

Community College Student Understanding and Perceptions of Evolution

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ABSTRACT

Learning about evolution is a foundational part of biology education, but most current studies that explore college student evolution education are conducted at universities. However, community college students tend to be more diverse in characteristics shown to be related to evolution education outcomes. To explore how studies involving university students may generalize to community college students, we surveyed students from seven community college ($n = 202$) and nine university ($n = 2288$) classes. We measured students' evolution interest, acceptance, and understanding, and for religious students, we measured their perceived conflict between their religions and evolution. Controlling for state and major, we found that community college students had similar levels of evolution interest as university students but perceived greater conflict between their religions and evolution. Further, community college students had lower evolution understanding and acceptance compared with university students. Religiosity was a strong factor predicting community college and university students' evolution acceptance. However, unique to community college students, evolution understanding was not related to their macroevolution or human evolution acceptance. This indicates that, although some results between community college and university students are similar, there are differences that have implications for evolution instruction that warrant the need for more evolution education research at community colleges.

INTRODUCTION

Evolution is a core theme of biology that educators have been encouraged to teach at every level of biology education, including at the level of introductory college biology (American Association for the Advancement in Science, 2011; Brownell *et al.*, 2014). Even though evolution is a foundational concept in biology, it is controversial among introductory biology students, particularly when they are considering the validity of macroevolution and human evolution (Nadelson and Southerland, 2012; Barnes *et al.*, 2020a; Pobiner, 2016). Introductory students also tend to have low understanding of evolution (Paz-y-Mino and Espinosa, 2011), even after instruction on evolution (Short and Hawley, 2015; Green and Delgado, 2021). These low levels of evolution acceptance and understanding have led researchers to explore what factors influence students' evolution acceptance and understanding as well as how to increase these outcomes (Wiles and Alters, 2011; Glaze *et al.*, 2014; Barnes *et al.*, 2017a; Dunk *et al.*, 2017; Lindsay *et al.*, 2019). However, almost all these studies have been conducted with students at 4-year universities.

Prior Research on Evolution Education at Community Colleges and Universities

While dozens of studies have explored university students' understanding and acceptance of evolution (e.g., Nehm and Reilly, 2007; Rice *et al.*, 2010; Wiles and Alters, 2011;

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Rutledge and Sadler, 2011; Winslow *et al.*, 2011; Ha *et al.*, 2012; Rissler *et al.*, 2014; Barnes *et al.*, 2017a; Dunk *et al.*, 2017; Archer *et al.*, 2018; Sbeglia and Nehm, 2018; Betti *et al.*, 2020), only a small number of peer-reviewed studies have explored community college students' evolution understanding and acceptance, and these studies are mostly limited to examining descriptive levels and not relationships between variables (McKeachie *et al.*, 2002; Flower, 2006; Scharmann and Butler, 2015; Brown and Scott, 2016; Dorner, 2016; Green and Delgado, 2021). Further, studies on community college students' evolution perceptions are often limited to one geographic region. The religious demographics of populations in the United States vary substantially between geographic regions and is a major factor impacting evolution acceptance. So, the geographic region in which studies are conducted can have a large impact on the results. Below we describe prior research conducted at community colleges and universities in different geographic regions of the United States.

One study of 60 community college students in the Midwest found that only half of biology students reported that they accepted evolution, while the other half were either unsure of their acceptance or did not accept evolution (McKeachie *et al.*, 2002). Another study that examined students in introductory biology community college classes in California found that, among biology majors and nonmajors students, only around half of them reported that animals, plants, and humans developed from earlier species (Flower, 2006). In this same study, it was documented that ~13% of students were not at all familiar with evolution before taking the biology class at the community college. At one community college on the West Coast, Dorner (2016) found that ~17% of biology students had low scores on the Measure of Acceptance of the Theory of Evolution, and in the Southeast, Green and Delgado (2021) showed that community college students scored low on their understanding of evolution at the beginning of their introductory biology classes. Thus, studies demonstrate that there are low levels of acceptance and understanding among community college students, but we know of no studies that directly compare community college students and university students. Beyond the lack of comparisons, no studies to our knowledge have adequately explored factors that influence evolution education outcomes for community college student populations.

It is common for researchers to explore factors related to evolution acceptance in studies on university students. At 4-year universities, students often describe experiencing a perceived conflict between their religions and evolution when they are exposed to evolution instruction (Dagher and BouJaoude, 1997; Winslow *et al.*, 2011; Barnes *et al.*, 2017b). In survey studies of university students, researchers have found that some of the strongest factors influencing evolution acceptance are students' religious backgrounds and how much conflict they perceive between their religions and evolution (Glaze *et al.*, 2014; Rissler *et al.*, 2014; Dunk *et al.*, 2017; Barnes *et al.*, 2021b). However, these studies have not been conducted with community college students, so we do not know whether these results extend to this population.

The relationship between evolution acceptance and understanding is inconsistent in studies of university students. Researchers have found that evolution understanding and acceptance are strongly associated with one another in some university populations (Rutledge and Warden, 2000;

Trani, 2004; Lombrozo *et al.*, 2008; Glaze *et al.*, 2014; Dunk *et al.*, 2017), while evolution understanding is only weakly or not at all associated with evolution acceptance in other university populations (Lawson, 1983; Bishop and Anderson, 1990; Brem *et al.*, 2003; Sinatra *et al.*, 2003; Deniz *et al.*, 2008; Nadelson and Sinatra, 2009; Cavallo *et al.*, 2011; Athanasiou and Papadopoulou, 2012; Großschedl *et al.*, 2014). Although different evolution acceptance surveys that researchers use may influence their results (Barnes *et al.*, 2019), results have also been shown to be different across populations of students (Barnes *et al.*, 2019). The only study that we know of that has examined the extent to which evolution understanding is related to evolution acceptance among community college students used an instrument known to conflate evolution acceptance and understanding (Rutledge and Warden, 1999; Smith, 2009; Smith *et al.*, 2016), so the results may not be valid (Brown and Scott, 2016).

Differences between Community College Students and University Students That May Affect Their Perceptions of Evolution

Community college students differ in several ways from university students that may result in a misalignment between what is effective evolution instruction for community college students and what is effective for university students. Community college students are more diverse than university students. They tend to have a wider age range compared with university students, resulting in a higher average age in introductory classes. They are also more likely to be first-generation college students (American Association of Community Colleges, 2021). Further, students at community colleges are more likely to identify as Black, Hispanic, or Indigenous and come from lower socioeconomic backgrounds (American Association of Community Colleges, 2021). These demographic differences are important to consider, because some of these variables have been associated with lower evolution acceptance and understanding.

First-generation status and race/ethnicity are associated with differences in evolution education variables (Sbeglia and Nehm, 2018; Barnes *et al.*, 2019; Barnes *et al.*, 2020b). Students whose parents have lower levels of education tend to accept evolution less compared with students whose parents have higher levels of education (Barnes *et al.*, 2019). Further, students of color, particularly Black students, also tend to have lower rates of evolution acceptance (Sbeglia and Nehm, 2018; Barnes *et al.*, 2020b), and relationships between variables such as student religiosity and evolution acceptance have also been found to vary by race/ethnicity (Barnes *et al.*, 2020b). Among Black students, there is a weaker negative relationship between religiosity and evolution acceptance compared with white students (Barnes *et al.*, 2020b). Thus, research involving university students may not be transferable entirely to community college students due to differences in demographic variables between community college and university students that are associated with evolution acceptance.

Importance of Conducting Evolution Education Research with Community College Students

Community college students are an important population to include in evolution education studies, but they are rarely included in discipline-based education research. Community

colleges train approximately half of the students who enroll in higher education (American Association of Community Colleges, 2021), and yet between 2012 and 2015, only ~3.2% of studies in discipline-based education research journals included community college students (Schinske *et al.*, 2017). Further, the majority of students from underrepresented groups in science go to community colleges (Van Noy and Zeidenberg, 2014; American Association of Community Colleges, 2021), making instruction at community college not only relevant for half of college students but disproportionately relevant for Black, Hispanic, and Indigenous students (Schinske *et al.*, 2017). Evolution instruction in introductory biology provides a foundation for studying the rest of biology (Dobzhansky, 1973; American Association for the Advancement in Science, 2011; Brownell *et al.*, 2014), and most community college students take introductory biology at a community college and then move to a university to take upper-level courses, making evolution instruction at community colleges particularly important for their later outcomes in upper-level biology courses at universities. Increasingly, we are asking instructors to base their classroom practices on evidence published from the literature, but the lack of research on community college students forces community college instructors to depend on the results of studies that may not generalize to their student populations. Thus, research examining community college student evolution education experiences and perceptions can provide community college instructors with a more relevant literature base to inform their instructional practices.

Current Study and Research Questions

The goal of this study is to illuminate ways that evolution acceptance, understanding, interest in evolution, and perceived conflict with religion may differ between community college and university students to inform community college instruction. We also aim to explore whether variables related to evolution acceptance among university students are also related to evolution acceptance among community college students.

Our specific research questions are:

1. To what extent is interest in evolution, understanding of evolution, acceptance of evolution, and perceived conflict with evolution and students' religions different between community college and university students?
2. To what extent are community college students' understanding of evolution and their religiosity related to their evolution acceptance?

METHODS

Survey Context and Population

The data set used in this study was collected as part of a larger nationwide study examining the impact of instructor use of Religious Cultural Competence in Evolution Education (ReCCEE) on student evolution education outcomes. Cultural competence is the ability of people of one culture to effectively communicate with people of another culture, and ReCCEE provides a framework to help secular instructors communicate about evolution effectively to students of faith (Barnes and Brownell, 2017). The ReCCEE framework includes a set of practices to help reduce perceived conflict between students' religious identities and evolution. We collected data for this project across 14

states. We sampled for this current study by identifying data we had for both community colleges and universities in a similar region in the same state (within 50 miles of one another). Comparing universities and community colleges in the same regions will reduce any differences we might detect between institutions that are due to regional differences rather than institution type. We used data from this study to explore differences between these two student populations before any evolution instruction occurred.

Between Fall 2018 and Fall 2020, we surveyed 202 community college students from northern California and central Arizona and compared these students' responses with responses from 2288 university students who we surveyed in similar geographic regions within central Arizona and northern California. These students came from 15 introductory biology courses (11 majors and four nonmajors). Students from these community colleges often transfer to universities within the same geographic region of our sample. These community colleges and universities have partnerships to facilitate successful transfer from the 2-year to the 4-year institutions and specifically have articulation agreements in which the introductory courses at both institutions are designed to be equivalent so that students can easily transfer credits from the community college to the university. Although we surveyed both majors and nonmajors courses, every course included students who self-reported as biology majors as well as students who reported being nonmajors. The survey response rate was 74%. See Table 1 for a breakdown of course characteristics and the sample size and response rate for each course.

Instructors sent a form email to students with instructions to complete the survey online for a small amount of extra credit. After following the link to the survey, students were taken to a consent form in which they were told they would be taking a survey about their beliefs about biology topics and the relationship between science and religion. Students were told that their responses would be confidential and their instructor would never see their responses. Students could skip any question if they wanted. The survey took approximately 10 minutes for students to complete. All activities were approved by Arizona State University's Institutional Review Board protocol 8191.

Survey Measures

In this study, we measured the following variables: interest in evolution, understanding of evolution, acceptance of evolution, and student perceived conflict between evolution and their religion. Other demographic variables that we collected included parent educational levels, religiosity (how religious one considers oneself), whether the student was a biology major, gender, age, and race/ethnicity, which were all presented at the end of the survey. We also collected information on students' religious denominations. All survey questions analyzed in this study can be found in the Supplemental Material. Descriptions of each measure used in our analyses are presented in the following sections in the order they were presented on the survey.

Understanding of Evolution. Understanding of evolution refers to the extent to which a student has an accurate conceptual grasp of current evolutionary theory and can answer questions about evolutionary theory correctly. We used two subscales from the previously published Evolutionary Attitudes

TABLE 1. Characteristics of each course sampled for this study

Course	Institution type	State	Majors	Response rate	Final sample size
1	Community College	AZ	Majors	87%	79
2	Community College	AZ	Majors	50%	48
3	Community College	CA	Majors	60%	18
4	Community College	CA	Majors	85%	17
5	Community College	CA	Majors	17%	4
6	Community College	CA	Majors	73%	19
7	Community College	CA	Nonmajors	57%	17
8	University	AZ	Majors	74%	115
9	University	AZ	Majors	70%	110
10	University	AZ	Majors	79%	126
11	University	AZ	Nonmajors	90%	388
12	University	AZ	Nonmajors	48%	128
13	University	AZ	Nonmajors	56%	179
14	University	CA	Majors	55%	171
15	University	CA	Majors	82%	1071

Literacy instrument (EALS) to measure students' evolution understanding (Hawley *et al.*, 2011). These subscales were related to understanding of evolution: Evolutionary Knowledge (e.g., "In most populations, more offspring are born than can survive") and Evolutionary Misconceptions (e.g., "Evolution is a linear progression from primitive to advanced species"). The survey questions gave true or false answer options, along with the option "I don't know enough to answer" to avoid correct answers by guessing. The proportion of correct answers was the student's score for evolution understanding.

Other evolution education studies have used the EALS (Short and Hawley, 2015; Dunk *et al.* 2017) and have shown reliability and validity evidence among college students (Hawley *et al.*, 2011). Most importantly, the items of the survey do not seem to conflate evolution acceptance and evolution understanding (Barnes *et al.*, 2019), which is a major critique of many evolution understanding instruments ($\alpha = 0.59$, which is typically considered acceptable for a test that measures content knowledge of a domain; e.g., see Carlson *et al.*, 2010, pp. 136–138).

Acceptance of Evolution. Acceptance of evolution is a distinct construct from evolution understanding and indicates the extent to which a student sees evolution as scientifically valid. A student can understand evolution, yet not accept evolution (Hermann, 2012). Acceptance of evolution can be different for microevolution, macroevolution, and human evolution (Nadelson and Southerland, 2012; Sbeglia and Nehm, 2019; Barnes *et al.*, 2020a), so we used a measure with previous validation evidence for college students that measures all three constructs of evolution acceptance, the Inventory of Student Evolution Acceptance (I-SEA; Nadelson and Southerland, 2012; Sbeglia and Nehm, 2019). Each construct was measured with eight items with which the student agreed or disagreed on a five-point Likert scale. Reliability as determined by Cronbach's alpha was good; α (microevolution) = 0.83; α (macroevolution) = 0.84; α (human evolution) = 0.90.

Perceived Conflict and Religious Affiliation. We measured perceived conflict using a recently published survey of students' perceived conflict between their religions and evolution (Barnes *et al.*, 2021b). This instrument includes four dimensions of per-

ceived conflict between students' religions and evolution: 1) perceived conflict with their belief in God and evolution, 2) perceived conflict with their religious beliefs and evolution, 3) perceived conflict with their religious teachings and evolution, and 4) perceived conflict about evolution within their religious communities. These dimensions were determined based on student interviews and prior literature indicating that there are differences in perceived conflict across different aspects of a religious person's life. For each dimension, students were asked to respond to five questions on a Likert scale from 1 (strongly disagree) –5 (strongly agree). We also asked students to report their religious affiliations, and the perceived conflict items were not presented to students who did not indicate an affiliation with a religion, because the items are specific to those who identify with a religious affiliation. Reliability as determined by Cronbach's alpha was good; α (perceived conflict with God) = 0.94; α (perceived conflict with beliefs) = 0.94; α (perceived conflict with teachings) = 0.94; α (perceived conflict within religious community) = 0.95.

Interest in Evolution. Because interest can be a strong indicator of motivation to learn, we measured students' interest in evolution (Hidi and Harackiewicz, 2000; Harackiewicz *et al.*, 2016). We defined interest as the extent to which students were interested in pursuing course work, research, or careers in evolution. We measured interest in evolution using a previously published instrument with validation evidence for college biology students (Barnes *et al.*, 2021a). This measure consists of four items that ask students to answer on a scale of 0 (not at all) to 10 (very much) the extent to which they would be interested in 1) taking a course in evolution, 2) pursuing undergraduate research in evolution, 3) involving the study of evolution in their career, and 4) becoming an evolutionary biologist. Reliability as determined by Cronbach's alpha was good; $\alpha = 0.88$.

Religiosity. We measured religiosity using four items from a survey previously published with validity evidence for college students (Cohen *et al.*, 2008). This measure defines religiosity based on items inquiring about the strength of religious identity and level of participation in religious activities. Students answered each item on a Likert scale from 1 (strongly disagree)

to 5 (strongly agree). Reliability as determined by Cronbach's alpha was good; $\alpha = 0.87$.

Demographics. We also asked students to report their race/ethnicity, age, gender, and parent educational levels. The exact questions used can be found in the Supplemental Material.

Analyses

Only students who finished the survey were used in analyses, and less than 5% of data for each item was missing. We calculated students' composite average scores for each measure. Regression analyses were completed using SPSS v. 26. Data and syntax for these analyses are included in the Supplemental Material. A result was deemed statistically significant in our regressions when $p < 0.05$. However, p values can be misleading, and a result can be statistically significant and yet still not be meaningful. So, to illustrate the distribution of data within each group, we provide violin plots showing the distribution of data among community college students and university students for each outcome variable. We report the unstandardized coefficients, p values, and 95% confidence intervals (CIs) for variables that are part of our research questions. However, full regression tables with coefficients, p values, and confidence intervals for all variables included in the analyses can be found in the Supplemental Material.

To examine differences between community college and university student evolution variables, we used multiple linear regressions so we could control for the potential confounds of state and major. We controlled for state, because populations in Arizona tend to have lower acceptance of evolution than populations in California; we also controlled for major, because biology majors tend to have higher acceptance of evolution than nonmajors. Outcome variables included microevolution acceptance, macroevolution acceptance, human evolution acceptance, understanding of evolution, perceived conflict with religious beliefs and evolution, perceived conflict with belief in God and evolution, perceived conflict with religious teachings and evolution, and perceived conflict in one's religious community about evolution. Our regression equations for these analyses were as follows:

interest in evolution ~ state + major + institution type

microevolution acceptance ~ state + major + institution type

macroevolution acceptance ~ state + major + institution type

human evolution acceptance ~ state + major + institution type

conflict with religious beliefs ~ state + major + institution type

conflict with religious community ~ state + major
+ institution type

conflict with belief in God ~ state + major + institution type

conflict with religious teachings ~ state + major
+ institution type

Because demographics are often different between university and community college students, we wanted to check whether there were differences between the demographics of

university and community college students in our sample. So, to determine demographic differences, we ran binary logistic regressions with student race/ethnicity (Asian, BIPOC, multiracial, and white (reference group)), parent educational levels (no college (reference group), some college - no four-year degree, and four-year degree or higher), religiosity, religion (no religion (reference group), other religion, and Christian), age, and gender (woman and man (reference group))¹ as a predictor of whether the student was attending university or community college. Our regression equation was:

institution type ~ race + parent education + religiosity
+ religious affiliation + age + gender

To determine whether religiosity and evolution understanding contribute to students' levels of evolution acceptance differently for community college students than university students, we analyzed data separately for community college and university students. We ran three linear regressions for each population, with microevolution, macroevolution, and human evolution acceptance as outcome variables and student evolution understanding and religiosity as predictors in each of the three regressions. To avoid any confounding findings based on differences in states and major, we added state and major as control variables. Our regression equations were:

microevolution acceptance ~ evolution understanding
+ religiosity + state + major

macroevolution acceptance ~ evolution understanding
+ religiosity + state + major

human evolution acceptance ~ evolution understanding
+ religiosity + state + major

After each regression model was fit to the data, we performed regression diagnostics to make sure the statistical assumptions of this method (i.e., the error term follows an independent identical normal distribution with constant variance) were adequately met and that the fitted linear model results adequately represent the data (i.e., checking linearity, multicollinearity, and influential points; Kutner *et al.*, 2005).

Positionality Statement

The collaboration author team includes biology instructors and education researchers from 4-year institutions (M.E.B., S.E.B.) and community colleges (J.C.). Multiple members of the author team have taken community college courses (J.C., S.E.B., M.E.B.) and/or received a 2-year degree from a community college (M.E.B.). The author team includes atheist, agnostic, and Christian individuals.

All activities were approved by Arizona State University's Institutional Review Board protocol 8191.

RESULTS

Population

A total of 202 community college students and 2288 university students from Arizona and California completed the survey. Of

¹We recognize gender is a spectrum and not binary (Cooper *et al.*, 2020). See Table 2 for the number of nonbinary students in our data set, which were too few to include in the analyses.

TABLE 2. Demographics of students disaggregated by whether they attend university or community college and results of binary logistic regressions predicting community college attendance

	University (<i>n</i> = 2288)	Community college (<i>n</i> = 202)
Race/ethnicity		
Asian ^a	32.5%	9.4%
Black/Hispanic/Indigenous ^a	23.2%	38.6%
Multiracial	11.1%	13.9%
White ^b	31.8%	35.6%
No answer ^c	2.1%	2.5%
Gender		
Woman	65.1%	69.8%
Man ^b	33.6%	29.9%
Nonbinary ^c	1.1%	0%
Other ^c	0.2%	0%
No answer ^c	0.6%	0.5%
Religion		
Christian	39.6%	44.1%
Other religion ^a	16.5%	8.9%
No religion ^b	39.6%	40.1%
No answer ^c	4.3%	6.9%
Parents educational level		
No college ^a	21.2%	33.2%
Some college ^a	16.7%	30.2%
Bachelor's or higher ^b	60%	34.2%
No answer ^c	2.1%	2.5%
Continuous variables		
Mean age (SD) ^a	19.17 (4.23)	22.61 (5.38)
Mean religiosity (SD) Range = 1–5	2.97 (1.10)	2.97 (1.11)

^aCommunity college students were found to be statistically significantly different from university students in binary logistic regressions ($p < 0.05$).

^bReference group in binary logistic regression predicting attendance at community colleges.

^cGroups were not included in binary logistic regressions due to low sample size.

the students surveyed, 65.5% identified as a woman, 32.7% identified as a man, and 1.0% identified as nonbinary, while 0.6% declined to state and 0.2% identified as other. In terms of race/ethnicity, 32.2% of students identified as white; 31.1% of students identified as Asian; 25.0% of students identified as Black, Hispanic, or Indigenous; and 11.6% of students identified as multiracial. When looking at religious affiliation, 39.7% of students identified with no religion, 39.9% of students identified as Christian, 15.9% of students identified with another religion, and 4.5% declined to state. For major, 63.9% identified biology as their major and 36.1% of students identified another major.

As expected, community college students in our sample were more likely to identify as Black, Hispanic, or Indigenous, less likely to identify as Asian, more likely to identify as a religion other than Christianity, and more likely to be first-generation college students compared with university students. Community college students were also significantly older. However, we did not see differences between community college and university students' gender or religiosity levels. See Table 2 for

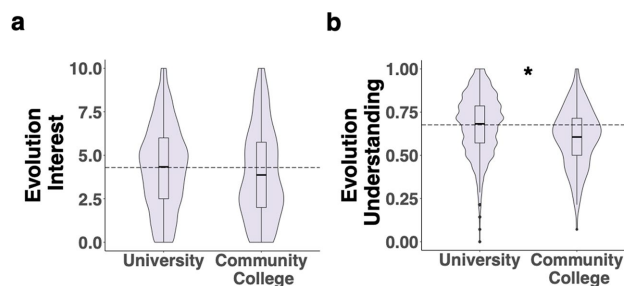


FIGURE 1. Violin plots of students' (a) interest in evolution (university: $n = 2098$; community college: $n = 181$) and (b) evolution understanding (university: $n = 2288$; community college: $n = 200$) scores disaggregated by institution type. The shape of each violin represents the density of data points on that specific point on the y-axis. The horizontal line represents the mean of the data, and the box shows the lower and upper quartiles of the data points. * $p < 0.05$ determined by linear regressions.

the specific demographic breakdown of community college and university students.

Finding 1: Community College Students Had a Similar Level of Interest in Evolution Compared with University Students but Lower Understanding of Evolution

In our models of this sample, community college students had similar levels of interest in evolution as university students ($\beta = -0.015$, $p = 0.478$, $CI = -0.495$, 0.232). Despite their interest in evolution being similar to that of university students, community college students scored ~8% lower on their understanding of evolution compared with university students ($\beta = -0.080$, $p = 0.000$, $CI = -0.076$, -0.026). See Figure 1 for the distribution of evolution interest and evolution understanding scores by institution type.

These results indicate that, although community college and university students in our sample may hold similar interest in taking courses on evolution, doing research on evolution, and pursuing evolution as part of their careers, they may have a lower understanding of evolution compared with university students when they first enter their introductory biology courses.

Finding 2: Community College Students Have a Slightly Lower Acceptance of Microevolution and Human Evolution Compared with University Students but a Similar Level of Acceptance of Macroevolution

Students surveyed from the community colleges in our sample had a slightly lower level of acceptance of microevolution ($\beta = -0.088$, $p = 0.03$, $CI = -0.167$, -0.008) and human evolution ($\beta = -0.111$, $p = 0.046$, $CI = -0.219$, -0.002), but differences between macroevolution acceptance of university and community college students did not reach statistical significance ($\beta = -0.049$, $p = 0.277$, $CI = -0.137$, 0.039). See Figure 2 for distribution of microevolution, macroevolution, and human evolution acceptance by institution type.

These results indicate that, although community college students' acceptance of evolution was slightly lower than that of university students in our sample, these differences were small, and we did not detect a statistically significant difference for macroevolution acceptance.

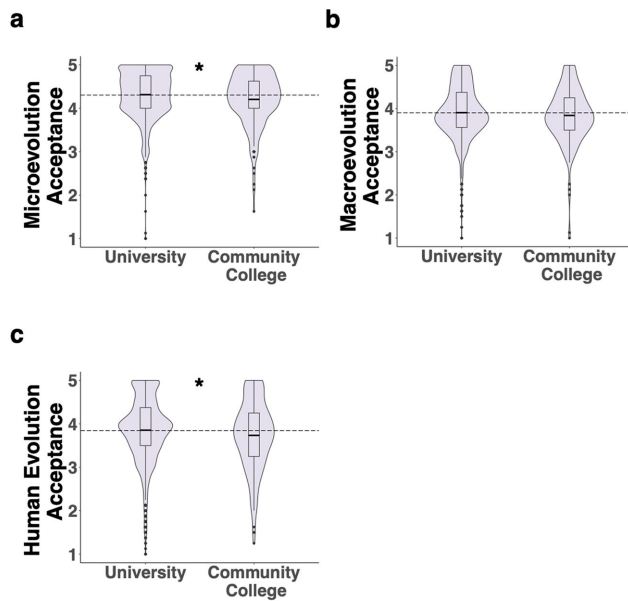


FIGURE 2. Violin plots of students' scores of (a) microevolution acceptance (university: $n = 2285$; n (community college) = 201), (b) macroevolution acceptance (university: $n = 2285$; community college: $n = 202$), and (c) human evolution acceptance (university: $n = 2286$; community college: $n = 202$), disaggregated by institution type. The shape of each violin represents the density of data points on that specific point on the y-axis. The horizontal line represents the mean of the data, and the box shows the lower and upper quartiles of the data points. * $p < 0.05$ determined by linear regressions.

Finding 3: Community College Students Perceived More Conflict with Their Religious Beliefs and within Their Religious Communities about Evolution

Community college students had statistically significantly higher perceived conflict with their religious beliefs and evolution ($\beta = 0.195$, $p = 0.035$, $CI = 0.014$, 0.376) and perceived more conflict with evolution among their religious communities ($\beta = 0.220$, $p = 0.021$, $CI = 0.033$, 0.407). Community college students also had higher average scores on perceived conflict between evolution and their religious teachings ($\beta = 0.179$, $p = 0.067$, $CI = -0.012$, 0.371) and between evolution and their belief in God ($\beta = 0.139$, $p = 0.129$, $CI = -0.040$, 0.318), but these differences were not statistically significant. See Figure 3 for distribution of perceived conflict scores by institution type.

These results indicate that community college students in our sample had slightly higher levels of perceived conflict with evolution and their religions, but these differences were small. Further, differences in conflict with evolution and belief in God and conflict with evolution and religious teachings were not statistically significant.

Finding 4: Among Community College Students, Understanding of Evolution Is Not Related to Acceptance of Human Evolution or Macroevolution, whereas Religiosity Is the Strongest Factor Related to All Three Evolution Acceptance Constructs

When looking at factors related to only community college students' acceptance of evolution, we found that understanding of

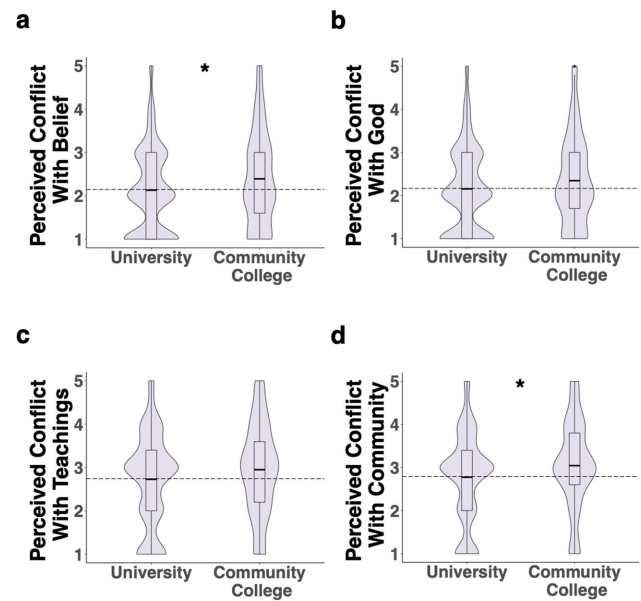


FIGURE 3. Violin plots of students' perceived conflict with evolution and (a) their religious beliefs (university: $n = 1818$; community college: $n = 123$), (b) their belief in God (university: $n = 1816$; community college: $n = 124$), (c) their religious teachings (university: $n = 1817$; community college: $n = 124$), and (d) within their religious communities (university: $n = 1818$; community college: $n = 124$), disaggregated by institution type. The shape of each violin represents the density of data points on that specific point on the y-axis. The horizontal line represents the mean of the data, and the box shows the lower and upper quartiles of the data. * $p < 0.05$ determined by linear regressions.

evolution was not related to their human evolution acceptance ($\beta = 0.310$, $p = 0.295$, $CI = -0.272$, 0.893) or their macroevolution acceptance ($\beta = 0.036$, $p = 0.883$, $CI = -0.439$, 0.510), but was related to their microevolution acceptance ($\beta = 0.609$, $p = 0.014$, $CI = 0.125$, 1.092). This is in contrast to what we found for university students, for whom understanding of evolution was related to their human evolution acceptance ($\beta = 1.064$, $p < 0.000$, $CI = 0.905$), macroevolution acceptance ($\beta = 0.922$, $p < 0.000$, $CI = 0.788$, 1.055), and microevolution acceptance ($\beta = 1.025$, $p < 0.000$, $CI = 0.904$, 1.146). Similar to university students, religiosity was the strongest factor related to community college students' acceptance of human evolution ($\beta = -0.348$, $p < 0.000$, $CI = -0.440$, -0.256), macroevolution ($\beta = -0.232$, $p < 0.000$, $CI = -0.307$, -0.157), and microevolution ($\beta = -0.120$, $p = 0.002$, $CI = -0.197$, -0.044). See Table 3 for regression coefficients and significance of each variable for university and community college students.

This finding implies that community college students' understanding of evolution does not significantly predict their acceptance of human and macroevolution, but it does positively predict their acceptance of microevolution. This contrasts with university students, in which we found that understanding and religiosity were related to all three evolution acceptance constructs.

DISCUSSION

Our study is the first to our knowledge that directly compares evolution education variables and factors that influence these

TABLE 3. Unstandardized beta coefficients from regressions predicting acceptance of human evolution, macroevolution, and microevolution among community college and university students only

	Human evolution acceptance		Macroevolution acceptance		Microevolution acceptance	
	Community college	University	Community college	University	Community college	University
State	−0.067	0.030	−0.110	−0.008	−0.047	0.009
Evolution Understanding	0.310	1.064*	0.036	0.922*	0.609*	1.025*
Religiosity	−0.348*	−0.249*	−0.232*	−0.156*	−0.120*	−0.078*
Major	0.110	0.013	0.177*	0.016	0.104	0.033

* $p < 0.05$.

variables between community college and university students. Our results indicate that, while there are some similarities, there are also notable differences that could be important for community college instructors to know. Community college student interest in evolution was comparable to that of university students, and even though community college students were slightly less accepting and understanding of evolution, these differences were small. These similarities between community college students and 4-year university students could mean that community college instructors can use the literature on university students in terms of student levels of interest, acceptance, and understanding of evolution, although we encourage caution in extrapolating from studies in different geographic areas.

However, we did find that the relationships between evolution education variables seem to be different among community college students compared with university students. Among community college students, religiosity was a stronger predictor of microevolution acceptance, macroevolution acceptance, and human evolution acceptance compared with university students. Further, perceived conflict with religion was higher among community college students compared with university students. Finally, among university students, understanding of evolution was related to all three constructs of evolution acceptance, but among community college students, understanding of evolution was not related to their macroevolution acceptance or their human evolution acceptance. These findings indicate that community college students may benefit more than university students from having discussions about how evolution and religion do not necessarily have to be in conflict. We did not have enough community college students in this study who took our perceived conflict scale to include it as a variable in our models predicting acceptance ($n = 123$), but perceived conflict has been shown to be the biggest factor influencing college students' evolution acceptance (Barnes *et al.*, 2021b), and given that community college students perceive a higher conflict with their religions and evolution compared with university students, community college students may benefit from explicit discussion and reflection about the potential compatibility of religion and evolution.

Religious cultural competence in evolution education (ReCCEE) has been recommended to encourage biology instructors who are mostly not religious to become more adept at helping religious students reduce their perceived conflict with their religions and evolution (Barnes and Brownell, 2017). Instructors can help students recognize that their perceived conflicts may not be real. Real conflict exists between a student's religion and evolution when the student believes that God/god(s) created species separate from one another, because it contradicts that species share a common ancestor, a core tenant of evolu-

tionary theory. However, there are many examples of perceived conflict between religion and evolution that do not reflect reality in terms of evolutionary theory. For instance, although approximately half of college biology students believe one has to be an atheist to accept evolution (Barnes *et al.*, 2020a), science and evolution are agnostic as to the influence or existence of supernatural beings. Thus, students who believe that God was responsible for evolution do not have to perceive a conflict between belief in God and evolution. Further, many students do not know that their religions have official stances that either support evolution or are neutral; students' perceived conflict can be reduced if they become aware of this (Manwaring *et al.*, 2015). Showing students examples of religious evolutionary biologists and religious leaders who accept evolution can also help reduce students' perceived conflict and increase evolution acceptance (Barnes *et al.*, 2017a; Holt *et al.*, 2018). While these strategies have been shown to be effective for reducing conflict and increasing acceptance among university students, these practices may be even more impactful among the community college student population due to their higher perceived conflict between their religions and evolution and because religiosity is more strongly related to acceptance. There is already evidence that culturally competent practices may be effective among community college students. An intervention study using culturally competent practices at a community college found that students' acceptance and understanding increased more in a class with culturally competent practices compared with a class that did not receive the culturally competent practices (Green and Delgado, 2021). However, some of our prior work indicates that, in contrast to instructors who teach evolution at Christian universities, instructors at both community colleges and 4-year institutions were less likely to use these culturally competent practices in teaching evolution (Barnes and Brownell, 2016, 2018).

Students at community college may also perceive more conflict between their racial/ethnic identities and evolution. Evolution has a history of promoting racism and oppression based on research questions and results being biased against non-white groups (Graves and Graves, 2001; Graves, 2019; Graves and Goodman, 2021). Because community college students tend to be more racial/ethnically diverse than their 4-year university counterparts, we may see more of this conflict among this population of students. We have previously found that higher rates of religiosity among Black students at universities help to explain their lower evolution acceptance (Barnes *et al.*, 2020a). However, our analyses showed that religiosity only explained up to half the difference between Black and white students. Among Black students, religiosity was related to evolution

acceptance less than for other students. This indicates that perceived conflict with evolution may exist beyond religion among Black students. This could explain why we saw lower evolution acceptance among community college students, and it is an area of future research interest for our group.

Limitations

This study was done in only two states in the Southwest and West Coast, so results may not generalize to other regions and contexts, particularly to the Southeast, where populations tend to have higher levels of religiosity (Gallup, 2018). Further, although we had an adequate sample to detect differences between populations, the community college population had a particularly low sample size for the perceived conflict measure. We may not have had the power needed to see some significant differences. This lower sample size also did not allow us to test the association of perceived conflict with religion and evolution on evolution acceptance for community college and university students. Even though we recruited from 15 classes, the smaller class sizes at community colleges necessitate recruiting from many more community college classes. This illustrates one of the challenges of conducting quantitative research involving community college students and presents a need for more collaborative projects across many community colleges.

CONCLUSION

In this study, we found that there are similarities and differences between community college and university students that can inform community college instructors and researchers. We found that interest in evolution was similar between university and community college students, and although there were differences in evolution acceptance and understanding between the two populations, these differences were small. We did find that students at community colleges perceive a higher conflict between their religions and evolution compared with university students. Further, we found that, contrary to results from university students, understanding of evolution was not related to community college students' acceptance of macroevolution and human evolution. Further, community college student religiosity was more strongly related to their evolution acceptance compared with university students. These results indicate that, although both community college and university students can have low evolution acceptance and understanding, the factors related to these students' evolution perceptions may be different. Instructors may be able to use ReCCEE to help reduce conflict, but future studies should further explore the role of perceived conflict with religion and race/ethnicity in community college students' evolution acceptance and understanding.

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