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Mapping out Students' Opportunity to Learn about Sustainability across the Higher Education Curriculum

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Abstract
Decades of policy initiatives, a developing body of literature, and a growing cadre of practitioners are united in suggesting that the preeminent approach to educating students about sustainability is by infusion throughout the higher education curriculum. While there is mounting evidence that sustainability should be taught to students beyond the disciplinary confines of natural science and geography, little is known about the prevalence of this topic throughout an entire higher education curriculum. Therefore the study reported here aimed to capture a bird's eye view of the presence of sustainability subject matter at one higher education institution through survey research. The findings showed that nearly two-thirds of the student participants reported that they had exposure to sustainability subject matter during the course of one academic semester. Of the students who reported that they did have the opportunity to learn, most of them only learned about sustainability at one point in time. Inadequate time is being devoted to educating students about sustainability, especially given the amount of time and effort needed to promote a transformative learning experience. As a result of these findings, the recommendation is that administrators and policymakers advocate for repetition of sustainability subject matter across the curriculum, instead of the common discourse merely calling for it to be infused throughout the curriculum.

Keywords Sustainability · Education for sustainability · Opportunity to learn · Higher education · Teaching and learning

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Although an overwhelming majority of scientists agree that we are experiencing unprecedented environmental crises and although decades of policy initiatives have identified education as the most promising mechanism for cultivating a more sustainable future, the involvement of higher education with sustainability problems is sorely lacking (Dobson 2011; Orr 2005). However, higher education institutions have a moral responsibility to equip future citizens to cultivate a more sustainably engaged world (Baker-Shelley 2016; Brundiers and Wiek 2011). Institutions can contribute to the sustainability forefront in many ways, such as experimenting with innovative approaches toward environmental management and serving as laboratories for conducting sustainability research (Ralph and Stubbs 2014; Sterling 2004). The most unique contribution of higher education to the sustainability movement and where it has the strongest impact is through educating students about sustainability—thereby empowering them with the information, skills, and tools needed to increase the overall knowledge, attitudes, and behaviors that contribute to a more sustainable society (Stephens et al. 2008; Wiek et al. 2011).

Prior research has shown that sustainability learning increases when students are exposed to this topic in higher education classrooms. In fact, taking just one sustainability course has been recognized to increase students' pro-sustainability behaviors (Ryu and Brody 2006; Wolfe 2001). Nonetheless, sustainability education is still not being promoted frequently nor well enough. Renowned environmental education scholar David Orr's 1990s observation that "we are still educating as if there is no planetary emergency" is even truer (and more urgent) today (Jensen 2014, p. 24). Despite the increased attention to sustainability, the quantity of coursework has remained stagnant. For instance, a survey of chief academic officers at four-year institutions in the United States found at that around the turn of the century, a mere 12% required that students take an environmental education course; and only 55% offered such a course that fulfills a general education requirement (Wolfe 2001). Several years beyond this survey, the United States National Report Card on Sustainability in Higher Education reported that between 2001 and 2008 the quantity of sustainability education had not grown (Jensen 2014). While research has found that this kind of education increases sustainability learning (Ryu and Brody 2006; Wolfe 2001), it is still not being incorporated to an extent that will result in meaningful social change.

Sustainability was introduced to the higher education landscape in 1990 with the Talloires Declaration, which stipulated ten actions that universities ought to take to create a sustainable future (University Leaders for a Sustainable Future 1990). Since the implementation of the Talloires Declaration, there has been an increase of empirical studies on the presence of sustainability in higher education worldwide (Aikens et al. 2016; Wright and Pullen 2007). Scholars have begun to examine sustainability teaching and learning in higher education by studying pedagogy (Cotton et al. 2007; Lozano et al. 2017), or learning outcomes (Buckley and Michel 2020; Wiek et al. 2011), or the infusion of sustainability subject matter into disciplinary coursework (Abdul-Wahab et al. 2003; Vincent and Suh 2017).

Missing from the scholarship, however, is an examination of the presence of sustainability content across the curriculum. Throughout the higher education sustainability literature, scholars have argued that this topic, rather than being taught as one individual course, should be embedded throughout students' coursework in order to support them in connecting core concepts with their future role as citizens (Orr 2005; Sterling 2004). The question then is to what extent sustainability is being infused throughout existing coursework. Therefore, the study reported here aimed to map out students' opportunity to learn about sustainability across a higher education curriculum by exploring the following two research questions. 1) To what extent, if at all, do higher education students have the opportunity to learn about sustainability

throughout their coursework? 2) To what extent does this opportunity differ across student demographics (i.e., gender, race, domestic/international status, and parental education) and academic characteristics (i.e., discipline, class year, grade point average, and admittance status)?

The Status of Sustainability Learning in Higher Education

Definition

The definition of *sustainability* that I used in this study comes from the Brundtland Commission's (1987) report entitled *Our common future*. The Brundtland Commission is often recognized for articulating the most widely accepted definition of sustainability in the higher education field (Buckley and Michel 2020; Merkel and Litten 2007). This report was created to address poverty in a way that is sustainable by considering both the environment and the economy, and it defined *sustainability* as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (p. 1). This definition elucidates the complex connections between a healthy environment, social justice, and economic growth.

Incorporation into the Curriculum

Historically, sustainability subject matter has largely been taught in natural science or geography classrooms and has focused primarily on the environment. The emerging interdisciplinary field of sustainability, which has transitioned towards a more complex focus by weaving in the social and economic dimensions of the environment, has been informed by the natural sciences, "with its emphasis on 'good science' that is rigorous, reliable, and objective" (Redclift 1990, p. 268). However, given the growing sense of urgency about sustainability problems, there is an emergent movement to incorporate sustainability in an interdisciplinary and transdisciplinary way across the curriculum, aiming to integrate it throughout all coursework. The purpose of weaving this topic across an entire curriculum is that it "makes it possible for every human being to acquire the knowledge, skills, attitudes, and values necessary to shape a sustainable future" (Agbedahin 2019, p.4). The field of sustainability differs from more traditional fields of study as it does not adhere to traditional disciplinary paradigms because it is interdisciplinary in nature (Agbedahin, 2018; Baker-Shelley 2016). There are several ways for institutions to infuse sustainability into their curriculum: in sustainability-specific programs (major coursework), general education coursework, and electives. Illustrative examples of types of sustainability education in higher education can be found in Table 1.

Conceptual Framework

Opportunity to Learn

The framework employed to guide this study was *opportunity to learn* (OTL). OTL came to the spotlight in K-12 educational policy scholarship in Carroll's (1963) model of school

Table 1 Illustrations of Examples of Higher Education Sustainability Education

Category	Example
Sustainability courses required for a major in a related field	Required courses to complete a Bachelor of Science degree in Environmental Studies at the University of Pennsylvania include *Earth and Life through Time; Environmental Studies Seminar;* and *Environmental Modeling* ("Environmental Policy & Application concentration n.d.").
Sustainability electives for a major in a non-related field	The fashion industry is increasingly hiring college graduates who are competent in sustainable fashion practices (Fletcher 2008). Therefore, some fashion curricula, such that of the Fashion Institute of Technology, offer sustainability-related courses to satisfy students' major elective requirements. Examples include *Sustainability in Fashion Merchandising; Sustainable Packaging; and Corporate Social Responsibility* ("Courses of Interest n.d").
General education courses related to sustainability	All undergraduate students at the University of Vermont are required to complete a sustainability general education requirement before they graduate (*New Undergraduate General Education Requirement in Sustainability* n.d.). Courses that fulfill this requirement include: *Writing Science, Nature, and Sustainability; Religious Perspectives on Sustainability;* and *Political Economy for a Finite Planet* ("Sustainability Courses at the University of Vermont n.d.").
Non-sustainability specific courses that integrate a semester-long theme on sustainability	Traditional macroeconomic courses cover concepts on economy-wide phenomena. However, Venkatesan (2015) noted, "There is an inherent endogeneity between the current expenditure-based teaching of Principles of Macroeconomics and the observable natural resource degradation, and economic and social inequities" (p.6). Therefore, in her *Principles of Macroeconomics* class, Professor Vankatesan incorporates sustainability topics. While the primary focus of this course is not sustainability, by using it consistently throughout the semester to teach about macroeconomics, students learn about sustainability in the context of their more traditional higher education disciplinary learning.
Non-sustainability specific courses that integrate a unit on sustainability	The learning goals for students in Professor Wright's (2012) *Broadcast News Producing* course at the University of Maryland are "to practice the major theories of broadcast journalism; to learn and practice the basics of television news producing techniques; newscast design, writing, and management techniques; to explore possible careers in broadcast journalism; to produce an actual newscast." In one class session the specific area of coverage is "looking through the lens of sustainability." Although the main focus of this course is not sustainability, by including a course session on this topic, students can learn to connect their future role as journalists with the increasing presence of sustainability communication.

learning. OTL, initially used as a measure of students' opportunities to study a particular topic (Banicky 2000; Carroll 1963; Schmidt et al. 2015), has evolved into a concept which signifies that students' ability to learn a subject is dependent on whether and for how long they are

exposed to it in the classroom (Banicky 2000; Carroll 1963; Schmidt et al. 2015). In this vein I also examined where (by discipline and course type) students learn. Although OTL in its most traditional sense does not consider the location of learning (except that it occurs in the formal classroom), with regard to sustainability, prior literature has argued that sustainability subject matter should not be taught in isolation, but rather infused throughout students' coursework to support them in connecting core ideas with their future role as citizens (Orr 2005; Sterling 2004). In this study I used OTL as a frame for measuring whether and for how long students were exposed to sustainability subject matter throughout their coursework as well as where they learned about this topic.

OTL and its implications for equity. Inherent in the concept of sustainability is equity. For example, racial disparities exist in natural-disaster preparedness like increased severe weather patterns from climate change in ways such as "communication, physical impacts, psychological impacts, emergency response, clean-up, recovery, and reconstruction" (Bullard and Wright 2009, p. 2). Therefore, it is imperative to ground the present study in a framework like OTL, with social justice at its core.

Opportunity to learn has been employed in prior equity-minded education studies. For example, in his article on science education as a civil right, Tate (2001) argued that science education in an urban setting "is a civil rights issue and that to effectively address it as such we must shift from arguments for civil rights as shared physical space in schools to demands for high-quality academic preparation that includes the opportunity to learn science" (p. 1015). Tate further argued that reconstructing "urban school science as a civil rights initiative grounds this work in a longstanding struggle for quality education for all rather than in the cyclical debates of economic competitiveness and enlightened self-interest that typically are coupled with … science education" (p. 1018). Tate thus reinforced the notion that the absence of scientific literacy in urban and rural communities, or lack of opportunity to learn about math, "is an issue as urgent as the lack of registered Black voters in Mississippi was in 1961" (Moses and Cobb 2001, p. 5, as cited by Tate 2001). Thus understood, OTL is inextricably linked with social justice issues, particularly for marginalized minority racial communities; and it can provide an important route toward equity.

Distressingly, students in lower-income schools continue to suffer from fewer opportunities to learn essential subject matter (Banicky 2000). This can be seen in prior K-12 research, which found a positive relationship between socioeconomic status and OTL (Banicky 2000). In one study Schmidt et al. (2015) used 2012 Programme for International Student Assessment (PISA) data to explore the relationship between OTL, socioeconomic status, and students' math literacy. They found that OTL was significantly related to student outcomes, with a positive relationship between socioeconomic status and OTL.

Biglan's (1973) Classification of Academic Domains

According to Finnegan and Gamson (1996), disciplines are "demarcated knowledge domains with distinctive epistemologies and methods. They are also cultures that are embodied in the social relations among members" (p. 152). For this study I used Biglan's (1973) classification of academic domains to demarcate the disciplines of courses where students reported OTL. Biglan's classification distinguishes disciplinary categories through heuristics that are associated with individual or environmental understanding, worldviews, traits, or subject matter substance. Disciplines can be broadly defined as hard (single mature paradigms) versus soft (a multiplicity of paradigms), pure (knowledge for discovery) versus applied (knowledge), and

Table 2 Sample Student Participant Major Disciplines Demarcated by Biglan's (1973) Categories

	Hard	Soft
Pure-Life	Environmental Science	Anthropology
	Human Biology	Psychology
	Zoology	Sociology
Pure-Non-Life	Chemistry	Japanese Language
	Geological Sciences	Jazz Studies
	Physics	Philosophy
Applied-Life	Agriculture and Natural Resources	Criminal Justice
	Pre-medicine	Secondary Education
	Pre-veterinary	Women's and Gender Studies
Applied-Non-Life	Computer Engineering	Accounting
	Environmental Engineering	Economics
	Mechanical Engineering	Hospitality Business

life versus non-life (concerning life systems or not; Michel et al. 2018). In accord with Biglan's classification, examples of major disciplines of study participants can be found in Table 2.

The Study

Site

The site of this study was Michigan State University (MSU), a large, public, four-year, research-intensive university ("Carnegie Classifications"). MSU was founded in 1855 as "the [United States'] pioneer land-grant university, [which originally] began as a bold experiment that democratized higher education and helped bring science and innovation into everyday life" (*MSU facts* n.d.). MSU's rich history cultivating informed, active, and engaged citizens made it an appropriate site for the study. Additionally, MSU has a focus on sustainability. Given its status as one of the nation's top sustainable campuses through teaching, research, outreach, and campus innovation (*About sustainability at MSU* n.d.), it allowed me to examine a case where there is an emphasis on sustainability education. Institutional Review Board approval was sought and received both from MSU and the researcher's home institution at the time of the study.

Study Sample

This study was part of a larger sustainability education study that explored students' sustainability learning over the course of the fall 2017 semester (Michel 2019). As part of this larger study, a first survey was emailed to a random sample of 65% of the MSU undergraduate population (24,999 students); and 3164 (12.7%) students participated. Of the 3164 students who completed this survey, 1366 (43.2%) consented to being contacted for the second survey. Of these 1366 participants, 748 completed it (54.8% response rate). The study reported in this article is based upon data from the second (or post) survey.

Table 3 presents the student sample compared with the MSU student population. According to the chi-squared goodness of fit tests, women; "traditional" aged students; and Asian, White, mixed race, and "other" students were overrepresented in the sample when compared with the

Table 3 Representativeness of Student Sample ($N = 748$) Compared with MSU Student Population ($N = 39{,}090$)

Demographic Characteristics	Student Sample		Student Population	
	N	**%**	**N**	**%**
Gender				
Male	225	31.9%	19,312	49.5%
Female	481	68.1%	19,778	50.5%
Race/Ethnicity				
Hispanic/Latino	24	3.4%	1629	4.8%
Black or African American	25	3.5%	2724	8.0%
White	553	78.3%	26,169	77.1%
Asian	62	8.8%	1946	5.7%
Two or more races, non-Hispanic	30	4.2%	1155	3.4%
Race and/or ethnicity unknown	12	1.7%	330	1.0%
Age				
Average age of students:	Average age: 20		Average age: 20	
Percent of students less than age 25		95.3%		84.4%
Percent of students equal to or greater than age 25		4.7%		15.6%

overall population ($p \leq .05$). With regard to sample age, the minimum age for participants was 18, with the maximum capping off at 55. Although the average age for both the sample and population was 20, the distribution statistically differed due to overrepresentation by "traditional" aged college students, that is, those less than 25 years old ($p \leq .001$).

Survey Instrument

At present there exists no publicly available, validated survey on students' sustainability learning experiences. Accordingly, to question students about OTL, I used language from Pizmony-Levy's (2015) Survey of Students' Engagement with Social Issues, in conjunction with measures derived from a literature review. Prior to distributing the survey, items were reviewed by a panel of experts in related subject areas of higher education teaching and learning, sustainability, and assessment, for the purpose of both construct and content validity. After a review by this panel, the revised version of the survey was pilot tested with 27 first-year students in a public institution in New York City, which was a convenient location for doing so. After analyzing the pilot survey data and conferring with the participants, I made the necessary revisions.

An example stem for a finalized set of questions is as follows. During the past semester how often did your instructor mention sustainability topics in the following types of classes? This stem was applied to the following contexts: major courses, general education courses, elective courses, lectures, labs, recitations, and practicums. Response options for this set of questions were: never, a few times, sometimes, many times, all the time, and not applicable (i.e., I did not take this kind of course).

Analysis

The first research question explored the extent to which students had OTL. To respond to this question I analyzed descriptive statistics. The second research question charted the kinds of students, as per their demographics and academic characteristics, who had OTL. To answer

this question I ran regressions (logistic and ordinary least squares) to explore whether student demographics differed by whether or not they had access to sustainability subject matter.

I conducted logistic regression, which provides a modeling strategy for the analysis of binary data in the form of dichotomous outcomes (O'Connell and Amico 2010) in order to investigate whether having OTL differed across student demographics and academic characteristics. Logistic regression estimates the probability of the dependent variable occurring as the values of the independent variables change. The purpose of logistic regression is the classification of individuals into groups (Menard 2002). Since the survey item asked students whether they had OTL during the fall 2017 semester (with response options of yes or no), logistic regression was useful because the outcome variable was binary. The independent variables were the student demographics and academic characteristics with the categorical variables of gender, race/ethnicity, domestic/international status, major discipline, and admittance status and the continuous variables of parental education, class year, and GPA.

Next I conducted ordinary least squares (OLS) regression, a type of regression that has the ability to estimate the relationship between one or more independent variables and one dependent variable (Mertler and Reinhart 2016). I conducted three OLS regressions, given its ability to control for students' demographic and academic characteristics while exploring their OTL. The three dependent variables were how often sustainability subject matter was present in major, general education, and elective coursework. The independent variables were the student demographic and academic characteristics. Before running the logistic and OLS regressions, I checked assumptions, including normality, linearity, and homoscedasticity (meaning same variance). Using listwise deletion (a technique for handling missing data in which an entire case is excluded from analysis if a single value is missing), I explored the missing data investigating if any one item had more missing data than others (Mertler and Reinhart 2016).

Results

Research Question 1

The first research question explored the extent to which students had OTL about sustainability throughout their coursework. Table 4 presents frequencies of OTL variables. Out of the 748 participants, 432 (64.2%) reported that they had exposure to sustainability in at least one of their courses throughout the duration of the fall 2017 semester, while 241 (35.8%) of students did not.

Next I examined how often students had OTL by the course types of major, general education, and elective. Overall, students reported on having access to sustainability subject matter across all three course types, with varying degrees of its presence. I also examined how often students had OTL by the course formats of lectures, labs, recitations, and practicums. The trend seen by these frequencies is that students reported having the most OTL in lectures, followed by labs, then in recitations, with the least OTL in practicums.

Lastly I investigated the frequency with which students had OTL. I examined how many individual class sessions there were (within one course) where students had exposure to sustainability content. Of the 432 students who reported that they had exposure to sustainability subject matter, 260 (60.2%) learned about it in one class session within one course. There was an inverse relationship between the number of

Table 4 Descriptive Statistics of Opportunity to Learn Variables (N = 748)

Variable	Coding/Frequency	Mean	SD
Opportunity to learn about sustainability	Yes: 432 (64.2%) No: 241 (35.8%)		
Opportunity to learn about sustainability in course contexts	0 = Never 1 = A few times 2 = Sometimes 3 = Many times 4 = All the time		
Course Type			
Major coursework		1.68	1.340
General education coursework		1.42	1.283
Elective coursework		1.24	1.326
Course Format			
Lectures		1.68	1.264
Labs		1.17	1.289
Recitations		.72	1.082
Practicums		.62	1.068
Frequency of learning about sustainability	0 = Never 1 = 1 course 2 = 2 courses 3 = 3 courses 4 = 4 (or more) courses		
In at least one class session		.95	.968
In many class sessions		.40	.735

classes and the number of students who had OTL: as the number of classes went up, the number of students went down. Additionally, in terms of learning about sustainability in many class sessions, 20% learned about it across multiple class sessions in one course.

Research Question 2

The second research question explored the extent to which OTL differed across student demographics and academic characteristics. It is worth noting here that, before conducting the regression analyses, I ran initial descriptive analyses to explore the data. Having at least 5% of respondents respond to each option was important because, in order to predict an outcome, there needed to be sufficient variance. In the end, due to insufficient variance, I omitted the part-time versus full-time student variable (3.9% versus 96.0%, respectively). In addition, this variable was not especially meaningful for examining OTL because part-time students, for example, have less chance to learn across the board. In terms of race and ethnicity, I removed students who identified as other, or race/ethnicity unknown, because only 1.7% of students self-selected this category. This presents a limitation, as this small, minority group of students who did not identify with a dominating racial group were not included in the analysis due to limited statistical power.

Logistic regression. I conducted logistic regression in order to investigate whether having OTL differed across student demographic and academic characteristics. Table 5 presents the classification table for the logistic regression. Classification is based on the probabilities estimated from the model to reveal the predicted accuracy of the logistic regression model. It is worth noting here that, as seen in the table, while the predicted probabilities were not

Table 5 Classification Table

		Predicted During the Fall 2017 semester, did you learn about the environment or sustainability in at least one class?		Percentage Correct
		No	Yes	
Observed:	**No**	36	143	20.1%
During the Fall 2017 semester, did you learn about the environment or sustainability in at least one class?	**Yes**	29	286	90.8%
Overall Percentage				65.2%

strong in predicting those who did not have OTL, they were very strong for predicting those who did learn about sustainability. Given that I did not run this logistic regression model with the intention of being able to predict, I note this limitation while at the same time accepting this model. With this analysis I was interested in the relationship between demographics characteristics and outcome of interest, which is OTL.

Table 6 shows predictors comparing students who did and did not have OTL. All of the reported effects are for the independent variable of interest after controlling for the other independent variables in the model. In terms of demographics, students whose parents had higher levels of education had higher OTL. In other words, the higher the level of parental education, the higher the odds of OTL (Exp(b) = 1.219, $p \leq .05$). However, the other demographics, including gender, race, and domestic/international status, did not influence students' OTL ($p \geq .05$).

In terms of students' academic characteristics, GPA and admittance status did not influence OTL ($p \geq .05$). In terms of discipline, students with hard versus soft majors did not influence OTL ($p \geq .05$). However, students in applied discipline majors (as exemplified in Table 2) were more likely to learn about sustainability than students in pure majors. Applied majors had 1.677 the odds of pure majors to have OTL ($p \leq .05$). Additionally, life majors had a higher

Table 6 Results of Opportunity to Learn (Binary) Regressed on Demographics

Predictor	β	Std. error	Sig	Exp(b)
Gender (male is the reference group)	−.423	.225	.060	.655
Race (White is the reference group)				
Asian	−.739	.832	.374	.478
Black or African American	−.739	.818	.366	.477
Latino/Hispanic	−1.234	.770	.109	.291
2 or more	−.796	.683	.244	.451
Domestic/international status (domestic is the reference group)	.189	.497	.109	.291
Parental Education	.198	.094	.035*	1.219
Discipline				
Hard versus soft (hard is the reference group)	.246	.208	.236	1.279
Pure versus applied (pure is the reference group)	.517	.237	.029*	1.677
Life versus nonlife (life is the reference group)	−.895	.249	.000***	.409
Class Year	−.188	.095	.049*	.829
GPA	−.357	.271	.188	.700
Admittance status (transfer is the reference group)	−.028	.248	.909	.972

Note: *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$

probability to learn about sustainability than non-life majors. Students who had non-life majors had .409 the odds compared with life majors ($p \leq .001$). In terms of students' class year, the lower the class year, the higher the odds of OTL (Exp(b) = .829, $p \leq .05$).

Ordinary least squares regressions. I ran three OLS regressions in order to investigate more granular demographic differences regarding how much exposure to sustainability students had within particular course types, as seen in Table 7. As demonstrated by the results, very few demographics influenced students' OTL. It is worth noting here that all of the reported effects were for the independent variable of interest after controlling for the other independent variables of interest in the model. Like the findings of the logistic regression, gender did not significantly influence students' OTL ($p \geq .05$), nor did any of the racial minorities compared with the reference group of students who identified as White ($p \geq .05$). Interestingly, however, students' domestic/international status did influence their OTL. International students had higher exposure to sustainability subject matter in all three types of coursework: major coursework ($\beta = .136$; $p \leq .01$), general education coursework ($\beta = .158$; $p \leq .05$), and elective coursework ($\beta = .170$; $p \leq .05$). These significant results, albeit in small effect sizes, together serve as an interesting finding since prior literature shows that citizens and students in other countries have a higher endorsement of sustainability issues than do U.S. citizens and students (Weber and Stern 2011).

Given the demographic data to which I had access, I attempted to uncover some indicator of socioeconomic status by looking at parental education, particularly in terms of its influence on students' OTL. Across all three course types, parental education did not significantly influence students' OTL ($p \geq .05$). This provides evidence that the results of the logistic regression in which students whose parents had higher levels of education had higher OTL ($p \leq .05$) could be a spurious finding.

Table 7 Standardized Coefficients of Opportunity to Learn about Sustainability on Student Demographics and Academic Characteristics

	Major ($N = 476$)	General Education ($N = 384$)	Elective ($N = 365$)
Gender (male is the reference group)	.001	−.003	.043
Race (White is the reference group)			
Asian	.020	.032	.005
Black or African American	−.052	−.011	−.025
Latino/Hispanic	−.058	−.064	−.015
2 or more	.020	.032	.004
Domestic/international status (domestic is the reference group)	.136**	.158*	.170*
Parental Education	−.002	.090	.041
Major Discipline			
Hard versus soft (hard is the reference group)	−.140**	.124*	−.062
Pure versus applied (pure is the reference group)	.150**	.047	−.034
Life versus nonlife (life is the reference group)	−.239***	−.065	−.072
Class Year (first year is the reference group)			
Sophomore	−.038	.042	−.116
Junior	.066	−.006	−.077
Senior	.110	.014	.030
GPA (4.0 is the reference group)	−.039	−.030	.-047
Admittance status (transfer is the reference group)	.016	.110*	.036
adj. R^2	.115	.062	.061

Note: *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$

Next, I explored students' academic characteristics, first by looking at discipline through Biglan's (1973) paradigms. In terms of major coursework, students in hard majors had more exposure to sustainability subject matter than did students in soft majors ($\beta = -.140$; $p \leq .01$). Students in applied majors had more exposure to sustainability subject matter than did students in pure majors ($\beta = .150$; $p \leq .01$). Students in life majors had more exposure to sustainability subject matter than did students in nonlife majors ($\beta = -.239$; $p \leq .001$). In terms of general education coursework, students in soft majors had more exposure to sustainability than did students in hard majors ($\beta = .124$; $p \leq .05$). However, there was no difference in exposure to sustainability in general education coursework between pure versus applied majors or life versus nonlife majors ($p \geq .05$). Additionally, across all majors in all three disciplinary paradigms, there was no difference for presence of sustainability subject matter in elective coursework ($p \geq .05$).

With regard to admittance status, although transfer and first-time students did not have a significant difference in OTL in major or elective coursework, transfer students did report lower OTL in their general education coursework ($\beta = .110$; $p \leq .05$). This finding may be a result of their having completed general education courses before transferring to MSU, and they were likely mostly engaged in major coursework after transferring. Finally, there were no differences with regard to class year or GPA ($p \geq .05$).

Limitations

The analysis of an exemplar (MSU) was useful for this study because it allowed me to examine the topic of interest in a case where it was highly developed. However, amidst the current higher education landscape, the presence of sustainability subject matter across the curriculum is largely still emerging. Therefore, while results may be applicable to other institutions engaged in the sustainability forefront, care should be taken in generalizing to other institutions.

Discussion

Although there is evidence indicating that sustainability should be taught to students beyond the disciplinary confines of natural science (Hopkinson and James 2010; Saylan and Blumstein 2011), little is known about the prevalence of sustainability throughout an entire higher education curriculum. This study sought to gather information about that question at one institution. The findings showed that nearly two-thirds of the study participants reported that they had exposure to sustainability subject matter during one academic semester. Of those who reported that they did have OTL, most only learned about sustainability at one point in time. While there were exceptions (less than 8.3% of student participants learned about sustainability in many class sessions across several different courses), overall the students reported that they did not spend appreciable time with the sustainability subject matter.

Higher education learning theory deems such lack of repetition inadequate. Indeed, many studies have found that the amount of time that students devote to learning activities influences their acquisition of knowledge (e.g., Astin 1993; Tinto 1993). In other words, as stated by Astin (1993), "the amount of physical and psychological energy that the student devotes to the academic experience [matters]" (p. 518). Regardless of the topic, repeated exposure, reiteration of ideas, and application of the topic to different contexts are essential for deep learning.

Where Students Are Learning

After finding that most students had at least some OTL, it leaves one wondering where in the curriculum exposure to sustainability subject matter was actually occurring. The subject matter was most frequently present in major courses (73%), followed by general education (65%), and then by electives (57%). Overall, one can conclude that sustainability subject-matter is emerging from the curricular periphery and becoming integrated throughout its entirety.

Of the students who had OTL, nearly three-fourths reported learning about sustainability in their major coursework. Such prominence of sustainability was auspicious because students' majors are generally understood to be preparing them for their future careers. This finding indicated that learning about what sustainability meant in their major coursework, as well as understanding the sustainability issues likely to arise within their chosen fields, provided promise that these students would be prepared to consider and act upon anticipated sustainability issues in their future careers (Colby et al. 2003).

In addition, 64.8% of the students who reported OTL indicated that they learned about sustainability in general education coursework. Given the importance of general education requirements, these courses can become fertile ground for sowing sustainability learning. Second, general education courses are among the first classes in which college students enroll (Lattuca and Stark 2009; Tinto 1993). As these courses are generally taken early at a time when students are confronting the academic and emotional challenges of transitioning into the college community (Shulman 1987; Tinto 1993), it might be said that they lay the foundation for students' learning, including learning about sustainability. Furthermore, and I argue most importantly, a primary objective for general education coursework is to position students to live their future, post-higher education lives mindfully, in unity with a shared vision of the highest moral values. General education courses prepare students for conscientious citizenship, exercising their knowledge not just for increased salaries, but for the betterment of humankind and for our world (Baker-Shelley 2016; Colby et al. 2003; Nussbaum 1998).

Additionally, of the students who had OTL, 57% of them reported learning about sustainability in their elective coursework during the fall 2017 semester. Electives were important, too, in that students chose these courses on a topic they care about—an instance where they have agency in something that personally concerns them.

OTL and Student Characteristics

The second research question addressed the relationship between OTL and student demographics and academic characteristics. Results showed that few demographics, including gender, race, and SES, influenced students' sustainability learning opportunities. With regard to sustainability education, equal opportunity is especially urgent. As noted earlier, climate change has a higher likelihood of affecting persons from vulnerable populations, such as communities of color and low socioeconomic status, which already endure disproportionately high exposure to pollution and toxins, with resultant economic and health consequences (Brainard et al. 2009; Bullard and Wright 2009). Because many persons from marginalized minority groups often have high demands outside the classroom, such as working to help fund college other economic commitments (Titus 2006), OTL is vital to their having equal access to learn about sustainability.

The finding that race, gender, and socioeconomic status did not influence OTL at MSU during the fall 2017 semester, while edifying, compels further investigation, as it contradicts

the literature stating that White persons from higher socioeconomic status have higher sustainability literacy (Brainard et al. 2009; Bullard and Wright 2009). This contradiction to the overall theme throughout the literature is conceivably due to the way I framed students' OTL about sustainability, as I included all instances in which it occurs. It may also be that the literature points to the fact that marginalized students are less likely to take sustainability-specific courses. Perhaps marginalized students are being exposed to this subject matter throughout their coursework, even if they are enrolled in an unrelated major and do not actively seek sustainability courses. However, student demographics ought to be further explored because environmental injustices are still occurring.

What accounts for ongoing racial and cultural variations in sustainability knowledge, attitudes, and behaviors? Would these results hold at a more racially diverse institution? Many would agree that higher education is not yet doing enough—but what more can or should be done? Perhaps these results hark back to the results of the first research question in that more time needs to be spent on sustainability for all students, and especially those from marginalized populations.

Although sustainability was largely an equal opportunity topic across student demographics at MSU, it was imbalanced from the perspective of international student status. In this study, international students displayed higher exposure to sustainability subject matter. These results, albeit in small effect sizes, support previous findings which suggest that students in other countries have a greater concern about sustainability than do their U.S. counterparts (Weber and Stern 2011). These results are especially important given that sustainability issues are interconnected and global across social borders (Ralph and Stubbs 2014).

Future Research

Given that two-thirds of the students in this study had OTL only once at MSU, which has a strong institutional emphasis on sustainability, it leads one to a related question. What about students' exposure to sustainability subject matter at less sustainably-engaged institutions, particularly those with higher enrollments of racial minorities and students of low socioeconomic status? Future research ought to examine this broad question across multiple higher education curricula in order to inform research and practice about gaps so as to better educate future citizens to live sustainably-engaged lives.

Conclusion

Nearly half a century of policy initiatives across the globe have pointed toward the importance of educating students about sustainability as one way to address the current global crises we are facing. Sustainability scholars have advocated for sustainability subject matter to be included in all classes, rather than in isolated classes (Dobson 2011; Orr, 1991; Sterling 2004). The findings showed that nearly two-thirds of the student participants reported that they had exposure to sustainability subject matter during the course of one academic semester. Of the students who reported that they did have the opportunity to learn, most of them only learned about sustainability at one point in time. Inadequate time is being devoted to educating students about sustainability, especially given the amount of time and effort needed to promote a transformative learning experience. As a result of these findings, the recommendation is that administrators

and policymakers advocate for repetition of sustainability subject matter across the curriculum, instead of the common discourse merely calling for it to be infused throughout the curriculum.

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