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Introducing Interdisciplinary Curricula Into Conservation Biology: Exploring Changes in Students' Perceived Proenvironmental Attitudes and Behaviors

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Abstract

Today, conserving the natural environment is paramount. Educators have been striving to develop pedagogical approaches that facilitate greater engagement in conservation behaviors. However, many of these reforms have been targeted at an institutional level, without necessarily testing whether changes in proenvironmental perceptions, attitudes, or behaviors occur for students. This step seems important when developing conservation biology courses that provide well-rounded education that may better prepare students for future challenges in biodiverse conservation contexts. Our objective was to assess the proenvironmental attitudes and conservation values of undergraduate students enrolled in an undergraduate conservation biology course before and after instruction to determine whether a multidisciplinary curriculum, in conjunction with traditional conservation biology content, would alter their perceptions. Students in both the control and intervention groups felt relatively neutral about a range of environmental and conservation topics. No statistical significance between curricula and impact on student perception was revealed. However, in the experimental course, shifts were found concerning students' understanding of the complexity of conservation. Results also highlight long-standing issues related to conservation education, such as a bias toward mammal conservation, and suggest that guest lectures are insufficient to bring about attitude change related to sustainability. Further research on incorporating cross-disciplinary pedagogy into STEM courses is recommended.

Keywords: *Conservation, conservation biology, proenvironmental behavior, proenvironmental attitudes, environmental psychology*

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Introduction

Anthropogenic effects on biological diversity are serious and wide-reaching (Bowler et al., 2020). At the same time, a number of empirical studies have connected biodiversity with human health and psychological wellbeing (e.g., Barton & Rogerson, 2017; Collado et al., 2017; Engemann et al., 2019; Maas et al., 2009; Neill et al., 2018). Ecological outcomes of climate change, such as a lower number of species and reduced resources for sustaining animal and plant populations, are compounded by economic (e.g., reduced harvest and resource extraction) and cultural (e.g., altered sense of place and value) impacts (Devine-Wright & Quinn, 2021; Gifford, 2014a; United Nations, 2022). It seems that addressing such complex and global problems undoubtedly requires a better understanding of the ways in which people think about (and behave toward) the natural environment (Gifford, 2014a). Gathering (and capitalizing upon) this knowledge necessarily involves measuring proenvironmental attitudes in relation to conservation and biodiversity, as well as the eco-conscious behaviors that result from these attitudes (Gifford, 2014b). Not only will this effort benefit researchers and policy makers, but it may also benefit educators as they tailor curricula to stimulate interest and enthusiasm about sustainability—especially for students at the undergraduate level.

Research communities in the social and natural sciences have been devising interdisciplinary approaches to proactively address environmental and climate-related issues through higher education for some time (Nielsen et al., 2021). Despite these efforts, many individuals continue to think and act in ways that suggest they do not hold strong or productive proenvironmental attitudes (Gifford, 2011, 2014a). Arguably, for environmental and conservation initiatives to succeed, we must understand when these attitudes form, and how we might influence change—especially for young adults.

With this goal in mind, educators in the fields of science, technology, engineering, and mathematics (STEM), as well as those in the social sciences, arts, and humanities, have been developing educational frameworks and program evaluation models to enhance student learning and engagement at the undergraduate level in the areas of biology and conservation (Trombulak, 1994, 2004; Rosin & Zedler, 2019), as well as sustainability (e.g., Ward et al., 2016). Within a conservation biology context, studies have largely focused on assessments at the level of the institution (e.g., Rosin & Zedler, 2019), or within professional societies (e.g., White et al., 2000), rather than with post-secondary students themselves. These assessments reveal a general scarcity of faculty expertise to teach broad, transdisciplinary conservation and sustainability topics (Roisin & Zedler, 2019). They also reveal a lack of incentive for students to enroll in subjects, or enter research fields, related to conservation biology (Trombaluk, 1994). Indeed, non-traditional biology topics (i.e., economics, policy, recreation, and tourism) are increasingly important in the field's professional roles but are not commonly incorporated into undergraduate courses (Trombulak, 2004).

Typically, undergraduate biology programs focus on traditional subjects in the biological and natural sciences, along with the development of the scientific method. However, graduates of these programs, whether they actively pursue a conservation biology career or not, face a number of societal challenges that are outside the realm of traditional biology topics (e.g., economics, politics, marketing, cultural values, etc.; Trombulak, 1994, 2004). Thus, students are believed to benefit from a broader, multidisciplinary education related to conservation biology (White et al., 2000). A well-rounded education may better prepare students for future challenges—for example, conserving biodiversity is less likely to be successful when feelings of psychological hope and motivation are low (Berkes, 2007). Providing lessons that help students develop a general sense of their own eco-consciousness, as well as understanding the principles and practices of conservation biology during their undergraduate program may foster positive, proenvironmental attitudes, and conservation behaviors in the future.

Testing pedagogical approaches that are more transdisciplinary and encouraging action research in real-world settings is a compelling next step for educators teaching courses that center on biodiversity and conservation

topics. As Nielsen et al. (2021) note, considering the human dimensions of topics such as sustainability, nature conservation, and biodiversity is important to combatting the global problem of climate change. Unfortunately, although other researchers have demonstrated success after adopting such approaches in sustainability-related disciplines (e.g., Feierabend & Eilks, 2011; Siegner, 2018), pedagogical assessment of conservation biology and sustainability topics at the student level remains lacking. Thus, a multidisciplinary undergraduate curriculum that includes opportunities to learn from experts currently working to combat conservation problems may help students integrate diverse perspectives into their eco-conscious values and beliefs prior to and after changes are made to curricula that provide a multidisciplinary approach to teaching conservation biology and biodiversity in a time of great environmental change.

The aim of the present study was to augment existing knowledge about whether transformative, cross-disciplinary course material, as well as an incorporation of discussions with conservation-focused professionals, will affect self-reported proenvironmental attitudes and behaviors in undergraduate STEM students. Our objective was to understand the extent to which students enrolled in a fourth-year biology course centered on conservation biology and biodiversity hold proenvironmental attitudes and conservation values before instruction and how much those attitudes and values change during the semester, depending on whether a curriculum is expanded to include non-traditional conservation biology content (e.g., social science, tourism, policy) and exposure to a variety of people in professions that make use of conservation biology skills.

Although the nature of this small study is exploratory (i.e., precluding broad generalization and directional hypotheses), its findings may offer a preliminary understanding of the effectiveness of introducing topics from other disciplines, and external information providers (i.e., guest lecturers), into traditional biology courses, and perhaps inspire educators to think critically and strategically as they augment their curricula to relate to climate change and sustainability.

Course Details

At the time of this study, the elective course offered by the biology department at Vancouver Island University (VIU) called “BIOL 457: Biodiversity and Conservation Biology” was undergoing re-development to include a more comprehensive curriculum. The department’s goal was to insert a number of topics from the social sciences, such as environmental psychology, political studies, eco-tourism, economics, and First Nations perspectives, into the course. The researchers in this study, notably a biologist and an environmental psychologist at VIU, wished to capitalize on this opportunity and examine whether undergraduate students enrolled in an “experimental” intervention-based version of BIOL 457 using the enhanced curriculum showed statistically significant changes in their conservation-based attitudes and perceptions of their proenvironmental behavior before and after the semester, compared to a “control” version of the course offered before changes were made to its curriculum.

We adopted the five conservation biology education themes identified by Trombulak (2004) in the control course. Broadly, topics covered biodiversity measurement, biodiversity values within a Canadian context, environmental economics, species-level conservation methods, landscape-scale conservation methods, species-at-risk legislation and policy (both international and national), future conservation challenges (e.g., climate change and translocations), restoration, and “de-extinction.” The experimental course covered the same topics as the control course but incorporated selected topics in the social sciences in relation to the environment, as well as specific national and international case studies to illustrate challenges and successes for conservation topics commonly addressed in the course.

Specifically, weekly interviews with professionals working in a broad range of conservation-related areas (and with the topics explored in this course) were delivered to students in the experimental course. Students heard first-hand accounts of the challenges and rewards associated with the type of work that each professional is

engaged in. Each professional was asked a standard set of questions that they could answer and elaborate on as they wished. Each interview typically lasted for approximately 40 minutes. Some examples of the questions that were asked of each professional are "how do you deal with the disappointment of a conservation nonsuccess?" and "how do you remain hopeful that we can make a difference?" These kinds of questions not only provided students with information about a professional's expertise, but were also likely to stimulate self-reflection as they related experts' answers to their own lives and career plans.

Professionals included a lecturer specializing in ecosystem services, environmental economics, and entomology from the University of New England in Australia, a member of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) small mammal subcommittee, the Director of the Vancouver Island Marmot Recovery Foundation, a Professor specializing in ecotourism and Indigenous engagement from VIU, a postdoctoral researcher applying genetics and genomics to the conservation and re-establishment of rare species (i.e., Galapagos tortoises), the founder of the Canadian ReNew Zoo initiative that facilitates research opportunities among academics and conservation bodies (e.g., zoos and aquaria), an environmental psychologist from VIU (i.e., LM), and a British Columbia provincial government biologist.

Methods

Participants

Control course. Nineteen students took part in the questionnaire at the start of the semester (10 females, 8 males, 0 transgender, 1 "other"). Because BIOL 457 has an enrollment capacity of 21 students, the response rate was 90%. Each participant was asked to create a unique code for themselves so that differences could be understood between their responses at the start and end of the term in a way that afforded student anonymity. Seventeen students created a code for themselves at the start of term.

We also asked participants to respond "yes," "no," or "I do not know" to a single item: "Does biodiversity hold any cultural significance for you?" At the start of the term, many participants (63.2%) stated that it did, while 26.3% reported that it did not; 10.5% were not sure.

At the end of the term, 16 students completed the questionnaire (10 females, 6 males, 0 transgender, 0 "other")—a response rate of 76%. Every participant except one recalled the code that they created at the start of term. Again, most participants stated at the end of the term that biodiversity held particular cultural significance to them (62.5%), while 18.8% reported that they did not think that it did, and 18.8% were unsure.

Experimental course. Twenty students took part in the questionnaire at the start of the semester (13 females, 7 males); the response rate was 95%. Eighteen participants created a code for themselves. Forty percent of students thought that biodiversity held particular cultural significance to them, while 20% reported that they did not think so and 40% reported that they were not sure.

At the end of the term, 16 students took part in the questionnaire (12 females, 4 males). Every participant except one recalled their code; the response rate was 80%. Compared to the start of the semester, more participants at the end of the term stated that biodiversity held particular cultural significance to them (50%)—and more students also noted that it did not (37.5%). The remainder (12.5%) reported to be unsure.

Materials

Control course. The questionnaires given at the start and end of the semester for the control course were identical and composed of a combination of standardized scales and items created specifically for this research. Section A of the questionnaire contained 37 items revised from Kaiser and Wilson's (2004) list of 50 conservation behaviors. We chose particular items from this list that would most likely relate to the life

experience of a typical undergraduate student in North America. These items in our Conservation Behaviour Scale (CBS) were grouped into six subheadings: energy conservation, mobility and transportation, waste avoidance, consumerism, recycling, and vicarious social behaviors toward conservation. Eight items were worded in reverse and required re-coding (see Table 1 for exact wording for all items). Each item was measured on a 5-point Likert scale of agreement ranging from "strongly disagree" (1) to "strongly agree" (5). Section B of the questionnaire contained a 29-item Perceptions of Climate Change and Conservation Scale (CCPS) that also included six subheadings (see Table 2 for exact subheading and item wording). Although some items were inspired by Soliman and Wilson's (2017) research (but revised so that each item was measured on the same 5-point Likert scale as the CBS), others were created specifically for this study by one of the authors (LM) based on her knowledge of what biology students at VIU typically learn in the department's curriculum. Five items were reverse coded.

We performed reliability analyses on both scales to ensure internal consistency. At the start of the semester, the CBS had a Cronbach's alpha of .75 while the CCPS had an alpha of .56 (and .83 and .67 at the end of the term, respectively, likely because of stronger inter-item correlations and repeated exposure to the items). Overall, these values are adequate, as per Cortina (1993), but not very strong (i.e., < .9). The low sample size and the number of reverse-coded items may have hindered reliability (Tavakol & Dennick, 2011). Because boosting alpha values by deleting particular items was shown to be negligible in SPSS (and because many items were drawn from previously published standardized scales), all items were retained for statistical analyses. In addition, the two scales were not statistically correlated at either time points ($r = .60$, $p > .05$ at the start of the term, and $r = .45$, $p > .05$ at the end) and, thus, were able to be understood and utilized as scales that measure distinct constructs.

Experimental course. The questionnaires used at the start and end of the experimental course were identical to those used in the control course except that the questionnaire given at the end of the semester contained a section with five personal attitude appraisal items measuring opinions about the augmented curriculum and whether it had changed students' thoughts about conservation (see Table 8 for exact item wording). These additional items used the same Likert scale as the other sections.

Once again, we performed reliability analyses on the CBS and the CCPS to ensure internal consistency in the experimental course. The CBS had a Cronbach's alpha of .78 and the CCPS had an alpha of .84 at the start of the semester (and .88 and .91 at the end of the term, respectively—again, likely because of repeated exposure to the items). Just as in the control course, these values are adequate (and one was strong, i.e., > .9) as per Cortina (1993).

Procedure

Control course. During the first week of the semester in the spring of 2020, one of the researchers (LM) verbally alerted students that they had an opportunity to participate in a study using a script approved by the authors' institutional ethics board (2019-077-VIUF-JANES MCCUNN). This was done to reduce undue influence associated with the other author performing this study (JJ, the course's instructor). A URL for a SurveyMonkey (SurveyMonkey Inc., Palo Alto, California, USA) questionnaire was posted on the course's online learning platform for students to access and decide whether to take part. An implied consent form was the first page of each questionnaire. It asked participants to click a button to proceed to the questionnaire and indicate their voluntary and informed consent.

The questionnaire offered at the start of the term was available on SurveyMonkey for two weeks for students to complete the questionnaire at their convenience. The questionnaire offered at the end of the term was communicated and distributed in the same manner except that it was open for three weeks to provide students with extra time to participate during start of the COVID-19 pandemic.

Experimental course. Because this semester occurred during the COVID-19 pandemic, online learning procedures were in place at VIU. At the start of the spring 2021 semester, a co-author of this study (LM) alerted students, via video conferencing, that they had an opportunity to participate in a study using the same script from the control course. Just as in the control course, a URL for a SurveyMonkey questionnaire was posted on the course's online learning platform for students to access and decide whether to participate. Both questionnaires were communicated and distributed in the same manner as in the control course, and both were open for two weeks.

Results

Control Course

All items at both data collection points in the control course met the criteria for acceptable skewness (values between +3 and -3) and kurtosis (values between +8 and -8) as per Kline (1997).

Start of semester. Descriptive statistics for items in the CBS and CCPS were quite neutral (i.e., around 3 on a Likert scale ranging from 1–5; see Tables 1 and 2). The scale means were also neutral for both the CBS (M = 3.35, SD = 0.33) and the CCPS (M = 3.86, SD = 0.22).

Table 1: *Descriptive Statistics Per Item in the CBS in the Control Course at the Start of the Semester*

Item (n)	Mean	SD
Subheading: Energy Conservation		
In winter, I prefer to shower rather than take a bath. (n = 19)	3.74	1.20
In winter, I turn down the heat when I leave my home for more than four hours. (n = 19)	3.32	1.38
I use the dryer to dry my clothes.* (n = 19)	4.05 (1.95)	0.78
I wash dirty clothes using a cold water cycle rather than hot. (n = 19)	4.16	1.26
I wait until I have a full load before doing my laundry. (n = 19)	4.63	0.60
I turn off unnecessary lighting (e.g., when a room is empty). (n = 19)	4.53	0.61
I choose the most energy efficient appliance, light bulb (and so on) where possible. (n = 19)	3.84	0.96
Subheading: Mobility and Transportation		
I drive a car to school or work. (n = 19)	3.58 (2.42)	1.61
I keep the car engine running while waiting in a traffic jam.* (n = 19)	3.53 (2.47)	1.07
I refrain from owning a car. (n = 19)	2.32	1.57
I am a member of a carpool. (n = 19)	2.21	1.18
I drive in such a way as to keep my fuel consumption as low as possible. (n = 19)	3.53	0.96
In nearby areas (around 30 km), I use public transportation or ride a bike. (n = 19)	2.53	1.47
I ride a bike or take public transportation to school or work. (n = 19)	2.53	1.61
Subheading: Waste Avoidance		
I buy drinks in returnable bottles. (n = 18)	3.61	1.09

If I am offered a plastic bag in a store, I take it.* (n = 18)	2.11 (3.89)	1.23
I re-use my shopping bags. (n = 18)	4.50	0.62
I buy products in refillable packages. (n = 18)	2.95	1.00
I dispose of other people's garbage when enjoying nature. (n = 18)	3.72	1.07
Subheading: Consumerism		
I kill insects with a chemical insecticide. (n = 19)	1.47 (4.53)	0.70
I use a chemical air freshener in my bathroom. (n = 19)	1.84 (4.16)	1.26
I buy seasonal produce on purpose. (n = 19)	3.05	0.85
I buy meat and/or produce with eco-labels. (n = 19)	2.79	0.98
I buy domestically-grown wooden furniture or other wooden goods. (n = 19)	2.37	0.90
I have, at some point, stopped buying/using a product (e.g., palm oil) when I learned from mainstream or social media that it was bad for a particular species (e.g., orangutan). (n = 19)	3.63	1.11
Subheading: Recycling		
I recycle used paper. (n = 19)	4.32	1.06
I bring empty bottles and other packages to a recycling bin. (n = 19)	4.74	0.45
I put dead batteries in the garbage.* (n = 19)	2.89 (3.11)	1.29
After meals, I compost leftover food. (n = 19)	4.32	1.06
I regularly buy bottled water.* (n = 19)	1.53 (4.47)	0.91
Subheading: Vicarious Social Behaviours Toward Conservation		
I am a member of an environmental organization. (n = 19)	2.63	1.26
I seek out things to read about environmental issues. (n = 19)	3.63	1.01
I talk with friends or family members about problems related to the environment. (n = 19)	4.47	0.61
I have pointed out un-ecological behaviour to someone. (n = 19)	4.21	0.54
I boycott companies with an un-ecological background. (n = 19)	3.32	1.06
I donate to conservation-based societies. (n = 19)	2.68	1.06
I volunteer my time for local conservation initiatives. (n = 19)	2.89	1.29

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

Table 2: *Descriptive Statistics Per Item in the CCPS in the Control Course at the Start of the Semester*

Item (*n*)	Mean	*SD*
Subheading: Environmental Skepticism		
How much do you agree that the negative outcomes that you read about, such as a warming climate and North American water and food shortages, will happen by the year 2100? (*n* = 19)	4.53	0.51
How much do you agree with the statement: "Global warming is a theory that has not yet been proven."* (*n* = 19)	1.26 (4.47)	0.45
How much do you agree with the statement: "Global warming is a proven fact." (*n* = 19)	4.63	0.50
How much do you agree with the statement: "We don't need to worry about the current rate of extinction; mass extinctions have occurred before—it's survival of the fittest."* (*n* = 19)	1.11 (4.89)	0.32
Subheading: Belief That Climate Change and Conservation Are Anthropogenic Issues		
How much do you agree that current behaviors of humans are causing climate change effects in the future? (*n* = 19)	4.68	0.95
How much do you agree with the statement: "The overwhelming cause of all species loss is the rapidly expanding human population." (*n* = 19)	4.53	0.77
Subheading: General Beliefs About Sustainable Behavior Effectiveness		
If humans engage in more sustainable behaviors, how much do you agree that this can be an effective way of reducing potential effects of climate change in the future? (*n* = 19)	4.05	0.52
If humans engage in more sustainable behaviors, how much do you agree that this increase will be an effective way of reducing future biodiversity loss? (*n* = 19)	4.05	0.71
Subheading: Beliefs About Effectiveness of Personal Action		
I feel that by engaging in environmentally sustainable behaviors, I can make a real difference. (*n* = 19)	3.42	1.07
I feel like any action I take to be environmentally responsible is only a "drop in the bucket" and won't make a difference.* (*n* = 19)	3.00 (3.00)	1.16
I believe that by engaging in environmentally sustainable behaviors, I encourage or inspire others to do likewise. (*n* = 19)	4.16	0.60
I believe that biodiversity should be preserved for the benefit of all people. (*n* = 19)	4.84	0.38
Subheading: Beliefs About Conservation Initiatives		
I feel that government conservation initiatives are a worthwhile cause. (*n* = 19)	4.53	0.61
I feel that non-government conservation initiatives are a worthwhile cause. (*n* = 19)	4.63	0.50
I do not think that we do enough to conserve species. (*n* = 19)	4.47	0.70
I believe researchers should focus on conserving habitats rather than individual species. (*n* = 19)	3.94	0.85

I think that ecotourism is dangerous because it seeks to make a profit from endangered species and habitats. (*n* = 19)	2.63	1.07
I think that conservation biology is equivalent to environmentalism. (*n* = 19)	2.47	1.07
I believe that conservation planning is a relatively straightforward and easy process so I do not understand why people aren't doing more to conserve. (*n* = 19)	1.84	0.76
I think that zoos are more important than botanic gardens with respect to conservation. (*n* = 19)	2.26	0.81
Subheading: Valuing Biodiversity		
I think that conservation biology is purely a life sciences discipline. (*n* = 19)	2.26	1.05
I have a good understanding of what ecosystem services are, and how they help society. (*n* = 19)	3.32	1.06
I don't often think about the indirect value of biodiversity (i.e., its non-monetary value).* (*n* = 19)	1.84 (4.16)	0.76
I regularly visit natural wilderness areas (e.g., parks, reserves). (*n* = 19)	4.53	0.70
If I was financially able, I would feel comfortable donating $30 a month toward a Vancouver Island Marmot conservation program. (*n* = 19)	4.47	0.61
If I was financially able, I would feel comfortable donating $30 a month toward an Eastern Prickly Pear conservation program. (*n* = 19)	4.05	0.91
If I was financially able, I would feel comfortable donating $30 a month toward a Bogbean Buckmoth conservation program. (*n* = 19)	4.05	0.97
I would accept paying an additional tax for fruits and vegetables so that the government could pay for pollination services. (*n* = 19)	3.74	1.10
I think it would be unfair for conservation areas to make nearby residents pay a fee for any ecosystem services that they provide.* (*n* = 19)	2.95 (3.05)	0.91

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

End of semester. Descriptive statistics for items in the CBS and CCPS were neutral in general (see Tables 3 and 4). The overall scale means were also neutral (and very similar to the start of the semester) for the CBS (*M* = 3.43, *SD* = 0.37) and the CCPS (*M* = 3.88, *SD* = 0.24).

Table 3: *Descriptive Statistics Per Item in the CBS in the Control Course at the End of the Semester*

Item (*n*)	Mean	*SD*
Subheading: Environmental Skepticism		
In winter, I prefer to shower rather than take a bath. (*n* = 16)	3.94	1.18
In winter, I turn down the heat when I leave my home for more than four hours. (*n* = 16)	3.56	1.46
I use the dryer to dry my clothes.* (*n* = 16)	4.06 (1.94)	0.68
I wash dirty clothes using a cold water cycle rather than hot. (*n* = 16)	4.31	1.14
I wait until I have a full load before doing my laundry. (*n* = 16)	4.69	0.48

I turn off unnecessary lighting (e.g., when a room is empty). (n = 16)	4.63	0.50
I choose the most energy efficient appliance, light bulb (and so on) where possible. (n = 16)	4.06	1.00
Subheading: Mobility and Transportation		
I drive a car to school or work. (n = 19)	3.75 (2.25)	1.57
I keep the car engine running while waiting in a traffic jam.* (n = 16)	3.50 (2.50)	0.97
I refrain from owning a car. (n = 19)	2.13	1.41
I am a member of a carpool. (n = 19)	2.31	1.20
I drive in such a way as to keep my fuel consumption as low as possible. (n = 19)	3.19	0.91
In nearby areas (around 30 km), I use public transportation or ride a bike. (n = 19)	2.56	1.21
I ride a bike or take public transportation to school or work. (n = 19)	2.13	1.31
Subheading: Waste Avoidance		
I buy drinks in returnable bottles. (n = 16)	3.88	0.81
If I am offered a plastic bag in a store, I take it.* (n = 16)	2.25 (3.75)	1.24
I re-use my shopping bags. (n = 16)	4.44	0.63
I buy products in refillable packages. (n = 16)	3.69	1.02
I dispose of other people's garbage when enjoying nature. (n = 16)	4.00	1.03
Subheading: Consumerism		
I kill insects with a chemical insecticide. (n = 16)	1.38 (4.62)	0.62
I use a chemical air freshener in my bathroom. (n = 16)	1.69 (4.31)	0.87
I buy seasonal produce on purpose. (n = 16)	3.19	0.91
I buy meat and/or produce with eco-labels. (n = 16)	3.38	0.81
I buy domestically-grown wooden furniture or other wooden goods. (n = 16)	2.63	1.03
I have, at some point, stopped buying/using a product (e.g., palm oil) when I learned from mainstream or social media that it was bad for a particular species (e.g., orangutan). (n = 16)	3.81	0.83
Subheading: Recycling		
I recycle used paper. (n = 16)	4.31	0.48
I bring empty bottles and other packages to a recycling bin. (n = 16)	4.56	0.51
I put dead batteries in the garbage.* (n = 16)	2.50 (3.50)	1.16
After meals, I compost leftover food. (n = 16)	4.06	1.06
I regularly buy bottled water.* (n = 16)	1.56 (4.44)	1.03
Subheading: Vicarious Social Behaviours Toward Conservation		
I am a member of an environmental organization. (n = 16)	2.88	1.20
I seek out things to read about environmental issues. (n = 16)	3.63	1.03
I talk with friends or family members about problems related to the environment. (n = 16)	4.38	0.50

I have pointed out un-ecological behaviour to someone. (n = 16)	4.13	0.72
I boycott companies with an un-ecological background. (n = 16)	3.38	0.81
I donate to conservation-based societies. (n = 16)	2.88	0.72
I volunteer my time for local conservation initiatives. (n = 16)	3.25	1.00

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

Table 4: *Descriptive Statistics Per Item in the CCPS in the Control Course at the End of the Semester*

Item (n)	Mean	*SD*
Subheading: Environmental Skepticism		
How much do you agree that the negative outcomes that you read about, such as a warming climate and North American water and food shortages, will happen by the year 2100? (n = 16)	4.75	0.45
How much do you agree with the statement: "Global warming is a theory that has not yet been proven." * (n = 16)	1.00 (5.00)	0.00
How much do you agree with the statement: "Global warming is a proven fact." (n = 16)	4.38	0.89
How much do you agree with the statement: "We don't need to worry about the current rate of extinction; mass extinctions have occurred before—it's survival of the fittest." * (n = 16)	1.19 (4.81)	0.40
Subheading: Belief That Climate Change and Conservation are Anthropogenic Issues		
How much do you agree that current behaviors of humans are causing climate change effects in the future? (n = 16)	4.88	0.34
How much do you agree with the statement: "The overwhelming cause of all species loss is the rapidly expanding human population." (n = 16)	4.69	0.48
Subheading: General Beliefs About Sustainable Behaviour Effectiveness		
If humans engage in more sustainable behaviors, how much do you agree that this can be an effective way of reducing potential effects of climate change in the future? (n = 16)	4.19	0.66
If humans engage in more sustainable behaviors, how much do you agree that this increase will be an effective way of reducing future biodiversity loss? (n = 16)	4.25	0.58
Subheading: Beliefs About Effectiveness of Personal Action		
I feel that by engaging in environmentally sustainable behaviors, I can make a real difference. (n = 16)	3.63	0.81
I feel like any action I take to be environmentally responsible is only a "drop in the bucket" and won't make a difference.* (n = 16)	2.94 (3.06)	1.12
I believe that by engaging in environmentally sustainable behaviors, I encourage or inspire others to do likewise. (n = 16)	4.06	0.57
I believe that biodiversity should be preserved for the benefit of all people. (n = 16)	4.88	0.34
Subheading: Beliefs About Conservation Initiatives		
I feel that government conservation initiatives are a worthwhile cause. (n = 16)	4.00	0.73
I feel that non-government conservation initiatives are a worthwhile cause. (n = 16)	4.50	0.52

I do not think that we do enough to conserve species. (n = 16)	4.63	0.62
I believe researchers should focus on conserving habitats rather than individual species. (n = 16)	4.38	0.62
I think that ecotourism is dangerous because it seeks to make a profit from endangered species and habitats. (n = 16)	2.88	0.81
I think that conservation biology is equivalent to environmentalism. (n = 16)	1.81	0.98
I believe that conservation planning is a relatively straightforward and easy process so I do not understand why people aren't doing more to conserve. (n = 16)	1.44	0.81
I think that zoos are more important than botanic gardens with respect to conservation. (n = 16)	2.19	0.17
Subheading: Valuing Biodiversity		
I think that conservation biology is purely a life sciences discipline. (n = 19)	1.88	1.15
I have a good understanding of what ecosystem services are, and how they help society. (n = 16)	4.19	0.54
I don't often think about the indirect value of biodiversity (i.e., its non-monetary value).* (n = 16)	2.13 (3.88)	1.09
I regularly visit natural wilderness areas (e.g., parks, reserves). (n = 16)	4.44	0.51
If I was financially able, I would feel comfortable donating $30 a month toward a Vancouver Island Marmot conservation program. (n = 16)	4.38	0.51
If I was financially able, I would feel comfortable donating $30 a month toward an Eastern Prickly Pear conservation program. (n = 16)	4.31	0.60
If I was financially able, I would feel comfortable donating $30 a month toward a Bogbean Buckmoth conservation program. (n = 16)	4.19	0.83
I would accept paying an additional tax for fruits and vegetables so that the government could pay for pollination services. (n = 16)	3.69	1.08
I think it would be unfair for conservation areas to make nearby residents pay a fee for any ecosystem services that they provide.* (n = 16)	2.88 (3.13)	1.03

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

Comparisons within the control course. Paired-samples *t*-tests were run on scale data for the 12 participants who remembered to re-use their personal code across the two data collection time points. Scores on the CBS, $t(11) = -1.96$, $p > .05$, and the CCPS, $t(11) = -1.50$, $p > .05$, did not differ significantly over time[1].

[1] Aside from there being acceptable normality shown in the data, Mann-Whitney tests were not used for comparisons between two groups of five-point Likert scale data because both the Mann-Whitney test and the two-sample *t*-test often provide the same protection against false negatives, as well as against false positives. These patterns appear to hold true for sample sizes of 10, 30, and 200 per group (de Winter & Dodou, 2010).

All items (except one) at both data collection points in the experimental course met the criteria for acceptable skewness (values between +3 and -3) and kurtosis (values between +8 and -8) as per Kline (1997). The exception was the item "I recycle used paper" measured at the start of term, which had a kurtosis statistic of 8.24.

Start of semester. Many descriptive statistics for items in the CBS and CCPS were neutral (see Tables 5 and 6). The scale means were also neutral for the CBS (M = 3.36, SD = 0.36) and the CCPS (M = 3.79, SD = 0.36).

Table 5: *Descriptive Statistics Per Item in the CBS in the Experimental Course at the Start of the Semester*

Item (n)	Mean	SD
Subheading: Energy Conservation		
In winter, I prefer to shower rather than take a bath. (n = 20)	4.35	0.99
In winter, I turn down the heat when I leave my home for more than four hours. (n = 20)	3.70	0.92
I use the dryer to dry my clothes.* (n = 20)	3.90 (2.10)	0.97
I wash dirty clothes using a cold water cycle rather than hot. (n = 20)	3.75	1.21
I wait until I have a full load before doing my laundry. (n = 20)	4.75	0.44
I turn off unnecessary lighting (e.g., when a room is empty). (n = 20)	4.40	0.68
I choose the most energy efficient appliance, light bulb (and so on) where possible. (n = 20)	3.80	0.95
Subheading: Mobility and Transportation		
I drive a car to school or work. (n = 20)	4.05 (1.95)	0.89
I keep the car engine running while waiting in a traffic jam.* (n = 20)	3.50 (2.50)	1.05
I refrain from owning a car. (n = 19)	1.79	1.08
I am a member of a carpool. (n = 20)	2.10	0.91
I drive in such a way as to keep my fuel consumption as low as possible. (n = 20)	3.75	0.91
In nearby areas (around 30 km), I use public transportation or ride a bike. (n = 20)	2.25	1.16
I ride a bike or take public transportation to school or work. (n = 20)	2.00	1.08
Subheading: Waste Avoidance		
I buy drinks in returnable bottles. (n = 20)	4.05	0.69
If I am offered a plastic bag in a store, I take it.* (n = 20)	2.35 (3.65)	1.23
I re-use my shopping bags. (n = 20)	4.10	1.25
I buy products in refillable packages. (n = 20)	2.90	1.21
I dispose of other people's garbage when enjoying nature. (n = 20)	3.60	1.14
Subheading: Consumerism		
I kill insects with a chemical insecticide. (n = 20)	1.75 (4.25)	1.02
I use a chemical air freshener in my bathroom. (n = 20)	1.80 (4.20)	1.11
I buy seasonal produce on purpose. (n = 20)	3.30	0.92

I buy meat and/or produce with eco-labels. (n = 20)	3.05	0.89
I buy domestically-grown wooden furniture or other wooden goods. (n = 20)	2.40	0.68
I have, at some point, stopped buying/using a product (e.g., palm oil) when I learned from mainstream or social media that it was bad for a particular species (e.g., orangutan). (n = 20)	3.90	0.85
Subheading: Recycling		
I recycle used paper. (n = 20)	4.65	0.75
I bring empty bottles and other packages to a recycling bin. (n = 20)	4.70	0.57
I put dead batteries in the garbage.* (n = 20)	2.00 (4.00)	1.17
After meals, I compost leftover food. (n = 20)	4.60	0.75
I regularly buy bottled water.* (n = 20)	1453 (4.55)	0.95
Subheading: Vicarious Social Behaviours Toward Conservation		
I am a member of an environmental organization. (n = 20)	2.30	1.17
I seek out things to read about environmental issues. (n = 20)	3.25	0.97
I talk with friends or family members about problems related to the environment. (n = 20)	4.20	0.77
I have pointed out un-ecological behaviour to someone. (n = 20)	3.90	1.07
I boycott companies with an un-ecological background. (n = 20)	3.00	1.03
I donate to conservation-based societies. (n = 20)	2.60	1.19
I volunteer my time for local conservation initiatives. (n = 20)	2.80	1.15

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

Table 6: *Descriptive Statistics Per Item in the CCPS in the Experimental Course at the Start of the Semester*

Item (n)	Mean	*SD*
Subheading: Environmental Skepticism		
How much do you agree that the negative outcomes that you read about, such as a warming climate and North American water and food shortages, will happen by the year 2100? (n = 20)	4.45	0.83
How much do you agree with the statement: "Global warming is a theory that has not yet been proven."* (n = 20)	1.55 (4.45)	0.83
How much do you agree with the statement: "Global warming is a proven fact." (n = 20)	4.30	1.08
How much do you agree with the statement: "We don't need to worry about the current rate of extinction; mass extinctions have occurred before—it's survival of the fittest."* (n = 20)	1.20 (4.80)	0.52
Subheading: Belief That Climate Change and Conservation are Anthropogenic issues		
How much do you agree that current behaviors of humans are causing climate change effects in the future? (n = 20)	4.75	0.55
How much do you agree with the statement: "The overwhelming cause of all species loss is the rapidly expanding human population." (n = 20)	4.50	0.51

Subheading: General Beliefs about Sustainable Behaviour Effectiveness		
If humans engage in more sustainable behaviors, how much do you agree that this can be an effective way of reducing potential effects of climate change in the future? (n = 20)	4.30	0.98
If humans engage in more sustainable behaviours, how much do you agree that this increase will be an effective way of reducing future biodiversity loss? (n = 20)	4.50	0.61
Subheading: Beliefs About Effectiveness of Personal Action		
I feel that by engaging in environmentally sustainable behaviours, I can make a real difference. (n = 20)	3.75	0.79
I feel like any action I take to be environmentally responsible is only a "drop in the bucket' and won't make a difference."* (n = 20)	2.60 (3.40)	0.94
I believe that by engaging in environmentally sustainable behaviors, I encourage or inspire others to do likewise. (n = 20)	4.15	0.49
I believe that biodiversity should be preserved for the benefit of all people. (n = 20)	4.55	0.61
Subheading: Beliefs About Conservation Initiatives		
I feel that government conservation initiatives are a worthwhile cause. (n = 20)	4.30	0.73
I feel that non-government conservation initiatives are a worthwhile cause. (n = 20)	4.45	0.69
I do not think that we do enough to conserve species. (n = 20)	4.25	0.85
I believe researchers should focus on conserving habitats rather than individual species. (n = 20)	3.50	0.89
I think that ecotourism is dangerous because it seeks to make a profit from endangered species and habitats. (n = 20)	3.50	0.89
I think that conservation biology is equivalent to environmentalism. (n = 20)	2.30	1.03
I believe that conservation planning is a relatively straightforward and easy process so I do not understand why people aren't doing more to conserve. (n = 20)	2.55	1.15
I think that zoos are more important than botanic gardens with respect to conservation. (n = 20)	1.90	0.97
Subheading: Valuing Biodiversity		
I think that conservation biology is purely a life sciences discipline. (n = 20)	2.10	0.79
I have a good understanding of what ecosystem services are, and how they help society. (n = 20)	3.00	1.12
I don't often think about the indirect value of biodiversity (i.e., its non-monetary value).* (n = 20)	2.10 (3.90)	1.07
I regularly visit natural wilderness areas (e.g., parks, reserves). (n = 20)	4.45	0.51
If I was financially able, I would feel comfortable donating $30 a month toward a Vancouver Island Marmot conservation program. (n = 20)	4.05	0.83

If I was financially able, I would feel comfortable donating $30 a month toward an Eastern Prickly Pear conservation program. (*n* = 20)	3.35	0.93
If I was financially able, I would feel comfortable donating $30 a month toward a Bogbean Buckmoth conservation program. (*n* = 20)	3.45	0.95
I would accept paying an additional tax for fruits and vegetables so that the government could pay for pollination services. (*n* = 20)	3.75	0.91
I think it would be unfair for conservation areas to make nearby residents pay a fee for any ecosystem services that they provide.* (*n* = 20)	2.90 (3.10)	1.21

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

End of semester. Descriptive statistics for items in the CBS and CCPS were quite neutral (see Tables 7 and 8), as are the CBS and CCPS scale means (*M* = 3.40, *SD* = 0.46; *M* = 3.69, *SD* = 0.49, respectively). In addition, the means of the five items measuring students' personal attitudes at the end of the experimental course were also neutral—however, the strongest (i.e., most positive) response was for the item asking whether the social science curriculum introduced in the course helped students understand how complex conservation issues are.

Table 7: *Descriptive Statistics Per Item in the CBS in the Experimental Course at the End of the Semester*

Item (*n*)	Mean	*SD*
Subheading: Energy Conservation		
In winter, I prefer to shower rather than take a bath. (*n* = 16)	4.31	0.79
In winter, I turn down the heat when I leave my home for more than four hours. (*n* = 16)	3.94	1.24
I use the dryer to dry my clothes.* (*n* = 16)	3.69 (2.31)	0.95
I wash dirty clothes using a cold water cycle rather than hot. (*n* = 16)	3.94	1.29
I wait until I have a full load before doing my laundry. (*n* = 16)	4.88	0.34
I turn off unnecessary lighting (e.g., when a room is empty). (*n* = 16)	4.50	0.63
I choose the most energy efficient appliance, light bulb (and so on) where possible. (*n* = 16)	4.13	0.89
Subheading: Mobility and Transportation		
I drive a car to school or work. (*n* = 16)	3.81 (2.19)	1.11
I keep the car engine running while waiting in a traffic jam.* (*n* = 16)	3.50 (2.50)	1.21
I refrain from owning a car. (*n* = 16)	1.75	1.18
I am a member of a carpool. (*n* = 16)	2.81	1.33
I drive in such a way as to keep my fuel consumption as low as possible. (*n* = 16)	3.56	1.09
In nearby areas (around 30 km), I use public transportation or ride a bike. (*n* = 16)	2.00	1.16
I ride a bike or take public transportation to school or work. (*n* = 16)	1.75	1.07

Subheading: Waste Avoidance		
I buy drinks in returnable bottles. (*n* = 16)	3.25	1.00
If I am offered a plastic bag in a store, I take it.* (*n* = 16)	2.19 (3.81)	0.75
I re-use my shopping bags. (*n* = 16)	4.13	0.89
I buy products in refillable packages. (*n* = 16)	3.25	1.24
I dispose of other people's garbage when enjoying nature. (*n* = 16)	3.56	1.37
Subheading: Consumerism		
I kill insects with a chemical insecticide. (*n* = 16)	2.00 (4.00)	1.21
I use a chemical air freshener in my bathroom. (*n* = 16)	2.13 (3.87)	1.31
I buy seasonal produce on purpose. (*n* = 16)	3.25	0.93
I buy meat and/or produce with eco-labels. (*n* = 16)	3.19	0.91
I buy domestically-grown wooden furniture or other wooden goods. (*n* = 16)	2.56	0.63
I have, at some point, stopped buying/using a product (e.g., palm oil) when I learned from mainstream or social media that it was bad for a particular species (e.g., orangutan). (*n* = 16)	3.75	1.07
Subheading: Recycling		
I recycle used paper. (*n* = 16)	4.44	0.81
I bring empty bottles and other packages to a recycling bin. (*n* = 16)	4.63	0.50
I put dead batteries in the garbage.* (*n* = 16)	2.44 (3.56)	1.41
After meals, I compost leftover food. (*n* = 16)	4.38	1.20
I regularly buy bottled water.* (*n* = 16)	1.56 (4.44)	1.03
Subheading: Vicarious Social Behaviours Toward Conservation		
I am a member of an environmental organization. (*n* = 16)	2.63	1.41
I seek out things to read about environmental issues. (*n* = 16)	3.25	1.24
I talk with friends or family members about problems related to the environment. (*n* = 16)	4.38	0.62
I have pointed out un-ecological behaviour to someone. (*n* = 16)	4.00	0.10
I boycott companies with an un-ecological background. (*n* = 16)	3.38	0.96
I donate to conservation-based societies. (*n* = 16)	2.88	0.36
I volunteer my time for local conservation initiatives. (*n* = 16)	2.94	1.18

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

Table 8: *Descriptive Statistics Per Item in the CCPS in the Experimental Course at the End of the Semester*

Item (*n*)	Mean	*SD*
Subheading: Environmental Skepticism		
How much do you agree that the negative outcomes that you read about, such as a warming climate and North American water and food shortages, will happen by the year 2100? (*n* = 16)	4.44	0.89
How much do you agree with the statement: "Global warming is a theory that has not yet been proven."* (*n* = 16)	1.25 (4.75)	0.58
How much do you agree with the statement: "Global warming is a proven fact." (*n* = 16)	3.88	1.41
How much do you agree with the statement: "We don't need to worry about the current rate of extinction; mass extinctions have occurred before—it's survival of the fittest." * (*n* = 16)	1.56 (4.44)	1.15
Subheading: Belief That Climate Change and Conservation are Anthropogenic issues		
How much do you agree that current behaviors of humans are causing climate change effects in the future? (*n* = 16)	4.75	0.58
How much do you agree with the statement: "The overwhelming cause of all species loss is the rapidly expanding human population." (*n* = 16)	4.81	0.40
Subheading: General Beliefs About Sustainable Behaviour Effectiveness		
If humans engage in more sustainable behaviors, how much do you agree that this can be an effective way of reducing potential effects of climate change in the future? (*n* = 16)	4.00	1.03
If humans engage in more sustainable behaviors, how much do you agree that this increase will be an effective way of reducing future biodiversity loss? (*n* = 16)	3.75	1.13
Subheading: Beliefs About Effectiveness of Personal Action		
I feel that by engaging in environmentally sustainable behaviors, I can make a real difference. (*n* = 16)	3.56	0.96
I feel like any action I take to be environmentally responsible is only a "drop in the bucket" and won't make a difference.* (*n* = 16)	2.69 (3.31)	0.95
I believe that by engaging in environmentally sustainable behaviors, I encourage or inspire others to do likewise. (*n* = 16)	4.38	0.50
I believe that biodiversity should be preserved for the benefit of all people. (*n* = 16)	4.31	0.70
Subheading: Beliefs About Conservation Initiatives		
I feel that government conservation initiatives are a worthwhile cause. (*n* = 16)	4.06	0.77
I feel that non-government conservation initiatives are a worthwhile cause. (*n* = 16)	4.44	0.51
I do not think that we do enough to conserve species. (*n* = 16)	4.00	1.16
I believe researchers should focus on conserving habitats rather than individual species. (*n* = 16)	4.19	0.83

I think that ecotourism is dangerous because it seeks to make a profit from endangered species and habitats. (n = 16)	2.94	0.12
I think that conservation biology is equivalent to environmentalism. (n = 16)	1.75	1.18
I believe that conservation planning is a relatively straightforward and easy process so I do not understand why people aren't doing more to conserve. (n = 16)	1.25	0.45
I think that zoos are more important than botanic gardens with respect to conservation. (n = 16)	1.81	0.98
Subheading: Valuing Biodiversity		
I think that conservation biology is purely a life sciences discipline. (n = 19)	1.44	0.51
I have a good understanding of what ecosystem services are, and how they help society. (n = 16)	4.00	0.63
I don't often think about the indirect value of biodiversity (i.e., its non-monetary value).* (n = 16)	1.56 (4.44)	0.51
I regularly visit natural wilderness areas (e.g., parks, reserves). (n = 16)	4.50	0.63
If I was financially able, I would feel comfortable donating $30 a month toward a Vancouver Island Marmot conservation program. (n = 16)	4.00	0.97
If I was financially able, I would feel comfortable donating $30 a month toward an Eastern Prickly Pear conservation program. (n = 16)	3.75	1.07
If I was financially able, I would feel comfortable donating $30 a month toward a Bogbean Buckmoth conservation program. (n = 16)	3.69	1.14
I would accept paying an additional tax for fruits and vegetables so that the government could pay for pollination services. (n = 16)	3.38	1.50
I think it would be unfair for conservation areas to make nearby residents pay a fee for any ecosystem services that they provide* (n = 16)	2.88 (1.50)	1.41
Subheading: Personal Attitude Appraisal		
In my opinion, the social science curriculum in this course has significantly changed the way I think about global conservation issues.	3.75	1.07
The exposure to different views and opinions in this course has significantly changed the way I think about global conservation issues.	3.94	1.06
I believe that the social science curriculum in this course has increased my sense of individual-level control over the effects of global conservation issues, including global climate change.	3.25	0.86
I believe that the social science curriculum in this course has motivated me to act in more pro-environmental ways.	3.63	1.15
I think that the social science curriculum in this course helped me understand how complex conservation issues are.	4.44	1.09

SD = Standard deviation; * = reverse coded items; means in parentheses are reverse coded for statistical analysis of continuous scale variables.

Comparisons within the experimental course. Similar to the control course, paired-samples *t*-tests were run on scale data for the 13 participants who remembered to re-use their personal code across the two

data collection points. Scores on the CBS, $t(12) = -1.63$, $p > .05$, and the CCPS, $t(12) = 0.31$, $p > .05$, did not differ significantly over the duration of the semester.

Comparisons between courses. An independent samples summary *t*-test was run to determine whether the end of semester means for both scales in the control course differed significantly from scale means at the end of the semester in the experimental course. The two comparisons were statistically insignificant (all *p*s > .05).

Discussion

Students' average scores on scales measuring their perceptions of conservation behaviors (i.e., the CBS scale), and of climate change and conservation (i.e., the CCPS scale) were neutral at the start and end of both courses. Although an assumption may exist that students choosing biology as a major (and who enroll in a course concerning biodiversity and conservation) would likely report stronger baseline appraisals of their own proenvironmental attitudes and behaviors, this phenomenon appears to be more nuanced, given our data. In fact, the CBS scale mean at the start of term for both the control and experimental courses were almost identical (and the scale mean for the CCPS was also very similar). This indicates that, at the start of the semester in two different academic years, BIOL 457 students held similar attitudes about the content of the six sub-scales in the CBS. This may aid in our understanding of the extent to which the new curriculum introduced in the experimental course associated with students' attitude change during the semester.

Other patterns that emerged, while not statistically significant, serve as reminders about broader, long-term issues related to conservation biology. For example, both courses continued to place more value on mammal conservation than on plant or insect conservation. "Plant blindness"—a tendency to underappreciate plants (see Balding & Williams, 2016)—and negative perceptions of insects (see Kawahara et al., 2021) are commonly-recognized concerns in conservation and science education (Jose et al., 2019; Kawahara et al., 2021). Interestingly, considerable effort was made to ensure that all taxonomic groups were equally referenced in examples, case studies, and in professional guest lectures. However, this effort appears to have had very little effect on student perceptions despite being touted as effective strategies to reduce bias (Jose et al., 2019; Kawahara et al., 2021). It may be that varied exposure methods need to be employed earlier in students' undergraduate experiences (or even at the high-school level).

In addition, the perceived dangers of eco-tourism operations exploiting biodiversity declined more in the experimental course than in the control course, suggesting that exposure to "real world" eco-tourism operators had a positive impact on students' environmental perceptions. Similarly, students in the experimental course reported strongly that the augmented curriculum helped them understand the complexity of conservation issues. This result may be akin to the well-known Dunning-Kruger Effect in which one often does not recognize their own "ignorance" on a topic until one is provided (or seeks out) more information (Dunning, 2011). The exposure to a variety of professionals who are actively engaged in conservation work seems to have enhanced students' ability to self-evaluate their assumptions about conservation and appreciate how different perspectives and motivations contribute to the complexity around environmental action. Further study employing a qualitative approach will be useful to more fully explore these patterns and why they occur and identify pedagogical methods that can predictably reduce bias.

Although average scores on the two scales measured in this study did not statistically improve with (or without) varied instruction, it appears as though students were meaningfully affected by the augmented curriculum offered to them in the experimental course by the end of the semester. Arguably, this is a step in the right direction if students are to be educated about how critical and interconnected conservation research and practice must be after graduation. In the future, undertaking studies using mixed methodologies to gather qualitative data about the reasons why students feel the way they do about the curriculum and the changes in

their perceptions during a course, may be worthwhile. Moreover, this study's results communicate a word of caution to educators who wish to motivate biology students toward eco-consciousness and instill a sense of appreciation of the environment in a broader context. It seems that asking experts in a variety of fields to discuss the importance of biodiversity and conservation from their professional perspectives is not necessarily enough to significantly change students' proenvironmental attitudes or behaviors. A combination of pedagogical tactics should be tested to understand how they add to (or detract from) the impact that guest lecturers from other fields have on conservation biology students' appraisals of their own intentions with respect to sustainability.

Limitations

One limitation of this study is the moderate scale reliability. It may be useful to further validate the two scales by employing factor analysis with a larger, more diverse sample in the future. Other limitations include a restricted sample size and the online delivery of courses because of the COVID-19 pandemic. Unfortunately, the study's sample size was necessarily constrained by institutional capacity limits on the number of students enrolled per semester. Although this study is similar to one published by McCunn & Cilli-Turner (2020) in terms of sample size and style, follow-up research with students learning alongside their peers in a classroom setting (rather than online) should be undertaken to explore whether the natural discussions that inevitably emerge in a classroom setting contribute to a different result. A larger sample size may also be obtained if this study were to be replicated at different institutions with larger class size capacities.

Conclusion

The intention of this study was to help educators in the natural sciences know more about whether cross-disciplinary course material, along with practical discussions with professionals working in positions related to conservation and biodiversity, will affect eco-conscious attitudes and behaviors in undergraduate biology students. Given the seriousness of climate change, as well as the continued degradation of biodiversity worldwide, examining the extent to which undergraduates' environmental perceptions are affected by particular forms of pedagogy is justified. We used a quasi-experimental method to explore whether fourth-year biology students' self-reported proenvironmental attitudes and behaviors associated with their exposure to an augmented interdisciplinary curriculum in an "experimental course" compared to students in a traditional "control course" that did not include broader professional discussions of conservation, biodiversity, or the social dimensions of sustainability.

Generally, students felt quite neutral about their proenvironmental attitudes and behaviors—and their self-perceptions did not significantly improve after experiencing a semester of enhanced curricula (nor did their perceptions differ from students who took the control course). However, at the end of the semester, students in the experimental course strongly agreed that the interdisciplinary curriculum had helped them understand how complex conservation issues can be. It appears that weaving in topics and discussions from professionals who work in the social sciences, as well as in "real-world" contexts related to conservation and biodiversity, may not be particularly effective in improving proenvironmental attitudes and behaviors but may, however, meaningfully add to students' appreciation of how multi-faceted environmental issues are—and will continue to be as climate change-related pressures mount.

Given the outcome of this small study, further research into the strengths and challenges of including cross-disciplinary pedagogy and learning material in STEM courses is recommended. We hope that the findings in the present work will aid in the development of new interdisciplinary strategies and pedagogical considerations for educators in the biological sciences to implement and improve upon now and for years to come

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