An Environmental Engineering Sequence: Deliberately Addressing and Evaluating Environmental Attitudes and Knowledge (presentation & 6-page paper)

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Abstract

The need for improved environmental knowledge and attitudes has never been greater due to increased stress on Earth's resources. The unique pedagogical structure of an engineering sequence at the undergraduate level provides a means to improve environmental knowledge and attitudes. This increase in skill sets enables permeation of sound science and principles that have the potential to influence policies made by the next generation of leaders. This study explored the environmental knowledge and attitudes of two different populations including those with a STEM and non-STEM academic field of study taking a similar introductory environmental science course at the United States Military Academy. Initial environmental knowledge differences between Hispanic/Latino and Black/African American students ($p=0.0137$), between Black/African American and White students ($p=0.0002$), and between male and female students ($p=0.0016$) were found to be statistically significant. After taking an environmental science course at the undergraduate level, our results suggest that these differences are no longer significant.

Keywords

environmental attitudes, environmental literacy, behavior

Introduction

The need for environmental knowledge began with the origin of the human population. There was a need to vent smoke from enclosed spaces (e.g., tents, caves, etc.) to improve air quality and reduce eye and lung irritation. The need for more informed environmental attitudes to guide policy came to the forefront based upon a number of keystone events addressing the potential for a "Silent Spring" and the "tragedy of the commons", for example [1]-[2]. Shortly after the National Environmental Policy Act, the creation of the Environmental Protection Agency, and the establishment of Earth Day, Saarinen [3] emphasized the need to understand the link between human activity and environmental impact as future decisions grow in significance. These concepts are not new as Thomas Malthus [4] emphasized the stresses the human population may place on resources essential for continued survival may result in collapse due to essentially exceeding the Earth's carrying capacity. Although technological improvements provide a means to continually change projected resource exhaustion, the current use of Earth's natural resources exceeds what the planet can renew each year, known as Earth Overshoot Day [5], which occurred on August 2, 2017. Of significant concern is that the Earth Overshoot Day occurs earlier each year. The challenges to ensuring a healthful environment for the next generation centers around the ability to ensure environmental sustainability. Leaders, both military and civilian, must have fundamental environmental knowledge to understand the interconnectedness within nature and possess attitudes that help to shape environmental stewardship. Education provides the framework to set positive conditions for this stewardship.

A number of studies explored the connection between environmental knowledge and attitudes based upon educational background [6], high school students attending a 10-day environmental science course [7], and undergraduate students in a variety of college environments [8]-[10]. Although the more recent studies [9] incorporate investigation at the collegiate level, none evaluates the impact of a dedicated semester long course to shape and influence the environmental knowledge and attitudes of a diverse population of students based upon gender, ethnicity, and academic field of study. Here we evaluate how a similar introductory environmental science course fosters environmental attitudes and knowledge leading to environmental stewardship as assessed using questions incorporated in previous studies and evaluate trends in comparison with the aforementioned research [11].

Methods

Participants

This study implemented a post-course survey and a pre-course survey during calendar year 2017 with 240 students enrolled in a three-course environmental engineering sequence at the United States Military Academy. The pre-course survey student population took the survey during the first week of the environmental science course, whereas the post-course survey student population took the survey during the last week of the course. All students with an academic field of study other than a form of engineering must take an engineering sequence consisting of three courses during a student's third and fourth year. Approximately 90% of the participants were third-year students with the remainder consisting of second and fourth-year students across a similar introductory environmental science course. One course is designed for students enrolled in an environmental science or environmental engineering major, whereas the enrollment of the similar

environmental science course is for those majoring in other academic fields of study. The United States Military Academy maintains a four-year program from which every student graduates with a bachelor in science. Finally, the environmental engineering sequence consists of three courses, the first focuses on global and local environmental problems that impact public health and the environment, whereas the second and third courses are engineering design courses that build upon the themes introduced in the first course to understand the linkage of scientific principles to create and evaluate proposed sustainable solutions.

Instrument

We assessed the students' environmental knowledge and environmental attitudes using a twelve-question knowledge survey and a seven-question attitude survey focused on the environmental subjects integrated into the introductory environmental science course. Since the target population was within the same age group between 20 and 22 years of age, the differentiating demographic factors taken into account include the students' academic field of study, ethnicity, and gender. The environmental knowledge and attitudes surveys follow the nationwide 2000 National Environmental Education and Training Foundation (NEETF)/Roper Survey [11]. To ensure there was no bias reflected from the instructors or the course material with regard to the students' environmental knowledge and attitudes, we administered the initial paper-copy survey during the first two lessons of the academic term. The post-course survey focused on the results from the end of the semester during the last week of the course, whereas the pre-course survey incorporated results obtained during the first week of the course.

The twelve-question environmental knowledge survey linked to the first five themes covered in the first course of the environmental engineering sequence, consisting of Earth as a System (ES), Strained Resources (SR), Energy (EN), Human Health (HH), and Pollution Management (PM). The final theme within this environmental science course, Impact Assessment (IA), ties the ideas of sound science and interconnectedness with nature. We are not only focused on understanding the science, but informing attitudes in the context of what are the potential impacts that then inform design considerations in the latter two courses. The attitudes survey asked students to express their attitudes on the environmental policies by using a Likert-type scale with responses consisting of strongly agree to strongly disagree. Because the sample size for the participants of the post-course survey was less than thirty, we used a Wilcoxon rank sum test [12] to test for significant differences in student responses to the environmental knowledge survey. First, we examined the students' raw scores at the start and end of the term. We examined students by gender, ethnicity, and whether or not they are pursuing a STEM degree. We used the analysis of variance (ANOVA) with Tukey pairwise comparisons to determine significant contrasts of categorical ethnic data.

Results

Environmental Knowledge Survey

We surveyed 19 students as the post-course survey participants and 221 students as the pre-course survey participants (Figure 1). In terms of gender, males accounted for 72 percent of pre-course survey participants and 84 percent of post-course survey participants. By academic field of study, students enrolled in STEM fields of study accounted for 32 percent of the pre-course survey participants and 53 percent of the post-course survey participants. With respect to ethnicity,

students who identify as Asian/Pacific Islanders accounted for 7 percent of the pre-course survey participants, however, were not represented in any of the post-course survey participants. Black or African American students were present in both cohorts. Students who identify as Black or African American were 14 percent of the pre-course survey participants, but only 5 percent of the post-course survey participants identified as such. Students who identify as Hispanic or Latino accounted for 6 percent of the pre-course survey participants, but were not represented in the post-course survey. Students who identified as more than one ethnic group accounted for 8 percent of the pre-course survey participants, but were also not represented in the post-course survey. Less than 1 percent of pre-course survey participants identified as Other, and no post-course survey participants identified as such. Students who identified as White accounted for 62 percent of the pre-course survey participants and 37 percent of the post-course survey participants.

In general, the two cohorts surveyed at the beginning and end of the environmental science course did not demonstrate a significant increase in their environmental knowledge when comparing the results from the pre-course surveys and post-course surveys ($p=0.0784$) based upon the use of a significance level of 0.05. Results from start to end of the course were not significant across the five course themes (ES, $p=0.4459$; SR, $p=0.2646$; EN, $p=0.5142$; HH, $p=0.0771$; PM, $p=0.5551$).

Among students with an academic major in environmental science or environmental engineering, we found very a high baseline knowledge entering the course in each of the themes (Table 2), though survey results were not significantly higher at the end of the course than at the start of the course (Figure 3). We also found no significant increase in knowledge survey scores among students enrolled in a STEM program of study than those who are not ($p=0.2855$).

Gender

We found a significant difference ($p=0.0016$) among the environmental knowledge of males and females at the start of the course (Figure 4). Males' knowledge was higher than their female counterparts in the areas ES ($p=0.0056$) and HH ($p=0.0363$). Other comparisons were not statistically significant. Gender differences were not significant at the end of the course ($p=0.2954$).

Ethnicity

ANOVA found significant differences among students from the diverse ethnic groups we teach ($p=0.0002$) (Table 3). Tukey pairwise comparisons of each group revealed students who identified as Hispanic or Latino scored higher initially than students who identified as Black/African American ($p=0.0137$). Students who identified as White also scored higher than their Black or African American peers ($p=0.0002$) (Figure 5). We did not find any other significant differences between racial/ethnic groups at scales finer than overall survey scores. At the end of the course, however, ANOVA demonstrated no significant contrasts on survey scores by ethnicity ($p=0.2520$).

Environmental Attitudes Survey

The first two questions of the survey enable understanding of the motivation to take action regarding environmental sustainability. When asked the question, "Most of the time, do you think environmental protection and economic development can go hand in hand, or that we must choose between environmental protection and economic development?" about 60 percent of all males and

females, all STEM and non-STEM academic field of study, and students who identified as White responded that environmental protection and economic development can go hand in hand at the start of the course (Figure 6). Between 2 and 5 percent of the same groups responded that we must choose to pursue economic development or protection of the environment and between 35 and 40 percent responded with, it depends. Fifty percent of students who identified as Asian/Pacific Islander and 50 percent of those who identified as Black or African American stated they believe economic development and environmental protection can go hand in hand. Alternatively, 70 percent of those who identified as Hispanic or Latino students selected that response. The largest population that indicated we must choose between economic development and environmental protection were those who preferred no response for ethnicity at 33 percent, followed by those who identified as Asian/Pacific Islanders at 10 percent. By the end of the course, nearly every demographic showed a large increase in the belief that we must choose between economic development and environmental protection, or that it depends.

We also asked students, "When it is impossible to find a reasonable compromise between economic development and environmental protection, which do you usually believe is more important: economic development or environmental protection?" Responses from almost all demographic groups, with the exception of Other, held strong beliefs that either economic development (greater than 20 percent of respondents) or environmental protection (over 50 percent) is more important (Figure 7). At the end of the course, however, only students identified as White and non-STEM academic field of study in general remained unchanged.

When asked an opinion on the statement, "There are differing opinions about how far we've gone with environmental protection laws and regulations. At the present time, do you think environmental protection laws and regulations have gone too far, not far enough, or have struck about the right balance?" many students in all demographic groups at the start of the course responded, 'I do not know" (Figure 8). However, at the end of the course, two demographic groups still felt uninformed. Fewer students in almost all demographic groups indicated that current laws and regulations have struck the right balance. Nearly all groups increased their belief in that current laws and regulations have not gone far enough. Only students enrolled in STEM academic field of study increased their belief in that current laws and regulations have gone too far, from 2 to 10 percent. We observed a significant increase in students of all demographic groups who strongly agree or mostly agree with the statement, "Technology will find a way of solving environmental problems" (Figure 9).

We generally saw all students' support increase for the statement, "The condition of the environment will play an increasingly important role in the nation's economic future." The opinions of students who identified as female increased, from 75 percent responding that they strongly agree at the start, to 100 percent of females responding mostly agree at the end of the course (Figure 10). Moreover, students who identified as either White or male and non-STEM academic field of study each disagreed with the statement in larger numbers at the end compared with the start of the course.

We saw increased support at the end of the course among almost all demographics to the statement, "Private companies should train their employees to solve environmental problems" (Figure 11). No student strongly disagreed with that statement at the end of the course, and fewer numbers

indicated that they mostly disagree. Students who identified as female increased from 25 percent strongly agree at the start to 66 percent strongly agree at the end of the course.

Finally, we asked students to indicate their support for the statement, "Government agencies should support environmental education programs for adults." There was greater than 70 percent of respondents that strongly or mostly agreed with this statement from nearly every demographic at the start of the course (Figure 12). This statement also elicited the most "strongly disagree" responses of any question, by many demographics. By the end of the course, however, most demographics increased their support for adult environmental education, funded by the government. Only students identified as female or non-STEM academic field of study decreased in support.

Discussion

Initial environmental knowledge differences between Hispanic/Latino and Black/African American students, between Black/African American and White students, and between male and female students were found to be statistically significant; however, final differences were found to be insignificant. Amongst the different demographic factors measured, there are differences which can result from a variety of factors, possibly including the form of education (public/private) and cultural or social values based upon geographic location. While understanding these factors and addressing them prior to undergraduate education is beyond the scope of this study, taking an environmental science course at the undergraduate level, at least in this case, appears to minimize these differences through the growth or evolution in one's thoughts after studying the science and issues.

While learning about the various scales and intensities of humanity's potential negative environmental impacts is certainly eye-opening and can seem disheartening initially, this education will likely have positive results. Students across the demographics studied showed increasingly positive attitudes for the future. After receiving environmental education, student attitudes indicated that they increasingly wanted government support for environmental protection programs, wanted private support for employees to receive environmental training, felt hopeful that technological solutions to environmental problems would be discovered, felt that environmental protection laws should become more robust, and felt that environmental and economic development could occur simultaneously.

The results of the environmental knowledge and attitude surveys demonstrate the potential impact of environmental education. Environmental education may not only result in a more informed public, it leaves the public with informed scientific knowledge and the informed attitude necessary to solve the complex problems involved with environmental protection. Additionally, the public will want to solve environmental problems after receiving environmental education as well as work toward ensuring economic growth occurs simultaneously.

Conclusion

Our results suggest that taking an environmental science course at the undergraduate level appears to erase these differences which were initially significant. This is a pilot-study, taking into account the result of a small post-course survey and a much larger pre-course survey population. This study

demonstrates the importance of environmental education. Our students are voters, taxpayers, and future military leaders. In order for them to make informed decisions, they must first be informed. Statistically significant differences in initial environmental knowledge among three key demographics became insignificant after receiving such education.

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Appendix A

Figures

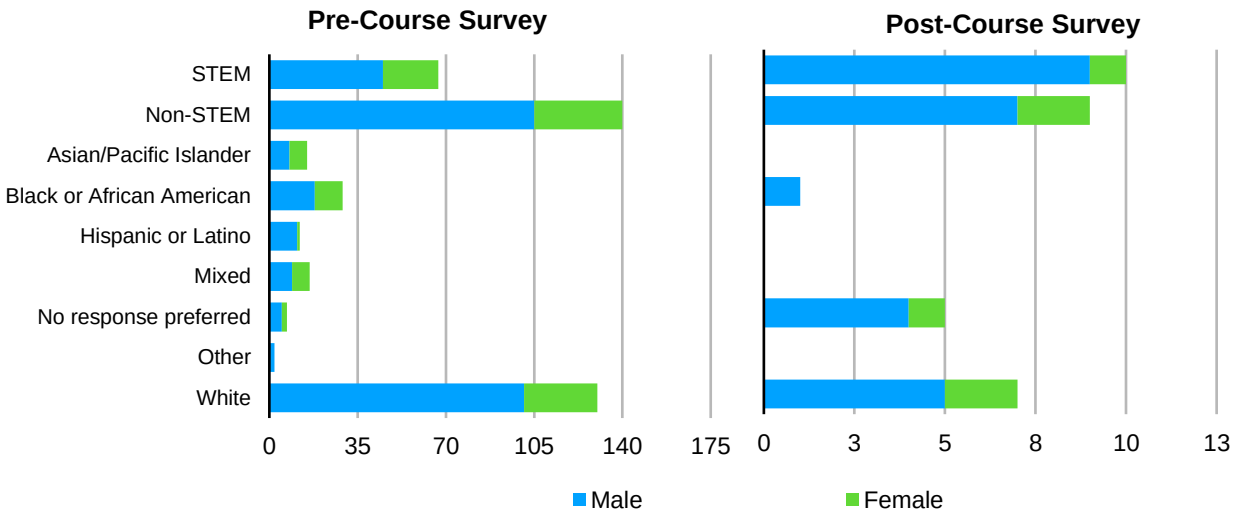

Figure 1. Demographic composition of students enrolled in Environmental Science during the 2017 calendar year.

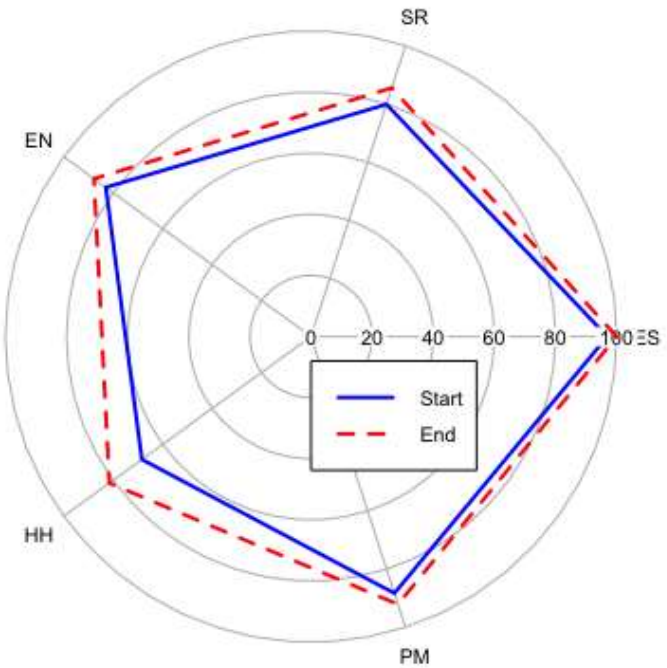

Figure 2. Survey results by course theme from all Students Enrolled in Environmental Science consisting of post-course participants (n=19) and pre-course participants (n=231). Results from start to end of the course were not significant across the five course themes (ES, p=0.4459; SR, p=0.2646; EN, p=0.5142; HH, p=0.07713; PM, p=0.5551).

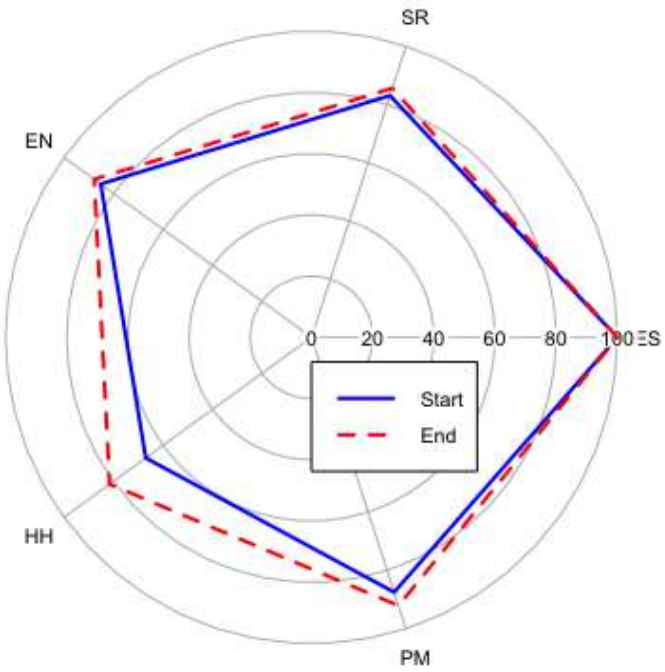

Figure 3. Survey results by course theme from all Environmental Science and Environmental Engineering Majors at the beginning of the course (n=56) and end of the course (n=19). Results from start to end of the course were not significant across the five course themes (ES, p=1; SR, p=1; EN, p=0.7; HH, p=0.0673; PM, p=0.4876).

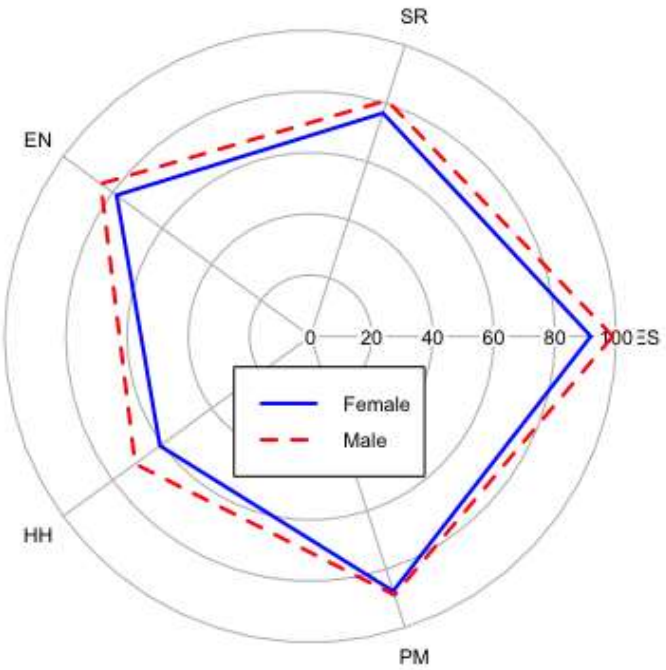

Figure 4. Survey results by course theme among male (n=170) and female (n=60) students of all academic fields of study at the beginning and end of the course. Results were significant for two of the five course themes (ES, p=0.0056; SR, p=0.1063; EN, p=0.1127; HH, p=0.0363; PM, p=0.8229).

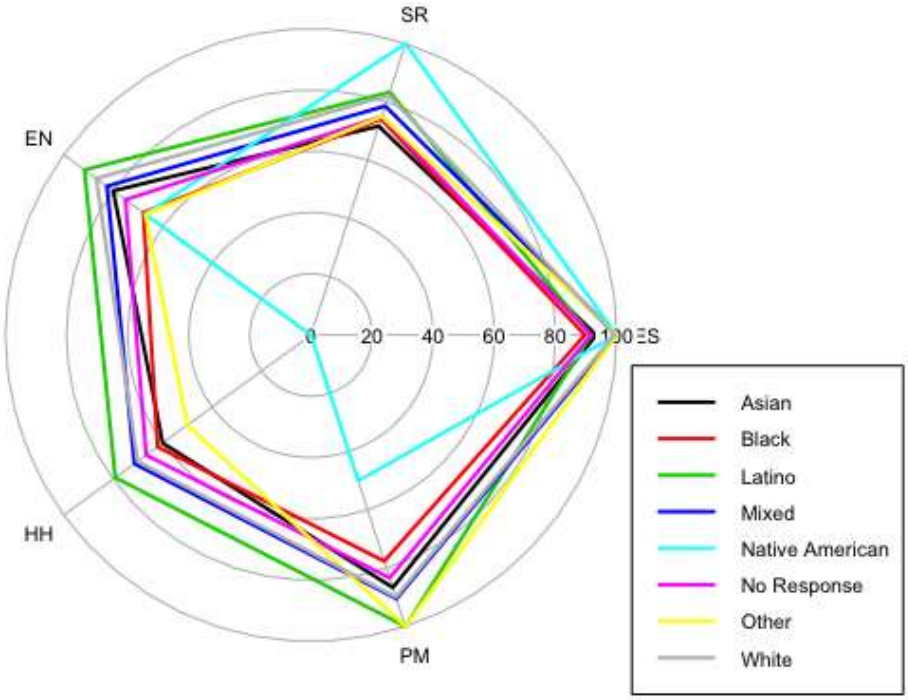

Figure 5. Survey results by course theme among Asian/Pacific Islander (n=15), Black or African American (n=29), Hispanic or Latino (n=12), Mixed Ethnicity (n=21), Native American (n=1), No Response (n=12), Other (n=2), and White (n=139) students of all academic fields of study at the beginning and end of the course. Pairwise comparisons were significant for Hispanic/Latino and Black/African American students (p=0.0137) and between Black/African American and White students (p=0.0002). Results were significant for two of the five course themes (ES, p=0.0056; SR, p=0.1063; EN, p=0.1127; HH, p=0.0363; PM, p=0.8229).

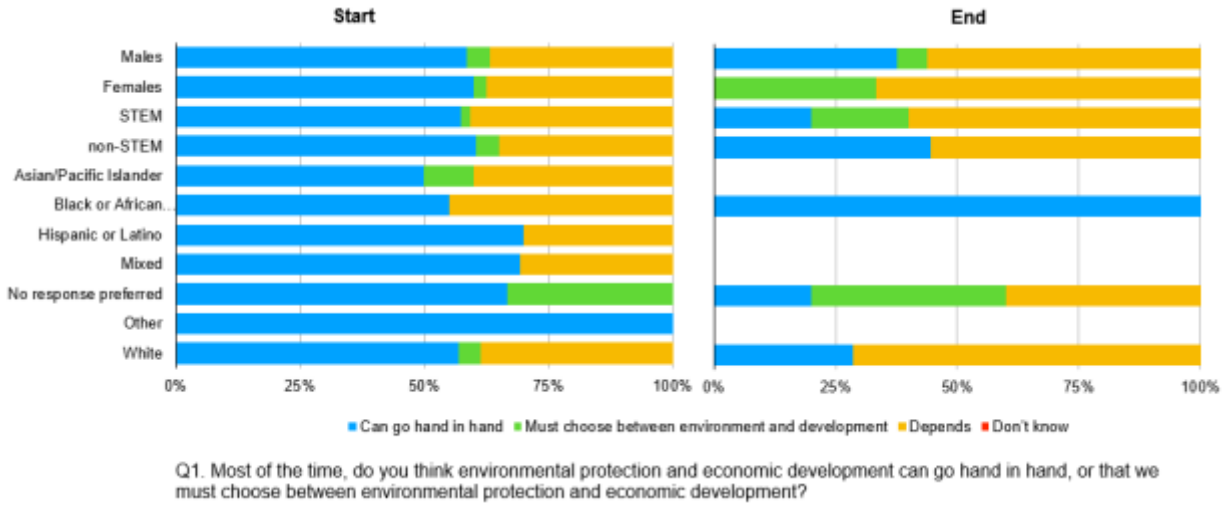

Figure 6. Students' attitudes towards environmental protection and economic development at the beginning and end of the course.

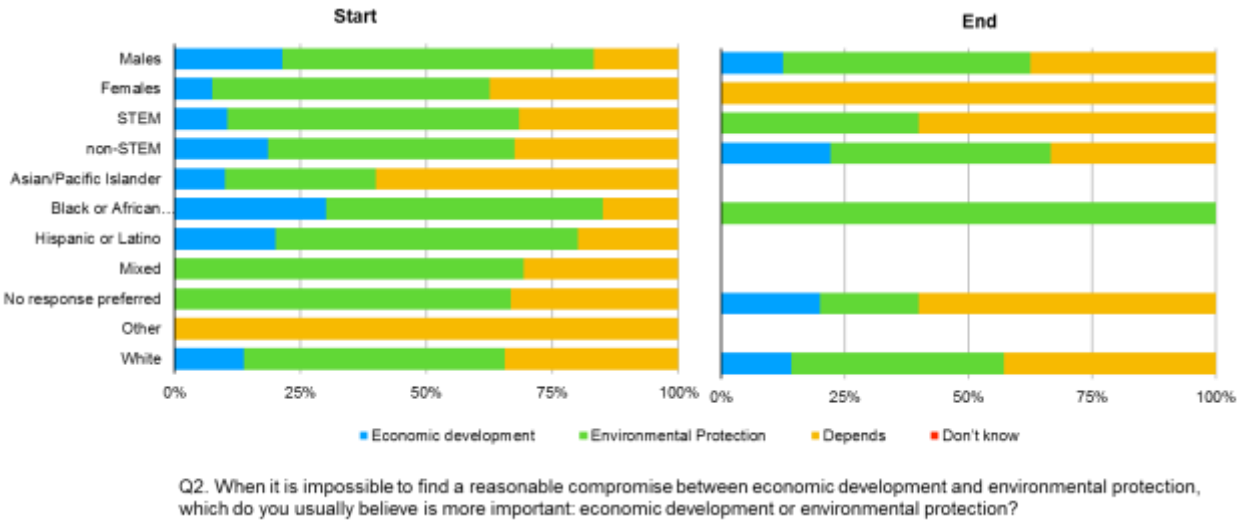

Figure 7. Students' attitudes towards which is more important: environmental protection and economic development, at the beginning and end of the course.

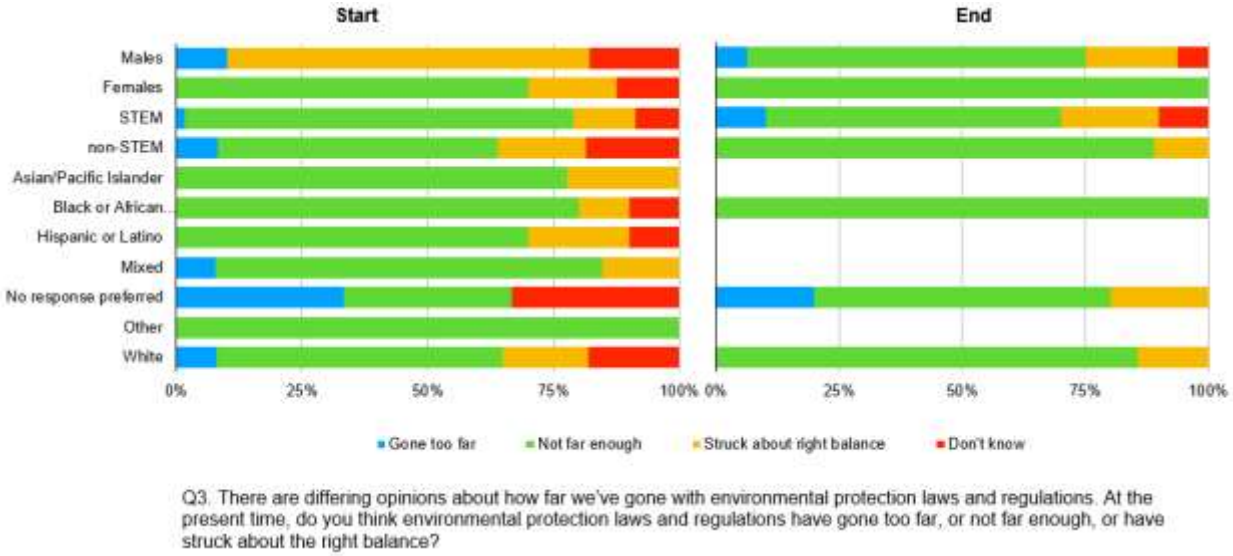

Figure 8. Students' attitudes towards the scope of environmental protection and regulations at the beginning and end of the course.

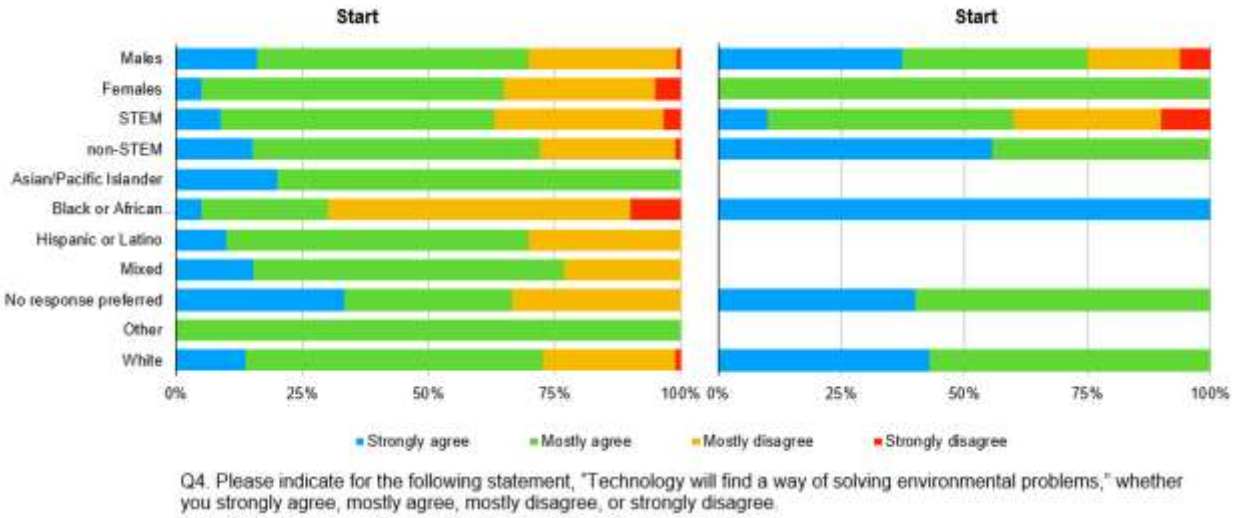

Figure 9. Students' attitudes towards the belief that technology will find a way of solving environmental problems at the beginning and end of the course.

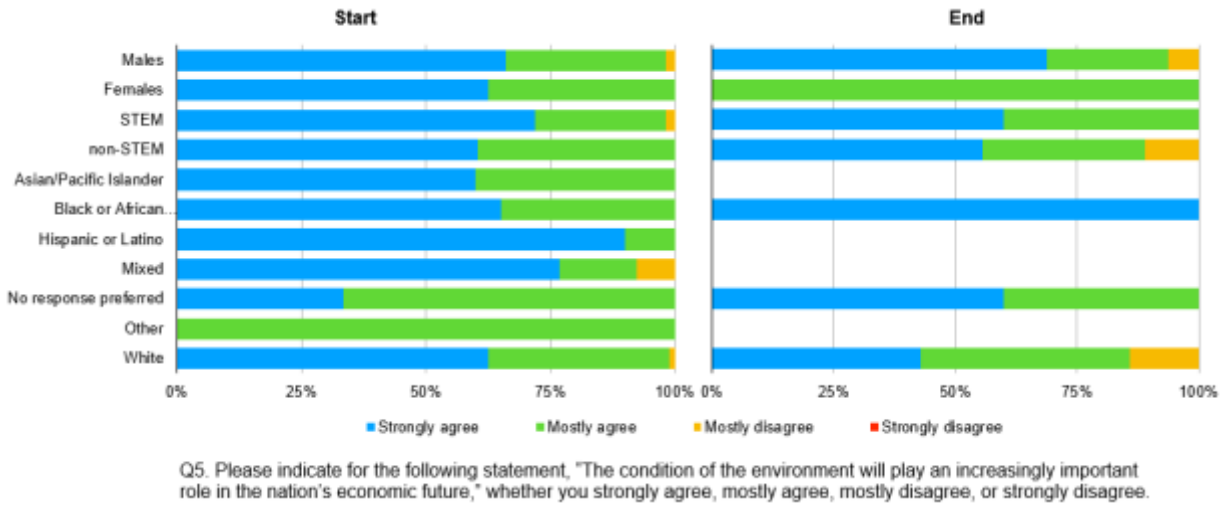

Figure 10. Students' attitudes towards the belief that the environment will play an increasingly important role in the nation's economic future at the beginning and end of the course.

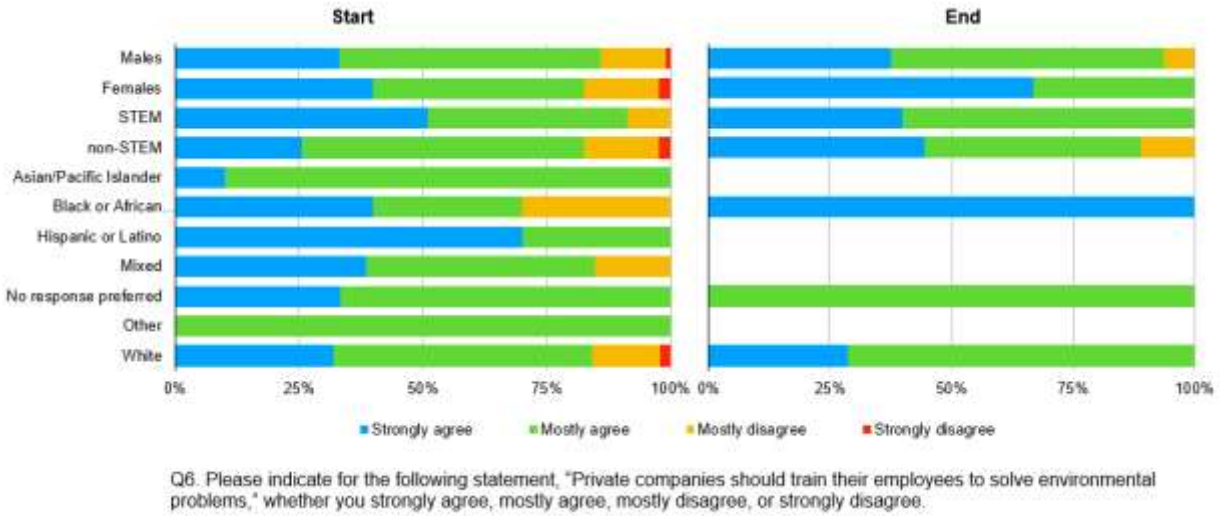

Figure 11. Students' attitudes towards the belief private companies should train their employees to solve environmental problems at the beginning and end of the course.

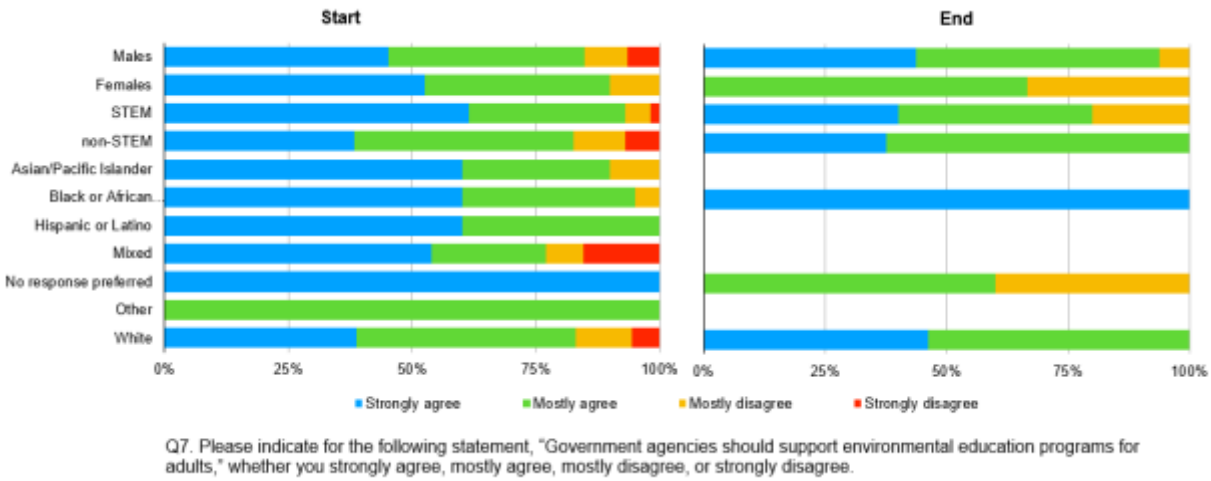

Figure 12. Students' attitudes towards the belief government should support adult environmental education programs at the beginning and end of the course.

Appendix B

Tables

Table 1. Students' score and summary statistics on each of the five environmental science course themes at the beginning and end of the course.

		N	***mean***	***SD***	***SE***	***CI***
ES	*Start*	231	97	17.2	1.1	2.23
	End	19	100	*NA*	*NA*	*NA*
SR	*Start*	231	79.9	19.4	1.3	2.51
	End	19	85.5	15.2	3.5	7.31
EN	*Start*	231	83	24.9	1.6	3.22
	End	19	87.8	19.9	4.6	9.57
HH	*Start*	231	68.4	32.9	2.2	4.27
	End	19	81.6	29.9	6.9	14.4
PM	*Start*	231	88.3	23.6	1.6	3.06
	End	19	92.1	18.7	4.3	9.03
Total	*Start*	231	81.6	14	0.9	1.81
	End	19	87.7	10.2	2.3	4.9

Table 2. Environmental Science and Engineering students' score and summary statistics on each of the five environmental science course themes at the beginning and end of the course.

		N	***mean***	***SD***	***SE***	***CI***
ES	*Start*	56	100	*NA*	*NA*	*NA*
	End	19	100	*NA*	*NA*	*NA*
SR	*Start*	56	83.04	21.90	2.93	5.87
	End	19	85.53	15.17	3.48	7.31
EN	*Start*	56	85.18	21.94	2.93	5.88
	End	19	87.79	19.86	4.56	9.57
HH	*Start*	56	66.96	32.02	4.28	8.57
	End	19	81.58	29.86	6.85	14.39
PM	*Start*	56	87.50	23.84	3.19	6.38
	End	19	92.11	18.73	4.30	9.03
Total	Start	56	83.04	14.12	1.89	3.78
	End	19	87.72	10.16	2.33	4.90

Table 3. Analysis of Variance (ANOVA) Table of Environmental Knowledge Survey results at the start of the course.

	DF	***Sum Sq.***	***Mean Sq.***	***F-value***	***Pr (>F)***
Ethnicity	7	5146	735.2	4.208	0.000213
Residuals	242	42282	174.7		

Author Biographies

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