs, such as self-efficacy and student motivation, as well as student in-class participation. Self-efficacy is defined as students' confidence in their ability to perform a task (4) and is distinct from academic self-concept. Students develop self-efficacy by considering their abilities compared with the goal they are trying to achieve (4), whereas students develop academic self-concept by comparing their academic abilities in a domain with the academic abilities of other students (4). Ferla and colleagues (18) found that high school students' academic self-concept in math strongly influenced their math self-efficacy or their belief that they would do well in the math course. However, there was not a reciprocal relationship between these two constructs; student self-efficacy did not influence student academic self-concept (18). Academic self-concept has also been shown to increase student motivation. In a study conducted with undergraduate students studying education, academic self-concept in education was found to be the strongest predictor of student motivation to study material for the course (33). Similarly, students' academic self-concept in the context of a high school math course directly influenced their motivation to complete their math homework (24). Lastly, there is some evidence to suggest that students' academic self-concept may influence their participation in class. In an interview study exploring undergraduate resistance to active learning, some biology students expressed that they were reluctant to participate in small-group discussion because they were afraid that other students might perceive them as less intelligent (12). Furthermore, in a case study of graduate students, nonnative English speakers expressed that one reason they were quiet during class was because they felt that their language abilities and content knowledge were insufficient to express themselves clearly (40).

Student characteristics, such as gender, race/ethnicity, and anxiety level, have been shown to influence student academic self-concept. For example, female high school students studying physics and chemistry were found to have a lower aca-

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demic self-concept in each of these domains compared with men, even after controlling for a measure of academic ability (25). Similarly, high school women have been shown to have lower academic self-concept in math compared with their male peers (32). Student race/ethnicity has also been shown to influence academic self-concept. In a study exploring first-generation college students' math academic self-concept, Asian and Latino(a) students had significantly higher math academic self-concept compared with African American students; white students' math academic self-concept did not differ significantly from any other racial or ethnic group (15). Student anxiety level in the classroom may also be related to student academic self-concept. Students with low academic self-concept in nursing have been shown to be more likely to have high anxiety in academic settings (28). Thus a student's characteristics may influence the development of his/her academic self-concept in a specific domain.

One framework describing the development of student academic self-concept is the internal/external frame-of-reference model, which suggests that academic self-concept is formed by both *1*) internal comparisons, or a student's comparison of his/her abilities in different domains (e.g., a student's ability in math compared with his ability in English); and *2*) external comparisons, when a student compares his/her ability in a domain to the abilities of other students (31). Historically, studies have explored external comparisons by measuring students' conceptions of their abilities as they compare with the abilities of a large group of peers in a domain (e.g., an entire class). However, we propose that a student's external frame of reference can also be formed by the student's perception of his/her academic ability compared with another student with whom he/she works closely in class. In a class in which a student's frame of reference is largely based on with whom he/she works during class, then groupmates would likely influence the development of that student's academic self-concept (12, 13). Thus a student in physiology has an academic self-concept in physiology relative to the collective ability of the class as a whole, but he/she also has an academic self-concept relative to the ability of a single student in class with whom he/she works closely; these two academic self-concepts may be different, depending on how similar the person with whom he/she works most closely is to the rest of the class. For example, a student may perceive that she is smarter than most of the students in her physiology class and thus have a high academic self-concept relative to the class as a whole, but she may perceive that the groupmate with whom she works on problems in class is much better at physiology then she is, and thus she would have a low academic self-concept relative to that particular groupmate. Both perceptions may influence a student's overall academic self-concept in physiology.

As we transition college sciences courses from traditional lecture to student-centered active learning, there are more opportunities for students to compare themselves to other students in the class. In active learning classes, students regularly have opportunities to compare themselves to the whole class. For example, instructors in active learning often use clicker questions to poll the class about a concept, and then instructors often reveal what the class as a whole answered and sometimes what percentage of the class answered it correctly. Thus students can compare their own answers to the answers of the class and get a sense for how many other students had the correct answer. Students also have opportunities to compare themselves to individual students in the class. Sometimes instructors pair clicker questions with whole class discussions where instructors ask individual students to share their ideas in front of the class, so everyone in the class can compare his/her own thinking with that student's thinking. Commonly, instructors have students work with partners or in small groups in active learning, where students frequently share their ideas and hear the ideas of a small number (approximately one to three) of other students. Because of these repeated interactions, we propose that students likely develop an academic self-concept in biology relative to individuals with whom they work frequently in addition to an academic self-concept relative to the whole class. We predict that students' characteristics may have an even greater influence on their academic self-concept relative to a student in their group, because previous studies have shown that students' characteristics can influence their experiences in active learning classrooms where students are working in groups (12, 16). For example, Eddy and colleagues (16) showed that men are more likely than women to prefer a leader/explainer role in a small group, and women are more comfortable in small groups when they work with a friend. Furthermore, lesbian, gay, bisexual, transgender, queer/questioning, intersex, and asexual (LGBTQIA) students report being concerned that students with whom they work during class will perceive them as less competent if their LGBTQIA identity is revealed (12). These studies highlight that student characteristics can influence student experiences in active learning classrooms, but it is unclear whether these characteristics could also affect student academic self-concept in biology, and particularly their academic self-concept relative to other students with whom they work in active learning classes. Furthermore, it is unknown whether a student's academic self-concept in biology has an impact on his/her experience in the classroom, particularly whether academic self-concept influences how students interact during active learning.

In this study, we explored student academic self-concept in an upper-level physiology course taught in an active learning way. We set out to answer the following research questions:

1. To what extent do student characteristics predict student academic self-concept in biology, specifically physiology, relative to the whole class?
2. To what extent do students' characteristics predict student academic self-concept in physiology relative to the student with whom they worked most closely in class (hereafter referred to as "groupmate")?
3. How do students determine their academic self-concept relative to their groupmate?
4. To what extent does student academic self-concept in physiology predict self-reported student participation in peer discussion?

METHODS

Course Description

All data were collected from a large-enrollment, upper-level physiology course composed of 244 students. The class was taught in an active learning way; every class session included student-centered instruction, typically using a combination of groupwork using worksheets and clicker questions. During clicker questions, students typically first answered a question individually and then discussed with their neighbor before answering the question again. During the debrief of the clicker question, the instructor would typically repeat out student ideas that she heard while walking around during the peer discussion, but there was no whole class discussion where single students spoke out in front of the whole class. The instructor would also show students a histogram of their responses to the question. Thus a student could compare how he/she answered the question to how the other students in the class answered in aggregate. Students had the opportunity to choose where they sat every class period and were not assigned to groups. However, most students chose to sit in the same general area during every class period and worked with the same student(s) during class; only 9% of students reported that they did not sit in the same section during most class periods. The class met three times a week for 50 min each.

Data Collection

During the first week of class, all students were asked to complete a demographic survey. Students were asked to report their demographic information, including gender, race/ethnicity, whether the student was a native English speaker, and whether the student transferred to the institution from a 2-yr institution. Students were also asked a yes/no question about whether they had ever struggled with an anxiety disorder. Of the 244 students enrolled in the class, 230 students (94%) completed this survey. To assess students' academic self-concept, students were surveyed again at the end of the 7th week of class, after relationships with other students had been established, but before the first exam in this course. We chose to survey students before the first exam so that students' grades on the first exam did not influence their academic self-concept. Although students would have had opportunities to estimate their standing in the course through other assignments, including preclass reading quizzes, in-class clicker questions, and practice exam questions, they did not yet have their score on a high stakes summative assessment to compare with other students. Of the 244 students in the class, 218 students (89%) completed the second survey. Two-hundred and two students (83% of students enrolled in the class) completed both surveys and are included in the data set. To determine students' academic self-concept in physiology relative to the whole class, all students reported the percentage of the whole class that they perceived they are smarter than, in the context of physiology. Students also indicated whether they regularly worked with other students in the physiology course. Students' academic self-concept relative to the person with whom they worked most closely in class was only analyzed for students who indicated that they worked regularly with other students in physiology lecture (190 students, 94% of students with a complete data set). The person with whom they worked most closely in class will be referred to as the "groupmate". To measure students' academic self-concept in physiology relative to the groupmate, we asked students to name the student with whom they worked most closely in class and to indicate whether they were smarter or less smart than this person in the context of physiology. Students also reported whether they participated more than, less than, or the same as the groupmate during peer discussions about physiology. On the survey, students responded to an open-ended question about how they determine whether they are more or less smart than another student in the physiology course. Surveys were vetted for face validity using a think-aloud interview protocol (10). This study was approved by an Institutional Review Board from Arizona State University.

Data Analysis

Studies have shown that student demographic characteristics can influence student academic self-concept as well as their experiences in active learning biology courses (9, 12, 15, 17, 28, 32). After reviewing the prior literature on student academic self-concept and the influence of different characteristics on student experiences in active learning classrooms, we hypothesized that student level factors such as gender[1] (a factor with two levels: female and male), race/ethnicity [a factor with three levels: white, Asian, and underrepresented racial or ethnic minority[2] (URM)], whether a student is a native English speaker (a factor with two levels: native English speaker and nonnative English speaker), whether the students transferred to the institution from a 2-yr college (a factor with two levels: transfer and nontransfer)[3], and whether the students struggled with an anxiety disorder[4] (a factor with two levels: anxiety and no anxiety) could influence student academic self-concept in physiology relative to the whole class or their groupmate.

General Statistical Approach: Model Selection

The research questions in this paper are exploratory, and we identified multiple student-level factors (gender, race/ethnicity, native language, transfer student status, and anxiety level) that may influence student academic self-concept. However, we did not have hypotheses about which of these factors would be most important in predicting student academic self-concept in physiology relative to the whole class or relative to their groupmate. Therefore, we used model selection as our statistical approach because null-hypothesis testing is not appropriate (6, 16). Using model selection approach, we began with a full model that included all predictor variables (e.g., student gender, race/ethnicity, transfer status, anxiety status), and using Akaike's information criterion corrected for small sample sizes (AICc), we determined the best model by selecting the model with the lowest AICc. The best models were used for both analyses. Model selection analyses were implemented in R using the MuMIn package (1). We present the best model for each research question in RESULTS.

Research question 1: To what extent do student characteristics predict student academic self-concept in physiology relative to the whole class? To identify student characteristics that best predict students' academic self-concept in physiology relative to the class as a whole, we used a model selection approach paired with linear regression. Linear regression is a linear approach for modeling the relationship between a linear-dependent variable: in this case, the percentage of classmates a student perceives he/she is smarter than, and explanatory variables (e.g., student gender, race/ethnicity, transfer status, anxiety status). We included all student demographics that we hypothesized might contribute to student academic self-concept as predictors (i.e., explanatory variables) and controlled for students' academic ability by including students' prior grade point averages (GPAs) (25). The full model that was tested is as follows: percentage of classmates than whom student perceives he/she is smarter ~ prior GPA + gender + race/ethnicity + transfer status + native language + anxiety. We used the highest ranked linear model to identify

[1] Gender is not a binary (male/female) variable, and we recognize that some students identify with nonbinary gender identities. Unfortunately, there were too few students who identified as nonbinary identities to include this as a factor in our models.

[2] The relatively low numbers of students who identify as black and Native American or Alaska Native made it necessary to pool their responses with Latino(a) students in a category, which we call underrepresented racial or ethnic minority students (URM). While we recognize that the experiences of these students are different, we decided to pool these identities as one factor because of their shared experience of being underserved by institutions of education (16, 30).

[3] We did not include students who transferred from a 4-yr institution in analyses, because previous research on transfer students' academic and psychosocial experiences in college generally compares students transferring from 2-yr institutions or community colleges to native students who started their academic career at the 4-yr institution (29).

[4] Students self-reported whether they struggled with an anxiety disorder. This is not to imply that they have been diagnosed with anxiety, and it does not take into account the many types of anxiety, so it is a rough approximation of their experience with anxiety. However, we felt as though this variable is important to include because prior literature suggests that anxiety could impact student academic self-concept.

significant variables and predict the percentage of classmates than whom the average student perceives he/she is smarter.

Research question 2: To what extent do student characteristics predict student academic self-concept in physiology relative to their groupmate? To identify student characteristics that best predict students' academic self-concept relative to their groupmate, we used a model selection approach paired with logistic regression. Logistic regression is an approach for modeling the relationship between a dependent variable that is categorical, in this case, whether a student perceived he/she was smarter than the groupmate, and explanatory variables such as student gender. The logistic regression model can be used to estimate the probability of whether a student would perceive that he/she was smarter than the groupmate based on predictor variables (e.g., student gender). In our original model, we wanted to include the difference between the two groupmates' GPAs as a predictor variable, so we calculated the difference between the two students' GPAs by subtracting the GPA of the groupmate from the GPA of the student (prior GPA difference) and included this in the model as a rough control for the actual academic difference between two students. The full model that was tested is as follows: whether a student perceives he/she is smarter than the groupmate (Y/N) ~ prior GPA difference + gender + race/ethnicity + transfer status + native language + anxiety. We used the highest ranked logistic model to identify significant variables and predict whether the average student perceives he/she is smarter than the groupmate.

Research question 3: How do students determine their academic self-concept relative to their groupmate? Constant comparative methods were used by two authors (AK and KMC) to identify themes from a subset of student responses to the question, "How do you determine whether you think you are more or less smart than another student?" (21). Specifically, quotes that were assigned to themes were gathered together and compared with one another throughout the analysis to ensure that the description of the theme represented all quotes within the same group. This iterative comparison ensures that the quotes were not different enough to create a separate category (22). The two authors created a coding rubric, and one author (AK) coded a subset of 50 student responses. To establish that the coding scheme was reliable and could be used to replicate the results by other researchers, another author (SB) independently coded the same subset of responses, and the two results were compared. The authors had a consensus estimate of 96%. One author (AK) coded the remaining student responses.

Research question 4: To what extent does student academic self-concept in physiology predict self-reported student participation in an active learning physiology class? We used multinomial regression to identify whether student academic self-concept in physiology, relative to the groupmate, predicted the amount that the student contributes to in-class peer discussions with the groupmate. Multinomial logistic regression is an approach for modeling the relationship between a categorically distributed dependent variable, in this case, whether a student perceives that he/she participates more than, less than, or as much as the groupmate, and a predictor variable, whether a student perceives he/she is smarter than the groupmate. Student self-reported participation with regard to the groupmate had three levels: participates more than groupmate, participates equal to groupmate, and participates less than groupmate. The full model that was tested is as follows: participation (participates more than groupmate/ participates equal to groupmate /participates less than groupmate) ~ whether a student perceives he/she is smarter than his/her groupmate.

RESULTS

Of the 202 students with a complete data set, 130 were women (64.4%), 70 were men (34.7%), and 2 students identified as other (0.9%). There were 27 students who identified as Asian (13.4%), 111 students who identified as white (55.0%), 44 students who identified as Latino(a) (21.8%), 8 students who identified as black or African American (4%), and 2 students who identified as American Indian or Alaska Native (1%). Ten students declined to state their race/ethnicity (5%). The GPA range for the students was 1.9–4.0, and the average GPA was 3.35. One hundred and seventy-one students identified as native English speakers (84.7%), and 31 students identified a native language other than English (nonnative English speaker) (15.3%). Thirty-eight students (18.8%) indicated that they transferred to the institution from a 2-yr institution (transfer students), 20 students (9.9%) transferred to the institution from a 4-yr institution, 134 students (66.3%) started their academic career at the institution (nontransfer students), and, for 10 students (5.0%), none of these described their experience. Ninety-two students (45.5%) said they did not struggle with an anxiety disorder, 81 students (40.1%) said they did struggle with an anxiety disorder, and 29 (14.4%) students declined to state.

Research Question 1: Gender and Native Language Predict Student Academic Self-Concept in Physiology Relative to the Whole Class

The best model for predicting students' academic self-concept in physiology relative to the whole class contained student prior GPA, gender, native language, and whether the student struggled with anxiety. Students' prior GPA ($P < 0.001$), gender ($P < 0.001$), and native language ($P < 0.01$) were significant predictors of a student's academic self-concept in physiology relative to the whole class (Table 1). On average, men were significantly more likely than women to have a higher academic self-concept in physiology relative to the whole class. Using the best model and controlling for all other variables, the average man with a 3.3 GPA (average GPA of students in the class) is predicted to perceive that he is smarter than 66% of students in the physiology class, whereas the average woman with a 3.3 GPA is predicted to perceive that she is smarter than only 54% of the students in the physiology class (Fig. 1*A*).

Students whose native language is English were significantly more likely than students whose native language is not English to have higher academic self-concept in physiology relative to the whole class. Using the best model and controlling for all other variables, an average student whose native language is English is predicted to perceive that he/she is smarter than

Table 1. *Linear regression coefficients for the best model that predicts the percentage of physiology classmates that a student perceives he/she is smarter than*

	Intercept	GPA	Gender: Female (Reference Male)	Native Language: Not English (Reference English)	Anxiety (Reference No Anxiety)
β ± SE	29.1 ± 13.2	12.9 ± 3.67	−11.6 ± 4.11	−14.7 ± 4.98	−6.46 ± 4.03
P value	0.05*	0.001‡	0.001‡	0.01†	0.112

The model is percentage of classmates than whom the student perceives he/she is smarter ~ prior GPA + gender + native language + anxiety. Prior GPA, gender, and native language significantly predict the percentage of physiology classmates than whom a student perceives he/she is smarter. A positive number indicates the student is more likely to perceive he/she is smarter than a higher percentage of physiology classmates. *$P \leq 0.05$. †$P \leq 0.01$. ‡$P \leq 0.001$.

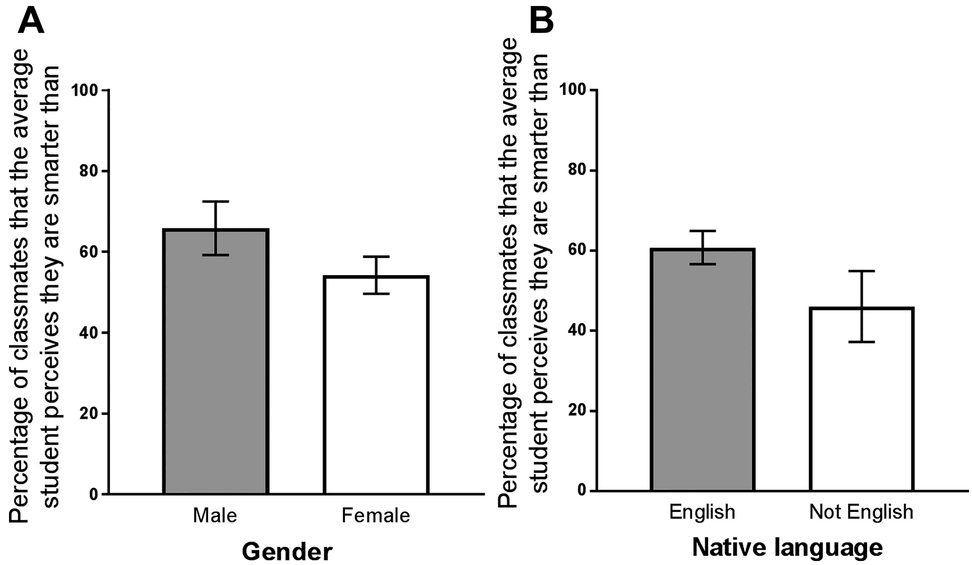

Fig. 1. Percentage of physiology classmates that the average student perceives he/she is smarter than, and 95% confidence interval. Predictions were based on top ranked model (percentage of classmates that student perceives he/she is smarter than ~ prior GPA + gender + native language + anxiety). *A*: controlling for all other variables, the average man with a 3.3 GPA perceives that he is smarter than 66% of the class, and the average woman with a 3.3 GPA perceives that she is smarter than 54% of the class. *B*: controlling for all other variables, the average native English speaker with a 3.3 GPA perceives he/she is smarter than 61% of the class, whereas a nonnative English speaker with a 3.3 GPA perceives he/she is smarter than 46% of the class.

61% of his/her physiology classmates; however, an average student whose native language is not English is predicted to perceive that he/she is smarter than only 46% of his/her classmates (Fig. 1*B*).

Unsurprisingly, our control variable for students' academic ability, prior GPA, was also a significant predictor of a students' perceived ability in physiology. For every 0.1 increase in a student's GPA, a student was likely to perceive that he/she was smarter than an additional 1.3% of the class.

Research Question 2: Gender Predicts Student Academic Self-Concept in Physiology Relative to Their Groupmate

The best model to predict whether a student perceives he/she is smarter than the groupmate included the difference between students' prior GPAs, gender, and transfer status. A student's gender ($P < 0.05$) was a significant predictor of a student's academic self-concept in physiology relative to his/her groupmate (Table 2). Men were more likely than women to have higher academic self-concept in physiology relative to their groupmate. Controlling for all other variables, including the difference in academic ability between the student and the groupmate, men are 3.2 times more likely than women to perceive they are smarter than their groupmate.[5] Using predictions from the best model and controlling for all other variables, the average man has a 61% chance of perceiving that he is smarter than his groupmate, whereas the average woman only has a 33% chance of perceiving that she is smarter than her groupmate (Fig. 2).

Research Question 3: How Students Answer Questions During Class and Perceptions of Other Students' Understanding of Physiology Influence Student Academic Self-Concept Relative to Their Groupmate

To understand what factors contribute to students' academic self-concept relative to their groupmate, we asked students to respond to an open-ended question asking how they determined whether they were more or less smart than another student. There were 180 students who provided a response to this question (94.7% of students who reported working regularly with at least one other students during the physiology class). We used constant comparison methods to code student responses, which generated nine factors that were mentioned by at least 3% of students (21). We chose 3% as a cut-off for reporting results because that meant that at least five students made a statement that fell into that particular theme. We wanted to be as inclusive as possible in our initial category formation due to the exploratory nature of this work. Because students were able to write as much as they wanted in response to the open-ended question, some students mentioned multiple reasons. However, students were not instructed to make an exhaustive list, so it is likely that we are underestimating the number of students who consider a particular factor when

[5] There are several ways to interpret model parameters from a logistic model. One way is to interpret the factor of change in odds that men compared with women will perceive themselves as smarter than their groupmate. Holding all other predictors constant, the odds for a man to perceive he is smarter than his groupmate is $e^{1.15}$, or 3.2 times more than women.

Table 2. *Logistic regression coefficients for the best model that predicts whether a student perceives that he/she is smarter than his/her groupmate*

	Intercept	GPA Difference	Gender: Female (Reference Male)	Transfer Student Status: Transfer Student (Reference Nontransfer Student)
β ± SE	0.66 ± 0.41	0.58 ± 0.35	−1.15 ± 0.49	−0.198 ± 0.563
P value	0.11	0.09†	0.02*	0.12

The model is whether student perceives he/she is smarter than his/her groupmate (Y/N) ~ GPA difference + gender + transfer status. Student's gender significantly predicts whether a student perceives he/she is smarter than his/her groupmate. The GPA difference between the two students is a nearly significant predictor. A positive number indicates the student is more likely to perceive he/she is smarter than his/her groupmate. $*P \leq 0.05$. $\dagger P \leq 0.1$.

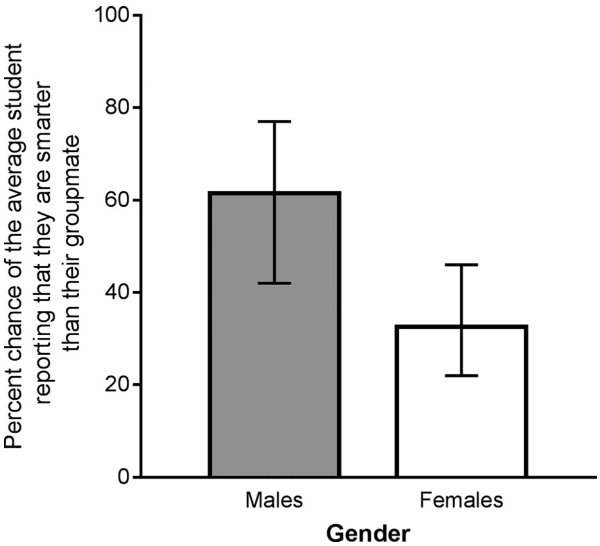

Fig. 2. Percent chance and 95% confidence interval that the average student, differing only in gender, perceives he/she is smarter than his/her groupmate. Predictions were based on top ranked model (whether student perceives he/she is smarter than his/her groupmate (Y/N) ~ GPA difference + gender + transfer status). Controlling for all other variables, the average man has a 61% chance that he will perceive that he is smarter than his groupmate, and the average woman has a 33% chance that she will perceive that she is smarter than her groupmate.

deciding whether they were smarter or less smart than another student in the context of physiology.

We identified nine factors that influenced student academic self-concept in physiology relative to their groupmate (Table 3). The most common factor that students reported that influenced their academic self-concept in physiology was who answered more questions correctly (30.6% of student responses). The next most frequently mentioned factor that influenced students' academic self-concept was who was perceived to have a better understanding of the material or more knowledge about physiology (28.3%). Additionally, students mentioned who was better at reasoning through a problem (9.4%), who provided new insight or new ideas during discussion (8.9%), who grasped material most quickly (7.2%), and who had better communication skills (3.9%) as factors they considered when determining who was smarter. Students also considered the role that students adopted during group work when determining who was smarter. Nearly 8% of students thought that a student was smarter if he/she took on a teacher role in the group and explained content to other students, and a small percentage of students indicated that a student was smarter if he/she dominated the conversation during group work (5.0%). Students also considered which student put more effort into class by reading or studying material (4.4%). Interestingly, a small subset of students (3.3%) stated that they generally assume they are either smarter or less smart than the people with whom they work during class.

Because we found that men were more likely than women to have a higher academic self-concept in physiology relative to their groupmate, we were interested in whether men and women consider different factors when evaluating whether they are smarter than their groupmate. We found no significant differences between the percentage of men and women who described specific factors that influence whether they perceive they are smarter than their groupmate.

Research Question 4: A Student's Academic Self-Concept in Physiology Relative to the Groupmate Significantly Predicts Participation in Peer Discussion

Students' academic self-concept in physiology relative to their groupmate significantly predicted their self-reported participation in group discussions relative to this person. About one-half of the students reported that, during small-group discussions about physiology, they participated an equal amount as their groupmate [103 of the 190 students who reported working regularly with at least one other student]. However, students who perceive they are smarter than their groupmate are 3.22 times more likely to self-report that they participate more than their groupmate than students who perceive they are less smart than their groupmate ($P = 0.0001$) (Table 4). Furthermore, students who perceive that they are less smart than their groupmate are 2.36 times more likely to report that they participate less than their groupmate than students who perceive they are smarter than their groupmate ($P = 0.0001$) (Table 4).

DISCUSSION

In this study, we explored academic self-concept in the context of an undergraduate physiology course. This study is the first to our knowledge exploring the construct of academic self-concept in the context of an active learning undergraduate biology classroom. Active learning classrooms increase the number of interactions between students, so students have more opportunities to compare themselves to other students. According to the internal/external frame-of-reference model, a student's academic self-concept in physiology can be influenced by the students' internal comparisons or how they perceive their ability in physiology compared with their ability in another domain, as well as their external comparisons or how an individual compares himself/herself to others in physiology (31). In active learning classrooms, student characteristics have been shown to influence student experiences, particularly their experiences with other students (12, 16). As such, we predicted that a student's academic self-concept in an active learning physiology course may be influenced by the student's characteristics.

We explored academic self-concept in two ways: relative to the whole class, and relative to a student's groupmate, the person with whom the student worked most closely in class. We found that men and native English speakers had higher academic self-concept relative to the whole class compared with women and nonnative English speakers. We also found that men had higher academic self-concept relative to their groupmate compared with women. These differences were observed even when we controlled for other aspects of the students, such as prior academic ability, which have been shown to influence academic self-concept. While we do not know exactly what is causing a difference in academic self-concept between these groups of students, we can speculate based in part on our findings for what students use to estimate whether someone is smart. Students used the interactions in class as a proxy for determining whether another student was smarter than them. They highlighted

Table 3. *Descriptions of factors that influence whether a student perceives he/she is smarter or less smart than the groupmate, percentage of students that reported each factor, and example student quotes*

Factor	Description of Factor	%Students Who Provided Factor	Example Student Quote
Who answers more questions correctly	The smarter student answers more questions correctly, usually with regard to clicker questions or worksheets during class.	30.6	"By whether or not I'm able to answer more clicker questions accurately."
Who has a better understanding of the material	The smarter student is more knowledgeable, has a better understanding of the content, and/or is better at applying content knowledge	28.3	"I base it off of how well the person knows the information and how easily they seem to grasp the concepts introduced in class."
Who is better at reasoning through a problem	The smarter student is able to reason through a question better, think more critically, or approach issues or questions more logically.	9.4	"On how well they reason through their answers. Some are very logical and thoughtful, while some are content with simply guessing based on key words or phrases."
Who provides new insights	The smarter student provides new insight, a new idea, or a new line of thinking to the discussion.	8.9	"Whether the person can think outside of the box and provide more insight than I can."
Who takes on a teacher role	The smarter student answers questions of the other group member, gives other group members help, or guides them to the right answer.	7.8	"When we share answers, she guides me to the right thinking."
Who grasps material fastest	The smarter student understands the material introduced in class more quickly.	7.2	"How quickly they pick up on the ideas and concepts in comparison to myself."
Who leads discussion	The smarter student answers the question first, talks first, talks for the majority of the time, or the group member is said to dominate or lead the discussion.	5.0	"When we are discussing, they are the ones that explain and talk the majority of the time."
Who puts more effort in	The smarter student spends more time studying or reading, spends more time on the subject outside of class, or takes better notes during class.	4.4	"I am less smart than they are during class because they do more notes and readings than I do."
Who has better communication skills	The smarter student is more articulate, has better communication skills, or is more confident when presenting his/her ideas.	3.9	"I determine whether I think they are smarter than me by their confidence level when they explain their reason to their answer."
General assumption about who is smarter	The student states that he/she always assumes that he/she is smarter or less smart than people with whom he/she works.	3.3	"I always consider people around me smarter than I am."

specific aspects of the active learning classroom, including answering clicker questions and who takes on leadership roles when working in a group, as providing opportunities for them to evaluate their peers. However, there were no significant differences between women and men in the factors that they used to determine whether another student was smarter than them. We interpret this to mean that men and women are using the same factors to determine other students' intelligence, but women may be judging their own behavior or ability more harshly than do men. For example, both men and women are determining whether a student is more intelligent by judging who has a better understanding of the material, but women are more likely to underestimate their own understanding.

The common finding across both types of academic self-concept was that men had higher academic self-concept, even

Table 4. *Multinomial regression coefficients for model used to determine whether student academic self-concept in physiology relative to their groupmate predicts self-reported participation in peer discussion with groupmate*

Student Level of Participation in Peer Discussion with Groupmate	Intercept	Perception of Intelligence: Student Perceives He/She Is Smarter Than Groupmate (Reference Student Perceives He/She Is Less Smart Than Groupmate)
Participates less (participates equal)		
$\beta \pm$ SE	-0.60 ± 0.24	-1.17 ± 0.47
P value	0.05*	0.001†
Participates more (participates equal)		
$\beta \pm$ SE	-1.5 ± 0.33	0.86 ± 0.43
P value	0.05*	0.001†

The model is participation (participates more than groupmate, participates the same as groupmate, participates less than groupmate) ~ whether student perceives he/she is smarter than his/her partner (Y/N). Student academic self-concept in physiology with regard to their groupmate predicts student self-reported participation in peer discussion with their groupmate. $^*P \leq 0.05$. $^†P \leq 0.001$.

after controlling for prior academic ability. This echoes what has been previously shown in the literature; a review of nearly 20 published papers on self-estimated intelligence concluded that men rate themselves higher than women on self-estimated intelligence, and the greatest gender difference is in mathematical and spatial intelligence (20). Furthermore, high school men have been shown to have higher academic self-concept than women in both physics and chemistry (25). However, to our knowledge, no studies have explored the relationship between gender and students' perception of their intelligence compared with other students in the context of undergraduate physiology. One recent study in an active learning undergraduate biology course explored student perceptions of which of their peers in class knew the course material best and found gender biases: men are more likely to be named by peers as knowledgeable, even when controlling for class performance and outspokenness in class (23). However, this study did not explore how students perceived their own knowledge of the material, and how the perception of their own knowledge compared with their perceptions of others' knowledge. Of note, the active learning class where our study took place did not involve any whole class discussion (i.e., no single student voices were heard in front of the whole class), so we would predict that students mostly used interactions in small-group peer discussions to form their academic self-concept relative to other students. Another study exploring group dynamics in undergraduate biology classrooms found that, during small-group discussion, men were more likely to prefer a leader/explainer role than women (16), which may explain why men are more likely to perceive they are smarter. When we asked students how they determined whether they were smarter or less smart than another student in class, whether a student adopts a teaching role and whether a student leads the discussion were both factors that emerged from student responses, which aligns with this previous study. However, more research needs to be done to further explore the impact of these factors on students' perception of their own intelligence and the intelligence of their groupmates.

To our knowledge, our study is the first to document differences in academic self-concept in nonnative English speakers compared with native English speakers. Prior research on the experience of nonnative English speakers in undergraduate and graduate classrooms typically has been focused on the silence or lack of active participation of nonnative English speakers (19, 27), but few studies have explored what may contribute to students' silence. A case study of nonnative English-speaking graduate students studying in the US found that nonnative English-speaking students are sometimes silent because they feel that their language abilities and content knowledge are insufficient to express themselves clearly (40). However, this case study probing the experiences of nonnative English speakers did not explore how students perceive themselves relative to other students in the classroom. Documenting the experiences of nonnative English-speaking students is the important first step for instructors to begin to consider how they may disrupt these inequities through inclusive active learning teaching practices (41).

Why does academic self-concept matter? We found that students with higher academic self-concept are more likely to report participating more in small-group discussions; this could have implications for student learning, because studies have shown that greater participation can lead to greater learning, since students are constructing their own knowledge rather than listening passively (8). We may need to explore ways to increase student academic self-concept if we want to increase students' voluntary participation and their subsequent learning. Alternatively, it may mean that we as instructors may need to structure participation so it happens more equitably, regardless of academic self-concept. For example, instructors could assign an "equity monitor" during group discussion, whose responsibility it is to make sure that each person in the group gets a chance to contribute (3, 39). Future studies may want to explore the extent to which academic self-concept is malleable and to what extent instructor behavior or course structure could influence it. Furthermore, future studies should explore actual student participation, as opposed to self-reported participation, to further examine the influence of academic self-concept on student behavior in class.

Limitations

This study was done in one physiology classroom at one institution with a specific student population. Future studies should explore the influence of student characteristics on academic self-concept in other settings. Additionally, students self-reported their participation with regard to their groupmate; the actual level of participation could be different than what the student perceives. Furthermore, reporting on how smart one feels compared with another person may cause students to answer the question in a socially desirable way, although 32.7% of the students admitted to perceiving themselves as smarter than their partner, and 71.3% perceived they were smarter than at least 50% of students in the whole class.

Conclusions

In exploring student academic self-concept, we found that men and native English speakers had significantly higher academic self-concept relative to the whole class compared with women and nonnative English speakers, respectively. We also found that men had significantly higher academic self-concept relative to their groupmate compared with women. Students identified aspects of active learning that impacted their perception of academic self-concept. Finally, we found that students were more likely to report participating less than their groupmate, if they had a lower academic self-concept.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

K.M.C. and S.E.B. conceived and designed research; K.M.C., A.K., and S.E.B. performed experiments; K.M.C., A.K., and S.E.B. analyzed data; K.M.C. and A.K. interpreted results of experiments; K.M.C. prepared figures; K.M.C., A.K., and S.E.B. drafted manuscript; K.M.C., A.K., and S.E.B. approved final version of manuscript.

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