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Amping-Up Pedagogy through Interdisciplinary Instruction:

A Study of the Effects of Interdisciplinary Instruction on Undergraduate Attitudes and Values Related to Energy Issues at the U.S. Naval Academy

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Abstract

This study makes use of a pre-test/post-test design (with a control group) to test the effect of an interdisciplinary energy course on student attitudes and values related to energy issues. The interdisciplinary energy course was co-taught by engineering, political science, economics, and oceanography professors at the United States Naval Academy during the fall of 2015. The study finds that students in the interdisciplinary energy course experienced significant changes in their energy attitudes on half the categories tested, while students in the control group did not experience similar changes. The changes were greatest among female students, politically moderate students, and engineering students. The findings suggest that interdisciplinary instruction can have a powerful impact on student values, but that the impact works through existing demographic and ideological factors.

Key Words: interdisciplinary, education, environment, attitudes, and values

Background and Literature Review

*O*nce considered a fringe movement within higher education, interdisciplinary programs have become a widely accept approach by leading colleges and universities for addressing the world's complex challenges (Frodeman, Klein, & Mitcham, 2010; Ledford, 2015). While no single definition of interdisciplinarity has been adopted within the literature, one commonly referenced definition of interdisciplinarity is "a means of solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches" (Klein J. T., 1990, p. 196).

Interdisciplinary approaches are sometimes distinguished from "multidisciplinary" approaches by the level of integration among the disciplines (Borrego & Newswander, 2010). Multidisciplinary approaches (sometimes referred to as cross-disciplinary approaches) typically involve a conglomeration of disciplines working side by side to address a single problem. This approach might include a diverse research team of engineers, social scientists, and natural scientists, each bringing their discipline specific expertise to a problem. In contrast, interdisciplinary approaches aim to erode disciplinary boundaries and produce an *integrated* solution to a complex problem (Berger, 1972; Chubin, Porter, Rossini, & Connelly, 1986). For example, this might include a research project that addresses a natural science problem (e.g., carbon emissions) from a perspective that combines elements of engineering, public policy, and economics.

Taking the approach one step farther, "transdisciplinary" approaches typically reject disciplines entirely and call for a unified approach that involve scholars working outside of their traditional disciplines, often including nonacademic practitioners and the general public in their problem-solving efforts (Borrego & Newswander, 2010; Jahn, Bergmann, & Keil, 2012; Gibbons, et al., 1994). While the distinctions between the categories are not always clear and the terms are often interchanged in the literature, this study will make use of the more conventional term "interdisciplinary," as it most accurately reflects the integrated approach discussed in this research.

In recent years, the rise of interdisciplinarity within higher education has been rapid and widespread. In part, the movement arose as a response to the difficulties that highly specialized academic disciplines face when attempting to address interconnected complex problems of society (Apostel, Berger, Briggs, & Michaud, 1972; Crow, 2010; Klein J. T., 1990; Klein J. T., 1996; Wuchty, Jones, & Uzzi, 2007). Interdisciplinarity is based on the belief that environmental problems, health care problems, and other complex problems demanded an academic approach that calls on scholars to function more like fence stringers (connecting previously distinct areas of inquiry) than fence hole diggers (those who dig deeper and deeper into ever narrowing academic holes).

Evidence of the acceptance of interdisciplinarity is widespread. Since the 1980s there have been sharp increases in the number of published articles that reference works across disciplinary boundaries and there have been steady increases in the number of works that include the word "interdisciplinary" in the title (Van Noorden, 2015, p. 306). The spread of the interdisciplinary approach has been particularly pronounced among scholars who focus on problems related to environmental, sustainability, and energy issues (Crow, 2010).

A recent study by the National Council for Science and the Environment (Vincent, Santos, & Cebral, 2014) found that in 2012 there were 1,151 interdisciplinary environmental and sustainability programs in the U.S. offering 1,859 interdisciplinary environmental and sustainability degrees from 838 colleges and universities. This represented a 57% increase in the number of interdisciplinary environmental and sustainability degree programs since the previous census in 2008. The study also found a 49% increase in the number of undergraduate students participating in these programs over the same period of time (Vincent, Santos, & Cebral, 2014, p. 9).

While the growth of such programs is irrefutable, the impact of the interdisciplinary approach is far less clear. To date, the support for the interdisciplinary approach to research and teaching remains more theoretical than empirical (Ackerman, 1989; Lattuca, Voigt, & Faith, 2004; Newell, 2001; Repko, 2008; Rosenfield, 1992; Whitfield, 2008). Even within interdisciplinary environmental and sustainability programs, where interdisciplinarity has become deeply engrained (Vincent , Bunn, & Sloane, 2013), there remains substantial variation in what constitutes an interdisciplinary program and the relative weight to be given to traditional disciplines (e.g., physical sciences, life sciences, social sciences, humanities, policy and other related fields).

Until very recently, there existed no definitive learning outcomes or common methods for assessing interdisciplinary programs (Borrego & Newswander, 2010, pp. 62-63; Vincent , Bunn, & Sloane, 2013; Strang & McLeish, 2015). Moreover, much of the existing research into the effectiveness of interdisciplinary approaches focused on the factors that influence the success of interdisciplinary research teams (Stokols, 2014), rather than falsifiable studies of the effect of interdisciplinary education on student attitudes and values (Kessel, Rosenthfield, & Anderson, 2008). The lack of empirical support has left the approach open to criticism. Scott Frickel, a sociologist from Brown University, summarized the situation this way, "The celebrations (of interdisciplinary programs) have begun, but the actual data on what kind of difference this makes are not in" (Ledford, 2015, p. 311)

Methodology

This study aims to build on the existing literature by empirically testing the impact of interdisciplinary instruction on student attitudes and values related to energy policy. The study compares attitudinal changes in undergraduate students participating in an interdisciplinary co-taught energy course at the United States Naval Academy in the fall of 2015 to a control group of students randomly assigned by the registrar to two required courses at the Naval Academy during the same semester. The research implements a pre-test/post-test design and measured changes in student attitudes and values in a number of dimensions (discussed in detail below).

Treatment Group: Interdisciplinary Energy Course

The interdisciplinary energy course was developed as an upper-level elective at the Naval Academy and co-taught by four professors from the United States Naval Academy (an assistant professor from the Oceanography Department, a professor from the Political Science Department, a professor from the Economics Department, and an associate professor from the Mechanical Engineering Department). The fifth member of the team was a Mechanical Engineering professor who served as the course coordinator for the energy course, but who did not teach the course. The team received outside funding from the Office of the Assistant Secretary of the Navy, Energy, Installations & Environment, which enabled team members to meet throughout the summer of 2015 to develop the course.

During half of the class meetings, students met as an interdisciplinary group and received large-group introductory lectures from one of the four co-instructors (on a rotating basis). The group lectures provided discipline-specific background to energy issues related to fossil fuels, nuclear power, and renewable energy. These group sessions also included a series of lectures from energy practitioners (from both industry and the U.S. military), as well as a field trip to the Bureau of Energy Resources, U.S. Department of State in Washington, DC for a day-long series of round-table discussions with expert panelists on international energy and diplomacy topics. Throughout the semester, specific steps were taken to promote interdisciplinary integration. Outside speakers were chosen from practitioners who spoke across disciplinary boundaries. During the large lectures by the co-instructors, time was allowed for professors and students to question the presenter. The aim was to create a lively discussion at the large session, rather than a series of discipline specific background lectures.

Integration was also achieved though the grading process and the design of student assignments. Students worked in interdisciplinary teams of four to assess the energy security context of an assigned country. These interdisciplinary student teams were required to answer discipline-specific questions, integrate their answers, co-present briefs, and formally defend their findings at an end of the semester campus-wide research poster session. Student grades were based on their individual performance and on the overall group success (a copy of the syllabus is available upon request).

It should be noted that students who participated in the course enrolled in one of four discipline specific sections (engineering, economics, political science, or oceanography). Each of the four sections of the interdisciplinary course adopted common elements for their syllabus. These included a common course overview, common course learning objectives, and common assignment descriptions (for the group material). The sections also include discipline-specific material for the 50% of the assignments that were unique to each section.

During the sections when students did not meet as a large group (roughly one half of the class meetings), students met in smaller discipline specific sections with their individual instructors. During these sections students delved more deeply into discipline-specific material. For example, engineering students might tackle a technology-related energy lab, while political science students would discussed the barriers to international energy agreements. Students would later work in their interdisciplinary teams and apply their lessons to specific nations. The overall course was designed to promote interdisciplinary integration, while maintaining discipline-specific foundations and exposing students to practitioners outside of the academic community. As such, the course included multi-disciplinary, interdisciplinary, and transdisciplinary elements, but for the most part aimed at interdisciplinary integration.

Control Groups: An Engineering Energy Course and Non-Energy Course

The control group was comprised of upper class students enrolled in a required mechanical engineering course at the United States Naval Academy and first-year students enrolled in a required political science course at the Naval Academy. The mechanical engineering course is commonly referred to as “Steam” at the Naval Academy, as it traces its origin to the introduction of steam engines in the U.S. Navy and has been part of the Naval Academy’s core curriculum since its inception 1845. Today, the course familiarizes students with a wide array of engineering concepts, including: thermodynamics, gas, steam, and diesel engines, nuclear power, heat transfer, propulsion, and others. The course is a requirement for non-technical majors at the Naval Academy (in fulfillment of their Bachelor of Science Degrees, which all students receive at the Naval Academy). The second component of the control group was comprised of students taking a section of American Governmental and Constitutional

Development, a required course that is taught to first year students at the Naval Academy. This course covers the basic institutions of American government and key founding principles. Students are randomly assigned by the registrar to both of these required courses. The primary function of the control group in this experimental research design is to rule out the possibility that value-based and attitudinal changes that take place in the treatment group are explained by larger factors that take place during the same period of time, rather than caused by exposure to the interdisciplinary course.

Survey Instrument (Pretest and Post-Test)

The survey instrument for the pretest (conducted the first week of the fall semester 2015) and post-test (conducted the final week of the same semester) were adapted from two energy surveys found in the literature: The University of Michigan Energy Survey: Year One Report (DeCicco, Yan, Keusch, Munoz, & Neidert, 2015) and the National Environmental Education & Training Foundation/Roper Report Card (2002). The questions in the pretest were identical to those of the post-test and were administered to both the treatment group and the control group. The selected questions were designed to capture respondent attitudes and values related to energy issues, as well as standard political and demographic information (such as gender, academic major, class year, and ideology). The survey includes questions covering numerous energy-related topics:

1) **Worry**: How much do you personally worry about the environmental impact of energy? (Not at all 0, Only a little 1, fair amount 2, great deal 3)

2) **Reduce**: How often do you reduce the energy you use for environmental reasons? (Never 0, sometimes 1, often 2, always 3)

3) **Economic Development v. Energy Conservation**: When it is impossible to find a reasonable compromise between economic development and energy conservation, which do you usually believe is more important? (Economic Dev. 0, Conservation 1)

4) **Environmental Laws**: 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, or not far enough, or have struck about the right balance? (gone too far 0, right balance 1, not far enough 2)

5) Please indicate for each of the following statements about energy whether you strongly agree, mostly agree, mostly disagree, or strongly disagree. (0 strongly disagree, 1 mostly disagree, 2 mostly agree, 3 strongly agree)

    a. **Technology**: Technology will find a way of solving energy problems.
    b. **National Security**: Energy issues will play an increasingly important role in national security.
    c. **Government Officials**: Government officials need to place more emphasis on energy conservation.
    d. **Taught**: Energy conservation should be taught in public schools.

6) (**Vote for Climate Change**) Next, you will read a statement that could be made by someone who wants to be a United States Senator or President of the United States. (0 less likely, 1 no effect, 2 more likely)

   Here is the statement:

   “I believe that global warming has been happening for the past 100 years, mainly because we have been burning fossil fuels and putting out greenhouse gasses. Now is the time for us to be using new forms of energy that are made in America and will be renewable forever. We can manufacture better cars that use less gasoline and build better appliances that use less electricity. We need to transform the outdated ways of generating energy into new ones that create jobs and entire industries, and stop the damage we’ve been doing to the environment.”

   If a candidate says this, would this make you more likely to vote for this candidate, less likely to vote for this candidate, or would it not affect how likely you would be to vote for this candidate?

7) (**Vote Against Climate Change**) Next, I will read you a statement that could be made by someone who wants to be a United States Senator or President of the United States. (0 less likely, 1 no effect, 2 more likely)

   Here is the statement:

   “When people ask me if I believe global warming has been happening, I’m not qualified to debate the science over climate change, because I am not a scientist. When people ask me if I believe human activity causes global warming, I don’t know. There is significant scientific dispute about that. We can debate this forever. I am not qualified to make this decision. But I am astute enough to understand that every proposal to deal with climate change involves hurting our economy and killing American jobs.”

   If a candidate says this, would this make you more likely to vote for this candidate, less likely to vote for this candidate, or would it not affect how likely you would be to vote for this candidate?

General Theoretical Expectations

The theoretical assumption tested in this study is that the effects of the interdisciplinary energy instruction will significantly impact student attitudes regarding a wide range of energy issues (Ackerman, 1989; Lattuca, Voigt, & Faith, 2004; Newell, 2001; Repko, 2008) and that similar effects will not be present in the control group. The study hypothesizes that the effect will generally be in the direction of greater concern regarding energy issues and more tolerance for government involvement in the energy sector, as the course outlines market failures in the energy sector and specific government policies designed to alter market forces.

This expectation is based on the existing interdisciplinary literature and a separate body of research that focuses on the effects of deliberative events on environmental attitudes (Akerlof, La Porte, Rowan, Ernst, & Brian , 2016; Moser & Ekstrom, 2001; Burton & Mustelin, 2011; Carpini, Cook, & Jacobs, 2004). The deliberative event scholarship has generally found that events that facilitate communication between diverse groups (decision-makers, interdisciplinary experts, stakeholders and the public) can significantly impact participant attitudes (Fishkin & Luskin, 2005). Studies have found that such experiences can increase citizen engagement in public affairs; increases tolerance of other viewpoints; and increase understanding of subject's policy preferences (Akerlof, La Porte, Rowan, Ernst, & Brian , 2016; Carpini, Cook, & Jacobs, 2004).

As the interdisciplinary energy course studied here serves as a type of semester-long deliberative event (including inputs from experts, stakeholders, decision-makers, an interdisciplinary team of scholars, and students themselves), this study hypothesizes that the experience should increase concern among participants and increase support for political action. In sum, the course should have a significant impact on student energy attitudes and similar changes should not occur in the control group.

Results

Table 1 displays a comparison of means (with levels of significance based on one tailed t-tests) for the treatment group and control group. Columns two and three reveal that students in the interdisciplinary energy course were slightly more concerned about energy issues going into the course than students in the control group, though these differences were statistically insignificant in 8 of the 10 categories. Only in the areas concerning "worry about the environmental impact of energy" and "connecting energy issues to national security" did the two groups significantly differ in the pretest. These minor differences are to be expected, as the students in the treatment group enrolled in the class as an elective and ostensibly had some concern about the topic prior to enrolling in the class.

Columns three and four of Table 1 show that following the course students in the interdisciplinary energy course significantly differed from students in the control group in half of the categories. Moreover, the gap between the treatment group and control group in the areas of "worry about the environmental impact of energy" and "connecting energy issues to national security" increased and remained statistically significant. At the end of the semester, students in the treatment group differed significantly from students in the control group in their desire for increased environmental laws, desire for government officials to take action, and their opposition to political candidates who deny climate change.

Table 1
Pretest and Post-Test Comparisons of Interdisciplinary Class to Control Group (Non-Paired T-Test)

	Pre-Treatment		Post-Treatment	
	Interdisciplinary	Control Group	Interdisciplinary	Control Group
	Mean (St. Dev.)	*Mean (St. Dev.)*	*Mean (St. Dev.)*	*Mean (St. Dev.)*
ENERGY ATTITUDES/VALUES				
Worry about Enviro Impact of Energy Not at all 0, Only a little 1, fair amount 2, great deal 3 N=54, N=41; N=54, N=41	**1.76 **** (.73)	**1.42 **** (.67)	**2.04**** (.78)	**1.56**** (.71)
Reduce Energy for Enviro Reasons Never 0, sometimes 1, often 2, always 3 N=54, N=40; N=54, N=41	1.24 (.70)	1.18 (.68)	1.19 (.65)	1.20 (.72)
Econ Dev v. Conservation Economic Dev. 0, Conservation 1 N=46, N=33; N=48, N=35	.46 (.50)	.42 (.51)	.44 (.50)	.57 (.50)
Enviro Laws gone too far 0, right bal. 1, not far enough 2 N=44, N=33; N=49, N=34	1.39 (.78)	1.30 (.68)	**1.74*** (.57)	**1.50*** (.71)
Technology Solve Energy Problems 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=54, N=41; N=54, N=41	2.06 (.63)	2.05 (.71)	2.09 (.62)	2.20 (.64)
National Security Connected to Energy Issues 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=54, N=41; N=54, N=41	**2.39 *** (.63)	**2.07 *** (.72)	**2.63**** (.56)	**1.93**** (.85)
Gov. Officials Need Greater Emphasis on Energy 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=54, N=41; N=54, N=41	2.06 (.74)	1.93 (.65)	**2.41**** (.66)	**1.93**** (.76)
Teach Energy Conservation in Public Schools 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=54, N=41; N=54, N=41	2.41 (..66)	2.32 (.52)	2.50 (.66)	2.34 (.62)
Vote for GHG Advocate 0 less likely, 1 no effect, 2 more likely N=50, N=39; N=53, N=40	1.61 (.67)	1.54 (.64)	1.60 (.66)	1.58 (.71)
Vote for GHG Denier 0 less likely, 1 no effect, 2 more likely N=48, N=39; N=52, N=40	.46 (.82)	.69 (.89)	**.35*** (.68)	**.61*** (.81)

One Tailed T-Test

* = p <= .05
** = p <= .01

Table 2 displays the results of a paired comparison of means (t-test) between the pretest treatment group and post-test treatment group, as well as the same test for the control group. Columns 1 and 2 show that that students in the interdisciplinary energy course (i.e., the treatment group) significantly increased their environmental concern in five of the ten categories (the same five categories that they differed from the control group in the post-test comparisons shown in Table 1). Columns 3 and 4 reveal that students in the control group experienced no statistically significant changes in their energy attitudes over the same period of time.

Table 2
Pretest / Post-Test Paired Comparison of Means (With One Tailed T-Test)

	Interdisciplinary		Control Group	
	Pretest	*Post-Test*	*Pretest*	*Post-Test*
ENERGY ATTITUDES/VALUES	*Mean (St. Dev.)*	*Mean (St. Dev.)*	*Mean (St. Dev.)*	*Mean (St. Dev.)*
Worry about Enviro Impact of Energy Not at all 0, Only a little 1, fair amount 2, great deal 3 N=52, N=41	**1.77**** (.73)	**2.04**** (.79)	1.42 (.67)	1.56 (.71)
Reduce Energy for Enviro Reasons Never 0, sometimes 1, often 2, always 3 N=52, N=40	1.25 (.68)	1.21 (.64)	1.18 (.68)	1.20 (.72)
Econ Dev v. Conservation Economic Dev. 0, Conservation 1 N=42, N=27	.45 (.50)	.41 (.50)	.44 (.51)	.59 (.50)
Enviro Laws gone too far 0, right bal. 1, not far enough 2 N=38, N=29	**1.47**** (.73)	**1.82**** (.46)	1.31 (.71)	1.45 (.74)
Technology Solve Energy Problems 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=52, N=41	2.06 (.64)	2.08 (.62)	2.05 (.71)	2.20 (.64)
National Security Connected to Energy Issues 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=52, N=41	**2.40**** (.60)	**2.64**** (.56)	2.07 (.72)	1.93 (.85)
Gov. Officials Need Greater Emphasis on Energy 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=52, N=41	**2.08**** (.74)	**2.42**** (.64)	1.93 (.65)	1.93 (.76)
Teach Energy Conservation in Public Schools 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree N=52, N=41	2.40 (.67)	2.52 (.64)	2.32 (.52)	2.34 (.62)
Vote for GHG Advocate 0 less likely, 1 no effect, 2 more likely N=48, N=38	1.63 (.67)	1.67 (.60)	1.55 (.65)	1.55 (.72)
Vote for GHG Denier 0 less likely, 1 no effect, 2 more likely N=45, N=38	**.44*** (.81)	**.20*** (.50)	.71 (.90)	.66 (.82)

Paired T-Test.

One Tailed
* = p <= .05
** = p <=.01

Table 3 reveals the results of five OLS regression models. The dependent variable in each model represents the five factors that experienced the greatest change in Tables 1 and 2 (worry about energy, laws have not gone far enough, national security and energy, government officials should do more, and vote for greenhouse gas denier). The independent variables in each model are a dummy variable for the treatment group and additional dummy variables for gender, major, and ideology. Here we see that while holding other factors constant, participation in the interdisciplinary energy course had a statistically significant impact in two of the five models. Students in this course significantly increased their perceived connection between energy and national security and significantly increased their desire for government officials to do more to address energy issues.[1]

Together the results of Tables 1 through 3 allow us to reject the null hypotheses that the course did not impact student attitudes or that the change in energy attitudes was the result of outside influences that occurred during the same period of time.

Table 3
Regression Models of Change in Pretest/ Post-Test Energy Attitude Scores by Treatment (While Controlling for Gender, Major, and Ideology)

	Model 1 Worry about Energy	**Model 2** Law Not Far Enough	**Model 3** Energy & Nat. Security	**Model 4** Gov Official Do More	**Model 5** Vote for GHG Denier
Treatment Variable					
1 Interdisciplinary, 0 Other	.02	.28	**.43***	**.41***	.01
Control Variables					
Gender					
1 Male, 0 Female	.14	.33	-.24	.01	.21
Major					
1 Poli/Sci, 0 Other	.29	.18	-.37	-.03	.12
1 Engineering, 0 Other	.32	-.06	-.18	-.07	-.11
1 Economics, 0 Other	.08	-.15	-.50	-.14	.03
Ideology					
1 Liberal, 0 Other	.43	**-.57***	.05	-.12	-.10
1 Conservative, 0 Other	-.10	-.26	-.15	-.28	-.02
R Squared	.11	.10	.15	.11	.02

N=86
p<= .05 *
p<=.01 **

Tables 4 allows us to move beyond the basic question of whether the interdisciplinary course had an impact on the students' attitudes and to test the demographic factors that influenced the strength of the course's impact. Here we see that the impact of the course was

[1] Note that that the baseline comparison for the "majors" variable is oceanography (the only major not included in the model). Likewise, the baseline comparison for the "ideology" variable is the moderate category.

somewhat greater for females than males. For example, females in the course increased their average worry about the environmental impact of energy by a score of .53 (which was a statistically significant difference from their pre-test score). Males in the course on average also increased their worry about the environmental impact of energy, though the change was a modest .14 increase and the difference was not statistically significant from their pre-test scores. A similar difference was seen in female opposition to voting for candidates who deny climate change. While males also experienced great opposition to greenhouse gas deniers following the course, the change was small and not significant.

The results for the class's interaction with ideology were more complex. Columns 3-5 show that the course increased worry among self-identified liberal students more than students who identified as moderates (.55 to .30), and conservatives actually worried less after taking the class (-.06). In general, however, the greatest impact was on moderate students. Students in this group significantly changed their energy attitudes in 5 of the 10 categories. Liberals and conservatives only saw significant changes in their attitudes in 2 out of the 10 categories.

Table 4.
Delta from Pretest and Post-Test (with Significance Level from Paired T-Test) for Students in Treatment Group (Interdisciplinary Energy Course)

	Gender		Ideology (Post-Test)			Class Type		
ENERGY ATTITUDES/VALUES	Female	Male	Con	Mod	Lib	Eng	Econ	Pol
Worry about Enviro Impact of Energy Not at all 0, Only a little 1, fair amount 2, great deal 3	**.53**** N=15	.14 N=36	-.06 N=16	**.30*** N=20	**.55**** N=11	**.38**** N=21	.11 N=9	**.40*** N=15
Reduce Energy for Enviro Reasons Never 0, sometimes 1, often 2, always 3	.00 N=15	-.08 N=36	-.06 N=16	-.10 N=20	.09 N=11	.05 N=21	-.11 N=9	.00 N=15
Econ Dev v. Conservation Economic Dev. 0, Conservation 1	.16 N=12	-.10 N=29	.00 N=12	.06 N=17	-.11 N=9	.13 N=16	**-.33*** N=9	.00 N=11
Enviro Laws gone too far 0, right bal. 1, not far enough 2	**.44*** N=12	**.36**** N=25	**.27*** N=11	**.58**** N=12	.00 N=10	**.47**** N=17	.29 N=7	.13 N=8
Technology Solve Energy Problems 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree	-.07 N=15	.06 N=36	.25 N=16	-.10 N=20	.18 N=11	-14 N=21	**.33*** N=9	.07 N=15
National Security Connected to Energy 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree	**.40*** N=15	**.14*** N=36	.06 N=16	**.35**** N=20	.27 N=11	**.19*** N=21	.11 N=9	**.33*** N=15
Gov. Officials Greater Emph. on Energy 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree	**.40**** N=15	**.33**** N=36	.13 N=16	**.50**** N=20	**.27*** N=11	**.43**** N=21	.11 N=9	**.46*** N=15
Teach Energy Con. in Public Schools 0 st. dis, 1 mostly dis, 2 mostly agree, 3 st. agree	.13 N=15	.11 N-36	-.06 N=16	**.35*** N=20	-.09 N=11	**.29*** N=21	.00 N=9	-.07 N=15
Vote for GHG Advocate 0 less likely, 1 no effect, 2 more likely	.13 N=15	.06 N=32	.00 N=14	.28 N=18	.00 N=11	**.26*** N=19	-.11 N=9	.00 N=14
Vote for GHG Denier 0 less likely, 1 no effect, 2 more likely	**-.33*** N=12	-.16 N=32	**-.31*** N=13	-21 N=29	-.10 N=10	**.-.35*** N=20	-.38 N=8	-.08 N=13

Paired T-Test.

One Tailed
*   = p <= .05
** = p <= .01

Perhaps the most interesting results are seen when looking at the results by class type. Here we see that the class's engineering students (who typically have less exposure to the value-based judgments that are common in the social science courses) experienced the greatest change in energy attitudes. Students in this category experienced significant changes in 7 out of 10 categories. Moreover, their confidence that technology will solve energy problems decreased, though the change was not significant. In contrast, students in the economics section only significantly changed in two categories (and these categories were their increased confidence that technology will solve environmental problems and their increased preference for economic development over environmental protection). Students in the political science section increased their worry, increased their perceived connection between energy and national security and increased their preference for government officials to take more action.

Conclusion

This study finds compelling evidence that students in an interdisciplinary energy course experienced significant changes in their energy attitudes, while students in the control group did not experience similar changes. The changes were greatest among female students, politically moderate students, and engineering students. The findings suggest that interdisciplinary instruction can have a powerful impact on student values and potentially impact institutional cultures regarding energy, but that the impact works through existing demographic and ideological factors.

Further research is needed to explore if the impact on energy attitudes found in this study surpasses the impact on student attitudes in traditional, discipline specific courses. To justify this time consuming approach to education it is not enough to know that it is effective, ultimately it is necessary to explore if interdisciplinary is a more powerful pedagogical tool than traditional single-disciplinary approaches. Further research is also necessary to explore if the effects found here persist over time and if the attitudinal changes correspond to actual behavioral changes. This study functions as an early step in this line inquiry.

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