Gaps in sustainability education

The impact of higher education coursework on perceptions of sustainability

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Abstract

Purpose – This paper aims to examine how both the amount and type of coursework impact students' conceptualizations of sustainability. Previous research demonstrates that academic coursework influences students' environmental attitudes, yet few studies have examined the impact of coursework on how students conceptualize "sustainability".

Design/methodology/approach – Data are examined from the 2011 Sustainability Survey, which yielded a sample of 552 students at a medium-sized university in the southeastern USA. A series of four linear regression models estimate the impact of academic coursework on students' conceptualizations of sustainability (ecosystems/nature, eco-efficiency, community/well-being and systemic change/innovation).

Findings – The results indicate that the type of course that students take significantly impacts the way in which students conceptualize this term; the number of courses taken has no statistically significant impact. This suggests that mere exposure to a particular theme in a class, rather than continued exposure to courses related to sustainability, is more important in shaping students' perceptions.

Originality/value – This study expands on previous research by examining the influence of the number and type of academic coursework on students' conceptions of sustainability and provides a framework for understanding the varied ways in which sustainability is defined. This has important implications for how students approach ways to achieve a sustainable future. The results suggest that students may be exposed to particular messages within an academic division that encourage students to emphasize particular elements of sustainability. While not problematic on its face, the data demonstrate that students lack an integrated or holistic understanding of sustainability. They usually view sustainability through the same prism as the academic division where their coursework was located, and this has implications for students' continued perceptions of sustainability, academic programming of sustainability and the practice of it.

Keywords Sustainability, Curriculum, Interdisciplinary, Sustainability education, Sustainability perceptions

Paper type Research paper

Introduction

Although the American public tends to think about "sustainability" in terms of basic environmental issues, there has been increasing nuance in the academic discourse about this term. While the concepts of ecosystems, environmental preservation and energy

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efficiency have begun to expand individuals' understandings of sustainability, academic scholarship demonstrates that there are different ways of thinking about sustainability well beyond the environmental realm. While some have emphasized democratic participation and social justice (Norton, 2005), other scholars have identified the importance of "systems" and their role in decision-making as central to sustainability (Cash *et al.*, 2003; Levin and Clark, 2010; Fisher, 2014). In other words, there are different dimensions to and definitions of "sustainability", which have expanded considerably since the inception of the term "sustainable development" from the Brundtland Commission (1987).The existence of these varied definitions has important implications for the ability of the scientific community to offer holistic and integrated solutions to advance the principles of sustainability, particularly as the solutions and policy prescriptions that are offered are directly related to the diagnosis and understanding of the problems encountered (Miller, 2013). Indeed, one's perception of what sustainability is necessarily impacts to what one attributes the cause of the problem, who or what one finds responsible for action and the type of solutions that one perceives are appropriate to address those concerns. A limited definition of sustainability may thus hamper debate and decision-making, question the credibility and legitimacy of prescriptions related to other definitions of sustainability and even limit the discovery of new and innovative solutions across disciplines and different areas of expertise. As a result, understanding how individuals define sustainability in different ways and the sources of those varied definitions becomes increasingly important.

Clearly, how individuals think about sustainability – and environmental concerns, more specifically – are rooted in their education of these issues in higher education. Previous research has demonstrated that students' academic coursework has impacted their environmental attitudes and behaviors; for example, taking a course in environmental studies has been found to encourage students to engage in more environmentally responsible behaviors (Smith-Sebasto, 1995), while taking an introductory course in environmental history generally causes students to perceive the environment in a preservationist (as opposed to a utilitarian) manner (Tomsen and Disinger, 1998). However, the bulk of this research has focused on attitudes related specifically to the environment – rather than the broader concept of sustainability – and has focused primarily on the impact of one particular course on students' environmental attitudes.

This article aims to expand on this research by examining the influence of both the number and type of academic coursework on students' conceptions of sustainability, recognizing that this concept potentially incorporates both environmental and broader elements. In addition, we compare how the type of course – whether in the natural sciences, humanities, social sciences, business/economics/policy or an interdisciplinary, integrated course that focuses on sustainability – impacts the ways in which students conceptualize and define this important term.

Literature review

Sustainability typology

Environmentalism has increasingly grown more complex, resulting in a breakdown in the singular, traditional understanding of the term (McGrail *et al.*, 2011). In fact, Mulvihill argues that an "emerging environmentalism" offers different characteristics

to "old or declining environmentalism", one that focuses on solutions, improvisation and innovation that occur through collaboration and networks (Mulvihill, 2009). Sustainability has further opened up the space by expanding beyond purely environmental concerns, and with it, different perspectives have emerged on what represents sustainability or aspects of it. As a result, sustainability equally defies clear definitional attributes.

To date, most of the survey research tests *environmental* attitudes as a monolithic variable, where environmentalism is a worldview captured by a series of questions testing various perceptions of the human – ecological relationship. For example, the New Ecological Paradigm was a 12-item scale developed in 1976 to measure adherence to an "ecological worldview" (Dunlap and Van Liere, 1978; Dunlap *et al.*, 2000). However, there is a paucity of research exploring *sustainability* literacy or perceptions and attitudes on sustainability (Carew and Mitchell, 2002; Kagawa, 2007; McGrail *et al.*, 2011). Moreover, *typologies* of environmental or sustainability attitudes are not prolific aside from general typologies around environmental discourse (Dryzek, 2005), worldviews on environmental change (Clapp and Dauvergne, 2005; Sauvé, 1996) or trends of environmentalism (McGrail *et al.*, 2011). Some have attempted to color-code various forms of environmentalism and sustainability, like Alex Steffen, who recognizes emerging categories of: Bright Greens (innovation for prosperity), Light Greens (lifestyle and consumer change), Dark Greens (local solutions to global industrialization) and Grays (those in denial) (Steffen, 2009). Sauvé (1996) developed six paradigmatic conceptions of the environment: nature, resources, problems (to be solved), place, biosphere and community project.

In its 1987 *Our Common Future* report, the Brundtland Commission established a definition of sustainability that focuses on the needs of present and future human populations and the limitations of our current system to meet those needs. Since then, these needs were represented by the convergence of three pillars that include economic development, social equity and environmental protection. In a review of the evolution of the definition of sustainability, Kajikawa (2008) notes that sustainability has been commonly represented by this set of triangular concepts, such as the three-pillar model of the environment, the economy and society (Kastenhofer and Rammel, 2005); the USA Environmental Protection Agency's P3 (People, Prosperity and the Planet) model (Zimmerman, 2005); or a model that promotes equitable economic growth, environmental protection and social well-being (Koehler and Hecht, 2006).

While a single, universal definition for environmentalism or sustainability remains opaque, there are emerging trajectories that are aligning around sustainability (inclusive of environmentalism). Building on previous environmental typologies, we attempt to capture those primary trajectories by developing a four-part typology designed to test meta-level perceptions of sustainability. The first three categories of this typology align with the common three pillars of sustainability noted above: the environment, the economy and society. However, a fourth category has also been added to the typology to better incorporate recent scholarship, noted above, that emphasizes inter-connected systems, technology and innovation and systemic change. Thus, our typology consists of:

- traditional environmental concerns of ecosystems and nature, and human relationships to environment;

- growing interests in building and energy efficiency, including waste minimization;
- community and participation as a form of sustaining well-being and prosperity; and
- systemic change and innovation as a form of macro-transformation of interconnected systems (see the operationalization of this typology below, which confirms the internal consistency of these four categories).

As with other typologies (Dryzek, 2005; McGrail *et al.*, 2011; Sauvé, 1996), these categories are not meant as mutually exclusive but rather represent complementary approaches to sustainability.

Environmental/sustainability education

Previous literature suggests that environmental education (EE) should be an interdisciplinary course of study with an integrative pedagogical approach (Rowe, 2002; Sauvé, 1996). Many scholars have argued for curricula integration across the full breadth of the campus (Abdul-Wahab *et al.*, 2003; Chase and Rowland, 2004; Creighton, 2001; Orr, 2004; M'Gonigle and Starke, 2006; Wolfe, 2001). Even more, some scholars have argued for a deeper, more robust approach to EE by augmenting contextualizing current approaches through place, self and community (Gruenewald, 2003; Kagawa, 2007; Kyburz-Graber *et al.*, 2006; Lundholm, 2005), and through systems-level analysis and synthesis (Everett, 2008). To create a more effective and integrated approach requires examining how students understand aspects of sustainability, and more importantly, how their coursework affects their perceptions and attitudes.

Previous studies demonstrate differences in environmentalism as a result of higher education programs. Specifically, different majors have been surveyed to understand changes in attitudes and behavior on the environment, in economics (Sherburn and Devlin, 2004); environmental studies (Smith-Sebasto, 1995); environmental history (Tomsen and Disinger, 1998); forestry (Ewert and Baker, 2001), hotel, restaurant and institutional management (Thapa, 2001); computer science, commerce and law (Hodgkinson and Innis, 2001); engineering and math (Smith, 1995); and business (Smith, 1995; Wysor, 1983). While the results have been mixed, there is clear evidence that courses can affect perceptions and attitudes on a broad range of social issues (Kagawa, 2007; Lundholm, 2005; Mann *et al.*, 2013; Smith-Sebasto, 1995), and that environmental courses increase environmental literacy and encourage environmentally responsible behavior (Benton, 1994; Rowe, 2002; Ryu and Brody, 2006; Smith-Sebasto, 1995; Stewart, 2010; Wolfe, 2001). Even more, this research indicates that taking just a single course affects students' attitudes and behaviors on the environment, for majors and non-majors alike. However, this body of research has focused primarily on the impact of students' majors on their environmental attitudes, leaving a gap for additional research in two ways:

(1) examining perceptions of sustainability (not just the environment); and

(2) examining the influence of sustainability-related courses on these perceptions.

In this study, we attempt to address these by examining the impact of both the number and type of courses on students' conceptions of sustainability, relying on the four-part typology identified above.

Methods

Data were examined from the 2011 Sustainability Survey, an original, Web-based survey of students, faculty, staff and administrators at the College of Charleston (a medium-sized public university in South Carolina). All students, faculty, staff and administrators were invited via email to participate in the anonymous and voluntary survey. Fielded from November 28 through December 20, 2011, the survey was completed by 930 individuals, including 552 undergraduate and graduate students, for a total response rate of approximately 10 per cent. The analyses presented here are limited to the 552 student respondents.

In addition to questions regarding respondents' environmental attitudes, behaviors and demographic information, the survey included a key question related to students' conceptions of sustainability: "how important are the following to your definition of sustainability?" for each of the following 13 factors: reusing waste to create new goods, energy efficiency, recycling and reducing waste, long-term human well-being, protecting ecosystems and biodiversity, democratic participation, preserving resources for future generations, local community, technology and innovation, assessing risk to human systems, social equity and justice, renewable energy and change to our political/economic systems.

Response options were presented in a four-point Likert scale, ranging from not at all important (coded as 1), somewhat important (2), important (3) to extremely important (4); "don't know" options were coded as missing data for this analysis. Students' responses on related factors were added together to create four indices, each corresponding to one of the categories in the four-part typology identified above: *Ecosystems & Nature* (ranging from 2 to 8), *Eco-efficiency* (ranging from 3 to 12), *Community and Well-being* (ranging from 4 to 16) and *Systemic Change anf Innovation* (ranging from 4 to 16). The maximum score possible for each index is based on the number of items included on each index, multiplied by the number of possible response options for each; higher scores on each index thus represent a higher level of importance of that category to students' overall definitions of sustainability. Table I lists the factors included in each category; reliability analyses confirm that each index is internally consistent and that these factors are appropriate empirical measures for each of these categories (Cronbach's $\alpha \geq 0.69$).

The survey results indicate that a vast majority of students surveyed perceive sustainability in a manner that emphasizes purely environmental factors. For example, 55 per cent of students scored a "perfect" (8.0) score on the Ecosystems and Nature Index, and 44 per cent scored a "perfect" (12.0) score on the Eco-efficiency Index. In contrast, just 16 per cent of students scored a "perfect" (16.0) score on the Community and Well-being Index, and just 15 per cent of students scored a "perfect" (16.0) score on the Systemic Change and Innovation Index. This pattern indicates that students' understanding of sustainability generally emphasizes environmental aspects the most and that broader, non-environmental factors are secondary to their conceptions of this term – a finding that confirms previous research (Barth and Timm, 2011).

Table I.
Factors related to different perceptions of sustainability

Descriptive statistics	Ecosystems and nature	Eco-efficiency	Community and well-being	Systemic change and innovation
	Preserving resources for future generations Protecting ecosystems and biodiversity	Reusing waste to create new goods Energy efficiency Recycling and reducing waste	Long-term human well-being Democratic participation Local community Social equity and justice	Technology and innovation Assessing risk to human systems Renewable energy Change to our political/ economic systems
Index min.	2	3	4	4
Index max.	8	12	16	16
Index mean *(all students)*	7.21	10.68	12.98	12.97
Index mean *(students who have not taken any sustainability-related course)*	6.70	10.11	12.35	12.90
Index mean *(students who have taken at least one course related to sustainability)*	7.41	10.85	13.32	13.19
Cronbach's α	0.691	0.808	0.717	0.696

Source: The 2011 Sustainability Survey (College of Charleston, Charleston, SC, USA)

There are, however, some differences in how sustainability is defined depending on whether or not a student has taken a course related to sustainability. Across each index, the average score of students who have taken at least one sustainability-related course is higher than the average score of students who have not taken such a course, although an independent *t*-test indicates that this difference is only statistically significant for the Eco-systems and Nature Index ($p = 0.043$). In other words, students who have taken a sustainability-related course indicate that preserving ecosystems and nature are more important to how they define the term "sustainability" at significantly higher rates that those who have not.

As noted above, the primary goal of this study is to determine the extent to which these divergent understandings of sustainability are influenced by the number and type of college-level courses related to sustainability that students have taken. Each index will thus serve as a dependent variable for four regression analyses below. To gauge our independent variables, we relied on survey questions designed to measure two elements of students' exposure to sustainability via their coursework. First, the survey asked students to self-report the number of courses "related to sustainability" that they had taken at the College, ranging from zero (0) to six (6) or more. As Table II reports, a majority (55 per cent) of students surveyed have taken at least one course that they have identified as being related to sustainability, while 45 per cent of students had not. However, relatively few students have taken three or more courses in this area. In fact, just 14 per cent of students report having taken three or more courses in sustainability.

The Sustainability Survey also asked students to self-report the course number, title and department of all courses they had taken at the College that were "related to sustainability". This latter question was re-coded to measure the type of course students had taken: *natural sciences* (including courses in biology and ecology); *humanities* (including courses in anthropology, English, philosophy and religious studies); *social sciences* (such as courses in political science, geography and psychology); *business/economics/policy* (including courses such as environmental economics, environmental policy and ecopreneurship); and courses directly related to *an integrated and interdisciplinary curriculum directly rooted in the sustainability literature* (i.e. Introduction to Sustainability or Applied Sustainability). As Table III reports, half (50 per cent) of the students who have taken at least one class related to sustainability did so in the natural sciences, while 18 per cent of students took a

Table II. Number of courses related to sustainability taken by college students

No. of courses	(%)
Zero (0)	45
One (1)	27
Two (2)	14
Three (3)	8
Four (4)	3
Five (5)	1
Six or more (6+)	3
N	344

Source: The 2011 Sustainability Survey (College of Charleston, Charleston, SC, USA)

class in the social sciences or a course with an integrated and direct emphasis on sustainability. Fewer students (15 and 13 per cent) took a course that was related to sustainability in the business/economics/policy arena or the humanities, respectively.

Results

To determine whether the number of courses related to sustainability or the type of sustainability-related courses that students take impacts their understanding of sustainability, a series of four ordinary least squares regression analyses were conducted – one on each of the four indices discussed above. As noted, the key independent variables include the number of courses that a student reports having taken at the College (ranging from zero to six or more) and five dichotomous variables, each measuring whether or not the student had reported having taken a sustainability-related course in the natural sciences, humanities, social sciences, business/economics/policy or a course with an integrated and direct emphasis on sustainability.

In addition, several social, demographic and political variables are included as control variables in the analyses. On the survey, students were asked to rate their own knowledge level on issues related to sustainability on a scale of one (1) through five (5), which helps to account for personal attention, knowledge and interest on such issues and to better isolate the impact of curriculum on their perceptions of sustainability. Also included are measures of gender, race/ethnicity, age and political ideology [in which respondents self-identified their political attitudes on a five-point Likert scale that ranged from very liberal (1) to very conservative (5]). The results are presented in Table IV, with each column representing the regression results for each of the four dependent variables.

The results indicate that the *type* of sustainability courses taken, not the number of courses, significantly impacts students' conceptions of sustainability. An examination of the first column in Table IV demonstrates the variables that impact students' scores on the Ecosystem and Nature Index; only one type of course – natural sciences – significantly impacts students' scores on this index. The positive coefficient for this variable (0.248) indicates that taking just one natural science course increases one's score on the Ecosystems and Nature Index by nearly one-fourth of a point on this eight-point scale. However, no other type of course has

Type of courses	(%)
Natural sciences	50
Humanities	13
Social sciences	18
Business/Economics/Policy	15
Sustainability	18
N	191

Table III.
Types of courses related to sustainability taken by college students[a]

Note: [a]Percentages do not add up to 100 because students could have taken more than one type of course related to sustainability
Source: The 2011 Sustainability Survey (College of Charleston, Charleston, SC, USA)

Variables	Ecosystems and nature index	Eco-efficiency index	Community and well-being index	Systemic change and innovation index
Key independent variables				
Number of courses taken *(0 to 6 or more)*	0.014	0.024	0.084	0.012
Natural science sustainability-related course *(0 = student did not take; 1 = student did take)*	0.248*	0.141	−0.393	−0.301
Humanities sustainability-related course *(0 = student did not take; 1 = student did take)*	0.297	−0.231	0.277	0.468
Social science sustainability-related course *(0 = student did not take; 1 = student did take)*	−0.282	−0.466*	0.889**	0.365
Business/economics/policy Course *(0 = student did not take; 1 = student did take)*	−0.169	0.656*	−0.922*	−0.621
Sustainability course *(0 = student did not take; 1 = student did take)*	0.233	−0.031	1.815**	0.968**
Control variables				
Self-reported knowledge level of sustainability issues *(1 = very little to 5 = a great deal)*	0.236**	0.306**	0.526**	0.381**
Type of student (0 = undergraduate student; 1 = graduate student)	−0.173	0.001	0.097	0.348
Gender (0 = male; 1 = female)	0.216	−0.394**	0.551*	0.120
Race (0 = not African American; 1 = African American)	−0.157	−0.904**	0.429	−0.738
Age (older)	0.027	0.272	0.538**	0.867**
Ideology (1 = very liberal to 5 = very conservative)	0.103*	0.101	−0.357**	−0.232*
Constant	6.609**	9.595**	10.870**	10.837**
R^2	0.140	0.107	0.221	0.133
N	259	260	250	243

Notes: The table presents unstandardized regression coefficients; *$p \leq 0.10$, two-tailed; **$p \leq 0.05$, two-tailed

Table IV.
The impact of coursework on college students' conceptions of sustainability (ordinary least squares regression)

a significant impact on this index. This finding suggests that the likely focus of natural science courses, such as biology, geology and ecology, is more focused on these specific elements of the environment and, thus, students exposed to this course material generally perceive "sustainability" in a more exclusively environmental manner.

On the other hand, taking a different type of course appears to shape how students conceptualize sustainability from alternative viewpoints. Although taking a sustainability-related course in the humanities does not significantly impact students' scores on any of the four indices, taking a course in business, economics or public policy significantly increases students' scores on the Eco-efficiency Index but significantly *decreases* students' scores on the Community and Well-being Index. The opposite pattern emerges for those who took a course in the social sciences: the negative coefficient in the second column of Table IV indicates that taking a social science course significantly *decreases* students' scores on the Eco-efficiency Index by nearly one-half of a point, and the positive coefficient in the third column of Table IV indicates that taking a social science course *increases* students' scores on the Community and Well-being Index by 0.889 points on this 12-point scale. Taking an integrated course that is directly related to sustainability also significantly impacts which factors students identify as important to their conception of sustainability. Taking such a course significantly increases students' scores on the Community and Well-being Index by 1.815 points and significantly increases students' scores on the Systemic Change and Innovation Index by nearly one point as well.

As noted above, the number of courses that students take does not significantly impact their conception of sustainability across any of the four indices examined – indicating that mere exposure to a particular theme or emphasis in a class, rather than continued exposure to courses related to sustainability, is more important in shaping students' perceptions. This may be due to the messages, types of information and focus presented within the course itself. While natural science courses tend to focus exclusively on the environment (and thus, cause students to think about sustainability in terms of the preservation of natural resources), courses in business, economics and public policy that are sustainability-related generally emphasize a market- or entrepreneurial-centered approach that would naturally lead students to think about sustainability in terms of efficiency rather than democracy, social equity or justice. These latter elements are typically the focus, though, of social science courses such as politics, anthropology and sociology; by focusing on these broader issues rather than on the environment, students who take such courses are less likely to focus on energy efficiency or other environmental issues and more likely to have an expanded view of sustainability. Finally, courses that have an integrated and direct emphasis on sustainability – and its literature – cause students to have the most expanded conception of sustainability, which is, again, a likely result of the way in which this course is taught. Future research might examine this proposed causal mechanism, particularly the degree to which certain material or messages are emphasized within each type of course.

Several of the control variables also emerge as significant predictors of these conceptions of sustainability. In each of the models presented above, self-reported knowledge of sustainability impacts students' scores on these indices; each self-reported knowledge level corresponds to an increase in each of the

sustainability indices. Political ideology also significantly impacts students' conceptions of sustainability in three of the four models analyzed. The direction of the coefficients indicates that, while students who self-identify as being more conservative are predicted to have higher scores on the Ecosystems and Nature Index, students who self-identify as being more liberal tend to have higher scores on the Community and Well-being and the Systemic Change and Innovation indices. These patterns may reflect broader differences in political attitudes, as liberals tend to be more focused on community and societal reform as a whole and conservatives tend to be more focused on individualism. However, these results may also be masking selection bias as well, particularly given the findings related to the type of courses associated with each conception of sustainability. In other words, liberals may find themselves more attracted to courses in the social sciences or those that directly emphasize sustainability, while conservatives may be drawn to take a greater number of courses in the natural sciences.

Gender, race and age also may play a role in the way in which students perceive sustainability. As presented in Table IV, female students tend to have higher scores on the Community and Well-being index compared to male students, and both female and African American students are predicted to have *lower* scores on the Eco-efficiency Index. Finally, students who are older are predicted to have higher scores on the Community and Well-being and Systemic Change and Innovation indices than do those who are younger, though whether students are undergraduate or graduate students does not significantly impact how students perceive sustainability. Future research would help to shed an important light as to why women, African Americans and older students have a tendency to understand sustainability in these divergent ways from their male, White and younger counterparts.

Discussion

Conceptions of sustainability

These results indicate that the type of coursework that college students take has an important influence on their understandings of sustainability and the factors that they perceive as important to the definition of this term. Although students, on average, generally emphasize the environmental aspects of sustainability to a greater extent in their conceptions of this term, other factors increase in importance based on the type of coursework that they take, particularly one in the social sciences or an integrated course that directly emphasizes the sustainability literature. However, these results do *not* suggest that students have only one conception of sustainability. Across all four dimensions, the average scores presented in Table I were relatively high, indicating that these different understandings of sustainability are not mutually exclusive. It is possible for students to have high scores on more than one of the indices presented – that is, some students may think of sustainability in environmental, community *and* systemic ways. Scores on the Ecosystems and Nature and the Eco-efficiency indices, for example, are highly correlated (Pearson's $r = 0.607$), such that students who tend to indicate that preservation of natural resources is important also tend to indicate that energy efficiency, recycling and reducing waste are important to their definitions of sustainability. Similarly, the Community and Well-being and

Systemic Change and Innovation indices are highly and positively correlated (Pearson's $r = 0.634$), though these two indices are less correlated with either of the more exclusively environmentally focused indices.

In finding that the type of sustainability-related coursework impacts how students define sustainability, these results also imply that college professors should be aware that the ways in which they frame sustainability shapes how students understand this term. Taking courses that cause students to perceive that only environmental factors matter – or conversely, that only economic, societal or systemic factors matter – may limit the way in which they frame sustainability-related problems and think about alternative potential solutions to address those concerns. While no one conceptualization of sustainability is "correct" *per se*, approaching the notion of sustainability without recognition of alternative conceptualizations limits the policy alternatives that are considered in addressing sustainability-related concerns. Instead, recognizing the existence (and legitimacy) of other definitions of sustainability leads to a more open discourse about potential and innovative solutions, thus yielding a more productive pathway to advancing sustainability (Miller, 2013).

Implications for higher ed

There are a number of implications from these data – to the degree they are generalizable. First, as the term "sustainability" gains traction within a diversity of campus programs and operations, it is important to understand the fuller aspects of sustainability – environmental; community, equity and participation; innovation, design and systems; and eco-efficiency and financial/economic concerns. Providing students with a robust perspective of sustainability aids in their understanding of a complex term and problem-solving tool. Our results suggest clear ways that those in particular disciplines can continue to maintain the disciplinary focus in sustainability while emphasizing broader aspects to cultivate a more robust understanding and application of sustainability. This will aid in the conceptual development of sustainability as well as students' perceptions of the term.

A second implication emphasizes the integration and interdisciplinarity of sustainability-related coursework in meaningful ways (Everett, 2008; Orr, 2004; Rowe, 2002). Certainly, there have been legitimate critiques leveled against higher education for its traditional fragmented disciplines (and the divisions) within the university system (Cortese, 2003; Orr, 2004). The patterns exhibited from our results suggest that students may be exposed to particular messages or themes within each academic division that encourage students to emphasize particular aspects of sustainability. This finding demonstrates that disciplinary training is successful in imparting specific elements of sustainability that are seen as most germane to the discipline in which it is taught. However, it may also come at the expense of the other aspects of sustainability or the full spectrum of sustainability, which further suggests that there are potentially deleterious effects of disciplinary silos that reduce knowledge into compartmentalized fragments. As a result, students then understand complex terms like sustainability within that fragmented frame and, more importantly, seek to apply it with that unidimensional knowledge frame. In some fundamental way, this dichotomy highlights the definitional issues with sustainability, and specifically, whether sustainability is transdisciplinary based on

a holistic approach or a multidimensional term based on a disciplinary approach but used contextually. Although our results do not empirically address this specifically, previous literature suggests that sustainability is the former: a holistic approach that seeks to integrate the disciplines in meaningful ways to generate solutions to complex problems at various scales.

From this perspective, this represents a clear opportunity to cultivate a diversity of interpretations of sustainability in a way that helps to redraw boundaries that are increasingly necessary to revitalize the educational mission that is required to address current social-economic-ecological issues. This requires environmental and sustainability education to inculcate "lateral rigor" across disciplines to match the "vertical rigor" within them (Cortese, 2003; Orr, 2004; Everett, 2008; Fisher, 2014). For sustainability, integrating lateral rigor though general education requirements seems paramount as a foundation for situating knowledge in the field. This would also create opportunities to apply sustainability *after* a disciplinary concentration is established to help avoid these potential disciplinary pitfalls. This approach emphasizes higher orders of learning around transdisciplinary problem-solving, collaborative learning, creative application and knowledge synthesizing (Barth and Timm, 2011; Sterling, 2004) that can be attained through transdisciplinarity and integration (Warburton, 2003).

Conclusion

Systems-level phenomena that lead to unsustainability demand "new approaches to teaching and learning" (Rowe, 2007; Jiusto *et al.*, 2013; Selby, 2007). Previous survey data have demonstrated that coursework can affect students' perceptions of social and environmental issues that lead to unsustainability. Our results here provide additional evidence that coursework in higher education has a significant impact on how students think about sustainability. While students who take a sustainability-related course in the natural sciences and business/economics/policy tend to think about this term in more environmentally centric ways, those who take courses in the social sciences and integrated courses directly related to sustainability tend to broaden their conceptualizations of this term to include notions of democratic participation, community, systemic change and innovation. While the results also show some crossover between conceptualizations of sustainability, there is also a clear message of disciplinary fragmentation, one that may shape students' definitions of what sustainability is and, as a result, how they approach sustainability concerns and policies. Therefore, while sustainability education touches on virtually all academic disciplines, this research demonstrates the need for greater interdisciplinary dialogue – not only on sustainability but for education in general.

This outcome also stresses the importance of curricular approaches to sustainability that are integrated. Three recommendations arise from these implications: first, that sustainability programs should incorporate a course or series of courses that expose students to a wide variety of scholarly approaches to sustainability early in the curriculum; second, within courses deeply entrenched in disciplinary silos, sustainability should be presented in a way in which disciplinary focus is situated within that larger frame; and third, greater attention should be paid within programs that are fully integrated with an emphasis on typical descriptors of effective sustainability education – "holistic systems, ability to

make connection, interdisciplinarity and lateral rigor" (Weissman, 2012). This latter recommendation conforms to previous arguments that sustainability should be approached from several different angles, including the social, cultural, political and artistic (Orr, 2004). Ideally, a comprehensive sustainability approach should address complementary conceptualizations of sustainability in an integrated pedagogical approach across disciplines and, indeed, across the entire campus.

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