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Research Article

Transfer-bound community college students' biology identity and perception of teaching

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ABSTRACT Community colleges are frequently an affordable, accessible entrance to a Science, Technology, Engineering, and Mathematics (STEM) education and career, but the transition from a 2-year program to a 4-year institution can be tumultuous. In this mixed-methods study, we explore the experiences of transfer and prospective transfer students. Through surveys and interviews, we identify the challenges faced by and the supports desired by biology transfer students. We describe how community college students perceive their introductory biology courses, and we compare the biology identity and self-efficacy of these students to peers at a 4-year institution. Students expressed uncertainty about what to expect from the transfer experience, and they benefitted from interventions that made the university experience more concrete or clarified their expectations. We found that community college students are just as interested in biology as peers at a 4-year university, but they are significantly less likely to believe that others recognize them as "biology people" and report less self-efficacy regarding biology courses. Students felt particularly well-prepared for transfer after community college biology courses they described as "rigorous" and "demanding," especially because students expressed that the community college environment helped support them through the challenges of higher education.

KEYWORDS transfer experience, biology identity, active learning, community college, undergraduate

Community colleges are a critical entrance point into STEM fields, especially for students from historically underrepresented groups (1). The affordability, accessibility, and flexibility of many 2-year programs often fit the needs of first-generation college students, non-traditional students, and students from racial and ethnic minorities better than 4-year programs. Community college educators have a platform for cultivating biology interest and skills in students who might have missed these opportunities earlier in their educations (2). A core goal of many community colleges is to prepare students to transfer to a 4-year institution (3), but despite the attention paid by researchers to community colleges as an entry point toward baccalaureate degrees, students' transition to a 4-year college or university can be difficult for them to overcome.

Our aim was to understand the experiences of community college students before and after transferring to a 4-year university, including the challenges or barriers they perceived and academic experiences that they found beneficial to the transfer process, particularly via their introductory biology courses. We were especially interested in three interrelated affective qualities, biology identity, interest, and self-efficacy, which have been shown to support persistence in undergraduates (4). Understanding differences in these affective qualities between biology students at a 2- and a 4-year institution may provide useful insights for programs seeking to improve the transfer experience.

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Students' perceptions of their biology courses are shaped not only by their performance but also by whether they believe themselves to be "science people," i.e., their science identity (5). This science identity is shaped by experiences in learning environments, accessibility of role models, and intersections with other aspects of identity (6). Identity can be a strong predictor of student persistence in classes (7) and longer-term persistence in science careers (8). These effects are stronger in first-generation students and members of historically excluded racial or ethnic groups (9–11). Community colleges in particular have been identified as a particularly important avenue to foster science identity in students (12, 13), though science identity among these students is not well-studied.

The theoretical framework for science identity includes recognition (how they see themselves and believe others see them), competence (knowledge and understanding of science content), and performance (ability to perform scientific practices) (14). More recently, researchers have modified instruments of science identity to measure discipline-specific identity (e.g., physics identity and chemistry identity) using social-cognitive career theory (15) and Bandura's social cognitive theory (16) to ground them. These discipline-specific identity measures expand upon the original sub-constructs of recognition, competence, and performance to include interest (desire to understand the subject). In addition, performance and competence were redefined to reflect confidence in ability rather than current ability. Self-recognition was also included in the discipline-specific model in addition to recognition by others. These discipline-specific measures have gone through multiple iterations and psychometric testing (17–21). Discipline-specific models are seen as more relevant than a generalized science identity with inexperienced student populations who have not had exposure to research experiences (22). We specifically explored *biology identity* as opposed to the more general *science identity*. Researchers have shown that discipline-specific wording in identity instruments more strongly predicted the relationships between major elements of identity formation (23).

Self-efficacy is defined as one's expectations about their ability to succeed at tasks (24). Although it is not named as a specific sub-construct in the theoretical framework for discipline-specific identity, self-efficacy is related to the sub-constructs of competence. Self-efficacy is crucial for forming a science or discipline-specific identity (25), particularly among minority students.

Since self-efficacy and interest (a sub-construct of identity) are important to the development of identity, they all can be influenced by active learning and may be part of the mechanism for why active learning leads to improved student outcomes. Active learning instructional methods help expose students to identity-building experiences. These methods give students practice and experience with the application and analysis of course material and particularly benefit students from underrepresented groups (26–28). Active learning has been shown to foster both interest and self-efficacy across a wide range of disciplines (29, 30). While active learning typically enhances students' identity, interest, and self-efficacy, the reverse can also be true: students' perceptions of their abilities, identity, and interests affect how they experience active learning (31).

Low interest or self-efficacy may increase student resistance to active learning. Student "buy-in" to formative assessments as part of active and problem-based learning can affect the benefits derived from these instructional methods. Student's perceptions of their instructional environment can have a stronger impact on academic success than prior performance (32), and students with positive impressions of specific active learning techniques saw increased academic benefits from those methods (33). Students still show increased learning from active learning classrooms, however, even when they have negative perceptions of that teaching style (34).

Using qualitative and quantitative data, we describe the experiences of groups of prospective transfer students at a community college and of students following transfer to a 4-year institution. With these data, we address three specific research questions:

RQ 1) How do students view the transfer process?

RQ 2) Do biology identity, self-efficacy, or interest differ between community college and 4-year college students completing introductory biology courses?

RQ 3) What instructional methods do prospective transfer students value in an introductory biology course?

METHODS

East Carolina University (ECU) and Pitt Community College (PCC) are located in neighboring towns in the same county in eastern North Carolina. ECU is a large doctorate-granting university (*R2*; 35); PCC is a 2-year college offering associate's degree and continuing education programs, technical certifications, and multiple programs for high school students. Approximately 300 students transfer from PCC to ECU each year (Integrated Postsecondary Data Education System [IPEDS] 2016). Demographic characteristics of both institutions are summarized in Table S1.

At ECU, there has been an effort to build identity-developing practices into the introductory biology curriculum using active, student-centered learning practices like problem-based learning in lieu of traditional lectures (36, 37). Since transfer students typically took their introductory courses at their previous institution, instructors at ECU and PCC collaborated to introduce pedagogical approaches to the introductory biology sequence at PCC (Bio 111, fall, and 112, spring) similar to those used at ECU. Additional details about course activities and delivery are available in the supplemental material.

Data sources

Data for this study included demographic and institutional data, along with three surveys, each addressing a different research question, and a series of semi-structured research interviews. Additional methodological information for each of the surveys and the interviews is included in the supplemental material. All aspects of the human subject research were approved by the Institutional Review Board at ECU (UMCIRB 18–001371).

Demographic and institutional data

Demographic data were collected on PCC students enrolled in introductory biology sections participating in the project. Students completed a demographic survey (n = 46) at the beginning of the semester, and we received final course grades from both PCC and ECU about the survey and interview respondents. We included gender, age, race/ethnicity, and parent education in our analysis. Due to small sample sizes, racial and ethnic groups were categorized as "persons excluded due to ethnicity or race" (PEER) or non-PEER after Asai (38). Students were also classified as "first-generation" college students if their parents' highest educational level was less than a bachelor's degree and as "early college" if they were enrolled as high school students, "non-traditional" if they were 24 years or older, and "traditional" otherwise.

Barriers and resources survey (RQ1)

This survey from 2016 of students who had transferred into ECU biology identified barriers the students experienced as well as resources they felt would have been beneficial to their transition to ECU. Students were categorized as "transfer students" if they transferred at least 24 course credits within the previous 3 years. Out of 179 potential transfer student participants, 41 students completed the survey; nine respondents were excluded because they were re-admitted students (n = 3), or their transfer credits were from dual high school-college enrollment (n = 6).

The survey used was developed by a committee of biology faculty members, with additional feedback provided by other faculty and current transfer students. The survey (see the supplemental material) included multiple choice and open-response questions on students' backgrounds, motivations for transfer, difficulties experienced, and supports recommended. Students gave an overall rating of their transfer experience on a scale of 1 (very easy) to 7 (very difficult).

Identity surveys (RQ2)

At the end of three semesters, PCC students were asked to complete a biology identity instrument (23). Forty-six students completed the survey, but we excluded the results of six individuals for whom we were unable to get final course grades leaving 40 responses for analysis. For comparison, the biology identity instrument and demographic survey were also given to ECU students completing their first semester of introductory biology in Fall 2018 (n = 166). We used propensity score analysis to subsample the ECU respondents to create a matching subsample of 40 ECU students with similar demographic characteristics to the sample of 40 PCC students to use for comparison (see the supplemental material for details).

The identity instrument we used was the biology-specific equivalent of discipline-specific identity instruments from chemistry, math, and physics (17–21, 23) that have been previously validated. The survey asked students their extent of agreement with 13 statements about themselves on a Likert scale ranging from 0 ("not at all") to 4 ("very much so"). Items on this instrument corresponded to the three sub-constructs: recognition (items 2–4), self-efficacy/competence (items 5–11), and interest (items 12–14). Additional details about the survey, including factor analysis and inter-item correlations, are available in the supplemental material.

FABUS survey (RQ3)

PCC students completed the "formative assessment buy-in survey" (FABUS, n = 45 (39)) near the end of the semester to assess student views of the formative assessments incorporated for active learning. The FABUS instrument included both open-response questions and Likert-style closed-response questions. Closed responses were summed as a total FABUS score ranging from 7 to 35 (see supplemental material for details).

Open responses on the FABUS instrument were coded in NVivo 12 (QSR International) using the codebook developed by Brazeal et al. (39) with some additions emerging from frequent responses. The surveys were coded by two researchers who achieved an inter-rater reliability of kappa = 0.73. After initial coding, codes were aggregated into several broad categories: "generic" positive comments, "specific" positive comments, negative or neutral comments, and hands-on activities, with examples given in Table 1.

Interviews

To evaluate how the students viewed the transfer process and how their experience in their introductory biology course at PCC impacted their beliefs and perceptions, semi-structured one-on-one research interviews were conducted with PCC students who completed Bio 111 in Fall 2020 and Bio 112 in Spring 2021 (n = 8), as well as with current ECU students who transferred from PCC and had completed Bio 112 at PCC in Spring 2019 or 2020 (n = 6). Transcriptions of recorded interviews were iteratively coded using a combination of structural coding to assign responses to the core questions asked and descriptive coding to categorize specific details (40). Major codes for each of the interview topics are summarized in Table 2, and a list of interview questions is provided in the supplemental material.

Survey analysis

We used Kruskal-Wallis rank sum tests to compare the survey responses across demographic groups and student type (traditional, non-traditional, or early college), and Wilcoxon rank sum tests to compare biology identity between PCC students and the matched cohort of ECU students. If Kruskal-Wallis tests suggested significant differences between groups, Dunn's test of multiple comparisons with a Bonferroni P-value correction was used to test for pairwise differences. All statistical analyses were completed in R 4.04 (41). Figures were produced using the *ggplot2* package, within the *tidyverse* toolset (42, 43).

TABLE 1 Most frequently used codes of the FABUS open-response questions, the percent of coded responses covered by that node, and a representative example for each code

Code	Example quotes	Percent coverage
Improves learning (general)	"To get a better understanding of the topic and to help remember it better."	27.700
Hands-on experience	"To gain hands-on experience."	14.085
Negative or neutral—aggregate	Negative: "made me feel stupid most of the time." Neutral: "Did not seem to influence the way my instructor teaches."	8.920
Encourages applications or connections	"To help us be able to relate what we are learning to real life applications."	8.920
Provides study tool for students	"They also are good practice and help me better retain the course material."	5.164
Allows students to self-assess or correct their misunderstanding	"In-class activities help clear up any confusion"	5.164
Promotes student ownership of learning	"Made me think more independently."	4.695
Generic positive comment	"Fun and educational"	4.225
Encourages or changes thinking	"I think in-class activities are used in this course to let students think about the topics on a deeper level and give us a better understanding rather than just reading about it and trying to comprehend the concepts."	3.756
Other purpose	"Maintain the integrity of the course."	3.286
Gives instructor evidence of student learning	"Find new ways to test our knowledge."	2.817
Changes instruction based on student understanding	"It helps [the teacher] understand what we don't understand."	2.817
Improves study habits or pre-class preparation	"Motivates me to try harder at home."	2.347
Facilitates peer learning	"Facilitate communication among the students."	1.878
Improves attendance or in-class behaviors	"To get us participating."	1.878
Provides general assessment	"One can show what they have learned."	1.408
Clarifies learning intentions and criteria for success	"So they can teach us … material that we need to know."	0.939

RESULTS

Perceptions of transfer

Barriers and resources survey

Over two-thirds (22 of 32) of ECU transfer students who completed the barriers and resources survey (supplemental material) had transferred to ECU from a 2-year college. Students who started at a 4-year institution reported a slightly but not significantly easier time beginning at ECU (median = 2.5) compared to students who started at a 2-year institution (median = 4, $P = 0.16$, Wilcoxon rank sum test).

Out of the 11 options listed (item p), students selected on average 3.25 difficulties that they had experienced. Most common among these were finding a social network (47% of respondents), adjusting to the teaching style at ECU (44% of respondents), and adjusting to larger class sizes (44% of respondents). In an open-ended prompt to describe barriers (item q), one-third of respondents reported advising or registration issues as the largest barrier they faced. Only four (out of 21) responses to this question compared academic experiences between students' current and former institutions; two of these focused on class size differences and the other two focused on the difficulty of coursework or teaching style differences.

When asked to select from a list of events or programs that would better support transfer students (item r), the most popular choices were increased programming to build a social network within biology (62.5%) or with student organizations (50%) and better access to advising opportunities (47%). One student wrote in the additional suggestion of advising opportunities at the community college level, before transfer, so that students could have a clearer plan or pathway for their degree. A complete summary of the barriers encountered and supports requested can be found in Fig. 1.

TABLE 2 Major codes used for interview analysis[a]

Research topic or theme	Code	Count	Example
Transfer challenges			
	Class size and instructor access	6	"I don't feel as though I'm doing as well in some of those science classes as I did in [instructor]'s class because they're so large. It's almost a little overwhelming."
	Logistical concerns	6	"Keeping up with everything. Like the campus is massive and like I think one of the biggest things for me was finding a place to park and just. I guess keeping up where like all the classes are."
	Life challenges	4	"I had just gone through a huge life transition. We moved […] corona virus, my daughter was home, my wife was still working, I mean it sounds like a country song, you know?"
	ECU course difficulty	3	"I thought the classes were going to be much, much more challenging."
	Uncertainty	3	"I'm so far I'm just confused."
Challenges and motivations			
	Grades or academic concerns	10	As challenge: "I had to withdraw from that class because, you know, I didn't want it to affect my GPA." As motivation: "And I really want good grades."
	Financial	2	"Of course I'm open to learning a lot and everything, but of course it's something that I would be paying for a time that I would be investing."
Desired supports			
	Advising and support pre-transfer	11	"I think a lot of students would find it beneficial if somebody just came in. Like maybe just like once or something like that and really explained the transition between … studying at [PCC] and then transferring to somewhere like ECU and how that would work?"
	Collaboration between schools	5	"I would have liked to interact with like ECU professors. OK, a little more like if they would have come to Pitt or if we would have done what we did at Pitt, like coming over to the campus here."
Goals for transfer			
	Career goals	10	"Learning and being able to find a career that I was interested in for the rest of my life."
	Networking and social	8	"Just to meet new people, to make connections and really find out what I'm trying to do for the rest of my life."
	Undergrad Research	3	"I was looking more to, well one I was looking for research experience."
	Campus Involvement	2	"I want to participate—hopefully when I go to campus—participate in clubs and volunteering and be active in the campus as much as I can."
	Personal growth	2	"Life skills, I want to get life skills. I have my college experience."
Connections between Bio 111/112 and transfer experience			
	Preparedness	13	"It helped me a lot with figuring out my study habits and ways I can prepare better compared to high school."
	ECU Visit	7	"[The visit was a] nice, kind of like introduction, or here's a little peek inside before you enroll and actually dive in headfirst. Like, dip your toe in the water."
	Comparisons to other courses	6	(Comparing Bio 112 versus ECU classes) "like material wise it's pretty similar. Or like how much you have to study and things like that."
Bio 111/112 course experience			
	Instructor	13	"My instructor. She's amazing and I love it to be there."
	Difficulty or amount of course content	12	"It's not, it's not easy. It is definitely a class that requires a lot of time."
	Hands on	11	"'hands on'" was the first word that came to my head because it was in person."
	Time management requirements	9	"It's not a class that you can really procrastinate on. Either you have to invest a lot of time, if you want to do well."

(*Continued on next page*)

TABLE 2 Major codes used for interview analysis[a] (*Continued*)

Research topic or theme	Code	Count	Example
	Group Work	8	"Sometimes the group work was beneficial, sometimes I felt like it was kind of counter-productive, like I would have just done better by myself."
	Traditional lectures or teaching methods	7	"I would feel like it was more lecture based, during the lecture time."
	Course resources	5	"And there was various resources, much more resources than from any other class I've ever taken."
	PBL[b]-specific mention	5	"The problem-based, kind of working in groups was a little bit of an adjustment for me."
	Study skills and habits	5	"It wasn't just biology, at the beginning of the course, actually she had started off with modules on how to study, time management, metric system and measurements."
	Independence	4	"You had to really work by yourself."
	Application of knowledge	3	"…when we learned about the animal section and everything it make me like look different of how my small activities might affect other animals or consuming lots of lots of things that I actually don't need that will affect the environment and the world."
	Activities or interactive work	2	"She had links to all sorts of interactive, either activities or learning things that were biology related."
Biology identity, career goals, and motivations			
	Science Interest	8	"I want to continue to learn, whether its when I go to get my bachelors, maybe taking another biology course or something. I want to teach my daughter a lot of this information, get her interested in this, because it was truly amazing, the information I've learned."
	Pre-health	4	"I just know I wanted to do premed, and I ultimately want to be a pediatrician."
	Motivation—helping others	3	"Help other people out and just making other people feel better."

[a]Count is the number of interviews (maximum of 14) in which the node was coded; examples are representative quotes from transcribed interviews.
[b]PBL, problem-based learning

Interviews

Uncertainty was a common theme when students were asked to describe challenges they anticipated or experienced during the transfer process. Three students explicitly noted being uncertain about what to expect as the primary challenge as they planned their transfers (quote 1, supplemental material). Other kinds of uncertainty, like the fear of getting lost on a much larger campus, not knowing where to park, or not knowing how credits would transfer, were also raised as potential challenges.

Students also had more concrete concerns about transfer. Several noted time management as their biggest challenge, in the context of either handling more coursework or balancing coursework with job or family responsibilities. Students also worried about their ability to build the kinds of relationships with instructors that they had at PCC due to larger class sizes. Four of the six current ECU students reflected this concern, noting that at the community college, it was easier to ask questions or get help because instructors knew students' names.

All but one of the current PCC students believed they were prepared for transfer. The student who felt unprepared based this assessment on experiences of peers at ECU. The interviewed ECU students affirmed the predictions of the prospective transfers; all of them noted that Bio 111 or 112 at PCC was similar in difficulty and workload to their ECU classes and described it as good preparation. One student emphasized that the problem-based learning experienced in Bio 112 was helpful preparation for a later problem-based learning (PBL)-focused class, noting that the teaching style was "not a total shock" when she encountered it at ECU.

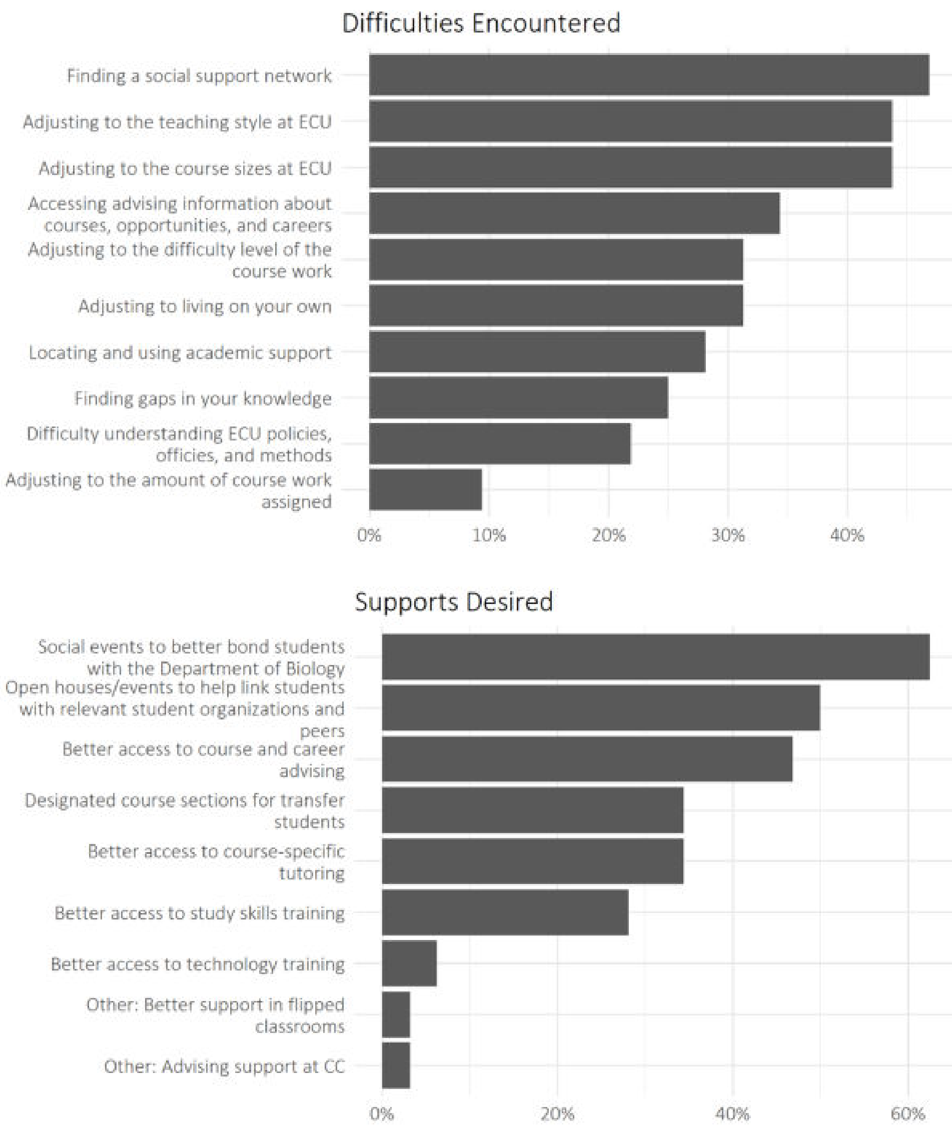

FIG 1 The major difficulties encountered (top) and supports desired (bottom) as selected by biology transfer students. Difficulties were included if they were selected by at least two respondents.

Four students described the opportunity to complete one of their Bio 112 lab activities at ECU with ECU students as an important experience in reducing their anxiety about the transfer process (quotes 2 and 3). This opportunity only occurred once before the COVID-19 pandemic made it too difficult to do. When asked for ideas about what would relieve some of their anxieties about transfer, four of eight current PCC students mentioned a campus visit experience in which they could meaningfully interact with ECU students and courses, like their experience visiting the ECU introductory lab course. The students reported this opportunity as being particularly meaningful, without us mentioning that experience, even though it had taken place 2 or 3 years earlier.

Biology identity

Identity survey

In the propensity-scored subsample, ECU (n = 40) and PCC (n = 40) students showed no difference in their interest (P = 0.89, Wilcoxon rank sum) or overall identity (P =

0.22, Wilcoxon rank sum) scores on the biology identity survey. ECU students reported significantly higher self-efficacy ($P = 0.04$, Wilcoxon rank sum) and recognition ($P = 0.03$, Wilcoxon rank sum) scores (Fig. 2).

Interviews

More than half of the interviewed students mentioned the introductory courses they completed at PCC as sparking a particular interest in biology. Students mentioned finding the material "cool," and being particularly excited by topics with real-world applications. Two students mentioned sharing material they learned with family members after class, and two students stated that, had they not already chosen other majors, Bio 111 or 112 at PCC would have convinced them to study biology.

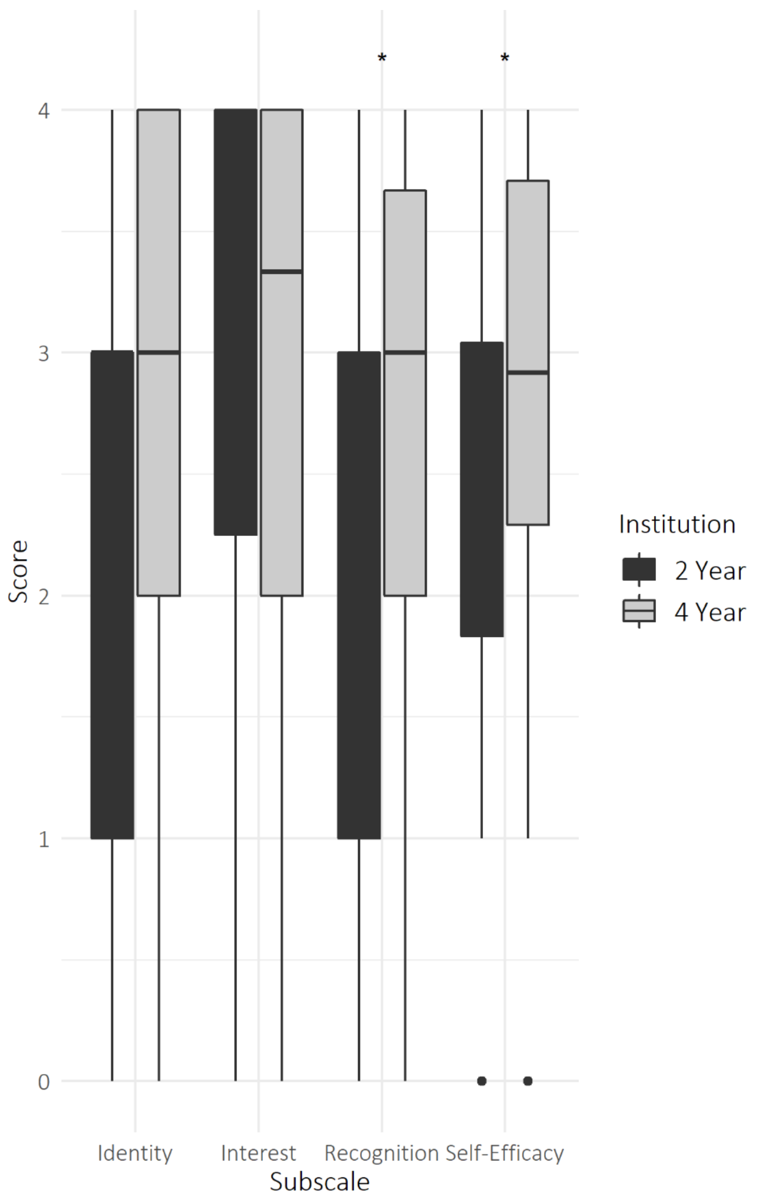

FIG 2 Biology interest and identity did not differ significantly between students completing an introductory biology course at a 2- (PCC) versus 4-year (ECU) college, but self-efficacy ($P = 0.04$) and recognition ($P = 0.03$) constructs were significantly lower among community college students (Wilcoxon rank-sum test, $n = 80$). All comparisons are with a propensity-matched subset of the 4-year college students.

Most interviewed students who were not biology majors or intended majors at ECU were motivated by other interests or specific career goals, but two students noted specific barriers to being a biology major. One current ECU student who had transferred from PCC explained that he changed his major away from biology after struggling with mathematics and physics courses online (during the pandemic). Another student focused on the challenges she faced as an ESL student learning the large amount of vocabulary needed for biology courses.

Course experiences

FABUS survey

PCC students generally agreed or strongly agreed that the formative assessment (in-class activities) they experienced were beneficial to them. FABUS scores ranged from 20 to 35, with a median of 30 and mean of 29.6. We found no difference in FABUS scores among students of different genders or student types or between first-generation and non-first-generation students. PEER students showed a marginally higher total buy-in (median 31.5) compared to non-PEER students (median score 27.5, $P = 0.09$, Kruskal-Wallis test).

The most frequently used codes for open-response FABUS questions are listed in Table 1. Over a quarter of the comments by students were general statements about how the activities "improved learning" without offering any specific details. The most often-mentioned specific benefit was the opportunity for "hands-on" experience, a code we added because of how frequently it appeared, which appeared in 14% of responses. Nine percent of students gave answers related to "applications or connections," especially to real-world issues.

Less than 10% of the 45 responses expressed neutral or negative feelings about the course activities. Very few of these comments were strictly negative; most of these students thought that the activities were partially beneficial to them or expressed uncertainty about them. Two students explicitly stated that activities detracted from their instructor's teaching, and three comments thought that activities confused or frustrated them.

Interviews

All interviewees were asked to describe the learning style in PCC's Biology 111 or 112 as they remembered it, with additional prompting if students focused on the instructor or course delivery method. The most common characteristics of the course, mentioned by 12 of 14 students, were the quantity or difficulty of information presented. For half of these students, it was the first thing mentioned about the class. Commonly used words included "rigorous," "demanding," or "challenging," with most students stating that it was harder than their other classes at PCC; two of the ECU students also believed it was more challenging than many of their ECU courses (see quote 4).

Seven students noted that good time management was necessary to be successful in the class, though this was more frequently mentioned by students who took the course primarily online (six of eight students) than those who took the course in person (two of six students). Despite the emphasis on difficulty and workload, most students described feeling well-supported in the class. Nine students described the practices their instructor used to support their learning: giving clear expectations for assignments, answering student questions regularly, and providing multiple course resources for topics covered.

More traditional course experiences, like lecture material, were mentioned more frequently (10 times in seven interviews) than problem-based or active learning (eight times in six interviews). Two students mentioned problem-based activities without prompting from the interviewer when asked to describe the course generally. Other students mentioned features of problem-based learning, like group work (14 references) and applications to the real world (four references), without mentioning problem solving specifically. As on the FABUS, 11 students also highlighted opportunities for other kinds of hands-on experience, especially microscope activities, anatomical models, and other lab activities (including at-home lab activities when the course was entirely remote).

DISCUSSION

Transferring from one institution to another can be a significant upheaval, and the challenge can be even greater for students transferring from smaller community colleges to a large 4-year college or university. Our goal in this paper has been to understand the perceptions of students planning to transfer from 2- to 4-year colleges through the context of their introductory biology courses. Evaluating the identity, self-efficacy, and interest of transfer and non-transfer students provides context for their perceptions of active learning approaches in these courses and suggests potential starting points for improving the transfer process for biology students.

How do students view the transfer process?

Among the students we interviewed who had not yet transferred, the attitude toward transfer can best be summarized as "cautiously optimistic." All the students we spoke to intended to transfer, and most had clear academic and career goals they were trying to achieve. Most felt prepared for courses at a 4-year college and thought that their biology course at PCC was good preparation for the study skills and time management they would need in the future, and these sentiments were echoed by the ECU students we interviewed.

When we asked current and prospective transfer students about opportunities that would improve their transfer experience, their responses reflected the recommendations of Townsend and Wilson (44) and Laanan (45) to focus on reducing students' feelings of uncertainty as they adjust to a new academic environment. These include meaningful campus visits that provide opportunities to sit in on courses, pre-transfer advising that clearly presents requirements and expectations of the transfer institution, and orientations that focus on logistics to navigate campus rather than typical "freshman" orientations for students new to the college experience (46, 47).

For the students who had the opportunity, completing a lab activity at ECU with ECU students in the equivalent introductory course was described as an important factor in reducing anxiety about transfer. After one class period, these students reported feeling more comfortable with the campus, other students, and class expectations. Because it was integrated into a class, students actively participated (unlike other interventions like advising visits, which were optional and poorly attended). Based on our interviews, visiting ECU's campus was more impactful than visits to PCC by ECU faculty, which no student mentioned when describing the course. When feasible, building course-based connections between 2- and 4-year colleges may provide significant benefits to transfer students, though long-term impacts on our population will not be seen until more students advance through the transfer process.

Do biology identity, self-efficacy, or interest differ between community college and 4-year college students completing introductory biology courses?

Identity has been found to be a strong predictor of persistence in STEM majors (and later, careers) (14), so the disparities we observed between 2- and 4-year college students, who had each completed a semester of introductory biology, were concerning. These community college students were just as interested in biology and only slightly less likely to see themselves as "biology people," but they were significantly less likely to believe that others see them this way or view themselves as able to do biology. "Being recognized as a certain 'kind of person'" is a core definition of identity development (5), so students at community colleges might benefit from having their introductory biology instructors be more intentional about recognizing them as "biology people." Activities that give students the opportunity to be "community science experts" (48) might be particularly beneficial, as would opportunities for students to interact with scientists who reflect underrepresented groups in biology (12).

Self-efficacy relates to the competence sub-construct of identity, and PCC students reported lower scores than their peers at ECU. Self-efficacy beliefs are strongly associated with academic performance and persistence, especially for students early in their university educations (49). If community college students leave introductory biology courses with lower self-efficacy than their peers at 4-year colleges, improving self-efficacy may be a way to improve the transfer experience (50). Active learning approaches have been shown to increase self-efficacy (29, 30) so changes in teaching styles at the community college might help reduce the gaps we observed.

What instructional methods do prospective transfer students value in an introductory biology course?

On the basis of the results of the FABUS survey, students respond well to formative assessments that let them experience their course material and activities with real-world applications. Students frequently asserted not only that the courses were "difficult" but also that they were a positive experience. The perception that a course is particularly difficult is often regarded as negative if the course acts as a barrier toward the completion of a degree; chemistry (51) and anatomy and physiology (52) are often considered in this manner with respect to biology students. It may be a worthwhile avenue of future research to try and understand the differences between "difficult" courses that are positively perceived by students versus "difficult" courses that leave negative impressions.

One trend in qualitative responses (to both the open-ended survey questions and interviews) was that students frequently described positive feelings about their PCC instructor when asked to describe the course itself. Cavanagh et al. (53) show that trust in the instructor is an important predictor of students' favorable assessment of and success in active learning classrooms. One current ECU biochemistry student explicitly discussed the problem-based activities in Bio 112 as good preparation for courses after transfer because it offered the chance for learning to be student-directed but with more instructor support than in later classes. This kind of instructor support, mentioned by many other students, is similar to "autonomy-supportive teaching practices," like self-pacing and time to ask questions; these practices have been shown to increase persistence among students in challenging courses (54, 55). Instructor support and small class size may make community college classrooms an excellent environment for introducing students to modes of instruction like problem-based learning, though this would require additional institutional support for the teachers in these classrooms.

Limitations

Our most significant limitation was our lack of longitudinal data. In the context of this study, we were unable to track students through the remainder of their educational careers to understand the impacts of their perceptions of their experiences and their identity, self-efficacy, and interest in retention and degree attainment. In addition, our sample size was limited by small PCC class sizes and somewhat low response rates to surveys and interview requests. This low response rate limited our ability to make pre-to-post-course comparisons for biology identity and self-efficacy data. To entice participation in completing our surveys and participating in interviews, students were offered either extra credit (current PCC students) or gift cards (PCC transfer students at ECU). Not always providing the same incentive was a limitation, but it was necessary due to logistical constraints from instructors. In general, we found that offering extra credit led to higher student responses than offering gift cards, though there might be bias based on course performance introduced by this type of incentive.

Conclusions

The changes that may be required to better support transfer students cannot be the sole responsibility of the community college but rather require partnership between 2- and 4-year institutions (47, 56, 57); our barriers and resources survey of current transfer students illustrated that many of the barriers that students identify come from inadequacies at the 4-year institution rather than from preparation at the 2-year institution. Giving students meaningful student-centered learning opportunities at 2-year colleges, as well as making sure that students understand the rationale for those activities, will help foster the affective characteristics, like strong biology identity and self-efficacy, that increase resilience and persistence in college students. While high-impact practices have demonstrated impacts on transfer success (58), even smaller changes, like replacing lectures with problem solving activities once or twice a month, or a single campus visit, may make a difference in improving the transfer experience of STEM students.

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ADDITIONAL FILES

The following material is available online.

Supplemental Material

Supplement (jmbe00116-23-s0001.pdf). Supplemental data and methods.

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