AN ASSESSMENT OF TEACHING AND LEARNING ABOUT SUSTAINABILITY ACROSS THE HIGHER EDUCATION CURRICULUM

by

Jessica Ostrow Michel

Dissertation Committee:

Professor Corbin M. Campbell, Sponsor
Professor Oren Pizmony-Levy

Approved by the Committee on the Degree of Doctor of Education

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ABSTRACT

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Jessica Ostrow Michel

Although the majority of scientists agree that we are facing unprecedented climate crises, higher education’s engagement with environmental and sustainability problems is lacking. While the role of human behavior on climate change has been well established by science, these insights have yet to be adequately applied by citizens, thus exacerbating the consequent economic and social problems (like inequity and poverty). In response to the imminent danger of climate change, calls have come for citizens to be mindful of their actions to reverse the deteriorating trajectory of environmental and sustainability decline. In particular, policymakers have deemed higher education classrooms a promising site for equipping future generations of citizens to engage with sustainability. Formal teaching and learning surrounding sustainability-related subject matter, or Education for Sustainability (EfS), is the process of developing students’ knowledge, attitudes, and behaviors toward sustainability. However, EfS is not being incorporated into the higher education curriculum with either the quantity or quality necessary to steer society toward social change.

Therefore, the purpose of this dissertation study was to explore the amount of, and the effectiveness of, EfS in an institution of higher education, and to analyze whether EfS was related to students’ sustainability learning outcomes. Data collection took place at Michigan State University, a public, large-size, four-year institution.
Students were surveyed at both the beginning and end of the fall 2017 semester to measure changes over one academic semester. Guided by the frameworks of opportunity to learn, cognitively responsive teaching, teaching for sustainability, and transformative sustainability learning outcomes, data were analyzed with logistic and ordinary least squares regression, and Structural Equation Modeling (SEM).

Results found that approximately two-thirds of participants reported that they had the opportunity to learn about sustainability. On average, neither cognitively responsive teaching, nor teaching for sustainability, pedagogical approaches were employed to teach sustainability. Interestingly, though, when instructors surfaced students’ prior knowledge about sustainability while teaching the subject, students’ sustainability behaviors increased over the course of the semester. As such, this study illustrated the importance of the pedagogical technique of utilizing students’ prior knowledge when teaching them about sustainability in higher education.
DEDICATION

I dedicate this dissertation to the Three Wahl Sisters: Alice, Barbara, and Evelyn.

Passionate visionaries, innovative thinkers, fiercely independent women.
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When I was a child, my mom asked me what I wanted for Chanukah. I responded, “world peace.” She told me that she could not give that to me; it was something I needed to find for myself. Instead, though, my mom gave me the greatest gift of all. She provided countless opportunities for me to figure out my own pathway to discovering world peace, ultimately leading me to the study of higher education. To my mama, thank you for encouraging me to pursue my scholarly aspirations. This dissertation would not have been even a vision, let alone an accomplishment, without you!

I was just a few days old when my father first took me sailing on the ocean. He taught me that no matter how far we travel, we are always anchored to home. Thank you, PQ, for showing me how small our vast world is, for instilling in me your eternal optimism and sunshine, and for teaching me to love our ocean. I sincerely thank my brother, Jeremy Sam Ostrow, whose brilliance, creativity, and kindness motivate me daily. Your chill-nature was contagious when I needed it most during this dissertation process!

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Chapter I

INTRODUCTION

In a world rife with social injustice and economic instability, it is higher education that has the unrivaled capacity to serve as a site for social change and cultivate a more equitable future for upcoming generations. In fact, a brief overview of American higher education history provides many successful examples of addressing social problems—such as the civil rights movement (Giroux & Giroux, 2004; Rojas, 2007), the women’s liberation movement (Eisenmann, 2005; Jacobs, 1996), the HIV/AIDS epidemic (Hightow et al., 2005; Kelly, 2005), and the LGBTQ rights movement (Beemyn, 2003; Young & McKibban, 2014)—that are politically charged and culturally sensitive in nature. Many scholars suggest that students’ formal classroom learning experiences originally inspired them to advance these social changes (Kezar, 2010; Rhoads, 2009; Wade, 2013). However, while formal classroom learning enables higher education to drive societal change (Crossley, 2008; Gaston-Gayles, Wolf-Wendel, Tuttle, Twombly, & Ward, 2005; Kezar, 2010; Rhoads, 2009), to date, our insight regarding how to teach students about interdisciplinary subject matter for social change is limited at best.

Increasingly, modern human problems across the globe reflect overlaps between traditional disciplines, and should therefore be situated in an interdisciplinary setting. However, what good teaching looks like in emerging interdisciplinary fields remains largely uncharted territory. To date, we still do not have a clear picture of good teaching of interdisciplinary subject matter. This is a lamentable gap because subject matter for social change is characteristically interdisciplinary in nature. Historically, research has
explored the characteristics of good teaching in traditional disciplines, such as mathematics and language arts, including pedagogies that impact citizenship in addition to knowledge acquisition (Ball, 1993; Dewey, 1916; Nussbaum, 1998). However, the research on effective teaching practices in newer interdisciplinary fields remains limited. Thus, unlike more established disciplines, it remains to be seen what good teaching looks like in the interdisciplinary fields that contribute towards social change.

One significant topic today, and one that is interdisciplinary in nature with subject matter toward social change, is sustainability, or the social and economic implications of environmental crises. Contemporary American society is desperate for social action to address a decisive impasse, one that arises from anthropogenic climate change and its related social and economic problems (Karl & Trenberth, 2003; Petit et al., 1999). As higher education students advance into citizens of society, their every action—confronting highly complex sustainability problem solving, requiring commensurate expertise and the ability to communicate across disciplines—will have implications for our world, both in the present and for generations to come (Baker-Shelley, 2016; Fadeeva & Mochizuki, 2010; Wals & Jickling, 2002; Wright, 2002).

This dissertation, therefore, explored how to better instruct higher education students about culturally sensitive, socially conscious, politically charged subject matter, using the case of sustainability (the social and economic implications of environmental problems such as climate change). Sustainability is a subject matter that is socially conscious and culturally sensitive because environmental crises target our most vulnerable populations—particularly communities of color and low socio-economic status—who are disproportionately affected by environmental disasters such as intensified storms, pollution, and water contamination brought on by climate change. This topic is deeply embedded in a social justice agenda as environmental hazards facing low-income communities and communities of color are too often excluded from the higher education sustainability curriculum (Garibay, Ong, & Vincent, 2016).
The Importance of Infusing Sustainability in Higher Education

Although an overwhelming majority of scientists agree that we are experiencing unprecedented environmental crises (Adelsman & Ekrem, 2012; Smith & Pangsapa, 2008), and although decades of policy initiatives identify education as the most promising mechanism for cultivating a more sustainable future, higher education’s engagement with these environmental and sustainability problems is sorely lacking (Dobson, 2011; Orr, 2005). Despite the Intergovernmental Panel on Climate Change’s (2015) argument that current environmental crises have “almost certainly” been caused by human behavior, environmental and sustainability knowledge is low among citizens (Leiserowitz, Smith, & Marlon, 2011). However, nearly half a century of policy initiatives across the globe point toward educating students about sustainability as the best intervention for preparing future generations to engage in the sustainable living that could save the planet (Dobson, 2011; Edwards, 2012; Orr, 1991; Sterling, 2004). As such, higher education institutions (HEIs1) have a “moral responsibility” to help our world address present needs, enabling future generations to achieve their goals and lead full lives (Baker-Shelley, 2016; Chase, Barlett, & Fairbanks, 2012; Fadeeva & Mochizuki, 2010). Human influence on environmental problems may have been well established by scientists, but their recommendations have yet to be adequately exercised by HEIs (Edwards, 2012; Stead & Stead, 2013).

In response to the imminent danger of climate change, there have been calls for citizens, including higher education students, to be mindful of their actions to reverse the deteriorating trajectory of environmental and sustainability problems (Adelsman & Ekrem, 2012; Smith & Pangsapa, 2008). Climate change can be understood as altered statistical distribution of meteorological patterns, often referred to as climate change.

1A full list of acronyms used in this dissertation can be found in Appendix A.
Environmental problems stemming from anthropogenic (i.e., human precipitated) change, such as environmental degradation, mass extension, and biodiversity loss, pose an existential risk to the human race (Allen, Stott, Mitchell, Schnur, & Delworth, 2000; Etheridge et al., 1996; Rosenzweig et al., 2008). Such threats also lead to intensified fiscal problems, such as inequity, and economic instability and volatility (Bromley, 2008; Edwards, 2012; Leal Filho & Pace, 2016; Sachs, 2005), not to mention social dilemmas like generational poverty and social injustice (Agyeman, Bullard, & Evans, 2003; Iverson, 2016; Merkel & Litten, 2007). Scientific calculations predict that these environmental problems, with their attendant economic and social implications, will continue to accelerate, negatively affecting humans’ overall quality of life (Adelsman & Ekrem, 2012; Solomon, Plattner, Knutti, & Friedlingstein, 2009; Steffen et al., 2015). These problems are very much an issue of equity. For instance, due to the pollution from hazardous waste sites disproportionately affecting their communities, lower-income people of color especially face unprecedented health consequences, including reduced life expectancy (Agyeman et al., 2003; Brainard, Jones, & Purvis, 2009; Bullard, Mohai, Saha, & Wright, 2008). These toxic hazards, stemming from environmental problems, bleed into economic and social domains, posing “particularly acute harm to poor black neighborhoods [that] are not random. Rather, they are the result of decades of actions and inaction by government and private actors” (Godsil, Huang, & Solomon, 2009, p. 118).

For the purpose of this dissertation, the definition of sustainability\(^2\) that I used comes from the Brundtland Commission’s (1987) report entitled Our Common Future. This report was created to address poverty in a sustainable way by considering both the environment and the economy (Edwards, 2012; Merkel & Litten, 2007) and defines

\(^2\)The term “sustainability” comes from the term “sustainable development” (Zwickle & Jones, 2018). Throughout the literature, these terms are used interchangeably, but for the purpose of consistency, I employ the more commonly used term “sustainability” in the present study.
sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (p. 1). In this vein, I understand sustainability to include “at minimum [a] consideration of the natural environment” (Bieler & McKenzie, 2017, p. 2), whereby the environment is considered in conjunction with any social, economic, or other considerations in relation to sustainability.

Growing alarm about human impact on our natural environment, and the survival of our current and future social and economic systems, has led policymakers to contend that HEIs have a key role to play. HEIs can help our society fulfill the needs of the present without destroying future generations’ right to life and prosperity (Brundtland Commission, 1987; Chase et al., 2012). Higher education, long recognized as an incubator for preparing students for the democratic participation necessary to improve society, is the most effective site for cultivating sustainably-engaged citizens (Gamson, 1984; Stevens, Armstrong, & Arum, 2008; Thomas & Hartley, 2010; Veysey, 1973). Sustainable citizenship is defined as “pro-sustainability behaviour, in public and in private, driven by a belief in fairness of the distribution of environmental goods, in participation, and in the co-creation of sustainability policy” (Dobson, 2011, p. 2). Yet we know little about how much teaching is directed towards this social change in higher education, nor do we know how effective this teaching is towards students’ learning about sustainability. Therefore, the purpose of this study was to explore the amount and effectiveness of Education for Sustainability (EfS) in an institution of higher education, and whether EfS is related to students’ learning about sustainability outcomes of knowledge, attitudes, and behaviors. In the next section, I introduce sustainability’s presence in the higher education landscape in order to illustrate its increasing presence across and within HEIs.
Policies Shaping Sustainability’s Presence in Higher Education

Although there is no easy path to rectifying current sustainability-related crises, encouragement is offered by three decades of policy initiatives across the globe—i.e., initiatives that point toward EfS as the single most promising instrument for preparing future generations to engage in the necessary sustainable living to save the planet (Anderson, 1993; Dobson, 2011; Edwards, 2012; Orr, 1991; Saylan & Blumstein, 2011; Sterling, 2004). In fact, the first international recognition of the connection between human behavior and environmental problems occurred at the United Nations Conference on Human Environment in 1972 (Clugston & Calder, 1999). Although this conference catalyzed sustainability’s presence in K-12 education (Beese & Liang, 2010; Lin & Shi, 2014), it took nearly two decades for higher education to follow suit (Bell, 2005; R. Brooks, 2005; Hodson, 2003). Sustainability first reached the eminence of higher education in 1990, when Tufts University President Jean Mayer congregated over 20 university leaders from around the world in Talloires, France, to produce the Talloires Declaration on The Role of Universities in Environmental Management and Sustainable Development. The Talloires Declaration, which stipulates ten actions that universities must take to create a sustainable future, has been signed by over 500 university leaders from over 60 countries. This declaration remains a leading impetus for progress toward sustainability, demonstrating the growing pressure for HEIs to address the sustainability challenge (Clugston & Calder, 1999; Juárez-Nájera, Dieleman, & Turpin-Marion, 2006; McMillin & Dyball, 2009). Since the inception of the Talloires Declaration, many more international declarations have been added, fueling policymakers’ aim to intensify the presence of education on sustainability in the higher education sector.

Along with the plethora of policy initiatives guiding sustainability in higher education (SHE), other forces, such as college leaders, are uniting to add their commitment. To cite one example, the American College and University Presidents’
Climate Commitment (ACUPCC), is a “network of colleges and universities that have committed to neutralize their greenhouse gas emissions and accelerate the research and educational efforts of higher education to equip society to re-stabilize the earth’s climate” (“The President’s Climate Leadership Commitments,” 2009). To date, over 650 college presidents have signed the ACUPCC (“Declarations on Higher Education and Sustainable Development,” n.d.; Jensen, 2014; Naditz, 2009; “The President’s Climate Leadership Commitments,” 2009). More recently, in 2017, Second Nature, a network of higher education presidents committed to climate change and sustainability actions, released a letter to President Trump’s administration asking for support in targeting carbon reduction and clean air; research to make certain that national climate, energy, and security policies are guided by scientific evidence; and investment in the low carbon economy so that Americans will be able to adapt to changing climate hazards. To date, over 235 college presidents and leaders have signed this letter (“Letter from Higher Education Leaders on Climate Action,” n.d.), which “show[s] that support for Climate Leadership comes from many sectors and that the message is clear: threats to progress are real, solutions are important and feasible, and we need to act now.” These signed initiatives, commitments, and letters confirm higher education leaders’ stand on sustainability both within the higher education community and broader national political movements. Despite this, large gaps remain in our understanding of how sustainability is applied in institutional practices (Bieler & McKenzie, 2017; Sterling, 2013).

**Sustainability’s Presence in Higher Education**

Resulting from a series of international meetings and declarations surrounding SHE, HEIs are now, more than ever, integrating sustainability in ways such as governance (e.g., mission statements, administration processes), campus operations (e.g., food procurement, greenhouse gas emissions), research (e.g., research centers’
foci, strategic research priorities), community outreach (e.g., partnerships with local communities), and education (e.g., curriculum, pedagogy) (Bieler & McKenzie, 2017; Vaughter, McKenzie, Lidstone, & Wright, 2016). Taken together, the involvement of these five domains reflects an HEI, as per Sterling (2013), that uses all domains of institutional activity to “explore, develop, contribute to, embody and manifest—critically and reflexively—the kinds of values, concepts and ideas, challenges and approaches that are emerging from the growing global sustainability discourse” (p. 23).

Higher education institutions, though, have the greatest force, and most unique impact, within the education domain, by way of their ability to instill sustainability behaviors in their students (Chase et al., 2012). HEIs educate students about sustainability through curricula that challenge them to connect classroom-learned knowledge to their lives and to the world, and co-curricular activities that provide experiences in community projects to stimulate social change (Anderson, 1993; Checkoway, 2001; Dewey, 1916; Kennedy, 1997). Although citizenship is cultivated both in and out of the classroom, the heart of educating students for active democratic citizenship remains in the classroom, where instructors facilitate key development not only in knowledge, but in practical skills and social responsibility (Checkoway, 2001; Kelly, 2005).

**Education for Sustainability**

As we can see, contemporary HEIs engage with sustainability in many ways, ranging from operations to research. However, the particular focus of this dissertation is on education, or the formal teaching and learning devoted to sustainability, referred to as Education for Sustainability (EfS). For the purpose of this study, EfS is distinguished as formal teaching and learning devoted to sustainability, the definition of which will be
expanded upon in Chapter II. For now, to situate the present study of teaching and learning of EfS in the current literature, I will introduce the places where EfS is currently happening, and what teaching practices are being used.

**Education for Sustainability Across the Curriculum**

When EfS is instilled solely in its traditional home of natural science classrooms, sustainability subject matter can only reach students of these disciplines. Additionally, when EfS is confined solely to natural science classrooms, the subject matter often misses the disproportionate environmental hazards experienced by low-income communities and communities of color, as these populations of students are less represented in these courses (Garibay, Ong, & Vincent, 2016). Ideally, EfS subject matter goes beyond the natural sciences in order to address complex problems that cut across social, economic, and environmental domains from local through global scales (Clark & Dickson, 2003; Fadeeva & Mochizuki, 2010; Kates et al., 2001; Yarime et al., 2012). Given the growing urgency about sustainability-related problems, a movement has emerged to incorporate sustainability across the curriculum, integrating sustainability subject matter across all majors and fields of study (Azar, Holmberg, & Lindgren, 1996; Hopkinson & James, 2010). As such, in seeking to meet today’s sustainability challenges, EfS needs to maintain its presence in the natural sciences, while also exploring the universality of the social and economic dimensions of sustainability (Clark & Dickson, 2003). Therefore, sustainability-related subject matter can no longer be isolated in one specific class, or discipline, as has traditionally been done, but ought to be infused across the entire higher education curriculum (Azar et al., 1996; Hopkinson & James, 2010). Instead of sustainability occupying the periphery of curriculum, I suggest that sustainability ought to be centered in it and integrated throughout all courses. Sustainability, an example of culturally sensitive, socially conscious, politically charged subject matter, demonstrates
one instance of making interdisciplinary subject matter infused throughout the curriculum.

It is important for today’s college students to learn how to connect their studies to their personal roles in our world. For instance, in an art major painting class, students might learn about toxic pigments in their oil paint (Cohen, 2007). Such students might also learn about purposefully creating art that conveys a message about sustainability to their audience (Reid & Petocz, 2006). Environmental art, to take one example, is often politically motivated regarding environmental issues (Jordan & Lenschow, 2010; Wallis & Kastner, 1998). In these art classes, students interact with sustainability subject matter in a way that is not isolated from the real world, but meaningfully linked with their own academic and creative pursuits (Wals & Jickling, 2002). This logic can be applied beyond the art classroom. Students from all disciplines will be similarly required to carry out practical implications from their studies in accordance with the environmental, economic, and social dimensions of sustainability (Lang, 2011; Stubbs & Cocklin, 2008). By thoughtful interaction with EfS in all disciplinary studies, sustainability subject matter becomes relevant to students’ everyday lives (Bransford, Brown, & Cocking, 2000; Dewey, 1916). These studies can then enhance future citizens’ personal and professional lives and together contribute to the cultivation of an ecologically sound, economically viable, socially just, and culturally vibrant world (Lubchenco, 1998; McFarlane & Ogazon, 2011).

Although scholars have largely neglected in-class experiences, a growing body of scholarship has at last begun to substantiate sustainability as an essential requisite of formal learning. This body of research is grounded in the work of David Orr (1991, 1992a, 1992b, 1995, 2004, 2005), a prominent figure within EfS, who has argued, “it is not education, but education of a certain kind, that will save us” (Orr, 1994, p. 8). EfS must be grounded throughout coursework and across disciplinary boundaries, rather than confined to one specific course (Cortese, 2003; Hopkinson & James, 2010).
The evolution of EfS from traditional science classrooms to those across the curriculum has encouraged all instructors to incorporate sustainability-related subject matter into their traditional disciplines. Unfortunately, pedagogical efforts have largely stopped there. Little discernible attempt has yet been made to provide instructors with professional development in the pedagogical tools needed to teach sustainability-related subject matter (Borg, Gericke, Höglund, & Bergman, 2012; Christie, Miller, Cooke, & White, 2013). These limited efforts create barriers for good EfS teaching—obstacles such as high insecurity of EfS teaching, low levels of sustainability understanding, lack of knowledge on how to translate sustainability concepts into subject matter, and lack of educational strategies for teaching in the context of EfS (Denby & Rickards, 2016; Forbes & Davis, 2008; Zint & Giles, 2000). Many of these barriers stem from insufficient understanding of sustainable development, ongoing apathy about sustainability, and ignorance regarding its teaching. In fact, prior research has definitively found many instructors struggling with incorporating EfS into their traditional disciplinary courses (Borg et al., 2012; Christie et al., 2013; Lemkowitz, Bibo, Lameris, & Bonnet, 1996; Reid & Petocz, 2006). Thus, there is a deficiency of faculty with expertise to teach EfS-related subject matter (Zint & Giles, 2000). Along with the acknowledged benefits of expanding EfS throughout the curriculum come concerns with how well it is actually being taught. It is unsurprising, therefore, when some scholars suggest that the actual teaching of sustainability is the primary challenge (Leal Filho & Pace, 2016).
Statement of the Problem of the Dissertation

Despite the Intergovernmental Panel on Climate Change’s\(^3\) (2015) argument that current environmental emergencies have “almost certainly” been caused by humans, sustainability knowledge is dismally low among American citizens (“Environmental Learning in America: Working Toward Nationwide Environmental Literacy,” 2002; Leiserowitz & Smith, 2010; Leiserowitz et al., 2011). In fact, two-thirds of Americans fail assessments of their basic environmental knowledge (Leiserowitz, 2010, 2011). These low levels of sustainability knowledge, and in turn attitudes and behaviors, are unlikely to change in the near future given that, along with the general population, higher education students lack basic environmental and sustainability knowledge (Jeffries, Stanisstreet, & Boyes, 2001; Lombardi & Sinatra, 2012; Rideout, Nicolson, Russell-Robinson, & Mecray, 2005). American citizens, including students, also struggle with conceptualizing the interconnectedness between the environment and broader, more complex sustainability issues, like the disproportionate effect of climate change on marginalized racial communities (Agyeman et al., 2003; Alkon & Agyeman, 2011; Bullard et al., 2008). Students’ failure to understand the environment and its broader relationship with sustainability is fraught with peril for American society. Low levels of knowledge are correlated with negative attitudes and lack of participation in sustainable behaviors (Leiserowitz, Kates, & Parris, 2006; Peattie, 2010). This apathy among students about sustainability problems is disturbing, given the role human behavior has in depleting natural resources, giving off gaseous emissions, and creating toxins, which together result in climate change (IPPC, 2007). It is also at the core of economic problems personified by inequity and economic volatility, along with social concerns, such as poverty and social injustice (Quinn, Littledyke, & Taylor, 2015; Stead & Stead, 2015).

\(^3\)The Intergovernmental Panel on Climate Change (IPCC, 2007) is an international body for assessing climate change sciences.
If higher education is intended to educate future sustainably engaged citizens, infusing sustainability throughout the higher education curriculum is pivotal.

Given the complex sustainability challenges facing our world, higher education is the most promising site for equipping future citizens to meet the demands of cultivating a more sustainably engaged population. HEIs contribute to the sustainability forefront in many ways (Stephens, Hernandez, Román, Graham, & Scholz, 2008). HEIs experiment with innovative approaches toward environmental management and sustainable practices that can serve as a model for the broader society (Ferrer-Balas et al., 2008; Stephens et al., 2008). HEIs serve as laboratories for conducting and disseminating innovative sustainability research, and test sites for sustainable practices (Chase et al., 2012; Stephens et al., 2008). However, HEIs’ most unique contribution to the sustainability movement, and where they have the largest impact, is through educating students about sustainability, thereby enabling them with information, skills, and tools to increase the overall knowledge, attitudes, and behaviors that contribute to a more sustainable society (Chalkley, 2006; Chase et al., 2012; Colucci-Gray, Camino, Barbiero, & Gray, 2006; Stephens et al., 2008). EfS, constructed broadly and inclusively across disciplines and courses, can steer society toward social change.

Prior research has shown that EfS increases students’ sustainability learning. In fact, taking just one EfS course has been recognized to increase students’ pro-sustainability behaviors (McMillan, Wright, & Beazley, 2004; Ryu & Brody, 2006; Smith-Sebasto, 1995; Stewart, 2010; Wolfe, 2001). Despite this, EfS is still not being practiced frequently nor well enough in the contemporary higher education landscape, and David Orr’s 1990s observation that “we are still educating as if there is no planetary emergency” remains true today (Jensen, 2014). Even with all the increased attention to sustainability, the quantity of sustainability coursework has remained stagnant. For instance, a survey of chief academic officers at four-year HEIs in the United States found
that a mere 12% require that all students take an environmental education course, and only 55% offer such a course that fulfills a general education requirement (Wolfe, 2001). Additionally, the National Report Card on Sustainability in Higher Education reported that between 2001 and 2008, the amount of sustainability-related education had not grown (Jensen, 2014). While research has found that EfS increases sustainability learning and encourages sustainably responsible behavior (McMillan et al., 2004; Rowe, 2002; Ryu & Brody, 2006; Smith-Sebasto, 1995; Wolfe, 2001), it is still not being incorporated with the quantity nor quality necessary to result in meaningful social change.

Since the 1990s (following the implementation of the Talloires Declaration), there has been an upsurge in the number of empirical studies on the presence of sustainability in higher education worldwide (Aikens, McKenzie, & Vaughter, 2016; Corcoran & Wals, 2004; Wright & Pullen, 2007). Some scholars have begun to examine EfS teaching and learning in higher education by studying pedagogy (Cotton, Warren, Maiboroda, & Bailey, 2007; Steinemann, 2003), or learning outcomes (Shephard, 2008; Svanström, Lozano-García, & Rowe, 2008), or embedding EfS subject matter into students’ major disciplinary coursework (Abdul-Wahab, Abdulraheem, & Hutchinson, 2003; Carew & Mitchell, 2008; Gray & Collison, 2002; Rusinko, 2010). With a dearth in the scholarship exploring EfS across the curriculum, though, the practices being used to teach it, and its impact on students’ learning, are missing and urgently needed. New research ought to investigate the inextricable relationship between students’ opportunity to learn about sustainability, the kinds of teaching practices they experience, and the extent to which their exposure to sustainability content and the effectiveness of such teaching influences their own sustainability learning outcomes.
Purpose and Significance of Dissertation

The purpose of this dissertation study was to explore the amount and effectiveness of EfS, and whether EfS was related to students’ learning outcomes. By examining the quantity and quality of EfS across the curriculum, this study—positioned to contribute to multiple stakeholders, including policymakers, faculty, and students—provides insight into how HEIs can enhance students’ EfS learning. This study used the operative frameworks of opportunity to learn, cognitively responsive teaching, teaching for sustainability, and transformative sustainability learning outcomes to map where EfS is located throughout the curriculum and what pedagogies are being employed to teach it. As well, this study also explored the relationship between students who experienced promising practices of teaching and learning with sustainability learning outcomes.

To date, EfS has been unable to stimulate changes in students’ behaviors to the extent necessary to create truly sustainably engaged citizens, and the lack of such key learning outcomes for sustainability will prevent them from becoming sustainably engaged citizens (Saylan & Blumstein, 2011). Thus, the root problem remains that EfS is neither happening consistently, nor well enough, across students’ formal classroom learning experiences. To prepare students to be sustainably engaged citizens and to drive social change in cultivating a more sustainable society, EfS, as shown, ought to enter the curriculum across all disciplines, sectors, and cultures (Wade, 2013). Accordingly, this study’s prime goal was to deliver insight on where EfS is happening and what specific teaching practices were effective in teaching it to improve these practices and, in turn, strengthen sustainability teaching and learning.

Overall, if this dissertation study succeeds in illustrating how best to teach sustainability subject matter, it will have implications for both higher education and our world at large. Findings from this study can enhance students’ sustainability learning, which then deepens their individual capacity as sustainably engaged citizens. This
research can help higher education better serve American society by developing determined citizens to guide our country toward imperative social change in the sustainability landscape—and thus, our world.

**Contributions to the Field**

This dissertation study explored the amount of, and the effectiveness of, EfS in an HEI and examined whether EfS was related to students’ sustainability learning. To my knowledge, there are no other higher education scholars studying the teaching and learning that specifically focuses on sustainability. Thus, this research contributed to the field in several important ways, and the study itself was positioned to enrich policy, practice, and research.

**Policy Contributions**

As previously mentioned, within the past three decades, there has been a surge of policies pervading sustainability into higher education (Dobson, 2011; Edwards, 2012; Saylan & Blumstein, 2011; Sterling, 2004). However, to date, there is little evidence of the enactment of such policies into practice, a complex iterative process that is “jumbled, messy, [and] contested” (Ball, Maguire, & Braun, 2012, p. 2). This is not unique to sustainability, as often in education, there is often a wide gap between policy and practice, leading to confusion and a loss of effectiveness (Sauvé, 1999). As such, one contribution of this study was to provide policymakers with insight on EfS practice: whether it is happening, where it is happening, and what specific teaching practices are being used to teach it. These insights could influence the revision of future policies to more accurately reflect what is taking place in practice. It could also support policymakers in making decisions about resources such as time and funds, such as
allocating funds to pedagogical training for instructors, and ultimately better supporting students’ access to EfS throughout their entire college education.

**Practice Contributions**

Furthermore, with regard to practice, this study was constructed to provide critical information to instructors about how to teach EfS well. Prior research has found that many instructors struggle with incorporating EfS into their traditional disciplinary courses (Borg et al., 2012; Christie et al., 2013; Lemkowitz et al., 1996; Reid & Petocz, 2006). Daunted by their limited expertise in teaching specific sustainability-related subject matter, they neglect to bring EfS into their classrooms (Dawe, Jucker, & Martin, 2005; Saylan & Blumstein, 2011; Smyth, 1995; Sterling, 1992). From this perspective, the present study can provide instructors with specific pedagogical strategies that effectively facilitate students’ EfS learning. Preparing instructors with information about how best to teach EfS will provide an essential toolkit for those with limited awareness and expertise of EfS subject matter. Understanding how to better integrate EfS into disciplinary coursework will help instructors make essential connections between their traditional coursework and EfS subject matter. This, in turn, will help them effectively incorporate EfS into their courses. Consequently, this study contributes practical insight not only for instructors, but also for curriculum developers and professional development facilitators, in addition, by specifying a set of best practices and tools for teaching sustainability in coursework throughout the curriculum.

Likewise, better understanding regarding where and how EfS occurs could enhance students’ EfS coursework experiences. Students’ EfS learning is vital in that it prepares future citizens to address global sustainability challenges (Cortese, 2003; Orr, 2004; Rowe, 2002). Students, it can be seen, must graduate with the knowledge and skills to address these complex sustainability problems at all levels. As well, improved
understanding of EfS practices will enrich the formal classroom learning opportunities expected of HEIs.

Furthermore, this dissertation study centered on assessment of teaching and learning of highly politicized and culturally sensitive subject matters for catalyzing social change. More specifically, this study contributed insight into how higher education is working as a vehicle toward social change, here in the context of sustainability. This study is a step toward understanding how higher education influences this important subject, specifically by examining how higher education coursework contributes to students’ learning about sustainability. From here, future research ought to consider how this teaching practice would equally succeed in blueprinting students’ activist behaviors in other forms of highly politicized and culturally sensitive subject matters.

**Research Contributions**

In terms of its methodological contributions, this dissertation also offers survey instruments for measuring both instructors’ sustainability teaching and students’ sustainability learning. Given that this study was exploratory in nature, I am hopeful that scholars use these instruments as a foundation to build a more robust literature based on teaching and learning about sustainability in higher education.

With respect to conceptual contributions, current higher education frameworks for teaching and learning are not designed to focus on highly politicized subject matters, like sustainability. To that extent, this study contributed the first higher education theoretical framework for teaching and learning about culturally sensitive, socially conscious, politically charged interdisciplinary subject matter using the case of sustainability, which will lead to further research through this precise framing of discussions, guiding data collection and analyses.

In addition, to explore teaching about sustainability, I employed Neumann’s (2014) cognitively responsive teaching, its first use in the context of studying EfS. Employment
of cognitively responsive teaching elucidates the notion that instructors need to guide students in cognitive processes that allow them to navigate the tension between prior and newly acquired knowledge about a particular subject matter embedded in disciplines. Therefore, it follows that one important contribution of using Neumann’s cognitively responsive teaching in the present study that it challenged thinking about how the complex subject matter of sustainability is being taught. Looking at EfS through this cognitively responsive teaching lens deepens the ways in which scholars and instructors think about such teaching.

In addition, the EfS literature still lacks its own framing for melding subject matter and teaching strategies, similar to Lee Shulman’s (2004) Pedagogical Content Knowledge4 (PCK). PCK is insufficient for analyzing EfS because it does not specify the subject matter that ought to be taught, let alone the best practices for teaching it. On the other hand, several EfS scholars have stipulated practices that they suggest are appropriate for teaching EfS. Hence, I developed an aspect of the overall framework that pulls key elements from the EfS literature, called Teaching for Sustainability. As such, this study offers a way to frame sustainability-specific subject matter and teaching practices.

**Timeliness of Dissertation**

Studying the intersection of sustainability and college teaching and learning is timely in our world today. As Johnston (2013) describes:

When you wake up tomorrow, the world will be a little less hospitable. The earth will be a warmer place, the air will be more polluted, the supply of

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4Pedagogical Content knowledge “represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented and adapted to the diverse interests and abilities of learners, and presented for instruction” (Shulman, 2004, p. 93).
safe drinking water will have diminished, less food will be available per person, and the biodiversity will be reduced. Social, health, and economic disparities will be evident not only in comparisons of national wealth, but even within the richest nations the gaps between the richest and poorest will contribute to social instability. The planet will be more crowded and still most of the wealth will be in the hands of a few. (p. viii)

Moreover, when we wake up tomorrow, we will have lost, on average, 116 square miles of rainforest and 40 to 100 species; we will have released 2,700 tons of chlorofluorocarbons and 15 million tons of carbon into the atmosphere (Orr, 1996). Yet, the general attitude toward our changing climate remains “out of sight, out of mind.” Many people are not despondent about climate change because they do not feel the direct effects of it themselves (Bloomberg & Pope, 2017; Gore, 2017). For example, 93% of the extra heat trapped by manufactured global warming pollution goes into the ocean, something we neither see nor experience in our everyday lives (Gore, 2017). These facts accentuate the urgency for higher education to cultivate future citizens’ learning about sustainability problems, resulting in active commitment as sustainably-engaged citizens.

Furthermore, since taking office, President Trump and his cabinet quickly abdicated US leadership in working to reduce the detrimental effects of climate change. In response to Trump’s opposition for supporting sustainability efforts, an army of politicians has come forward to urge citizens to get involved in sustainable efforts. Former Vice President Al Gore (2017) released a statement in response to Trump’s decision to withdraw from the Paris Agreement: “President Trump’s decision is profoundly in conflict with what the majority of Americans want from our president; but no matter what he does, we will ensure that our inevitable transition to a clean energy economy continues” (n.p.). These sentiments are echoed by former New York City Mayor Michael Bloomberg, as well as by veteran environmental movement leader, Curtis Pope. They suggest that we do not need to depend on national governments to lead our country and our world; rather, cities, businesses, and citizens can lead the way (Bloomberg & Pope, 2017). It is at this juncture that students’ learning about
sustainability comes into play, as it serves as a promising mechanism for educating future generations about climate change and how their actions influence our common future (Cortese, 2003).

Given the time-sensitive nature of sustainability issues, it is curious that there is such a lack of scholarship exploring EfS’s place across the curriculum, what teaching practices are being used to teach it, and the impact its exposure has on students’ sustainability learning outcomes. In order to make a case to policymakers to increase funding for EfS instructors’ development, to motivate instructors to integrate EfS into their courses, to increase students’ sustainability learning outcomes, and, in turn, to cultivate a more sustainably engaged citizenry, we need new research. In particular, we need investigations that examine the inextricable relationship between students’ opportunity to learn about sustainability, the kinds of teaching practices they experience, and the extent to which this teaching about sustainability influences their sustainability learning outcomes.

**Conceptual Framework**

Given the limited research on teaching and learning about sustainability in higher education, no framework exists to examine EfS teaching practices and the extent to which these practices influence students’ EfS learning outcomes. As such, based on an exhaustive literature review, I created a framework entitled the *Framework for Teaching and Learning for Sustainability in Higher Education*, which was employed to guide this study. This framework, couched in teaching and learning theories, is composed of four facets: *opportunity to learn*, *cognitively responsive teaching*, *teaching for sustainability*, and *transformative sustainability learning outcomes*. I used the first facet of the framework, *opportunity to learn*, to measure the presence of EfS across students’ higher education coursework. I used the next two facets, *cognitively responsive teaching* and
teaching for sustainability, to explore different kinds of teaching practices that surround EFs subject matter. Finally, I used the transformative sustainability learning outcomes facet to measure students’ EFs-specific learning outcomes.

The first facet of the framework, opportunity to learn (OTL), relies on the logical proposition that students’ ability to learn a subject is dependent on whether and for how long they are exposed to it in the classroom (Carroll, 1963; Schmidt, Burroughs, Zoido, & Houang, 2015). OTL falls short, as it only considers if and for how much time students have exposure to a certain subject matter. For the purpose of this study, I added a third tenet to opportunity to learn: where students learn about a particular subject matter. With regard to higher education EFs, prior literature has argued that sustainability subject matter should be taught not in isolation, but rather embedded throughout students’ coursework to support them in connecting core ideas with their future role as citizens (Orr, 2005; Sterling, 2004). OTL, therefore, provides a way to measure whether, for how long, and where students were exposed to EFs subject matter throughout their coursework.

Building off OTL, I used two theories that point to promising practices of teaching and learning. The first teaching and learning theory was Neumann’s (2014) cognitively responsive teaching. Here, Neumann identifies three claims that constitute cognitively responsive teaching: (1) an instructor provides the student with the opportunity to confront and interact with a subject matter idea derived from a discipline or interdisciplinary field; (2) an instructor has connected the student’s learning to prior knowledge and experiences; and (3) an instructor supports students both cognitively and emotionally when newly acquired knowledge leads them to question prior beliefs.

The three claims of cognitively responsive teaching contribute individually and collectively to examining the pedagogical practices used to teach EFs. The first claim provides a way to explore the teaching of the interdisciplinary field of EFs in the context of a subject matter that acts like a discipline. The second claim provides a lens for
exploring students’ prior sustainability knowledge, like what they have heard family and peers discuss about climate change. Furthermore, as students come to higher education with preconceived ideas about sustainability, this third claim explores how instructors support students in working through the cognitive and emotional features around the dissonance between their prior and newly acquired knowledge (Bransford et al., 2000; Neumann, 2014; Shulman & Hutchings, 2004). While cognitively responsive teaching does not speak directly to EfS, it contributes insight on teaching practices that are responsive to the cognition of the students. This is what can shape their deep EfS learning (Ball, 1993; Bransford et al., 2000; Dewey, 1916; Shulman & Hutchings, 2004).

The second facet pointing to promising practices of teaching and learning is teaching for sustainability. Ideally, the higher education EfS literature base would postulate a robust set of teaching practices that illustrate what good EfS teaching looks like. To date, though, while several scholars have stipulated practices that they suggest are appropriate for teaching EfS, no such specific EfS framing explains the fusion of core ideas and teaching strategies (e.g., Cotton & Winter, 2010). Therefore, I created a second arm for exploring promising practices for teaching and learning in sustainability. This arm employs key elements from the EfS literature to articulate the particular teaching practices around teaching sustainability-specific core ideas across the higher education curriculum. I posit that the core ideas essential to EfS are: defining sustainability, environmental crises, eliminating poverty, future generations, environmental justice, economic sustainability, resource management, anthropocentrism, biocentrism, ecocentrism, and ecofeminism. These specific teaching practices are: in the context of the area I live in, in the context of my school, in the context of current events, empowerment, case study, group discussion, debate, mindfulness, and learning who I am in relation to the larger purpose of life.

The final facet of the framework was Sipos, Battisti, and Grimm’s (2008) transformative sustainability learning outcomes. To meet the desired goals of EfS
learning, students need to acquire knowledge about the subject matter as well as develop the capacity to value this knowledge and behave in ways in accordance with it (Arbuthnott, 2012; Shephard, 2008; Svanström et al., 2008). Chalkley (2006) states, “Higher education’s most valuable contribution to sustainability lies in providing large numbers of graduates with the knowledge, skills and values that enable business, government and society as a whole to progress towards more sustainable ways of living and working” (p. 235). As such, transformative sustainability learning outcomes calls for students to reflect their learning through not just their knowledge, but also their attitudes and behaviors. In essence, EfS learning outcomes must go beyond knowledge by also incorporating the attitudes and behaviors that support sustainable engagement with society.

Within the *Framework for Teaching and Learning for Sustainability in Higher Education*, I posited that the opportunity to learn about sustainability directly influences promising practices of teaching and learning about sustainability, and thus transformative sustainability learning outcomes. Opportunity to learn can also indirectly influence transformative sustainability learning outcomes through direct impact on promising practices of teaching and learning about sustainability, which then directly influence transformative sustainability learning outcomes. I further describe how I contextualized the relationships across the four facets of this framework in Chapter II.

**Research Questions**

The following research questions guided this study:

1. To what extent, if at all, do higher education students have the opportunity to learn about sustainability throughout their coursework?
a. To what extent does this differ across student demographics and academic characteristics (e.g., gender, race/ethnicity, domestic/international status, major, class year)?

2. For students who have the opportunity to learn about sustainability, to what extent do they experience promising practices of teaching and learning about sustainability?
   a. To what extent does this differ across disciplines and course contexts (e.g., class type, class level, class size)?

3. Does the opportunity to learn influence cognitively responsive teaching and teaching for sustainability? And, does the opportunity to learn, cognitively responsive teaching, and teaching for sustainability, influence sustainability learning outcomes?

4. Does a model of Teaching and Learning for Sustainability in Higher Education hold in one public, large-sized, four-year institution?
   a. If not, what modifications can be made?

**Research Design**

In this section, I overview the research design of the present study including methodology, site, sample, and analytic technique.

**Methodology**

Longitudinal research was used to survey the same set of participants at two points in time. This methodology was advantageous because it permitted examining student participants over the course of an academic semester to measure change over time (Fowler, 2013; Fowler & Cosenza, 2009; Groves et al., 2011). The pre-survey consisted of pre-existing data from Zwickle’s (2017) Sustainability Survey. The post-survey was a
replicated set of items from the pre-survey, as well as a set of questions that asked participants about their sustainability learning experiences during the course of the semester.

**Site**

The site of the study was Michigan State University (MSU), a large, public, four-year, research-intensive university ("Carnegie Classifications" n.d.). MSU’s status as one of the nation’s top sustainable campuses, through teaching, research, outreach, and campus innovation ("About Michigan State University Sustainability," n.d.) makes it an exemplar on the higher education sustainability forefront. Exploration of an exemplar was useful in the present study because it allowed me to examine the topic of interest (EfS) in a case where it was highly developed (Bronk, 2012). Because the literature suggests that EfS is often not present as it should be throughout HEIs, choosing an exemplar site allowed me to go into the study knowing that the topic of investigation would, to some extent, be present.

**Sample**

The pre-survey was sent to a random sample of 65% of the MSU undergraduate population (24,999 students), and 3,164 (12.7%) students completed the pre-survey. Of the 3,164 students who completed the pre-survey, 1,366 (43.2%) consented to being contacted for the post-survey. Of these 1,366 participants, 749 completed the post-survey (54.8% response rate).

**Analytic Technique**

Data were quantitatively analyzed by logistic and ordinary least squares regressions, and Structural Equation Modeling (SEM). In the first part of the study, the first two research questions mapped out the extent to which students had the opportunity to learn about sustainability, and the pedagogical practices they experienced while
learning about sustainability. Regressions were employed here as a way to control for variables so that I could see the relationship between a dependent variable (either opportunity to learn or promising practices of teaching and learning) and independent variables (including student demographics and academic characteristics) more clearly (Mertler & Reinhart, 2016; Mertler & Vannatta, 2005).

The second part of the study, comprised of the third and fourth research questions, explored whether students’ sustainability learning experiences were related to their sustainability learning outcomes. More specifically, these research questions analyzed structural relationships between having the opportunity to learn and experiencing promising practices of teaching and learning, along with students’ sustainability learning outcomes. Consequently, I employed Structural Equation Modeling (SEM). SEM was advantageous to the study for three primary reasons: it was a confirmatory method that allowed for testing of a posited model (both the measurement model and the structural model); it provided the ability to confirm theoretically driven, hypothetical relationships; and it allowed for the study of multiple endogenous variables (Byrne, 2013; Kline, 2015; Mueller & Hancock, 2008).

**Conclusion**

Some of today’s most severe global crises are the economic and social implications of environmental problems, or sustainability-related problems (Costello, Gaines, & Lynham, 2008). However, we know little about whether or how higher education is helping to solve them. What we do know, though, is that higher education could serve as a leader in our sustainability-related crises by educating students to become more sustainably engaged in their role as citizens. I see this dissertation as the foundation to my maturing scholarly agenda exploring teaching and learning about sustainability in higher education. To do so, the following chapters describe in detail the literature on higher
education EfS (Chapter II), the data collection and analysis procedures (Chapter III), the results of the four research questions (Chapter IV), and the discussion of the findings (Chapter V).
In Chapter II, I review related literature from which the present dissertation study is both derived and seeks to contribute toward. I conclude Chapter II by detailing the conceptual framework used to guide this dissertation study.

**Toward Defining Sustainability**

The topic of this dissertation resides at the intersection between the concept of sustainability and the civic mission of higher education. I begin by introducing these two ideas, which together anchor this dissertation study, beginning with sustainability. The working definition of *sustainability* that I use in the present study comes from the Brundtland Commission’s (1987) report entitled *Our Common Future*. This report was created to address poverty in a way that is sustainable by considering both the environment and the economy (Edwards, 2012; Merkel & Litten, 2007) and defines *sustainability* as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (p. 1). Here, this report illumines the notion that *sustainability* does not signify mere human survival; instead, it is the modification of our actions to avoid compromising the lives of future generations. As such, this definition provides temporal focus on the future and, interestingly, as a phenomenon is not new. For example, the Iroquois people have a historic tradition of encouraging members of their communities to consider the impact of today’s decisions seven generations in the future
The concept of sustainability, therefore, with the support of the Brundtland Commission (1987), challenges us to think the same way (Edwards, 2012). This definition is useful in the case of higher education students because education for sustainability prompts consideration of students’ roles beyond short-term contributions to society while including their long-term impacts on our world (Merkel & Litten, 2007; Zwickle & Jones, 2018). Indeed, today’s college students will be confronted with such sustainability-related decisions for the rest of their lives (Edwards, 2012).

The Brundtland Commission (1987) is often recognized for contributing the most widely accepted definition of sustainability in the higher education field (Agyeman et al., 2003; Clugston & Calder, 1999; Merkel & Litten, 2007). However, I chose to employ this particular definition because it provides a broader conception of sustainability that acknowledges the natural environment in relationship to social inequity. For example, a decrease in natural resources has a negative impact on human life but has a more concentrated impact on low-income neighborhood, which are usually occupied by racial/ethnic minority groups. As stated by Agyeman et al. (2003), sustainability ought to be “ensure a better quality of life for all, now and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems” (p. 78). Consequently, my employment of the Bruntland Commission (1987) guides the utility of sustainability in the present study in tandem with Ageyman et al.’s (2003) notion of accentuating its reference to justice and equity, which will be of “pivotal importance in the move toward sustainable future” (p. 2).

Although sustainability is rooted in the natural environment, it is very much a social issue, and the Brundtland Commission’s (1987) definition represents an important shift from thinking about sustainability as only protecting the environment, to protecting it as integrated with social equity and economic vitality. Summarily, sustainability refers to consideration of the natural environment, the needs of future generations, and the
structural inequities that are embedded in decision making about the natural environment. In essence, this definition highlights the theory that environmental management must be integrated with broader societal development. Thus, it represents a triple bottom line approach to sustainability—composed of three main dimensions\(^1\): planet, profit, and people—also referred to as environmental, economic, and social (Elkington, 1997, 1999, 2001, 2004; Hacking & Guthrie, 2008), which I describe below.

**Environmental Dimension**

The environmental dimension of sustainability, also referred to as the planet or the ecological dimension, focuses on the relationship between humans and the environmental systems on which they depend (Brainard et al., 2009; Eldredge, 2001; IPPC, 2007). Thus, the environmental dimension encourages us to carefully deliberate how our decisions at individual, institutional, and societal levels impact the planet (Edwards, 2012; Merkel & Litten, 2007) so that we can cultivate an environment that has the capacity to sustain human life, as well as other life forms (Edwards, 2012; Merkel & Litten, 2007). Pressing environmental issues today include climate change, water quality and access, energy, pollution, overpopulation and overconsumption, and endangered species (Edwards, 2012). Key goals of the environmental dimension are clean air, water, and land; emissions reductions; zero waste; and biodiversity (Brainard et al., 2009; Eldredge, 2001; IPPC, 2007). Environmental sustainability, as we shall see, can only “occur when humanity consumes elements of the biosphere at a rate that does not exceed their regeneration and emits only as much waste as can be absorbed by biological systems” (Merkel & Litten, 2007, p. 9). Higher education serves as a mechanism for cultivating a sustainable environment by seeking new solutions through research, scholarship, and

\(^1\)Throughout the literature, the dimensions of sustainability are interchangeably referred to as dimensions or domains. For the sake of consistency, in this dissertation, I refer to them as dimensions.
service (Edwards, 2012). Examples include greening campus facilities, recycling campaigns, limiting energy use, and banning plastic water bottles (Iverson, 2016).

**Economic Dimension**

The economic dimension of sustainability, also referred to as the profit dimension, recognizes that human interactions occur within the natural environment and in turn, use resources to add value to their lives (Kerr & Hart-Steffes, 2012). Ideally, the policies of a sustainable economy would account fiscally for environmental and social externalities, prompting citizens to use resources optimally to indefinitely support human economic production needs (Agyeman et al., 2003; Merkel & Litten, 2007). As such, this dimension accentuates strong economies as stable, fair, and secure (Edwards, 2012; Sachs, 2005), as opposed to current sustainability-related economic issues, rooted in the unfair distribution of resources (Leal Filho & Pace, 2016). Challenges to these kinds of economies include corporate fraud, widening gaps between social classes, increased poverty, unfair working conditions, and unemployment (Edwards, 2012; Sachs, 2005). Economic sustainability can only be achieved when national expenditures are proportionate with long-term income, and when our use of economic resources is fair and just (Merkel & Litten, 2007; Venkatesan, 2015a, 2015b). One way the economic dimension comes into play in higher education is when institutions engage in energy reduction initiatives primarily for financial gains, and only secondarily to reduce their ecological footprint (Iverson, 2016).

**Social Dimension**

The social dimension of sustainability, also referred to as the people or equity dimension, represents the relationship among human rights, environmental justice, and corporate power (Iverson, 2016). This dimension is inclusive of people’s mental and physical well-being and emphasizes the need for equity within and between generations, as well as within and between ethnic and social groups. In other words, social sustainability is at the heart of “reducing risk to the welfare of the earth and its
inhabitants by modifying human behavior that poses risk” (Merkel & Litten, 2007, p. 9). Hence, this dimension challenges the status quo, taking on human rights, restricted access to health care, gender inequity, religious oppression, child labor, racism, slavery, violence, and genocide (Agyeman & Evans, 2003; Alkon & Agyeman, 2011; Godsil et al., 2009; van den Bergh, Atkinson, Dietz, & Neumayer, 2007).

The social dimension also accentuates equity among people from all communities as well as between present and future generations (van den Bergh et al., 2007). Socially, the most vulnerable populations (such as communities of color) face increased hunger and homelessness, and suffer disproportionately by the economic and health consequences of pollution and hazardous waste sites (Agyeman et al., 2003; Brainard et al., 2009; Bullard et al., 2008). It then follows that one prominent goal of the social dimension is livable communities for all people (Ageyman et al., 2003). An example of engagement with the social dimension in the higher education context is the support of marginalized communities. For instance, HEIs can provide lists of local businesses owned by women and persons of color, and consequently, staff, such as campus dining services, can use these specific businesses for goods and services (Kerr & Hart-Steffes, 2012).

The Interplay of the Three Dimensions of Sustainability

In the previous three sections, I explained each of the central dimensions of sustainability outlined in the triple bottom line approach, as undergirded by the Brundtland Commission (1987): environmental, economic, and social. Although prior literature lacks a unanimously agreed upon definition of the term (Leal Filho, 2000; Shriberg, 2002; Vos, 2007; Wals & Jickling, 2002), it is agreed that none of these dimensions can stand alone, but must be carried out in conjunction with one another (Edwards, 2012; Halfarce et al., 2013; Merkel & Litten, 2007; Zwittle, Koontz, Slagle, & Bruskotter, 2014). Figure 1 presents a widely used Venn diagram to illustrate the
interdependence of all three dimensions (Agyeman & Evans, 2003). The concept of sustainability is represented by the triangle in the middle that is overlapped by all three dimensions. While each dimension of sustainability is important on its own, they together offer more complete solutions to current crises (Gough & Scott, 2003; Iverson, 2016; Luke, 2001; Rowe & Johnston, 2013; Summers & Childs, 2007; van den Bergh et al., 2007). When combined, these three dimensions provide a pathway for human civilization to sustain itself amid the challenges of environmental limits, social injustice, and political instability (Rowe & Johnston, 2013).

Figure 1. Venn Diagram Visual of Sustainability Dimensions

To demonstrate the interplay of all three dimensions, I present the case of the Flint Water Crisis, which I argue is a sustainability-related problem. This crisis began in 2014, when the postindustrial city of Flint, Michigan, changed its water source from the Lake Huron water to the Flint River. This was the result of state-appointed emergency management, implemented as a short-term money-saving measure before a new pipeline to Lake Huron was completed. However, because of the shift to Flint River water, Flint residents began to express concerns about water color, taste, and odor, accompanied by various health complaints like skin rashes. It was soon found that, resulting from insufficient water treatment, lead leached from the water pipes into residents’ drinking water, exposing over 100,000 to contaminated water, particularly those in
socioeconomically disadvantaged neighborhoods with high rates of racial minorities. Not until two years later, in 2016, was the scientific evidence of lead contamination in the water proven. Only when a federal state of emergency was finally declared in January 2016, were Flint residents advised to use only bottled or filtered water for their basic human needs like drinking, cooking, cleaning, and bathing. By 2017, the water quality had resumed to an acceptable level. However, today Flint residents continue to be instructed advised to use bottled or filtered water until all the lead pipes have been replaced, something not expected until 2020 (Butler, Scammell, & Benson, 2016; Hanna-Attisha, LaChance, Sadler, & Champney Schneppe, 2016; Michigan Civil Rights Commission, 2017).

The Flint Water Crisis is a prime example of a sustainability disaster, one that stems from a human-caused environmental problem after decades of automobile industry pollution in the Flint River water. Here, human-caused pollution manifested an environmental problem in the form of contaminated water. However, this was not solely an environmental problem, as this crisis was inextricably linked with economic and social consequences. In terms of the economic dimension, political officials were narrowly focused on the city’s budget and they focused solely on cost-cutting measures. As such, these decisions had grave implications for the welfare of Flint’s most marginalized residents the lower socioeconomic (SES) communities that were severely affected. The median household income in Flint is $25,650, with the most common race being Black (57%); the median household income in Michigan is $57,617, with the most common race is being White (over 60%; “Flint, MI,” n.d.). As such, switching the water supply specifically for Flint, and not neighboring affluent communities, was a targeted decision to reinforce already-divisive issues of race and segregation. Historical policies and practices cultivated and perpetuated the separation of race, wealth, and opportunity, with a vicious domino effect. As this case illustrates, a solution to one aspect of sustainability (here, economic) is not viable if it does not include all three dimensions: environmental,
economic, and social. Solutions for one area that may cause harm elsewhere cannot be acceptable. The case of Flint is emblematic of the utmost need to consider all three dimensions. According to Edwards (2012),

Rather, because this is a compound crisis, if we limit our thinking about solutions to one aspect of sustainability rather than the big picture, we not only risk failing to address the issue, but could also make it worse. A focus on environmentalism or “green” issues in isolation will not help us understand, let alone effectively address, these and future crises…. Such a myopic view, no matter how well intentioned, can narrow our focus and limit our ability to understand the problem, seek potential solutions, and blind us to unintended consequences. Solutions that are not economically viable or burden some groups over others are not sustainable solutions. (p. 21)

As seen here, the concept of sustainability encourages us to consider solutions in a broader context, beyond merely environmental limits.

**Civic Mission of American Higher Education**

Moving forward, along with the concept of sustainability, the other central tenet undergirding the topic of this dissertation is the civic mission of American higher education. The civic mission is important in this study’s context as it provides evidence as to why sustainability belongs in higher education today, and in fact, why it has always belonged there. The role of higher education in developing citizenship—that it is essential to the well-being of a society—is inspired by theories of Plato and Aristotle (Carr, 2011; Curren, 2010; Nussbaum, 1998, 2010; O’Neill, 2002; Stonehouse, Allison, & Carr, 2011). In particular, these Ancient Greek philosophers advocated for education to impart knowledge from a variety of disciplines that stimulate students’ civic role, including educating them about the natural environment (Tsevreni, 2018). As such, environmental education has always been a fundamental component of educating students to become good citizens. These primitive roots are today paramount to the contemporary sustainability education discourse, demonstrating the role of sustainability
education in the context of education’s civic mission. Amidst a current political climate that debases climate science, and education, these same roots ground the argument that sustainability not only belongs in higher education, but that higher education has a responsibility to provide students with the opportunity to learn about sustainability as a pathway to cultivating a more sustainable future for our society, and our world.

The original colonial colleges, the first HEIs in America, were founded within the lexicon of the civic mission, to perpetuate the public good through a learned citizenry (Altbach, Gumport, & Berdahl, 2011; Bowen, Kurzweil, Tobin, & Pichler, 2005). Although American higher education has undergone many changes since then (including a far more diverse population of students), one fundamental aspect has not wavered: its commitment to contributing to the public good (Altbach et al., 2011)—defined as “perceived contributions of higher education to American society” (Drezner, Pizmony-Levy, & Pallas, 2018, p. 2). While higher education has not always succeeded in this mission, it has maintained its role as an incubator for the public good by preparing students for the democratic participation that improves society (Anderson, 1993; Checkoway, 2001; Dewey, 1916; Kennedy, 1997).

One way to engage in the well-being of a society, by way of the public good, is through social change—when “people take it on themselves to get involved and make a difference” (Astin & Astin, 2000, p. 5). The goal of social change in higher education is to “empower students to become agents of positive social change in the larger society” (p. 5). A brief overview of social movements in American higher education provides salient examples of its social justice role—the civil rights movement (Giroux & Giroux, 2004; Rojas, 2007), the women’s liberation movement (Eisenmann, 2005; Jacobs, 1996), the LGBTQ rights movement (Beemyn, 2003; Young & McKibban, 2014), and the HIV/AIDS epidemic (Hightow et al., 2005; Kelly, 2005).
Higher Education’s Contribution to Stopping the HIV/AIDS Epidemic

To illustrate higher education’s transformative effect on social change in regulating and improving a global crisis, I call on the case of the human immunodeficiency virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS) epidemic of the 1980s. The AIDS epidemic, caused by HIV, erupted in 1981 when doctors treating afflicted young gay men identified the same HIV virus at the heart of a mysterious epidemic (“Global HIV & AIDS Statistics,” 2018; “HIV/AIDS,” n.d.; Kelly, 2005; Krämer, Kretzschmar, & Krickeberg, 2010). HIV/AIDS became one of the most serious public health problems in the US and throughout the world (Fisher & Misovich, 1990; Lohrmann et al., 2000; Välimäki, Suominen, & Peate, 1998). In addition to enduring the immense physical pain and stigma associated with the infection, patients were targets of prejudice, discrimination, and violence. In particular, gay men faced the most bigotry (Fisher & Misovich, 1990; Fusilier, Manning, Santini Villar, & Rodriguez, 1998; Horsman & Sheeran, 1995). However, with the spread of the AIDS virus came a silver lining: higher education. Higher education’s stalwart contribution came from instructors’ ability to accumulate, develop, and disseminate knowledge. In fact, their cutting-edge research was recognized in controlling the outbreak and redirecting the public conversation toward better understanding and preventive measures (Beaman & Strader, 1989; Fisher & Misovich, 1990; Hightow et al., 2005; Kelly, 2005).

The discrimination facing AIDS patients (Fisher & Misovich, 1990; Fusilier et al., 1998; Horsman & Sheeran, 1995) stemmed from an underlying fear of contagion, anti-gay bias, and lack of knowledge about the virus (Fisher & Misovich, 1990; Fusilier et al., 1998; Horsman & Sheeran, 1995). For instance, despite health professionals’ traditional dedication to treat all people regardless of condition (Dubbert, Kemppainen, & White-

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2Human immunodeficiency virus (HIV) refers to a virus that attacks the immune system. Acquired Immune Deficiency Syndrome (AIDS) refers to symptoms and illnesses that occur during the final stage of the HIV infection (Global HIV & AIDS Statistics, n.d.; Kelly, 2005).
Taylor, 1994), many nurses had negative attitudes toward AIDS patients, affecting their willingness to care for them (Akinsanya & Rouse, 1992; Tsai & Keller, 1995). Classrooms then became a site to educate all medical students about compassionate behaviors to support those infected with the virus. Instructors used their platform as educators to redirect students’ fear. In fact, students’ positive attitudes toward HIV/AIDS were later correlated with how long they had been enrolled in higher education (Armstrong-Esther & Hewitt, 1990; Fennell, 1991).

The role of HEIs, by way of instructors’ research and teaching, was crucial in helping American society persevere in the direction of health, prevention, and acceptance. HEIs equipped students with knowledge, tools, skills, and attitudes in the context of their disciplinary field and career path, whether they were doctors, nurses, or social workers (Kelly, 2005). Their response to a global crisis, educating citizens about scientific and social subject matter, opened the door to a more informed society.

Despite the longstanding debate about whether higher education has a liberating or constraining effect on society (Aronowitz & Giroux, 2003; Denzin, 2008), the HIV/AIDS example illustrates higher education’s capacity to significantly combat a crisis. Although my dissertation is not about the HIV/AIDS epidemic, I employ this example of a highly politicized scientific problem with attendant social and economic implications to draw relevant parallels and to make a compelling case for infusing sustainability’s presence in higher education. The case of the HIV/AIDS epidemic demonstrates the role of higher education as an incubator for social change, important because my dissertation focuses on higher education’s role in social change around sustainability. As seen here, when higher education applies the lens of civic mission to a social issue, it succeeds in cultivating citizens to work toward the public good.
Civic Mission in the Classroom

The scientific community has long agreed that human behaviors are the primary drivers of contemporary environmental crises (IPPC, 2015). Creating a more sustainable world requires citizens to change their current behavioral patterns to reduce their individual and collective impact on our planet’s future. Given the increasingly daunting climate challenges facing us, many sectors—including local governments, businesses, and hospitals—have taken action to reduce their carbon footprint (Bloomberg & Pope, 2017; Gore, 2013). I suggest that HEIs, empowered by civic mission, can also play a unique and transformative role in a more sustainable future.

Higher education institutions develop students’ citizenship through curricula that challenges them to connect classroom-learned knowledge to their lives and to the world, along with co-curricular activities that provide experience in community projects that stimulate social change (Anderson, 1993; Checkoway, 2001; Dewey, 1916; Kennedy, 1997). Citizenship, cultivated in classroom learning that advances knowledge, attitudes, behaviors, and social responsibility, (Checkoway, 2001; Kelly, 2005), makes HEIs a powerful force in driving society toward change (Crossley, 2008; Gaston-Gayles et al., 2005; Kezar, 2010; Rhoads, 2009).

Contemporary American society is now desperate for social action to address a different impasse, one that stems from anthropogenic climate change with its related social and economic problems (Karl & Trenberth, 2003; Petit et al., 1999). Higher education classrooms bear the responsibility for preparing the engaged citizens who can cultivate a more sustainable future (Chalkley, 2006; Fadeeva & Mochizuki, 2010; Shephard, 2008; Wals & Jickling, 2002). Faculties need to provide students with knowledge of pressing sustainability issues, skills for dealing with them within their realm of expertise, and models of how to integrate sustainability into students’ personal lives. It is at this juncture, that I overlay the concept of sustainability, and the civic
mission of higher education, to explore the extent to which higher education serves as a mechanism for educating students about sustainability.

**Policies Shaping Education for Sustainability**

In order to set the foundation for studying education for sustainability (EfS), previously I explained how sustainability is understood in the present study and the civic mission of higher education. To further build upon this, in this section I introduce the intersection of sustainability and the civic mission of higher education by presenting policies that have shaped EfS.

In the context of sustainability in higher education (SHE), Grindsted and Holm (2012) refer to policies as “soft laws” or “declarations of intent” developed in the ongoing interactive process between postsecondary leaders, HEIs, and policymakers (Grindsted, 2011; Grindsted & Holm, 2012). A SHE policy is a joint agenda-setting position document that “frames” how HEIs articulate their function and role (Grindsted & Holm, 2012; Wright, 2004). While a full history of the SHE policies behind EfS is beyond the scope of this dissertation, this section provides a brief glimpse of it in order to situate the contemporary EfS in the context of its policy roots.

**Policies Shaping the Environmental Education Movement**

Similar to how the concept of sustainability is rooted in decades of environmental focus, so did EfS grow from its predecessor of environmental education (EE) (Malone, 1999; McCrea, 2006; Pizmony-Levy, 2011; Stapp et al., 1998). The earliest origins of educating students about the environment are demarcated by philosophical thought.

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3For example, explicit origins for educating students about the environment can be traced back to Jean-Jacques Rousseau’s (1762) *Emile*. In this educational philosophy novel, Rousseau explored the complex relationships between the nature of education and the nature of man in an attempt to resolve the contradictions between the natural human who is “all for himself” and
Eventually, the advancement of the EE movement was defined from political initiatives, such as declarations, treaties, meetings, and regulations to protect the natural environment. Within this context, EE grew to be recognized as the most promising long-term strategy to address environmental degradation (Kyburz-Graber, Hofer, & Wolfensberger, 2006; Lieberman & Hoody, 1998; McCrea, 2006; Pizmony-Levy, 2011).

In essence, political discourse on the link between human behavior and environmental problems led to the idea of education as the saving grace by teaching students about reversing the effects of this deterioration (Clugston & Calder, 1999; Leal Filho, 1996; Meyer, Frank, Hironaka, Schofer, & Tuma, 1997; Pizmony-Levy, 2011; Sato, 2006).

The first international political recognition of the connection between human behavior and environmental problems was at the United Nations Conference on Human Environment in 1972 (Clugston & Calder, 1999). This conference resulted in national educational systems throughout the world being charged to infuse EE into their curricula at the primary and secondary levels, specifically in the disciplines of geography and natural science (Pizmony-Levy, 2011; Smyth, 1995; Wals & Jickling, 2002). Although this conference did not have direct implications for higher education EfS at the time, it did contribute to its shape in higher education today; since more students were learning about the environment in their K-12 education, more students were enrolling in higher education with greater awareness about the environment. Furthermore, this conference laid the groundwork for EE’s formal entrance into the higher education classroom a few years later.

Following the United Nations Conference on Human Environment in 1972, I suggest that the next major political milestone in the EfS forefront occurred when the
United Nations Education Scientific and Cultural Organization (UNESCO) and the United Nations Environment Program (UNEP) convened three major declarations to formally guide the EE movement: the Stockholm Declaration; the Belgrade Charter; and the Tbilisi Declaration. The 1972 United Nations Conference on the Human Environment in Stockholm, Sweden is widely cited as the genesis of international recognition of EE, identifying it as a tool to address global environmental problems and their impact on rising levels of poverty (Edwards, 2012; McCrea, 2006; Rowe & Johnston, 2013; Tilbury, 1995). Next, the 1975 conference in Belgrade, Yugoslavia resulted in the Belgrade Charter, which expanded upon the Stockholm Declaration, particularly by adding guiding principles for EE programs. This marked the first time that a structured set of EE guidelines materialized (Edwards, 2012; McCrea, 2006; Rowe & Johnston, 2013; Tilbury, 1995). Soon after, in 1977, UNESCO and UNEP held another conference in Tbilisi, Georgia, resulting in the Tbilisi Declaration (Edwards, 2012; McCrea, 2006; Rowe & Johnston, 2013; Tilbury, 1995). The Tbilisi Declaration updated the Stockholm Declaration and the Belgrade Charter by including the roles, objectives, and characteristics of EE. It states that the goals of EE are

- to foster clear awareness of, and concern about, economic, social, political, and ecological interdependence in urban and rural areas; to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment, and skills needed to protect and improve the environment;
- [and,] to create new patterns of behavior of individuals, groups, and society as a whole towards the environment. (“Tbilisi Declaration,” 1977)

The next milestone to be cited is the previously mentioned Brundtland Commission of 1987. This commission met a decade after Tbilisi, when the UN General Assembly realized that environmental challenges had not been adequately addressed. Environmental problems were growing larger and more complex, exacerbated by the significant deterioration of the environment and natural resources (Quinn et al., 2015; Stead & Stead, 2013; Sterling, 2013). The Brundtland Commission, therefore, sought to unify countries in a common pursuit of sustainable development. It dissolved in 1987 after releasing Our
Common Future, also known as the Brundtland Report, a document that coined and defined the term “Sustainable Development.” This report was the first to demonstrate a political shift from a sole focus on the environment to one on sustainability, viewing environmental protection and economic growth as interdependent concepts (Edwards, 2012; Halfarce et al., 2013; Merkel & Litten, 2007). Accordingly, the report advocates for reconciliation of economic and social development, and environmental conservation (Tilbury, 1995). Rooted in the Brundtland Report (1987), sustainability casts a wider net to include the environment in conjunction with economy and equity (Edwards, 2012).

Moving into the 1990s, EE took a progressive turn once again, a direct result of the broader sustainability landscape defined by the Brundtland Report (1987). Although not specifically focused on education, it has been instrumental to its development because it stimulated EFS’s turn toward broader sustainability principles beyond the environment alone. As environmental problems continued to emerge, so did a need for an educational approach that went beyond considering environmental improvement, but also addressed educating for sustainability in the longstanding needs of our world. During this time, policy declarations (as discussed in the next section) began to situate EE in the broader context of sustainability, with EE soon transitioning into Environmental and Sustainability Education (ESE). Increasingly, more classroom time began to be devoted to environmental topics (Pizmony-Levy, 2011), with textbooks including more information on environmental problems (Bromley, 2008; Pizmony-Levy, 2011).

Policies Shaping the Environmental Education Movement in Higher Education

Although formal political recognition of the connection between human behavior and environmental problems dates back to the early 1970s, it took two decades for higher education to bring sustainability to the forefront (Bell, 2005; Brooks & Normore, 2010; Hodson, 2003). This was ignited in 1990 when Tufts University President Jean Mayer gathered over 20 university leaders from around the world in Talloires, France, to
produce “the first official statement … [on the] commitment to environmental sustainability in higher education,” entitled the “The Role of Universities in Environmental Management and Sustainable Development,” and often referred to as the “Talloires Declaration.” The Talloires Declaration (1990) stipulated that the role of institutions is to “educate most of the people who develop and manage society’s institutions. For this reason, universities bear profound responsibilities to increase the awareness, knowledge, technologies, and tools to create an environmentally sustainable future.” More specifically, the Talloires Declaration stipulates actions that universities must take to create a sustainable future. These are: increase awareness of environmentally sustainable development; create an institutional culture of sustainability; educate for environmentally responsible citizenship; foster environmental literacy for all; practice institutional ecology; involve all stakeholders; collaborate for interdisciplinary approaches; enhance capacity of primary and secondary schools; broaden service and outreach nationally and internationally; and maintain the movement. The Talloires Declaration has been signed by over 500 university leaders from more than 60 countries, demonstrating the growing pressure for institutions to address the sustainability challenge. This declaration remains an active impetus for sustainability progress today (Clugston & Calder, 1999; Juárez-Nájera et al., 2006; McMillin & Dyball, 2009; “Talloires Declaration Signatories List,” n.d.).

Since the inception of the Talloires Declaration (1990), higher education-specific declarations have abounded, with commitment to international sustainability declarations (Gale, Davison, Wood, Williams, & Towle, 2015; Lidstone, Wright, & Sherren, 2015), development of sustainability policies (McKenzie, Bieler, & McNeil, 2015; Wiek et al., 2015), and implementation of sustainable practices (Kerr & Hart-Steffes, 2012; Shriberg, Horning, Lund, Callewaert, & Scavia, 2013). Consistent among these declarations (including examples such as the American College and University Presidents’ Climate
Commitment⁴ [ACUPCC] and Sapporo, 2008⁵), is the moral obligation of sustainability in higher education (Clarke & Kouri, 2009; Corcoran & Wals, 2004; Grindsted & Holm, 2012; Wright, 2004). As stated by Wright (2004), “perhaps the unifying theme among all declarations and policies is the ethical and moral responsibility of universities to be leaders in promoting sustainability” (p.118). A secondary theme emerging from these SHE declarations is research (Grindsted & Holm, 2012; Wright, 2004). Declarations encourage institutions to implement research strategies and perform research that contributes to sustainable development (Corcoran & Wals, 2004; Grindsted & Holm, 2012). With research as a cornerstone of higher education, its role in establishing the necessary knowledge basis for political decision-making is to be expected. This can be seen, for instance, in the Sapporo Declaration (2008): “The role played by universities is changing and becoming increasingly critical, since universities, being neutral and objective, are best situated to inform political and social change toward a sustainable society.”

The proliferation of higher education-specific policies fueled policymakers’ desire to increase the presence of SHE (Bekessy, Samson, & Clarkson, 2007; de la Harpe & Thomas, 2009; Wright, 2010). In a recent study of thematic development of SHE declarations, Grindsted and Holm (2012) found four additional themes across sustainability in higher education declarations: (1) declarations within specific subject areas; (2) declarations specifically aiming at reducing institutions’ CO₂ emissions;

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⁴The American College and University Presidents’ Climate Commitment (ACUPCC) is a “high-visibility effort, supported by Second Nature, to address climate crises by creating a network of colleges and universities that have ‘committed to neutralize their greenhouse gas emissions and accelerate the research and educational efforts of higher education to equip society to re-stabilize the earth’s climate’” (Second Nature, n.d.).

⁵The Sapporo Sustainability Declaration states universities’ responsibility as the driving force for developing a sustainable society. This declaration is the result of the world’s first Group of Eight (G8) University Summit, held in Sapporo, Hokkaido, Japan, in 2008 (Sapporo Declaration, 2010; Sapporo Sustainability Declaration, n.d.).
monitoring tools; and (4) financing and grant models that have increasingly been made subject to debate in the declarations. Taken together, attention to sustainability throughout political and public discourse has been a catalyst for institutions integrating sustainability nationwide in a variety of ways. Students, instructors, and administrators at hundreds of HEIs are engaged in sustainability committees and actions, including advocating for socially and environmentally responsible criteria for endowments, pledging to use locally sourced food in dining halls, coordinating multi-stakeholder committees, and lobbying to create sustainability offices (Kerr & Hart-Steffes, 2012; Rowe, 2002; Walton, Helferty, & Clarke, 2009). Additionally, many institutions have explicitly included sustainability by assigning sustainability liaisons to each department, initiating sustainability-specific coursework, infusing sustainability into the general education core requirements, and creating a sustainability major (Liu, 2011; Rowe, 2007; Rowe & Johnston, 2013). Interestingly, although curriculum is the mainstay of higher education, policy initiatives rarely focus solely on students’ learning. Education itself is only tangentially mentioned in many policy movements. For instance, the UN initiative, Transforming Our World: The 2030 Agenda for Sustainable Development, “seeks to provide leadership and catalyze action in promoting and coordinating implementation of internationally agreed development goals, including the seventeen Sustainable Development Goals (SDGs).” While these 17 goals provide insight on what students ought to be learning about, they are neither limited to higher education, nor to learning—just to carrying them out.

**Toward Understanding Education for Sustainability**

Since the inception of EE, scholars, policymakers, administrators, and instructors have struggled to establish a unanimously agreed upon conception of what this body of teaching and learning encapsulates (Leal Filho & Pace, 2016; Martin & Wheeler, 1975;
Tilbury, 1995; Wheeler, 1975). Therefore, scholars (e.g., McCrea, 2006; Norton, 2005; Rowland, 2010, 2013) caution against a narrow definition of Education for Sustainability (EfS), as this interdisciplinary field can be applied differently depending both within and between HEIs. Hence, the growth of EfS reflects the diversity of American higher education in a broad range of institutional types, missions, cultures, and programs (Norton, 2005; Rowland, 2010, 2013).

Due to the wide range of EfS practices, I recognize the disadvantage of creating a constrictive definition to the body of teaching and learning classified as EfS. Therefore, I suggest that a broad description of what upholds EfS is best because it provides “support for the present field while supplying the nourishment for future growth” (McCrea, 2006, p. 1). In other words, a broad working definition of EfS deepens its meaning, helps classify what EfS is (and what it is not), and lends credibility to the field. Furthermore, for the purpose of the present study, structure is imperative to understand what counts as EfS in order to identify classroom instances where we can measure students’ learning about sustainability.

**Education for Sustainability**

Education for Sustainability differs from more traditional fields of study as it does not adhere to the boundaries of customary disciplinary paradigms, such as organizational (Pike & Killian, 2001) or theoretical definitions of disciplines (Biglan, 1973). Instead, EfS is grounded in multidisciplinary and interdisciplinary frameworks (Jones, Selby, & Sterling, 2010; Pizmony-Levy, 2011; Smyth, 1995; Sterling, 1992). While EfS has synergetic relationships with many traditional disciplines, such as the life sciences, social sciences, humanities, and professional studies, it also crosses disciplinary boundaries (such as those of earth science, geography, and economics) in order to draw on resources critical to address society’s most pressing challenges (Cortese, 2003; Johnston & Johnston, 2013).
Education for Sustainability is the process of developing students’ sustainability knowledge, attitudes, and behaviors in favor of the environment and its economic and social implications (Besong & Holland, 2015; Cotton & Winter, 2010; Leal Filho & Pace, 2016; Palmer, 2002). EfS’s ultimate goal is to motivate students to become sustainably engaged citizens (Blewitt, 2010; Cotton & Winter, 2010; Leal Filho & Pace, 2016; Orr, 2013), through their commitment to environmental stewardship, and reflection about the interaction of social justice, ethics, wellbeing and ecological and economic factors (Besong & Holland, 2015; Blewitt, 2010). As such, EfS ought to guide them in connecting their learning with and future professional and personal lives in all contexts.

In its most traditional sense, the consensus from the literature expresses EfS as a recurring set of sustainability instances in the classroom, integrating sustainability subject matter (like Introduction to Sustainability or Sustainability for Business Leaders) throughout the semester (Gough & Scott, 2003; Wals & Blewitt, 2010; Wals & Jickling, 2002). Due to its breadth, this definition precludes coursework that covers sustainability subject matter that might not fall in the delineated specifications above. Furthermore, with the political push for EfS’s presence throughout the curriculum, varied forms across different course disciplines, course types, and course levels are likely (2005-14 Decade for Education for Sustainable Development; Gough & Scott, 2008; Jones et al., 2010).

According to Gough and Scott (2008):

A sustainable world will require more than just a cadre of sustainable development specialists, and a world in which everyone was first and foremost an expert on sustainable development would hardly be sustainable. It is the unique potential contribution of higher education to prepare engineers, doctors, teachers, managers of all kinds, policy-makers, shipping agents, financial managers, journalists and film directors, whose contribution to the world, in their particular professional capacity, will be one that makes it more rather than less sustainable. (p. 159)
Therefore, for the purpose of the present study, EfS\(^6\) is distinguished as formal teaching and learning devoted to sustainability. Here, I include all structured classroom instances that touch upon sustainability in order to explore where and how it is happening in its most basic form. Examples of instances that I consider to be classified as EfS, along with illustrations of these examples, can be seen in Table 1.

**Educating for Sustainability Infused Across the Curriculum**

As seen in Table 1, in my conception of EfS, it can be embedded across course types and formats, and incorporated across disciplines. In terms of discipline, EfS was originally taught in natural science or geography classrooms.\(^7\) However, given the growing sense of urgency about sustainability-related problems, there is an emergent movement to incorporate sustainability across the curriculum, aiming to integrate

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\(^6\)Since the transition of environmental education to a body of education including sustainability, the body of education has taken many names from environmental and sustainability education, to education about sustainability, to education in sustainability, to education for sustainability. Education about sustainability concentrates on declarative knowledge in order to offer students information about environmental and sustainability-related systems and issues. Education in sustainability exploits the environment’s sustainability implications as a real-world resource for enquiry and discovery. Education for sustainability is transformative in nature by aiming to develop students’ knowledge and attitudes that motivate behavioral change in favor of sustainability and the environment (Cotton & Winter, 2010; Gough & Scott, 2003; Palmer & Neal, 1994). Given my deep belief that this body of education ought to serve as a mechanism to transform our society into a more sustainable future, I chose to use education for sustainability as the umbrella-term for the body of education under investigation in the present study.

\(^7\)Subject matter of EfS, principally sustainability, has been informed by the natural sciences, “with its emphasis on ‘good science’ that is rigorous, reliable, and objective” (Redclift, 1990, p. 268). Although the trajectory of EfS has transitioned from solely being taught in natural science classrooms to classrooms all across the curriculum, it is critical for EfS to remain anchored in “good” natural science. Natural science is important to the study of sustainability—understanding the reasoning behind environmental issues, like climate change, provides students, and as such, citizens, to be “well prepared to critically evaluate future problems they never were expected to in school” (Saylan & Blumstein, 2011, p. 79). Understanding the scientific foundation of sustainability provides students with a “conceptual toolkit” that will allow them to be able to navigate questions and issues throughout their lives (p. 79).
Table 1. Illustrations of Examples Education for Sustainability

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<thead>
<tr>
<th>Category</th>
<th>Example</th>
<th>Rationale</th>
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<tr>
<td>Sustainability-related courses that are required for a major in sustainability or a sustainability-related field</td>
<td>Required courses to complete a major in sustainability science at Montclair State University include: <em>Planet Earth, the Human Environment, Introduction to Sustainability Science, World Resources and Industries, and Sustainability Science Seminar</em> (&quot;Sustainability Science Major (B.S.) - Undergraduate - 2013 University Catalog - Montclair State University,&quot;) n.d.).</td>
<td>These courses are examples of the most traditional form of EfS because the focus of the course is directly related to sustainability.</td>
</tr>
<tr>
<td>Sustainability-related courses that are required for a major in a non-sustainability-related field</td>
<td>Many businesses worldwide are increasingly hiring college graduates who can implement and maintain sustainability-related initiatives within their companies (Cohen, 2007; Senge, Lichtenstein, Kaeufer, Bradbury, &amp; Carroll, 2007). Therefore, some HEIs, such as the Kelly School of Business at Indiana University at Bloomington, offer sustainability-related electives to satisfy business students’ major elective requirements. Examples include <em>Sustainable Enterprise, Sustainability Law and Policy, and Sustainable Operations</em> (“Undergraduate Program: Department of Business Economics and Public Policy: Kelley School of Business: Indiana University,” n.d.)</td>
<td>These courses are examples of the most traditional form of EfS because the focus of the course is directly related to sustainability.</td>
</tr>
<tr>
<td>Courses that are directly related to sustainability that count as a general education requirement</td>
<td>All undergraduate students at the University of Vermont must satisfy the sustainability general education requirement before they can graduate (“New Undergraduate General Education Requirement in Sustainability</td>
<td>UVM Office of Sustainability,” n.d.). Courses that fulfill this requirement include: <em>Sustainable Development &amp; Ecotourism in Costa Rica; Energy Action Seminar; Climate Justice &amp; Advocacy; Political Economy for a Finite Planet; and Ethics of Eating</em> (“Sustainability Courses &lt; University of Vermont,” n.d.).</td>
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8A major is the academic discipline to which a student formally commits to completing all courses required to earn a degree in that field. Students focus almost exclusively on their major fields for up to half or more of their undergraduate coursework. A students’ major often represents preparation in the field of their future careers, and it is important that they be well grounded in the moral and civic issues likely to arise in their chosen fields (Colby, Beaumont, Ehrlich, & Stephens, 2003), like sustainability.

9General education is a common component of the undergraduate program of study in virtually all not-for-profit HEIs. General education constitutes about one-third of the coursework required toward the bachelor’s degree (Lattuca & Stark, 2011; Levine, 2006). General education coursework aims is to foster students’ capacities to engage analytically, thoughtfully, and/or critically, and at times emotionally, with a variety of academic subject matters (Levine, 2006; Neumann, Bolitzer, Woodson, Delimma, & Ostrow, 2015; Nussbaum, 1998), in order to develop openness to the world in order to support them in becoming engaged citizens who lead meaningful lives (Castillo-Montoya, 2017; Neumann et al., 2015; Nussbaum, 1997).
Table 1 (continued)

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<th>Category</th>
<th>Example</th>
<th>Rationale</th>
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<tr>
<td>Courses that do not focus on sustainability but integrate a semester-long theme that is directly related to sustainability</td>
<td>Professor George Whitt teaches an <em>Introductory Statistics</em> class at Temple University using data from climate science. After teaching each core statistical concept, he demonstrates them by using climate science data. He suggests that introductory statistics can motivate students to see that statistics can help them better understand their world, in this case because the changing climate and its implications are inherently statistical concepts (Witt, 2013).</td>
<td>This course is classified as EiS because students learn how to make sense of sustainability-related data throughout the semester in a way that allows them to transfer the sustainability subject matter they learn into their lives as citizens.</td>
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<tr>
<td>Courses that do not focus on sustainability but devote a unit to sustainability-related subject matter.</td>
<td>In a US History course, one unit might discuss the Great Depression. While examining aspects of the longest, deepest, and most widespread economic depression of the 20th century (Eichengreen, 2014), the instructor mentions that The Great Depression and Dust Bowl resulted in intense dust damaging the ecology, agriculture, and American way of life. One response to these problems was <em>conservation education</em>, which was considered a scientific management tool that helped solve social, economic, and environmental problems during this challenging period (Kyburz-Graber et al., 2006; McCrea, 2006). Subsequently, the class begins to discuss implications that the Great Depression had for the environment, and educating citizens about the environment. This theme carries over throughout the entire unit on the Great Depression and the Dust Bowl. Both were avoidable catastrophic events driven by greed. The consequences of the Dust Bowl were much more physically obvious and seem especially relevant to a course devoted to a sustainability-related subject matter.</td>
<td>Although some courses do not devote significant time to the study of sustainability, when they repeatedly include instances of related-subject matter, they have opportunities to connect students’ disciplinary coursework to sustainability. This allows students to connect the seemingly disparate subject-matter they are learning to sustainability. Cultivating these connections between their traditional learning and learning about sustainability teaches them to make similar connections in their lives as citizens.</td>
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There are two main modes in which sustainability is incorporated into curriculum: diffusion and infusion (Michel & Pizmony-Levy, 2017). The diffusion mode occurs when new programs (e.g., Environmental Economics) and courses (e.g., Sustainable Fashion Marketing) are established to provide increased opportunities for students to learn about sustainability. The diffusion mode is limited due to its susceptibility to selection bias where students choose to engage with the specific learning opportunities. To date, there is more research on the diffusion mode opposed to the infusion mode (e.g., McMillan,
Wright, & Beazley, 2004; Smith-Sebasto, 1995). For instance, students of color are underrepresented in sustainability coursework (Garibay & Vincent, 2016). The infusion mode integrates sustainability-related content throughout the already-existing curriculum, across all disciplines. The infusion method occurs in courses that link environmental and sustainability challenges with broader topics, as in Introduction to Sociology (Obach, 2009). The focus of these courses, however, is not the environment or sustainability, but instead, it is one of several topics that is covered in the course. The upward trend of EfS is the infusion model because it supports students with connecting sustainability-related subject matter with their other coursework, such as their major courses. Therefore, many higher education scholars advocate for the infusion model to increase students’ sustainability-related knowledge, attitudes, and behaviors, motivating them to be sustainably engaged citizens.

Presence of Education for Sustainability

Although EfS is on the rise in HEIs around the world, there are mixed reports on the rate in which it is occurring throughout higher education classrooms. In one study, Beringer, Wright, and Malone (2008) found that the majority of HEIs in Atlantic Canada were engaged with sustainability by way of the curriculum. In another study, Wolfe (2001) surveyed chief academic officers at four-year HEIs in the United States and found that 11.6% specified that an environmental education course was required of all students. Fifty-five percent indicated that an environmental education course was countable toward the institution’s general education requirements. One-third (33.7%) of the HEIs offered at least one environmental minor, and 39% reported the existence of an environmental academic program that offered a course appropriate for non-environmental majors. Other studies find less optimistic results. For instance, the National Report Card on Sustainability in Higher Education found that between 2001 and 2008, the amount of sustainability-related courses offered in higher education has remained the same (Jensen,
Despite dramatically increased attention to the sustainability forefront, courses on sustainability have remained stagnant. David Orr’s observation from the 1990s that “we are still educating as if there is no planetary emergency” remains true today (Jensen, 2014). There is, as noted, a dearth of literature exploring where and how EfS is happening. Consequently, we know little about students’ learning experiences within the higher education EfS landscape (i.e., knowledge, attitudes, and behaviors). Further, we do not even know if particular EfS practices are tied to students’ sustainability learning outcomes.

**Conceptual Framework**

In the preceding literature review, I situated the present study in relevant literature on the concept of sustainability, civic mission of American higher education, and EfS. As demonstrated by this literature review, we know very little about where and how students learn about sustainability across the higher education curriculum. In fact, in his text exploring approaches to advancing SHE through research, Fien (2002) states that as “important and interesting as this work is, it remains predominantly atheoretical in that few studies have sought to go beyond description to include a critical and theoretical analysis of findings or to ground explanations in social or organisational theory” (p. 244). As such, in order to investigate the teaching and learning about sustainability across the higher education curriculum, I created a framework to guide my study, entitled *Framework for Teaching and Learning for Sustainability in Higher Education*. This framework draws from the fields of learning sciences (namely, cognitive science), anthropology, philosophy, psychology, sociology, K-12 education, as well as higher education, to provide the conceptual grounding for the present study. Moving forward, in this section, I illustrate the relationship among these facets in the context of the
Framework for Teaching and Learning for Sustainability in Higher Education. Following, I explain the four facets of the framework in depth.

In the *Framework for Teaching and Learning for Sustainability in Higher Education*, I posit that sustainability learning outcomes are influenced by students’ access to sustainability content (opportunity to learn) as well as the ways in which they learn about the content (promising practices of teaching and learning). The first facet of the framework, opportunity to learn, signifies the concept that students’ ability to learn a subject is dependent on whether, for how long, and where they are exposed to it in the classroom (Banicky, 2000; Carroll, 1963; Schmidt et al., 2015; Tate, 2001). Next, I use two theories that point to promising practices of teaching and learning in order to further explore the extent to which students have the opportunity to learn about EfS in the classroom. The first arm of the teaching and learning facet of the framework is Neumann’s (2014) cognitively responsive teaching, which provides a window into good higher education teaching. The second arm of the teaching and learning facet of the framework, teaching for sustainability, explores EfS-specific teaching practices and core ideas. The final facet of the framework, determining the measurement of students’ sustainability-related learning outcomes, is Sipos et al.’s (2008) transformative sustainability learning outcomes. Transformative learning outcomes are important for this framework in order to examine if students’ opportunity to learn and exposure to promising practices of teaching and learning for sustainability actually do lead to their increased sustainability-related learning outcomes. While I present these each of these frames as distinct, they are in fact conceptually connected with one another. Central to each is the idea that they provide students with exposure to the teaching and learning of sustainability-specific subject matter.
The Framework for Teaching and Learning for Sustainability in Higher Education

Figure 2 represents the hypothesized relationships among the four separate facets of the Framework for Teaching and Learning for Sustainability in Higher Education. Within this framework, I posit that opportunity to learn about sustainability can directly influence promising practices of teaching and learning about sustainability (cognitively responsive teaching and teaching for sustainability) and transformative sustainability learning outcomes. Opportunity to learn about sustainability can directly influence promising practices of teaching and learning about sustainability because it measures whether EfS is occurring and, since it must be present for teaching practices to take place, it influences the promising practices. For instance, in the cognitively responsive teaching facet of the framework, one measure is that the instructor delves deeply into the core ideas. If the core ideas were not presented at all (opportunity to learn), it would be impossible for this practice of exploring the core ideas to occur.

Additionally, in this model, I treat opportunity to learn as a scale of how much exposure to sustainability-related subject matter students have. Since promising practices of teaching and learning take time to carry out, I suggest that with more opportunity to learn about sustainability-related, students have more exposure to the specified teaching practices. For example, in the teaching for sustainability facet of the framework, one measure is sustainability-related teaching practices, which consists of nine particular teaching practices. Given that each of these teaching practices take time to carry out (for example, it takes time to carry out a case study, which is just one of the nine practices), with more opportunity to learn about sustainability, students have more opportunity to learn about sustainability through the prescribed sustainability-related teaching practices. In addition, I also posit that opportunity to learn can also indirectly influence transformative learning outcomes by directly influencing promising practices of teaching and learning about sustainability.
Opportunity to Learn

The first facet of the Framework for Teaching and Learning for Sustainability in Higher Education is the opportunity to learn (OTL). OTL was first introduced in the K-12 educational policy scholarship in Carroll’s (1963) model of school learning. OTL was originally used as a measure of students’ opportunities to study a particular topic (Banicky, 2000; Carroll, 1963; Schmidt et al., 2015). Today, OTL is understood to signify that students’ ability to learn a subject is dependent on whether and for how long they were exposed to it in the classroom (Banicky, 2000; Carroll, 1963; McDonnell, 1995; Schmidt et al., 2015; Tate, 1995, 2001). Furthermore, for the purpose of this study, I also examined where students learn about a particular subject matter. 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 EfS, 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). As such, I also use OTL as a way to measure whether, for
how long, and where students were exposed to EfS subject matter throughout their coursework.

**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 & Wright, 2009, p. 2). It is therefore imperative to ground the present study in a frame, 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 urban science education 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 employs OTL to ground his argument regarding science and math education as a civil right, stating, “Reframing 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 and science education” (p. 1018). Tate thus reinforces 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” (p. 1015). As thus illumined, OTL about science, or in this case, sustainability, is inextricably linked with social issues, particularly for marginalized racial communities, and can provide an important route toward equity for those affected.

Distressingly, though, students in lower-income schools continue to suffer fewer opportunities to learn essential subject matters (Banicky, 2000), like science and sustainability. This can be seen in prior K-12 research, which has found a positive
relationship between socioeconomic status and OTL (Banicky, 2000; Baratz-Snowden, 1993; Chudgar & Luschei, 2009; Wang, 1998). In one study, Schmidt et al. (2015) used the 2012 Programme for International Student Assessment (PISA)\textsuperscript{10} data to explore the relationship between OTL, socioeconomic status, and students’ math literacy. They found that OTL is significant to student outcomes, with a positive relationship between socioeconomic status and OTL. Roughly, a third of the socioeconomic status relationship to literacy was due to its association with OTL (Schmidt et al., 2015). Given the math deficit of students from low socioeconomic backgrounds and racial minorities, and their increased vulnerability to climate crises, it is indeed appropriate to use OTL to frame these students’ access to EfS.

**OTL in the higher education literature.** Although OTL has rarely been used in higher education research (Michel & Pizmony-Levy, 2017), several concepts related to OTL have been explored in depth in the higher education literature. These include time on task, quality of effort, and involvement. The time on task concept also originates from Carroll’s (1963) work and can be defined as the relationships between learning and the amount of attention students devote to coursework. Time on task focuses on the following aspects: expectations for the amount of work (hours); expectations for the amount of time students will be engaged in course material; and expectations for sustained attention on course material (Astin, 1993; Carroll, 1963).

Another highly related theory prominent in the higher education literature is Pace’s (1982) quality of effort. Pace argues that all learning requires students’ investment of both time and effort. Here, time is a frequency dimension, and effort “is a quality dimension in the sense that some kinds of effort are potentially more educative than

\textsuperscript{10}“The Programme for International Student Assessment (PISA) is a triennial international survey which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students” (“About-PISA,” 2018).
others” (p. 2). In this theory, like time on task, time is central. However, in quality of effort, the effort domain enters the field (Pace, 1982, 1984). The fundamental difference between time on task and quality of effort and OTL is this: OTL puts the focus on an instructor’s offering of the opportunity rather than simply the proportion of time students intellectually engage (sometimes a duty of students rather than instructors).

Another pertinent landmark theory in the higher education literature is Astin’s (1984) student development theory on student involvement. Astin defines involvement by saying, “student involvement refers to the amount of physical and psychological energy that the student devotes to the academic experience” (p. 518). He further explains that a highly involved student would allocate extensive energy to studying, spending a great deal of time on campus, participating in campus activities, and interacting with other members of the community, including instructors and other students. Many studies, similar to what I explore in the present study, have linked involvement with learning outcomes. For instance, Carini, Kuh, and Klein (2006) examined student involvement as associated with students’ academic learning outcomes and found that many measures of student engagement, including student involvement, were positively linked with such learning outcomes. Prior higher education studies, which serve as the foundation for my present study, have in fact demonstrated the link between time, opportunities, and involvement, with learning outcomes.

**Application to the present study.** Apropos to higher education EfS literature, scholars have argued that sustainability subject matter should not be taught as one individual course but be embedded throughout students’ coursework and thus support them in connecting core concepts with their future role as citizens (Orr, 2005; Sterling, 2004). One argument for infusing sustainability into all classrooms is to provide access to this subject matter to all populations. While we know that low socioeconomic status groups are disproportionately affected by climate disasters (Agyeman et al., 2003; Brainard et al., 2009; Bullard et al., 2008). This then, provides another compelling reason
why infusing sustainability into the classroom, and as such providing all students with the opportunity to learn, is so important: all students then have access to this subject matter.

Opportunity to learn, as seen, provides a method to measure if, for how long, and where students have the opportunity to learn about sustainability. The three main variables that emerge from the OTL literature are time, location, and quantity (Tate, 2001). Analysis of OTL variables contributes a better understanding regarding if and where students have exposure to sustainability subject matter in the classroom, and how it is taught. Measuring students’ OTL is also important because “if students are to be held accountable for their learning, then schools must be held accountable as well by demonstrating that they provide students with opportunities to learn what they must learn to meet the standards that have been set” (Baratz-Snowden, 1993, p. 317). In other words, OTL helps us understand how much, if any, sustainability subject matter students are exposed to, and for how long.

**Promising Practices of Teaching and Learning about Sustainability**

Given the importance of sustainability-related problems, it is necessary to consider not only how much students’ exposure to sustainability-related content, but also the teaching practices employed to facilitate the learning of it. Paramount to students’ EfS learning are their classroom experiences. *Teaching* is a communal act in which students’ learning is facilitated by an instructor’s selection of materials, examples, and experiences to aid in that endeavor (Austin, 2002; Boyer, 1990; Levinson-Rose & Menges, 1981). In particular, Neumann (2014) defines *teaching* as orchestrating an encounter of subject matter knowledge by exposing students to core ideas. Teaching and learning are interrelated (Shulman & Hutchings, 2004), and thus implicit in the definition of teaching as the definition of learning (Neumann, 2005). Neumann (2014) defines *learning* as encountering knowledge that “resonates with or contravenes” students’ prior knowledge (p. 251). In the present study, I assess teaching and learning about sustainability because
“teaching succeeds when learning occurs” (Davis & Arend, 2013, p. 31). As such, this section explores promising practices of teaching about sustainability (PPOT&LAS) that ideally lead to students’ learning about sustainability—namely, cognitively responsive teaching and teaching for sustainability.

**Cognitively responsive teaching.** Although learning has always been central in classrooms, the ways students learn have advanced in response to pressure to increase educational quality (Arum & Roksa, 2011) and adapt to changing social climates (i.e., wars and economic depressions/recessions) (Boyer, 1990; Finkelstein, 1983; Schuster & Finkelstein, 2006). While some scholars advance learning theory by exploring the confines of prior research (Hora & Ferrare, 2014), Neumann (2014) took a novel approach by steeping her work in K-12 research in the disciplines of learning sciences (namely, cognitive science), anthropology, philosophy, psychology, and sociology, as well as higher education research (Rose, 1990; Shulman & Hutchings, 2004). Neumann (2014) engaged in interpretive and ethnographic practices (Erickson, 1986; LeCompte & Preissle, 1993) by carrying out weekly classroom observations, artifact analyses, and instructors interviews in four liberal education classes (Neumann, 2014; Neumann et al., 2015). Neumann’s (2014) study culminated in three claims of what good teaching and learning in higher education encapsulate. Neumann’s cognitively responsive teaching is about good teaching in higher education, broadly, and not specifically intended for EfS. However, because the EfS literature is still developing and lacks sufficient theory on good EfS teaching, I borrowed from the broader higher education literature by using Neumann’s cognitively responsive teaching. I chose to use Neumann’s work in the present study because it mirrors the complexity that exists in postsecondary coursework today.

Neumann’s (2014) cognitively responsive teaching situates the college teaching and learning processes in disciplinary or interdisciplinary subject matter ideas, students’ own cognitions of the subject matter given their lived experiences, and the intersection of
course content, students’ understandings, and instructors’ understandings. Below, I describe how Neumann’s three claims manifest in sustainability teaching. Fictional examples of features within each claim, to help understand how these claims might look when teaching about sustainability, can be found in Table 2.

**Neumann’s first claim.** Neumann’s (2014) first claim stipulates that good instructors intentionally engage students in subject matter ideas of the discipline or interdisciplinary field. *Subject matter* is the content knowledge of the discipline or interdisciplinary field (Bransford et al., 2000; Grossman, Wilson, & Shulman, 1989), while *core ideas* are the substantive and structural building blocks of disciplinary knowledge that contribute to understanding of the discipline (Ball, Thames, & Phelps, 2008; Lee, 2007). As such, instructors thoroughly understand the discipline or interdisciplinary field and are able to identify core ideas of the subject matter, determine the sequence in which they are to be introduced, use multiple examples and pedagogical strategies to share the core ideas with students, and facilitate opportunities for students to situate these ideas within a broader discipline or field. This claim is rooted in prior K-12 research, including the work of Ball (1988, 1993), who suggests that learning subject matter entails more than receiving facts, but instead interacting with subject matter in a manner that assists students’ in thinking deeply about broader ideas of the discipline. Further, the roots of this claim date back to the work of John Dewey (1902, 1916), who historically ascertained that subject matter learning should be meaningful in students’ real lives, as only then can students (now able to conceptualize the complexities of subject matter) be truly prepared to transfer what they learn to new settings. This first claim emphasizes the importance of instructors’ facilitation of students’ interaction with subject matter learned in the classroom (Ball, 1988, 1993; Bransford et al., 2000; Dewey, 1902, 1916; Schwab, 1978; Shulman & Hutchings, 2004).
### Table 2. Fictitious Examples of Neumann’s (2014) Cognitively Responsive Teaching Employed to Teach Sustainability-related Content to Students

<table>
<thead>
<tr>
<th>Claim</th>
<th>Feature of Claim</th>
<th>Fictitious Example</th>
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<tbody>
<tr>
<td><strong>Claim 1:</strong> Good teaching in higher education requires that instructors guide students in encountering and interacting with a subject matter idea.</td>
<td>The instructor introduced, in-depth, a concept related to sustainability.</td>
<td>When an American history instructor mentioned the Dust Bowl of the 1930s, (s)he went beyond mentioning the event and explained it thoroughly with special focus on the environmental and health hazards it had on people, particularly on those of minority races and low incomes.</td>
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<td></td>
<td>The instructor explained the sustainability-related concept in a few different ways.</td>
<td>When explaining the economic impact of organic farming, the instructor explained how it might affect individual consumers, local farmers, and the local economy.</td>
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<td>The instructor introduced how sustainability is connected to course content.</td>
<td>When reading Shakespeare’s “A Midsummer Night’s Dream,” the instructor pointed out the reference to the time period’s unusually volatile weather, and drew a connection between ecological awareness in Shakespearian times and in our modern day.</td>
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<td>The instructor taught sustainability in a logical order.</td>
<td>Instead of just stating that the local town’s power plant is becoming coal free, the instructor discussed the systematic plan of becoming coal free.</td>
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<td>The instructor taught students how to think about sustainability.</td>
<td>The instructor used an analogy to help students think about sustainability by saying: imagine you have a magic candy jar that refills itself. The candy in the jar is sustainable because it can be used for a long time without it running out. In the real world, we do not have a magic candy jar. If we keep taking candy out of a jar and never put more back in, the jar will become empty. This is similar to the concept of sustainability.</td>
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<tr>
<td><strong>Claim 2:</strong> Good teaching in higher education requires that instructors guide students to encounter new ideas by surfacing their prior knowledge.</td>
<td>The instructor helped students use what they knew from their own personal experiences to help them learn about sustainability.</td>
<td>The instructor equated how the social norm of picking up after a student’s dog is similar to large corporations divesting from fossil fuel companies to help them understand this abstract concept in a way they can relate to.</td>
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<tr>
<td>Claim</td>
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<tr>
<td>The instructor helped students use what they knew from their high</td>
<td>The instructor made reference to ideas students learned in their high school</td>
<td>The instructor referred to ideas students learned in their other college courses (like a women’s studies class where they learned about ecofeminism) to help them understand the sustainability-related idea (s)he was teaching.</td>
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<td>school coursework to help them learn about sustainability.</td>
<td>school courses (like a natural science class where they learned about plate</td>
<td>The instructor referred to ideas students learned in their other college courses (like a women’s studies class where they learned about ecofeminism) to help them understand the sustainability-related idea (s)he was teaching.</td>
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<td>tectonics, or erosion and deposition) to help them understand the sustainability-</td>
<td>The instructor examined how some religions and cultures sacrifice animals for symbolic reasons, and challenged them to think about how their social and cultural roles may have sustainable implications.</td>
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<td>related idea (s)he was teaching.</td>
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<td>roles and culture (e.g., race, socioeconomic status, gender,</td>
<td>symbolic reasons, and challenged them to think about how their social and</td>
<td>The instructor examined how some religions and cultures sacrifice animals for symbolic reasons, and challenged them to think about how their social and cultural roles may have sustainable implications.</td>
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<td>sexuality, ethnicity, religion) to help them learn about sustainability.</td>
<td>cultural roles may have sustainable implications.</td>
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<td>The instructor helped students use what they knew from their family</td>
<td>The instructor used family situations, like a dynamic conversation around the</td>
<td>The instructor used family situations, like a dynamic conversation around the Thanksgiving table, to depict the complexity of converging views about sustainability.</td>
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<td>to help them learn about sustainability.</td>
<td>Thanksgiving table, to depict the complexity of converging views about</td>
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<td></td>
<td>sustainability.</td>
<td>The instructor used family situations, like a dynamic conversation around the Thanksgiving table, to depict the complexity of converging views about sustainability.</td>
</tr>
<tr>
<td>The instructor helped students use what they knew from their friends</td>
<td>The instructor used social situations, like sharing a bathroom in the college</td>
<td>The instructor used social situations, like sharing a bathroom in the college dorm, to show how conversations with friends about the length of showers can be used to make sense of water management.</td>
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<tr>
<td>to help them learn about sustainability.</td>
<td>dorm, to show how conversations with friends about the length of showers can</td>
<td>The instructor used social situations, like sharing a bathroom in the college dorm, to show how conversations with friends about the length of showers can be used to make sense of water management.</td>
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<td></td>
<td>be used to make sense of water management.</td>
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<tr>
<td>The instructor helped students use what they knew from the media to</td>
<td>The instructor mentioned an example a student knew about from the media, like</td>
<td>The instructor mentioned an example a student knew about from the media, like the wildfires in California, to help explain a sustainability-related idea.</td>
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<tr>
<td>help them learn about sustainability.</td>
<td>the wildfires in California, to help explain a sustainability-related idea.</td>
<td>The instructor mentioned an example a student knew about from the media, like the wildfires in California, to help explain a sustainability-related idea.</td>
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Table 2 (continued)
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<tr>
<th>Claim</th>
<th>Feature of Claim</th>
<th>Fictitious Example</th>
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<tr>
<td>Claim 3: Good teaching in higher education requires that instructors</td>
<td>The instructor helped students realize the differences or similarities between</td>
<td>At the beginning of the course, a student thought that using energy efficient lightbulbs was being sustainable but the instructor pushed the student to think about reduction of resources instead of just consumption of “better” resources.</td>
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<td>support students in acknowledging and working through differences</td>
<td>what they knew about sustainability before the class and what they learned about</td>
<td>Coming into the class, a student believed that the Lake Erie toxic algae bloom was solely an environmental issue. The student did not understand how this was a broader sustainability issue because it is an environmental problem. In one class discussion in early November, a peer offered that he was voting for a particular candidate because (s)he supported investing in research and practices that would limit the toxic algae from blooming, and resources to protect local communities from the devastating effects of the toxic algae. Using this peer’s insight, the instructor then guided the student in thinking about how this could be seen as an environmental issue, how this could be seen as a political issue, how this could be seen as an economic issue, and how this could be seen as a social issue. Then, the instructor helped the student understand how this is a broader sustainably issue, not just an environmental issue.</td>
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<td>between their prior knowledge and new ideas taught in the class.</td>
<td>sustainability in the class</td>
<td>The instructor supported students if and when they felt challenged by the sustainability content.</td>
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<td></td>
<td>The instructor helped students work through differences between what they knew</td>
<td>This past summer, a student visited SeaWorld. This semester, in a Documentary Filmmaking class, the student watched “Blackfish.” The student felt then conflicted by their recent visit to SeaWorld. The student felt comfortable about sharing their conflicting feelings in a class conversation, and the instructor helped the student feel supported. The instructor built on what the student experienced at SeaWorld to help them feel challenged about what the student saw there in a way to become empowered to be a critical, reflective thinker about their ways of their knowing.</td>
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<td>about sustainability before the class and what they learned about sustainability</td>
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<td>in the class</td>
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In her first claim, Neumann suggests that certain ways of thinking are inherent in a discipline or interdisciplinary field. Although EfS core subject matter ideas have not been validated, sustainability as a content area shares particular subject matter, assumptions, and values similar to the way a discipline would act. In this study, I am staking a claim about the interdisciplinary field of sustainability. I suggest that the subject matter of sustainability, stemming from the Brundtland Commission’s (1987) definition of sustainability, includes understanding the deeply complex interconnectedness of the environmental, economic, and social domains of sustainability. The specific core ideas I suggest are important for EfS will be discussed more in more detail in the teaching for sustainability section.

In the present study, I examined sustainability infused throughout the curriculum, but also its function as an interdisciplinary field. In other words, although sustainability subject matter is interdisciplinary in nature, it is taught in disciplinary contexts taking place in courses throughout the curriculum. As such, I argue that the subject matter of EfS acts like a discipline because regardless of the discipline in which it is being taught, there is a specific set of subject matter, assumptions, and values at hand that undergird the teaching of this content. In particular, to explore Neumann’s claim that good teaching in higher education requires that instructors guide students in encountering and interacting with a subject matter’s ideas, I examined the extent to which instructors introduced sustainability-related subject matter, explained the sustainability-related concept in a few different ways, introduced how sustainability is connected to course content, taught sustainability in a logical order, and taught students how to think about sustainability.

Neumann’s second claim. Neumann’s (2014) second claim stipulates that good instructors connect students’ learning to their prior knowledge. Prior knowledge is knowledge, beliefs, and skills students bring to the classroom, which in turn influence how they make sense of new information. Prior knowledge is affected by students’
demographics, such as gender, social class, ethnicity, and race (González, Moll, & Amanti, 2006; Ladson-Billings, 1995, 2006; Lee, 2007). In this claim, Neumann (2014) suggests that instructors brings forth a students’ prior knowledge of the new subject matter ideas, both personal and cultural (Bransford et al., 2000; González et al., 2006). This claim demonstrates that good teaching surfaces this prior knowledge and only then probes the ways in which students frame and work through the subject matter ideas (Bransford et al., 2000; Ladson-Billings, 1995).

It is likely that students come to the classroom with academically derived prior knowledge, learned from their previous formal schooling (Bransford et al., 2000; Castillo-Montoya, 2017). Many students have learned about the environment in K-12 education, as numerous national educational systems, including that in the US, have introduced environmental education at the primary and secondary levels (Bromley, Meyer, & Ramirez, 2011). Students have also likely learned about sustainability in other postsecondary coursework, as many HEIs have explicitly infused it in the curriculum space with sustainability-specific coursework (Liu, 2011; Rowe, 2007; Rowe & Johnston, 2013).

Furthermore, another form of prior knowledge is accumulated and internalized from everyday life (González et al., 2006) and from social and cultural interactions (Bernal, 2001, 2002; Vygotsky, 1978). This knowledge is rooted deeply within students’ identity via race, ethnicity, social class, and religion—identities, which reflect larger social, cultural, and historical realities (Castillo-Montoya, 2017; Nasir & Hand, 2006; Orellana & Bowman, 2003). For instance, prior research has found that the most important predictor of climate change skepticism among adolescents was the perceived skepticism among their parents and peers (Ojala, 2012). In addition to absorbing what their family and peers have expressed, students have also witnessed their behaviors (Mead et al., 2012; Ojala, 2012; Taber & Taylor, 2009), either pro-sustainable (conscious water usage) or unsustainable (carelessly leaving the lights on). Being exposed to
unsustainable behaviors and anti-climate science messages from trusted sources like family members can influence students’ sustainability attitudes (Cialdini, Reno, & Kallgren, 1990). Additionally, because of the increasing polarization of climate change coverage in the media, students likely arrive in the classroom with varying beliefs and opinions about sustainability (Boyce & Lewis, 2009; Boykoff & Boykoff, 2007; Lewis & Boyce, 2009; Wilson, 2000).

There are, as mentioned above, many origins of students’ sustainability-related prior knowledge, such as academic, demographics, personal connections, and media, which they bring with them to the higher education classroom. Most students have heard family, peers, and media discuss climate change (Bulkeley, 2000; Dispensa & Brulle, 2003), while others have personally endured environmental disasters (i.e., drought or flood), and have firsthand experience with our changing climate (Brody, Zahran, Vedlitz, & Grover, 2008; Leiserowitz, 2006; Myers, Maibach, Roser-Renouf, Akerlof, & Leiserowitz, 2013; Weber, 2006). As per Neumann’s (2014) second claim, it would be useful for instructors to surface this prior knowledge in helping students to learn new sustainability-related information. To investigate this, I explored the extent to which instructors helped students use what they knew from particular types of prior knowledge—personal experiences, high school coursework, college coursework, social roles, family, friends, and media—to help them learn about sustainability.

**Neumann’s third claim.** Neumann’s (2014) third claim is that good instructors support students in connecting their prior knowledge with the new core ideas of the course (Bransford et al., 2000; González et al., 2006). In other words, instructors use students’ prior ways of understanding the subject matter as a bridge toward teaching them new course information. To do so, instructors support students both cognitively and emotionally when the course leads them to question long-held beliefs in the process of reconciling their prior knowledge with what they are learning. This is critical to supporting students’ changing views. If the students’ prior knowledge and lived
experiences contrast with the new core ideas, instructors help students work through such dissonance in both cognitive and emotional ways. If the students’ prior knowledge and lived experiences correspond with the new core ideas, instructors’ support would even more successfully help students in deepening their understanding of the course subject matter by building upon their prior knowledge.

Neumann’s (2014) third claim is about the cognitive dissonance between long-held beliefs and new subject matter ideas. This is important in the context of EfS, as prior research, such as the work of Kahan (2015), has found that climate change is no longer an issue of knowledge for people who have reached adulthood, but rather, more an issue of changing views. Given that sustainability subject matter is highly politicized, culturally sensitive, and potentially catastrophic, students likely understand the subject matter in varying ways. Students, whether they believe in climate change or not, come to the classroom with different opinions on sustainability. In fact, traditional-aged college students were around 10 years old when Al Gore’s seminal An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do about It was published in 2006. As a result, most students have grown up in a world where these topics have been openly discussed and polarized, which has likely affected their thinking, in ways that either align or contradict with EfS subject matter. As such, Neumann’s (2014) third claim is of the utmost importance in teaching EfS.

To explore Neumann’s (2014) claim that good teaching requires that instructors support students in acknowledging and working through differences between their prior knowledge and new ideas taught in the class, I examined the extent to which instructors helped students realize the differences or similarities between what they knew about sustainability before the class and what they learned in the class, helped students work through differences between their prior sustainability knowledge and what they learned about it in the class, and supported students if and when they felt challenged by the
sustainability content. As can be seen here, in the present study, I adapted Neumann’s claims specifically to the context of teaching sustainability-related subject matter.

*Neumann’s (2014) cognitively responsive teaching in the context of the present study.* The three claims of cognitively responsive teaching contribute individually and collectively to examining the teaching practices used to teach EfS. The first claim provides a way to explore the teaching of the interdisciplinary field of EfS. In this context, EfS has a subject matter that acts like a discipline because there is a specific set of core ideas at hand. As such, I used Neumann’s first claim to explore EfS throughout the curriculum to examine EfS subject matter taking place in interdisciplinary contexts. The second claim explores if instructors tap into students’ sustainability-related subject matter. This is important because, as seen, most students come to higher education with preconceived ideas about sustainability (Bulkeley, 2000; Dispensa & Brulle, 2003; Lin & Shi, 2014; Myers et al., 2013). The third claim offers a lens for examining instructors’ support of students in working through the cognitive and emotional features of dissonance between their prior and newly acquired knowledge (Bransford et al., 2000; Neumann, 2014; Shulman & Hutchings, 2004). This, too, is important, since changing beliefs and attitudes, in addition to increased knowledge, stimulate students’ changed and increased sustainable behaviors (Arbuthnott, 2012; Joireman, Van Lange, & Van Vugt, 2004; Stern, 2000; Zwickle et al., 2014). Together, the three claims of cognitively responsive teaching contribute insight into teaching practices that are responsive to the cognition of the students, which in turn can shape their deep EfS learning (Ball, 1993; Bransford et al., 2000; Dewey, 1916; Shulman & Hutchings, 2004). Cognitively responsive teaching offers yet another key benefit: it challenges the normative stance expressed in the EfS literature that sustainability is universally understood. Instead, this Neumann’s three claims help conceptualize sustainability problems as formidable and complicated. Rather than just lecture students about sustainability, instructors must reengage students, connect with what they already know, and provide space for the
tension between their prior knowledge and newly acquired subject matter. Cognitively responsive teaching is limited in the context of the present study, however, in that its focus is mainly on the knowledge (and perhaps the attitudes in the third claim), but it fails to address behaviors, a key learning outcome for EfS.

**Teaching for sustainability.** The other arm of the PPOT&LAS frame culls specific teaching practices and core ideas that the literature has stipulated as practical for EfS learning. Ideally, the higher education EfS literature base would postulate a robust set of teaching practices and core ideas that defines good EfS teaching. For instance, in broader educational theory, Lee Shulman’s (2004) Pedagogical Content Knowledge (PCK) “represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented and adapted to the diverse interests and abilities of learners, and presented for instruction” (p. 93). To date, though, no specific EfS frame satisfactorily elucidates the melding of core ideas and teaching strategies. While PCK in K-12 EfS has been employed by some scholars (such as Birdsall’s, 2014, examination of two primary school teachers’ use of PCK in teaching sustainability), SHE scholars have mostly cited separate practices as appropriate for teaching EfS. I argue that a deficiency in the EfS literature is that it falls short in terms of explanation as to what specific core ideas needs to be taught, and how to teach these core ideas to students.

Therefore, in the present study, I am limited by the fact that the EfS literature has not yet developed to the point where we know the PCK for EfS. Since Neumann’s (2014) claims on good college teaching are limited in their broad application to higher education, I created a second arm as part of the promising practices for teaching and learning about sustainability that pulls key elements from the EfS-specific literature. I call this facet **Teaching for Sustainability.** Like PCK, teaching for sustainability has two main parts: core ideas and teaching practices. An illustration of teaching for sustainability can be seen in Figure 3. Here, we can see that the sustainability-specific teaching practices
instruct around sustainability-specific core ideas. The following two sections describe each element of teaching for sustainability, including the core ideas, which I refer to as core ideas, and teaching practices.

**Figure 3. Teaching for Sustainability Visual**

*Teaching for sustainability: Core ideas.* There is currently a growing body of literature that explores students’ sustainability knowledge. For instance, Kagawa (2007) conducted an online questionnaire survey at the University of Plymouth (UK) to examine students’ perceptions and understandings of, and attitudes toward, sustainability-related concepts. When asked about their familiarity with sustainability-related terms, about one-third of respondents declared themselves as “very familiar,” one-third identified themselves as “quite familiar,” and one-third reported that they were either “quite unfamiliar” or “not at all familiar.” This study aligns with the broader body of the
literature, which reveals that students lack in-depth sustainability knowledge (Jeffries et al., 2001; Kagawa, 2007; Lombardi & Sinatra, 2012).

Missing from this literature base, though, is what core ideas central to sustainability are. As such, I engaged in a review of the sustainability literature, resulting in a set of 11 items that were repeatedly present. I posit that these 11 items are the core ideas of the interdisciplinary field: defining sustainability, environmental crises, eliminating poverty, future generations, environmental justice, economic sustainability, resource management, anthropocentrism, biocentrism, ecocentrism, and ecofeminism.

Fundamental to being able to understand sustainability as a field is a deep grasp of what sustainability means. As such, one core idea of EfS is defining sustainability. Students can likely classify core ideas of more traditional paradigms, as if an algebraic equation would be considered mathematics, and conjugating verbs would be considered language arts. Being able to define sustainability is a core building block of EfS because it helps students identify what is classified as sustainability-related content and consider the interrelated relationships among environmental, economic, and social systems. Ability to define the term is rudimentary to truly being able to delve further into the field of EfS.

Another core idea in EfS is environmental crises, since sustainability grew out of the study of the environment. To date, many prominent scholars continue to reinforce their understanding of sustainability in the environment; for instance, Bieler and McKenzie (2017) understand the term to include “at minimum [a] consideration of the natural environment” (p. 2). As environmental problems often perpetuate related social and economic implications (Edwards, 2012; Iverson, 2016; Merkel & Litten, 2007), environmental crises ought to be considered a core idea of the EfS field.

The next two core ideas I posit come directly from the Brundtland Commission’s (1987) report: eliminating poverty and future generations and indicating their prominence in the field. Eliminating poverty, which is also the first goal of UN SDG’s, is defined by
the SDG’s as “Poverty is more than the lack of income and resources to ensure a sustainable livelihood. Its manifestations include hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion as well as the lack of participation in decision-making” (“Sustainable Development Goals,” 2018). Given that the Brundtland Commission (1987) was a report about eradicating poverty, it should be considered a core idea to EfS. Further, future generations represents thinking about actions in the context of both the implications for our present individual lives, and for those who will come after us (Edwards, 2012). This is central to sustainability because the concept is about living in our world such that future generations, too, can enjoy a quality of life as we know it today (Brundtland Commission, 1987; Chase et al., 2012).

Another core idea of EfS is environmental justice, which “requires that all people and communities receive equal protection of environmental and public health laws, and should have an equal and meaningful voice in decisions related to the environment” (Michigan Civil Rights Commission, 2017, p. 4). In other words, environmental justice signifies the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in the context of environmental policies (Agyeman et al., 2003; Bullard & Wright, 2009; Schlosberg, 2013). Agyeman et al. (2003) explain how this concept is core to sustainability, as they identify “the need to ensure a better quality of life for all, now and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems” (p. 78). Indeed, environmental justice is central to sustainability, as it is of “pivotal importance in the move toward sustainable future” (p. 2).

Economic sustainability is also intrinsic to sustainability, given its salience as one of the three main pillars holding up the larger, more complex concept. Economic sustainability refers to the recognition that interactions of humans occur within the natural environment and, in particular, use resources to create goods and services that add
value to their lives (Edwards, 2012; Merkel & Litten, 2007; Sachs, 2005; Venkatesan, 2015a, 2015b). Deeply related is the core idea of resource management, which refers to responsible resource use, with goal of waste disposal occurring within the capacity of our planet (Sachs, 2005; “Sustainable Development Goals,” 2018). Humanity’s current consumption exceeds Earth’s capacity to regenerate resources. Thus, resource management is often tied to economic principles, as it represents humanity’s ecological deficit spending (Wackernagel & Rees, 1998).

Furthermore, anthropocentrism indicates the belief that human beings are the most important species on the earth, a concept of human supremacy. Anthropocentrism is inherently embedded in many contemporary human cultures and decisions (Allen et al., 2000; Etheridge et al., 1996; Hoffman & Sandelands, 2005; Kortenkamp & Moore, 2001; Rosenzweig et al., 2008). In EfS, this idea ought to be challenged since anthropocentric behaviors cause the most severe environmental and implicit social and economic crises we are facing today (Edwards, 2012; Iverson, 2016). In addition, biocentrism represents the ethical point of view that human needs are not more important than the needs of other living things (Berman & Lanza, 2010; Emmenegger & Tschentscher, 1993; Taylor, 1983, 2011). Additionally, ecocentrism refers to a nature-centered, as opposed to human-centered, system of values (Bailey & Wilson, 2009; Gough, Scott, & Stables, 2000; Hettinger & Throop, 1999; Hoffman & Sandelands, 2005; Kortenkamp & Moore, 2001).

The last core idea I suggest is the notion of ecofeminism, which draws on the concept of gender to theorize on the relationship between humans and the natural world (Mies & Shiva, 1993; Salleh, 1997; Spretnak, 1990; Warren, Warren, & Erkal, 1997). It is important to include ecofeminism as a core idea in keeping with the SDG’s call for gender equality (“Sustainable Development Goals,” 2018), and as a way to integrate ideas that center on the philosophical movement that amalgamates ecological concerns with feminist concerns, rooted in the notion that both are consequences of a male
dominated society (Mies & Shiva, 1993; Salleh, 1997; Spretnak, 1990; Warren et al., 1997).

**Teaching for sustainability: Core ideas versus Neumann’s (2014) claim #1.** It is worth noting here that the teaching for sustainability core ideas facet of the *Framework for Teaching and Learning for Sustainability in Higher Education* is different from Neumann’s (2014) first claim in her cognitively responsive teaching. Neumann’s subject matter claim contributes the idea that instructors introduce subject matter ideas. They teach these subject matter ideas well: in-depth, in different ways, in a logical order. However, Neumann does not specify what these subject matter core ideas are. On the contrary, the teaching for sustainability core idea facet posits what the core ideas of the interdisciplinary field of EfS are but does not discuss how well they are taught, just that they are present. Furthermore, the teaching for sustainability core idea facet builds off Neumann’s first claim as that claim frames how EfS can be understood as an interdisciplinary field within a set of core ideas. As such, I use the teaching for sustainability core idea facet to stipulate what these core ideas, in fact, are.

**Teaching for sustainability: Teaching practices.** The teaching practices facet of teaching for sustainability arises from several texts that can together illumine specific teaching practices found to be beneficial for teaching sustainability-related core ideas. EfS pedagogy goes beyond the transfer of knowledge about sustainability (Palmer, 2002; Pizmony-Levy, 2011; Stapp et al., 1998). To facilitate EfS, instructors are encouraged to apply pedagogies on fostering cooperative learning and decision-making and to introduce core ideas that is locally relevant (Dawe et al., 2005; Jensen, 2014). EfS is rooted in problem solving and thus aims to foster students’ abilities to face challenges related to

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11Neumann’s (2014) first claim in her cognitively responsive teaching framework is that good teaching in higher education requires that the instructor guides students in encountering and interacting with a core subject matter idea.
sustainability. The literature has a diverse array of possible practices, and thus this facet focuses on a few that are repeatedly mentioned. The teaching practices I posit as useful for the teaching for sustainability are: connecting to the here and now; empowering the learner; contemplative practices; and active learning pedagogies.

One teaching practice, as mentioned above, is connecting to the here and now. Essentially, this means connecting sustainability-specific core ideas with the here, which is the local community, and the now, which is the present time. Dawe et al. (2005) state, “This is a local issue, which shouldn’t be delegated or deemed unimportant in the face of global challenges. Change will never come about if we continue to dream and fret about global changes, world summits and international agreements” (p. 59). For instance, an example of connecting sustainability-specific core ideas to students’ lives, by way of their present place and time, is as follows: In October 2012, many City University of New York (CUNY) Baruch students endured personal challenges and losses from Hurricane Sandy (“Baruch Students Weather Hurricane Sandy,” n.d.; “Baruch College Helps Community Through Hurricane Sandy,” n.d.; “NYCdata: Hurricane Sandy—2012,” n.d.). The following year, in 2013, while many students were still rebuilding their lives from the effects of the storm, the assigned reading for the First-Year Seminar was Karen Thompson Walker’s (2013) The Age of Miracles (“Baruch Beginnings,” n.d.; Francoeur, n.d.). In this fictional novel, the protagonist, Julia, shares her experiences, as the completion of one rotation of the earth takes longer than usual. In the seminar, class conversations discussed parallels between Julia’s world as the earth slowed down and the students’ local communities living in a time of increased weather catastrophes (“Baruch Beginnings,” n.d.; Francoeur, n.d.). Connecting the literary novel with students’ experiences in this particular event (Hurricane Sandy) allowed both a deeper insight into the novel itself and its sustainability implications for their lives as citizens in a world undergoing a climate crisis. Examples of the ways I explore this teaching practice are
teaching sustainability in the context of the area where students live, of their school, and in terms of current events.

Another teaching practice is *empowering the learner*. Dawe et al. (2005) suggest that “if we are serious about the empowerment aspect of sustainability (i.e., that people everywhere should be (re-)enabled to take control over all aspects of their lives), that surely needs to be reflected in the pedagogical approaches and apply to students as well” (p. 59). As such, an important pedagogical practice deems students as owners of their knowledge. To achieve this, instructors need to guide students in participating in the construction and transformation of their own study materials using methods that are meaningful in the socio-political milieus in which they live and work (Dawe et al., 2005). An example of what I explored with regard to this teaching practice is whether the instructor empowered students to be more sustainable (e.g., motivating them to think about their water consumption).

*Contemplative approaches to teaching sustainability* is another useful teaching practice for EfS. Contemplative approach is a pedagogical practice that integrates introspection and experiential learning into academic study with the purpose of supporting academic and social engagement, fostering self-understanding, developing analytical capacities, and cultivating skills for engaging constructively with other human beings (Barbezat & Bush, 2013; Goralnik, Millenbah, Nelson, & Thorp, 2012; Goralnik & Nelson, 2011; Holland, 2006; Shapiro, Brown, & Astin, 2008; Zajonc, 2013). Contemplative practices direct students with support for developing purpose and meaning, in other words, for helping students learn who they are, search for greater purpose for their lives, and graduate college as improved citizens of the world (Barbezat & Bush, 2013; Shapiro et al., 2008; Zajonc, 2013). Some practices of contemplative approaches to teaching include learner-centered pedagogy, mindfulness activities, traditional arts, ritual practices, and activist practice.
The final teaching practice I explore in this facet of the framework is active learning practices, which are pedagogical practices that engage students in their learning, such as class discussions, case studies, and debates (Astin, 1993; Braxton, 1993; Carini et al., 2006; McKeachie & Kulik, 1975; Pascarella & Terenzini, 2005; Rothkopf, 1973). A case study is a scenario that applies concepts learned in the classroom to a “real-life” situation. Case studies help students meaningfully understand core ideas by applying them to a particular case, so that they are better prepared for similar situations in their future (Hmelo-Silver & Barrows, 2015). In the context of EfS, case studies are useful because they allow students to examine issues affecting their local area, work with community groups, and work together in finding solutions to local problems (Cotton & Winter, 2010). Group discussion is when either the whole class or a small group of students in the class talk about course material. Group discussion requires several rounds of conversation among participants. In EfS, group discussions are facilitated to empower students to discuss their own views and hear the views of other students, instead of the instructor taking an authoritarian approach to lecturing on sustainability core ideas. As such, group discussions allow a range of perspectives on sustainability-related issues to be exposed and contended with in the classroom (Cotton & Winter, 2010; Hmelo-Silver & Barrows, 2015; Saye & Brush, 2004). Debates occur when the instructor divides the class into two groups of students and tasks them with arguing opposing sides of an issue. Debate in the classroom setting allows for collaborative discourse and enhances students’ conceptual understandings of a particular topic. This teaching practice is beneficial for teaching about sustainability, as it encourages students to collect information about the topic and then develop an argument (Cotton & Winter, 2010).

Contributions to present study. The teaching for sustainability facet of the framework contributes to the present study by stipulating the core ideas of the EfS field, in conjunction with a set of teaching practices that will increase students’ sustainability learning. However, it must be pointed out that the teaching for sustainability facet of the
framework is limited, since it has not been tested in the prior research. Additionally, teaching for sustainability does not address the interplay between the core ideas and the teaching practices. Rather, it just lays out these two separate parts. Due to the limitations of the current EfS literature base, we do not yet know what this intersection might look like. As a first step, teaching for sustainability lays out the two parts of the “PCK” for sustainability; future research could expand upon this by exploring the intersection of the core ideas and the teaching practices.

**Transformative Sustainability Learning Outcomes**

The final aspect of the *Framework for Teaching and Learning for Sustainability in Higher Education* was a learning outcomes. EfS learning outcomes are a fervent topic in the higher education landscape, much like the ill-defined term *sustainability*. Distinguishing the desired learning outcomes for EfS has long been attempted, dating back to the first intergovernmental conference on environmental education in Tbilisi, Georgia in 1977 (Hungerford, 2009; Palmer, 2002; Svanström et al., 2008; “Tbilisi Declaration,” 1977). Today, higher education learning outcomes for EfS are still a point of contention. The main consensus from the literature, though, is that EfS should increase students’ sustainability knowledge, attitudes, and behaviors (Chalkley, 2006; Sipos et al., 2008; Svanström et al., 2008). The argument for including more than knowledge in the set of prescribed learning outcomes is that one of the main goals of EfS is for students to practice what they have learned throughout their lives. Therefore, learning that enables students to engage in actions is as important as the formal knowledge they acquire in the classroom (Arbuthnott, 2012; Shephard, 2008; Svanström et al., 2008). Ergo, students should be able to demonstrate what they have learned through their actions, including their knowledge of key concepts, skills acquired, and disposition toward sustainability-related issues (Clair, 2003; Disinger & Roth, 1992), as outlined by the learning outcomes for EfS created by Sipos et al. (2008).
My review of the literature finds that the scholarship on learning outcomes for EfS is largely aligned with Sipos et al.’s (2008) transformative sustainability learning outcomes (Chalkley, 2006; Iverson, 2016; Shephard, 2008). Transformative sustainability learning outcomes emerged from the education guidelines stipulated in the UN Decade for Education for Sustainable Development from 2005 to 2014. At that time, Sipos et al. (2008) analyzed pedagogies specified in the declaration and identified key learning outcomes students should take with them from EfS. Burgeoning from this work, they developed a guiding set of transformative sustainability learning outcomes, a series of learning outcomes corresponding to the cognitive (head), psychomotor (hands), and affective (heart) domains of learning that facilitate learners’ changes in knowledge, skills, and attitudes related to enhancing the ecological, social, and economic dimensions of sustainability. Transformative sustainability learning outcomes are a helpful way to organize learning outcomes for EfS because it includes more than knowledge; it also explores the values and actions students learn about with regard to sustainability.

In the transformative sustainability learning outcomes, the head represents the cognitive domain, symbolic of sustainability knowledge learning outcomes (Sipos et al., 2008). Acquisition of sustainability knowledge is critical, since prior research has found that American higher education students lack basic environmental and sustainability knowledge (Jeffries et al., 2001; Kagawa, 2007; Lombardi & Sinatra, 2012). Sustainability knowledge is important, as failure to understand the environment and its broader relationship with sustainability is correlated with poor attitudes, negative values, and lack of participation in sustainable behaviors (Leiserowitz et al., 2006; Peattie, 2010). Examples of knowledge learning outcomes are understanding the purpose of the ozone layer and the most common cause of pollution (Zwickle et al., 2014).

In this series of learning outcomes, the heart represents the affective domain, which is symbolic of attitudes learning outcomes. Attitudes and values are important because they can be translated into behaviors (such as developing a learning community with both
individual and group responsibilities) (Sipos et al., 2008). Many studies find that students do, in fact, care about the environment. For example, Fernández-Manzanal, Rodríguez-Barreiro, and Carrasquer (2007) designed and validated an environmental attitudes scale with a sample of 952 university students. They found that students do indeed worry about environmental problems. They also found some differences in environmental attitudes between first-year and final-year students and male and female students. Although this study is helpful in understanding students’ attitudes toward the environment, it is limited in that attitudes are not addressed or contextualized in broader sustainability issues.

Examples of attitude learning outcomes are increased agreement with statements like “equal rights for all people strengthen a community” and “access to clean water is a universal human right” (Zwickle & Jones, 2018).

The hands represent the motor domain, symbolizing skills-based, or behavioral, learning outcomes (Sipos et al., 2008). Absent from higher education is a perspective present in other environmental fields that dichotomizes private and public behaviors (Hadler & Haller, 2011, 2013; Hunter et al., 2004; Stern, 2000; Yates et al., 2015). Household-oriented behaviors are often referred to as “private” behaviors (Poortinga, Steg, & Vlek, 2004). Private behaviors include daily decisions and actions such as recycling, reusing, and reducing. Prior research has revealed that, since the 1990s, there has been a large increase in private pro-sustainability behaviors, particularly those categorized as “sustainable consumption,” wherein individuals purchase “green” products, engage in recycling, and conserve energy (Peattie, 2010). To date, the majority of research conducted on personal sustainability behaviors has focused on environmental behaviors at the individual level (Zwickle & Jones, 2018).

Additionally, society-oriented behaviors are often referred to as “public” behaviors. Public behaviors include collective activism in the form of protest/demonstration. While private behaviors are less political and reflect a form of consumer behaviors, public behaviors are more political and reflect a form of active citizenship (Hunter, Hatch,&
Public behaviors are distinguished as visible forms of support for the environment, in ways such as joining an environmental group or participating in a protest. Public behaviors have been understood by the literature to be the ultimate evidence of one’s commitment to the environment (Yates et al., 2015). Consequently, I aimed to explore both private (borrowing items from peers instead of buying them) and public (engaging in a protest) pro-sustainability behaviors.

**Interplay of transformative sustainability learning outcomes.** To date, most EfS studies integrate all three transformative sustainability learning outcomes into measuring the learning process. For instance, Kagawa’s (2007) study (mentioned earlier) stems from an online questionnaire survey of University of Plymouth (UK) students’ perceptions of and attitudes toward sustainability. Kagawa found that, although the majority of student participants thought positively about sustainability, their responses did not correlate with their degree of familiarity with sustainability-related concepts. Additionally, students strongly associated sustainability concepts as pitted against economic and social habits. In terms of personal change for a sustainable lifestyle, “light green” actions addressing responsibility, such as changing shopping habits, saving energy and water, and recycling were most frequently expressed. Lastly, participants had dismayingly mixed feelings about the future of society with regard to sustainability-oriented challenges.

In another example, Nisiforou and Charalambides (2012) explored the knowledge, attitudes, and behavior toward biodiversity of 44 first- and second-year university students in the Department of Environmental Science and Technology at the Cyprus University of Technology. They found significant differences in the level of knowledge about biodiversity between those students. However, no significant differences were found regarding attitudes and behavior toward biodiversity. The results also showed that, despite all students having a positive attitude toward biodiversity, most of the time these same students seemed to be unwilling to engage in environmentally friendly behavior.
Evidently, the three prongs of head, heart, and hand, or knowledge, attitudes, and behaviors, work together as knowledge increases attitudes, and increased knowledge and attitudes increase behaviors (Arbuthnott, 2012; Joireman et al., 2004; Stern, 2000; Zwickle et al., 2014). Taken together, in the Framework for Teaching and Learning for Sustainability in Higher Education, I posit that opportunity to learn can directly influence promising practices of teaching and learning about sustainability (including both arms: cognitively responsive teaching and teaching for sustainability) and transformative sustainability learning outcomes. I also posit that opportunity to learn can indirectly influence transformative learning outcomes by directly influencing promising practices of teaching and learning about sustainability, which then directly influence transformative sustainability learning outcomes.

**Conclusion**

This chapter presented literature on EfS in higher education, by discussing the civic mission of American higher education, the policies shaping the EfS landscape, the definition of EfS in the contemporary higher education arena, and the presence of EfS across the curriculum. This chapter also presented Framework for Teaching and Learning for Sustainability in Higher Education, which was used to guide the present dissertation study. Taken together, this chapter set the foundation for this study, which explored the amount and effectiveness of teaching and learning about sustainability.
Chapter III

METHODS

In this chapter, I outline the methodological design of the present study.

Purpose of Study

The purpose of the present dissertation study was to examine the amount and effectiveness of Education for Sustainability (EfS) at an institution of higher education, and to analyze whether EfS was related to students’ sustainability knowledge, attitude, and behavior learning outcomes. Using the operative facets of the framework of opportunity to learn, promising practices of teaching and learning (cognitively responsive teaching, and teaching for sustainability), and transformative sustainability learning outcomes, this study mapped out where EfS was taking place throughout the curriculum, and what teaching practices were being used to teach this particular subject matter. Additionally, this study explored the relationship between students who experienced promising practices of teaching and learning about sustainability with learning outcomes. Overall, this study aimed to offer an assessment of the extent to which higher education institutions (HEIs) are carrying out their critical role of providing students with academic experiences to learn about sustainability.
Research Questions

The following research questions guided this study:

1. To what extent, if at all, do higher education students have the opportunity to learn about sustainability throughout their coursework?
   a. To what extent does this differ across student demographics and academic characteristics (e.g., gender, race/ethnicity, domestic/international status, major, class year)?

2. For students who have the opportunity to learn about sustainability, to what extent do they experience promising practices of teaching and learning about sustainability?
   a. To what extent does this differ across disciplines and course contexts (e.g., class type, class level, class size)?

3. Does the opportunity to learn influence cognitively responsive teaching and teaching for sustainability? And, does the opportunity to learn, cognitively responsive teaching, and teaching for sustainability, influence sustainability learning outcomes?

4. Does a model of Teaching and Learning for Sustainability in Higher Education hold in one public, large-sized, four-year institution?
   a. If not, what modifications can be made?

Conceptual Framework

Given the limited research on teaching and learning about sustainability in higher education (SHE), as elucidated in Chapter II, the field lacks a framework for examining EfS teaching practices along with the extent to which these practices influence students’ sustainability-related learning outcomes. Resulting from a review of K-12 education policy, higher education teaching and learning, and SHE and EfS literature bases, I
created a framework entitled the *Framework for Teaching and Learning for Sustainability in Higher Education*, which was employed to guide this study. This framework, couched in teaching and learning theories, was composed of four facets: *opportunity to learn, cognitively responsive teaching, teaching for sustainability,* and *transformative sustainability learning outcomes.* I used the first facet of the framework, *opportunity to learn,* to measure the presence of EfS across students’ higher education coursework. I used the next two facets of the framework, *cognitively responsive teaching* and *teaching for sustainability,* which I label as *promising practices of teaching and learning,* to explore different kinds of teaching practices that surround EfS subject matter. Lastly, I employed the *transformative sustainability learning outcomes* facet to measure students’ EfS-specific learning outcomes. The interplay of these four distinct facets of the overall framework allowed for the studying of where EfS was occurring throughout the curriculum, what pedagogical practices were used to teach EfS, and the extent to which these teaching practices influenced sustainability-specific learning gains.

Although not part of the framework in its most traditional form, I also framed students’ pre-disposition to their sustainability literacy by way of demographics and academic characteristics in ways shown by the literature to influence students’ learning about sustainability. These demographics included gender and race/ethnicity (Forgas & Jolliffe, 1994; Lang, 2011; Michel & Pizmony-Levy, 2017; Müderrisoglu & Altanlar, 2011). Academic characteristics included major field of study (Lang, 2011; Michel & Pizmony-Levy, 2017; Nisiforou & Charalambides, 2012; Walton et al., 2009).

Lastly, I also explored course discipline and course characteristics (course type, course format, course level, number of credits, and class size) because prior research has found these characteristics to influence teaching (Michel, Chadi, Jimenez, & Campbell, 2018a; Umbach, 2007). In terms of discipline, I distinguished discipline through Biglan’s (1973) classification of academic domains. As per Biglan, disciplines can be broadly defined as hard versus soft (disciplines with single, mature paradigms versus those with a
multiplicity of paradigms); pure versus applied (knowledge for discovery versus applied knowledge); and life versus non-life (concerning life systems or not). Biglan’s theory distinguishes disciplinary categories through heuristics that are associated with individual or environmental understandings, worldviews, traits, or subject matter substance.

**Use of Conceptual Framework**

The *Framework for Teaching and Learning for Sustainability in Higher Education* was employed in the present study, namely, opportunity to learn, cognitively responsive teaching, teaching for sustainability, and transformative sustainability learning outcomes, as well as the student demographic and characteristic items, and course discipline and characteristic items. Table 3 depicts which facets of the framework correspond with each of the four research questions.

<table>
<thead>
<tr>
<th>Table 3. Corresponding Facets of Conceptual Framework to Research Questions</th>
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<tbody>
<tr>
<td><strong>RQ1</strong></td>
</tr>
<tr>
<td>Student Demographics</td>
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<tr>
<td>Academic Characteristics</td>
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<tr>
<td>Course Characteristics</td>
</tr>
<tr>
<td>Opportunity to Learn</td>
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<tr>
<td>Cognitively Responsive Teaching</td>
</tr>
<tr>
<td>Teaching for Sustainability</td>
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<tr>
<td>Transformative Sustainability Learning Outcomes</td>
</tr>
</tbody>
</table>

The first research question explored the extent to which, if at all, students had the opportunity to learn (OTL) about sustainability throughout their coursework. This research question was answered by using OTL as it explored if students had exposure to sustainability-related subject matter throughout their coursework and, if so, how much time was devoted to this subject matter of interest, and where they learned about it (as per
course discipline and characteristics). The second part of this question charted what kinds of students, as per their demographics and academic characteristics, had the opportunity to learn about sustainability throughout their coursework.

The second research question explored the extent to which students whom had the opportunity to learn about sustainability experienced promising practices of teaching and learning about sustainability (PPOT&LAS). Building upon the first research question, this research question used the OTL frame, as well as the two frames that pointed to PPOT&LAS, cognitively responsive teaching (CRT) and teaching for sustainability (TfS), because it explored students’ exposure to PPOT&LAS when learning about sustainability. In particular, this question charted what kinds of students, as per their demographics and academic characteristics, had exposure to PPOT&LAS. Furthermore, the second part of this question explored if exposure to PPOT&LAS differed across disciplines and course contexts.

The third and fourth research questions explored the interplay of all facets in the Framework for Teaching and Learning for Sustainability in Higher Education in its entirety. In order to know how OTL and PPOT&LAS influenced transformative sustainability learning outcomes, I suggested consideration of a broader model that included student demographics and academic characteristics. As seen in Table 3, all facets of the framework, including opportunity to learn, cognitively responsive teaching, teaching for sustainability, and transformative sustainability learning outcomes, as well as the student demographic and characteristic items, and course discipline and characteristics, were used in exploring the third and fourth research questions.

Site

The site of the present study was Michigan State University (MSU), a large, public, four-year, research-intensive university (“Carnegie Classifications” n.d.). In fall 2016, the
student population was 50,344, of which 39,090 were undergraduates. Demographics of the student population can be found in Table 4. MSU was founded in 1855 as “the nation’s 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 Mission Statement,” n.d.). MSU’s rich history as a mechanism for cultivating informed, active, and engaged citizens proved it an appropriate site for the present study. MSU was additionally a viable site for inclusion in the present

Table 4. Demographics of Student Population at Michigan State University in Fall 2016 (N=39,090)

<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
<th>Student Population</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>19,312</td>
</tr>
<tr>
<td>Female</td>
<td>19,778</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>1,629</td>
</tr>
<tr>
<td>Black or African American</td>
<td>2,724</td>
</tr>
<tr>
<td>White</td>
<td>26,169</td>
</tr>
<tr>
<td>Asian</td>
<td>1,946</td>
</tr>
<tr>
<td>Two or more races, non-Hispanic</td>
<td>1,155</td>
</tr>
<tr>
<td>Race and/or ethnicity unknown</td>
<td>330</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Average age of students:</td>
<td>Average age: 20</td>
</tr>
<tr>
<td>Percent of students less than age 25</td>
<td></td>
</tr>
</tbody>
</table>

Note: Population data are from MSU’s official fall reporting date as of October 15, 2016 (Common Data Set 2016-2017, 2017); Inconsistencies in numbers are due to missing data.
study based on its focus on sustainability. Given MSU’s status as one of the nation’s top sustainable campuses, through teaching, research, outreach, and campus innovation, it was a most appropriate site for the present study, because it allowed me to examine a case where EfS would be present.¹

Exploration of an exemplar (MSU) was useful in the present study because it allowed me to examine the topic of interest (EfS) in a case where it was highly developed (Bronk, 2012). Amidst the current American higher education landscape, EfS is largely still emerging. Therefore while results may be applicable to other HEIs engaged in the sustainability forefront, care should be given when generalizing to other HEIs. In addition, fundamental to the concept of sustainability is the local community; therefore, it is also important to contextualize the site of the present study in the current landscape.

During the time of this study (2017), contaminated water in the neighboring community of Flint, Michigan was declared “safe” to drink (Butler et al., 2016; Hanna-Attisha et al., 2016; Michigan Civil Rights Commission, 2017). And while Hurricane Harvey pounded Southern Texas that same year, Michigan was facing other climate change problems. Bounded by four of the five Great Lakes, as its shorelines recede and temperatures rise, some of the state’s main businesses, like farming, are becoming untenable. Therefore, the unique context of Michigan’s changing climate, along with its economic and social

¹Michigan State University earned a silver Sustainability Tracking, Assessment and Rating System (STARS) rating (“About Sustainability,” n.d.; “Rated Institutions, AASHE STARS,” n.d.). MSU President Lou Anna Simon signed the We Are Still In letter declaring that the institution will continue to support climate action to meet the Paris Agreement (“We Are Still In,” n.d.). Furthermore, students are exposed to sustainability learning, as “on campus and around the globe, MSU students learn, explore, investigate, and increase their understanding of a range of environmental, social, and economic needs and issues—from clean water and food security to public policy, gender equality, and social justice” (“Learn Sustainability Michigan State University,” n.d.). MSU has 15 environment-focused majors, specializations in environmental studies and sustainability, and a residential learning community that focuses on the study of the environment, as well as sustainability-related research opportunities, related Study Abroad programs, student organizations, and university events and initiatives (“Learn Sustainability Michigan State University,” n.d.). As seen here, MSU is at the forefront in integrating sustainability throughout the institution.
implications for the immediate region, should be considered when generalizing this study to other HEIs in different geographic regions, facing diverse effects of their own from climate change. Appendix B includes MSU’s IRB permission for this study. Appendix C includes Teachers College’s IRB permission for this study.

Sample

I used data from Zwickle’s (2017) Sustainability Survey for the pre-survey. Dr. Adam Zwickle, assistant professor in the Department of Community Sustainability and Environmental Science, and the Policy Program in the School of Criminal Justice at MSU, randomly selected 65% of the 2017 undergraduate population (24,999 students) at MSU. Random selection represents an arbitrarily selected group of people from a population, in which all human influence is removed from the selections process. One main benefit of random selection is that the researcher can generalize from a sample to a population (Creswell, 2003; Groves et al., 2011; Johnson & Christensen, 2008). As seen in Table 5, 3,164 (12.7%) students completed the survey. Of the 3,164 students who completed the pre-survey, 1,366 (43.2%) consented to being contacted for the post-survey. Of these 1,366, 748\(^2\) completed the post-survey; the response rate for the post-survey was 54.8%.

\[^{2}\text{Seven hundred forty-nine students responded to the survey, but I excluded one student as they were a minor and did not present parental consent.}\]
Table 5. Sample

<table>
<thead>
<tr>
<th></th>
<th>Students Invited to Pre-Survey</th>
<th>Pre-Survey Participants</th>
<th>Pre-Survey Participants Consented to Being Contacted for the Post-Survey</th>
<th>Post-Survey Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>24,999</td>
<td>3,164</td>
<td>1,366</td>
<td>748</td>
</tr>
<tr>
<td>%</td>
<td>65% of MSU undergraduate population</td>
<td>12.7%</td>
<td>43.2%</td>
<td>54.8%</td>
</tr>
</tbody>
</table>

Table 6 presents the student sample by providing descriptive statistics and coding of student demographic and academic characteristic variables. Over half the sample identified as female, most participants were born in the United States, and most identified as White. Most students’ parents completed some degree of higher education. Most students enrolled at MSU as first-time students, and most attended MSU as full-time students during the fall 2017 semester. In terms of the international student sample, of the 81 students not born in the United States, 39 were born in China, while the others were dispersed worldwide.

Table 6. Descriptive Statistics and Coding of Student Demographic and Academic Characteristic Variables (N=748)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coding/ Frequency</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male: 225 (31.9%) Female: 481 (68.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>20.28</td>
<td>3.653</td>
</tr>
<tr>
<td>Domestic/International Status</td>
<td>Domestic (United States): 633 (88.7%) International: 81 (11.3%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6 (continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coding/ Frequency</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>White: 553 (78.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asian: 62 (8.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black or African American: 25 (3.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hispanic or Latino: 24 (3.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two or more races: 30 (4.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other: 12 (1.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest level of parental education</td>
<td>Less than high school/High school/GED: 55 (7.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vocational/technical degree or some college: 98 (13.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bachelor’s degree: 240 (34.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Master’s degree 232 (32.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Doctoral degree or equivalent: 86 (12.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class Year</td>
<td>First-Year: 257 (34.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sophomore: 159 (21.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Junior: 176 (23.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior: 155 (20.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission Status</td>
<td>Transfer student: 142 (19.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>First-time student: 604 (81.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enrollment Status</td>
<td>Part-time: 29 (3.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full-time: 718 (96.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade Point Average</td>
<td></td>
<td>3.6</td>
<td>.409</td>
</tr>
<tr>
<td>Major: Hard versus Soft</td>
<td>Hard: 366 (56.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soft: 288 (44.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major: Pure versus Applied</td>
<td>Pure: 226 (34.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applied: 428 (65.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major: Life versus Nonlife</td>
<td>Life: 365 (55.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonlife: 289 (44.2%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7 presents representativeness of the student sample compared with the overall MSU student population. According to chi-squared goodness of fit tests, women, “traditional” aged students, and Asian, White, mixed race, and “other” students were overrepresented in the student sample when compared with the overall student population (p ≤.05). With regard to student 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
Table 7. Representativeness of Student Sample (N=748) Compared with MSU Student Population (N=39,090)

<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
<th>Student Sample</th>
<th>Student Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>225</td>
<td>31.9%</td>
</tr>
<tr>
<td>Female</td>
<td>481</td>
<td>68.1%</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>24</td>
<td>3.4%</td>
</tr>
<tr>
<td>Black or African American</td>
<td>25</td>
<td>3.5%</td>
</tr>
<tr>
<td>White</td>
<td>553</td>
<td>78.3%</td>
</tr>
<tr>
<td>Asian</td>
<td>62</td>
<td>8.8%</td>
</tr>
<tr>
<td>Two or more races, non-Hispanic</td>
<td>30</td>
<td>4.2%</td>
</tr>
<tr>
<td>Race and/or ethnicity unknown</td>
<td>12</td>
<td>1.7%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average age of students:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of students less than age 25</td>
<td>95.3%</td>
<td>84.4%</td>
</tr>
<tr>
<td>Percent of students equal to or greater than age 25</td>
<td>4.7%</td>
<td>15.6%</td>
</tr>
</tbody>
</table>

Note: Population data are from MSU’s official fall reporting date as of October 15, 2016 (Common Data Set 2016-2017, 2017); Inconsistencies in numbers are due to missing data.

population was 20, the distribution statistically differed due to overrepresentation by “traditional” aged college students, i.e., those less than 25 years old (p ≤.001).

In addition to their demographics, there may be other differences between the student sample and the student population, such as their baseline level of sustainability literacy. Furthermore, differences may also exist between the baseline level of sustainability literacy amongst the students who responded to the pre-survey only, and those who responded to both the pre- and post-surveys in their entirety. Table 8 presents a
comparison of the pre-survey sustainability-related learning outcomes (knowledge, attitudes, and behaviors) for pre-survey answers for those who responded to the pre-survey only and those who responded to both surveys. Students who responded to both surveys had higher sustainability-related knowledge, attitudes, and behaviors than only pre-survey respondents. As such, from the beginning of the study (the first point in time of the pre-survey), those who chose to respond to both studies already demonstrated their higher sustainability literacy than those who completed only the pre-survey. The investment in sustainability shown in the sample of the present study (of those who chose to fill out both the pre-survey and post-survey) should be considered when reading this dissertation.

Table 8. Comparison of Pre-Survey Learning Outcomes for Post-Survey Respondents and Non-Respondents

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Coding</th>
<th>Sample</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of correct survey responses (ranging from none (0) correct to all 12 correct)</td>
<td></td>
<td></td>
<td>7.50</td>
<td>2.264</td>
</tr>
<tr>
<td>Pre-survey respondents who did not fill out the post-survey (N=801)</td>
<td></td>
<td></td>
<td>7.50</td>
<td>2.264</td>
</tr>
<tr>
<td>Pre-survey respondents who did fill out the post-survey (N=532)</td>
<td></td>
<td></td>
<td>9.10</td>
<td>1.932</td>
</tr>
</tbody>
</table>

\(^3\)In terms of knowledge, I reduced each sample to only the participants who responded to all twelve knowledge items in order to accurately sum correct responses to the knowledge questionnaire.
Table 8 (continued)

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Coding</th>
<th>Sample</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitudes</strong></td>
<td>1=Strongly disagree</td>
<td>Pre-survey respondents who did not fill out the post-survey (N=1,672)</td>
<td>5.01</td>
<td>.700</td>
</tr>
<tr>
<td></td>
<td>2=Disagree</td>
<td>Pre-survey respondents who did fill out the post-survey (N=678)</td>
<td>5.26</td>
<td>.594</td>
</tr>
<tr>
<td></td>
<td>3=Somewhat disagree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4=Somewhat agree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5=Agree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6=Strongly agree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Behaviors</strong></td>
<td>1=Never</td>
<td>Pre-survey respondents who did not fill out the post-survey (N=1,534)</td>
<td>2.86</td>
<td>.586</td>
</tr>
<tr>
<td></td>
<td>2=Rarely</td>
<td>Pre-survey respondents who did fill out the post-survey (N=731)</td>
<td>3.13</td>
<td>.736</td>
</tr>
<tr>
<td></td>
<td>3=Sometimes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4=Often</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5=Always</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Procedures**

The present study used quantitative methodology of longitudinal research, which allows for surveying the same sample of participants at two or more points in time. This type of research was advantageous for the present study because it allowed for estimating how student participants changed between the time points of the beginning and end of the semester (Bray, Pascarella, & Pierson, 2004; Padgett, Salisbury, An, & Pascarella, 2010; Pascarella et al., 2007; Seifert, Pascarella, Erkel, & Goodman, 2010). Many prominent higher education studies have used longitudinal research design. For instance, Astin’s
(1984) landmark theory of student involvement was derived from a longitudinal study. The core concepts of this theory are that students’ inputs (including their demographics, backgrounds, and previous experiences) and their environment (including all of the experiences they have during college) led to outcomes (including students’ characteristics, knowledge, attitudes, beliefs, and values that remained after they had graduated). Astin argued that the longitudinal design provides more reliable data than cross-sectional data, predominantly in cases in which the inputs include pretest measures of outcomes. In another instance, in his work that explored how college affects students, Pascarella (2006) claimed that longitudinal pre- and post-survey data provide a better estimate of the impact college has on students, as opposed to statistical manipulation from cross-sectional data. As seen in the prominent higher education works of Pascarella (2006) and Astin (1984), longitudinal research provides scholars with the ability to estimate the influence of college experiences on educational outcomes.

The particular procedure for carrying out longitudinal research in the present study was through pre- and post-surveys. Surveys were a useful way to gather data on the amount and effectiveness of students’ exposure to EfS because they permitted the measurement of latent constructs, such as knowledge, attitudes, and behaviors related to sustainability. Furthermore, by asking students about these characteristics before and after the semester, I was able to measure change over that specific time (Fowler, 2013; Fowler & Cosenza, 2009; Groves et al., 2011).

**Data Recruitment and Administration**

In order to measure change over time, data collection occurred over one semester, from September 2017 to December 2017. Data recruitment for the pre- and post-surveys took place via email because students readily access their email accounts (Fowler, 2013; Sue & Ritter, 2011). For both the pre- and post-surveys, potential participants were emailed one survey invitation, as well as three reminder emails (sample emails can be
found in Appendix D). Aligned with the ethics of survey research, potential participants were informed about what they were volunteering for before being asked to answer questions (Fowler, 2013; Groves et al., 2011). Informed consent forms can be seen in Appendix E.

In early September, at the very beginning of the semester, 65% of the undergraduate population at MSU was randomly selected to participate in the first part of the study (pre-survey) via email. To participate, students filled out a survey using Qualtrics software about their sustainability knowledge, attitudes, and behaviors. Following up, in late December, after the semester had ended, the same sample of students (who agreed to be contacted again) were invited to participate in the second part of the study (post-survey). To participate, they filled out a survey about their perceptions of the teaching and learning about sustainability they experienced during the fall 2017 semester, as well as a replicated set of questions about their sustainability knowledge, attitudes, and behaviors.4

**Pre- and Post-Survey Instruments**

The present study used data from two surveys: a pre-survey and a post-survey.

**Pre-survey.** I used data from Zwickle’s (2017) Sustainability Survey for the pre-survey. The 2017 Sustainability Survey collected data on students’ demographics, academic characteristics, sustainability knowledge, attitudes, and behaviors across the environmental, economic, and social dimensions of sustainability. Sustainability knowledge items had four response options, with one response option being correct and three being incorrect. Sustainability attitude items had response options on a six-point Likert scale ranging from **strongly disagree** to **strongly agree**. Sustainability behavior

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4Due to generous funding from the Teachers College Environmental and Sustainability Working Group, upon completing the survey, students were entered into a raffle to win one of ten $25 gift cards to Amazon.com.
items had response options on a five-point Likert scale ranging from never to always. Furthermore, Dr. Zwickle added an item on the survey that asked participants if they would be willing to be contacted again at the end of the semester for the post-survey. It is worth noting here that the full Sustainability Survey also asked students other questions related to sustainability that I did not use in the present study. After all pre-survey data were collected; Dr. Zwickle shared the data with me, as per a data sharing agreement (Appendix F). When I received the data, it was considered pre-existing data.

**Post-survey.** I created the post-survey which I used in this dissertation. The post-survey asked the exact set of sustainability knowledge, attitudes, and behaviors questions that were asked in the pre-survey. The post-survey also asked if they had the opportunity to learn about sustainability (with response options as either yes or no). If students did have the opportunity to learn, a skip matrix led them to respond to a series of questions about where they had opportunity to learn with response options on five-point Likert scale ranging from never to always. The post-survey also asked questions about whether they had exposure to promising practices of teaching and learning about sustainability during the semester, with response options on five-point Likert scale ranging from never to always, or strongly disagree to strongly agree.

**Survey question originations.** At present, no publicly available, validated survey on students’ sustainability learning experiences exists. Accordingly, survey items were gathered from a variety of sources. Table 9 provides a list of where survey questions were derived and adapted from.

With regard to OTL, I used language from Pizmony-Levy’s (2015) Survey of Students’ Engagement with Social Issues (SSES1) in the post-survey to ask students about whether they had exposure to sustainability-related content during the semester. Aligned with the literature (e.g., Carroll, 1963; Schmidt, Burroughs, Zoido, & Houang, 2015), I also included questions on the types of courses in which they had exposure to sustainability, and how often they were exposed to this particular subject matter.
Table 9. Pre- and Post-Survey Originations

<table>
<thead>
<tr>
<th>Construct</th>
<th>Where Derived From</th>
<th>Pre-survey</th>
<th>Post-survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opportunity to Learn</td>
<td>Survey of Students’ Engagement with Social Issues (Pizmony-Levy, 2015); Review of the literature on opportunity to learn (Carroll, 1963; Schmidt et al., 2015; Tate, 2001; Wang, 1998)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Teaching for Sustainability</td>
<td>Review of the literature on higher education EfS teaching practices (Cotton &amp; Winter, 2010; Dawe et al., 2005; Meagher, 2013; Sipos et al., 2008)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cognitively Responsive Teaching</td>
<td>College Educational Quality Research Project (Campbell, 2015, 2017; Campbell &amp; Dortch, 2018)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Transformative Sustainability Learning</td>
<td>Assessment of Sustainability Knowledge: 2.0 (Zwicker &amp; Jones, 2018; Zwicker et al., 2014)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Transformative Sustainability Learning</td>
<td>Sustainability Attitudes Scale (Zwicker &amp; Jones, 2018)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

In terms of questioning students about their exposure to Neumann’s (2014) cognitively responsive teaching practices, I employed survey questions from Campbell’s (2017) College Educational Quality (CEQ) research project that measure cognitively responsive teaching. Prior research has conducted factor analyses on the cognitively responsive teaching claims to explore if individual survey items have similar patterns of responses that fall within the three latent claims. In one recent CEQ study, Michel, Jimenez, Haley, and Campbell (2018b) conducted exploratory factor analyses on students’ self-reported survey responses on the extent to which they experienced these
teaching practices. In this study, Michel and colleagues surveyed students about a range of disciplinary courses. They found that students’ responses did fit within the three facets of the cognitively responsive teaching claims stipulated by Neumann (2014).

Accordingly, this study provided reason to believe that the cognitively responsive teaching claims could hold within the context of a specific discipline or interdisciplinary field (here, sustainability). However, to date, Neumann’s cognitively responsive teaching has only been used in the assessment of student learning across disciplines—never for a disciplinary-specific study. Building from this, I adapted CEQ’s cognitively responsive teaching survey items to be about sustainability-specific learning. Furthermore, in terms of questioning students about their exposure to Teaching for Sustainability, no relevant survey items currently exist. Therefore, I created survey items that questioned students’ exposure to the sustainability-related core ideas and teaching practices I stipulated in the framework.

In order to measure students’ sustainability knowledge learning outcomes, I used Zwickle et al.’s (2014) Assessment of Sustainability Knowledge (ASK) 2.0, which represents an early attempt to quantify knowledge of the abstract concept of sustainability. The first iteration of the ASK was created with input from sustainability subject experts and resulted in a 16-question measure (Zwicle et al., 2014). The next iteration was expanded to a pool of 28 questions, which was tested, condensed, and retested in multiple waves of surveys administered to students. Extraneous items were removed from the pool based on their content, confirmatory factor analysis, or item response theory (Zwickle et al., 2014). The ASK 2.0 is the result of this work, which is a 12-item scale consisting of questions of varying difficulty on the environmental, economic, and social domains (Zwickle & Jones, 2018). Because the ASK is the first sustainability assessment of higher education students’ knowledge, Zwickle et al. (2014) solicited input from experts across many disciplines, such as ecology, sociology, economics, business, forestry, political science, education, psychology, and
anthropology. They created questions to cover fundamental concepts central to each of
the sustainability domains (environmental, economic, and social). They compared their
questions to textbooks in the relevant fields to ensure that the language and focus of the
questions were similar to what is being taught to undergraduate students. To date, the
ASK has been used (or has been planned to be used) to assess students’ sustainability
knowledge at several institutions, such as Ohio State University (Bruskotter, Hitzhusen,
Wilson, & Zwicker, 2013; Zwicker et al., 2014), Colorado State University, the
University of Mississippi, Clark University, Clarkson University, the University of Idaho,
and the University of Maryland (Stewart, 2013).

In order to measure students’ sustainability attitudes, I used Zwicker and Jones’s
(2018) Sustainability Attitudes Scale (SAS). The impetus for the SAS was to create a
mechanism for measuring the triple-bottom approach to sustainability presented by the
Brundtland Commission (1987). Although the SAS has been developing since 2010, it
was tested in 2016 with approximately 1,000 undergraduates at Michigan State
University. SAS 2016 data were analyzed using confirmatory factor analysis (confining
the data to three sustainability factors: environmental, economic, and social) and item
response theory (used to select better discerning items with a range of difficulty). These
analyses found that 11 items could adequately measure the three dimensions of
sustainability with strong internal reliability. Furthermore, to test the SAS’s validity, a
follow-up study of 1,895 undergraduates compared the SAS’s predictive ability with the
traditional measure of sustainability attitudes entitled the New Ecological Paradigm
(Zwicker & Jones, 2018). The New Ecological Paradigm (NEP) is a scale that measures a
general set of beliefs or attitudes toward the environment (Dunlap & Van Liere, 1978).
Participants completed the SAS, NEP, and questions on sustainability behaviors and
beliefs. This study revealed that, while the NEP significantly predicted sustainability
behaviors and beliefs, the SAS predicted them with greater correlation coefficients. It
also has predictive power that aligns with a view of sustainability that is coordinated with
the triple bottom line approach, or the three main dimensions to sustainability—environmental, economic, and social (Zwickle & Jones, 2018; Zwickle et al., 2014).

In terms of questioning students’ sustainability behaviors, I collaborated with Dr. Zwickle to create a set of items that would measure them. In particular, we sought to create a set of questions that undergraduate students can actually do, verifying that they are engaging in these behaviors for sustainability (not for financial or other personal) reasons. Prior research has found that private (like recycling and buying local products) and public behaviors (like activism) manifest differently (Michel & Pizmony-Levy, 2017; Pizmony-Levy, 2015). As such, we chose to incorporate items that tested both students’ private and public sustainability behaviors. Some items came from the International Social Survey Programme 2010 Environment Module, some came from Pizmony-Levy’s (2015) SSESI, and we created some questions, as well.

Survey question pilot. Prior to distributing the post-survey, items that were not included in the pre-survey were reviewed by a panel of experts in related subject areas of higher education teaching and learning, EfS, student learning assessment, and sustainability, for the purpose of both construct and content validity. After review by the panel of experts, the newly revised version of the post-survey was pilot tested with 27 first-year students in a public HEI in New York. After the students filled out the survey (which took an average of 12 minutes), I engaged with the think-aloud technique, in which I guided the participants in sharing thoughts and perceptions of each of the questions, which helped me understand if college students interpreted the questions the way I had intended them to. I also asked them about length, flow, clarity, and language of the survey (Johnson & Christensen, 2008). For example, although I organized the Framework for Teaching and Learning for Sustainability in Higher Education with cognitively responsive teaching before teaching for sustainability, one student pilot participant suggested ordering teaching for sustainability before cognitively responsive teaching in the survey, to prompt participants’ minds about the examples of subject
matter that could be considered sustainability, before asking broader questions about sustainability in the classroom. After analyzing pilot survey data and conferring with the participants, I then made the necessary changes.

**Survey questions.** The pre- and post-survey instruments are provided in Appendix G. A construct item map for students’ EfS teaching and learning experiences in provided in Table 10.

Table 10. Construct Item Map for Students’ EfS Teaching and Learning Experiences

<table>
<thead>
<tr>
<th>Facet of Framework</th>
<th>Construct</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Demographics</td>
<td>Gender</td>
<td>To which gender identity do you most identify?</td>
</tr>
<tr>
<td></td>
<td>Race/Ethnicity</td>
<td>Do you consider yourself Latino or Hispanic?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Which of the following describes your race?</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td></td>
<td>What is the highest level of education your father completed?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What is the highest level of education your mother completed?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When it comes to paying for university tuition and living costs, which of the following are true?</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>In what year were you born?</td>
</tr>
<tr>
<td>Domestic/international status</td>
<td></td>
<td>Were you born in the United States?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In what country were you born?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How long have you been in the United States (in years)?</td>
</tr>
<tr>
<td>Town size of origin</td>
<td></td>
<td>Which of the following describes the area you come from?</td>
</tr>
<tr>
<td>Economic Views</td>
<td></td>
<td>In general, would you describe your views about economic issues as ...</td>
</tr>
<tr>
<td>Social Views</td>
<td></td>
<td>In general, would you describe your views about social issues as ...</td>
</tr>
<tr>
<td>Political Stance</td>
<td></td>
<td>In politics today, do you consider yourself a Republican, Democrat or Independent?</td>
</tr>
<tr>
<td>Religion</td>
<td></td>
<td>What is your present religion, if any?</td>
</tr>
</tbody>
</table>
Table 10 (continued)

<table>
<thead>
<tr>
<th>Facet of Framework</th>
<th>Construct</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Characteristics</td>
<td>Class Year</td>
<td>• What is your current academic status?</td>
</tr>
<tr>
<td></td>
<td>Full-time or Part-time Status</td>
<td>• Are you a full- or part-time student?</td>
</tr>
<tr>
<td></td>
<td>First-time student or transfer student status</td>
<td>• Did you enter into MSU as a first-time or transfer student?</td>
</tr>
<tr>
<td></td>
<td>Grade Point Average</td>
<td>• What is your current GPA, to the best of your recollection?</td>
</tr>
<tr>
<td></td>
<td>Discipline</td>
<td>• What is your college?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• What is your major?</td>
</tr>
<tr>
<td>Living Arrangement</td>
<td></td>
<td>• What is your current living arrangement?</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformative Sustainability Learning Outcomes</td>
<td></td>
<td>• What is the most common cause of pollution of streams and rivers in the U.S.?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ozone forms a protective layer in the earth’s upper atmosphere. What does ozone protect us from?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Which of the following is an example of sustainable forest management?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Which of the following is the most commonly used definition of sustainable development?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Over the past 3 decades, what has happened to the difference between the wealth of the richest and poorest Americans?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Which of the following countries passed the U.S. to become the largest emitter of the greenhouse gas carbon dioxide?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Many economists argue that electricity prices in the U.S. are too low because…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Which of the following is the most commonly used definition of economic sustainability?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Which of the following is a leading cause of depletion of fish stocks in the Atlantic Ocean?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Which of the following is the best example of environmental justice?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Of the following, which would be considered living in the most environmentally sustainable way?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Put the following list in order of the activities with the largest environmental impact to those with the smallest environmental impact:</td>
</tr>
</tbody>
</table>
Table 10 (continued)

<table>
<thead>
<tr>
<th>Facet of Framework</th>
<th>Construct</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitudes</strong></td>
<td>Please indicate how much you agree or disagree with each statement.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Equal rights for all people strengthen a community.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Community cooperation is necessary to solve social problems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Generally speaking consumerism is not sustainable.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Access to clean water is a universal human right.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• I am willing to put forth a little more effort in my daily life to reduce my environmental impact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• An unsustainable economy values personal wealth at the cost of others.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• I believe that many people can work together to solve global problems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Clean air is part of a good life.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Our present consumption of natural resources will result in serious environmental challenges for generations.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The well-being of others affects me.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Biological diversity in itself is good.</td>
<td></td>
</tr>
<tr>
<td><strong>Private Behaviors</strong></td>
<td>• Limit your meat consumption?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use a reusable drinking bottle instead of disposable plastic water bottles?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Switch off your electronics when they are not in use?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Limit water use?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Practice double-sided printing?</td>
<td></td>
</tr>
<tr>
<td><strong>Public Behaviors</strong></td>
<td>• Sign a petition?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Take part in a protest or demonstration?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Participate in a community or environmentally-focused club or organization?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Avoid companies with harmful practices?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Avoid using or buying certain products?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Choose locally-owned businesses over larger chains?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Try to convince a friend not to buy bottled water?</td>
<td></td>
</tr>
<tr>
<td>Facet of Framework</td>
<td>Construct</td>
<td>Item</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------</td>
<td>------</td>
</tr>
</tbody>
</table>
| Curricular: location | During the past semester, how often did your instructor mention sustainability-related topics in… | - Courses that are required for your major  
- General education courses  
- Elective courses  
- Lectures  
- Labs  
- Recitations  
- Practicums  
- Another type of course [text box] |
| Curricular: quantity | During the past semester, in how many of your courses did you | - See a visual of sustainability similar to the image below?  
- Complete an ecological footprint?  
- Learn about sustainability-related current events mentioned?  
- Learn about sustainability in at least once class session?  
- Learn about sustainability in semester-long theme or project?  
- During the Fall 2017 semester, did you learn about environmental or sustainability issues in at least one class? |
| Promising Practices of Teaching and Learning | Course Characteristics | - Think about the course that taught you the most about sustainability during the past semester.  
- What is the full name of the course?  
- Which college was this course in?  
- Which kind of course was this?  
- Which kind of course was this?  
- Across the semester, how much time in this course was devoted to sustainability? |
<table>
<thead>
<tr>
<th>Facet of Framework</th>
<th>Construct</th>
<th>Item</th>
</tr>
</thead>
</table>
| Teaching for Sustainability (Core Ideas) | How often did this course cover the following content? | • Defining sustainability  
• Environmental crises  
• Future generations  
• Resource management  
• Economic sustainability  
• Challenging human-centered views of the environment  
• Valuing all living things  
• Valuing the ecological system  
• Environmental justice  
• Relating oppression of subordinate human groups to oppression of nature  
• Eliminating poverty |
| Teaching for Sustainability (Teaching Practices) | How often was sustainability taught in the following ways? | • In the context of the *area I live in*  
• In the context of *my school*  
• In the context of *current event*  
• In a way that made me feel empowered to be more sustainable  
• Case Study  
• Group Discussion  
• Debate  
• Mindfulness  
• Learning who I am in relation to the larger purpose of life |
| Cognitively Responsive Teaching (Subject Matter) | | • The instructor introduced, in-depth, a concept related to sustainability.  
• The instructor explained the sustainability-related concept in a few different ways.  
• The instructor introduced how sustainability is connected to course content.  
• The instructor taught sustainability in a logical order.  
• The instructor taught me how to think about sustainability. |
Table 10 (continued)

<table>
<thead>
<tr>
<th>Facet of Framework</th>
<th>Construct</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitively Responsive Teaching (Prior Knowledge)</td>
<td>The instructor helped me use what I know from…</td>
<td>• My own personal experiences to help me learn about sustainability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• My high school coursework to help me learn about sustainability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• My other college coursework to help me learn about sustainability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• My social roles and culture (e.g., race, socioeconomic status, gender, sexuality, ethnicity, religion) to help me learn about sustainability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• My family to help me learn about sustainability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• My friends to help me learn about sustainability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The media to help me learn about sustainability.</td>
</tr>
<tr>
<td>Cognitively Responsive Teaching (Supporting Changing Views)</td>
<td></td>
<td>• The instructor helped me realize the differences or similarities between what I knew about sustainability before the class and what I learned about sustainability in the class.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The instructor helped me work through differences between what I knew about sustainability before the class and what I learned about sustainability in the class.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The instructor supported me if and when I felt challenged by the sustainability content.</td>
</tr>
</tbody>
</table>

Data Analysis

Data were analyzed using descriptive statistics, regression analyses, and Structural Equation Modeling.

Pre-analysis Data Exploration

Prior to the analyses of the four research questions, I first extracted the relevant survey items from the larger pre-survey into a sub-dataset. Then, using a unique identifier for each participant, I merged this sub-dataset with the post-survey data using SPSS 25 software. After creating the full dataset for the present study, I recoded necessary variables. For example, because the knowledge learning outcome items had three
incorrect answers and one correct answer, I recoded the variable to be binary where 1=correct and 0=incorrect. I also recoded the behavior learning outcome items such that never=0 and always=5. In the proceeding analyses, I treated the attitude and behavior items as continuous variables.

Next, I ran initial descriptive analyses to explore the data in order to engage in pre-analysis data screening. According to Mertler and Vannatta (2005), there are four main reasons to screen data prior to conducting a univariate analysis, including: ensuring the data are accurate, dealing with missing data, assessing the effects of extreme values on the analysis, and assessing the adequacy of fit between the data and the assumptions of a specific procedure. Univariate normality analyses were conducted on each of the variables employed in the study. Based on descriptive frequencies, if items had less than 5% of respondents selecting responses across all response options, I collapsed two response options to provide sufficient variance across response categories for analysis. Additionally, I conducted missing data analyses on each variable to determine which items had the highest number of missing responses in order to ensure that items did not have a pattern of missing data that could be explained by a confounding variable, introducing endogeneity and error. Listwise deletion was used in the analyses; therefore, exploring missing data was important because if one item has a large number of missing responses, those respondents would be excluded from the entire analysis, thereby lowering the overall sample size and the power of analysis, as well as introducing bias if there was a pattern to the missing data.

I then calculated descriptive statistics of means, standard deviations, and frequency distributions (SD). Descriptive statistics were used to characterize meaningful

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5A mean is the arithmetic average of a set of scores (Johnson & Christensen, 2008; Mertler & Vannatta, 2005; Urdan, 2016). I calculated means on continuous variables, or variables that were scored in a way in which numbers indicated a numeric amount (Urdan, 2016). For example, in the context of transformative sustainability learning outcomes, an item in the
features of the data (Coladarci et al., 2010; Johnson & Christensen, 2008; Mertler & Reinhart, 2016). I conducted chi-square goodness of fit tests to compare the representativeness of the student sample with the overall MSU undergraduate population. Chi-square goodness of fit tests was appropriate to use here because it is a non-parametric test that is used to discover how the observed value (Bentler & Bonett, 1980; Cheung & Rensvold, 2002; here, the student participants) is significantly different from the expected value (here, the student population).

**Research question 1.** The first research question explored the extent to which, if at all, higher education students had the opportunity to learn about sustainability throughout their coursework. In order to respond to this research question, I first analyzed means, frequencies, and standard deviations from the post-survey data. The second part this research question charted what kinds of students, as per their demographics and academic characteristics, had the opportunity to learn about sustainability. To answer this part of the research question, I ran regressions to explore whether student demographics differed by whether or not they had access to sustainability-related subject matter. A regression attitudes construct asked students about the extent to which they agree with the notion that access to clean water is a universal human right. Response options are a Likert scale from 1 to 6, with 1 being *strongly disagree* and 6 being *strongly agree*. Here, attitude toward access to clean water was a continuous variable because higher scores on this variable indicate higher levels of agreement.

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6 As standard deviation (SD) is an average distance of scores away from the mean (Mertler & Vanatta, 2005). In this study, SD provided insight on the total spread of the distribution of scores, when I wanted a glimpse at the distribution, such as whether all response categories of the survey item were used—i.e., all five points of the Likert scale (Urdan, 2007).

7 A frequency is “a systemic arrangement of data values in which the data are rank ordered and the frequencies of each unique data value are shown” (Johnson & Christensen, 2008, p. 520; Coladarci, Cobb, Minium, & Clarke, 2010; Mertler & Vannatta, 2005). In this study, I used frequencies on categorical variables, or variables for which the assigned values do not indicate more or less of a certain quality. For example, in order to analyze the course types that were providing students with the opportunity to learn about sustainability, response options in the student post-survey were coded as: 1= major requirement, 2=elective, 3=general education course, and 4=lab. A value of 4 on this variable is not *more* than a value of 1, 2, 3; it is just different.
“is a set of statistical procedures used to explain or predict the values of a dependent variable based on the values of one or more independent variables” (Johnson & Christensen, 2008, p. 540). I conducted two types of regressions, namely logistic regression and ordinary least squares regression.

First, I conducted a logistic regression using SPSS 25 software in order to investigate whether having the opportunity to learn about sustainability differed across student demographics and academic characteristics. A logistic regression is a type of regression analysis that provides a modeling strategy for the analysis of binary data in the form of dichotomous outcomes (Menard, 2002; O’Connell & Amico, 2010). Logistic regression was useful here because the outcome variable was binary, as the survey question asked students whether they had the opportunity to learn about sustainability during the fall 2017 semester (with response options of yes or no). In a logistic regression, the dependent variable can be dichotomous, like the variable I used (whether or not students reported on having the opportunity to learn about sustainability). 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). Logistic regression estimates the probability of this dependent variable occurring as the values of the independent variables change. The purpose, as such, is the classification of individuals into groups (Menard, 2002; Peng, Lee, & Ingersoll, 2002). It is important to note here, though, that before running the logistic regression, I checked assumptions, including linearity and homoscedasticity (Heck, Thomas, & Tabata, 2013; Mertler & Reinhart, 2016; Mertler & Vannatta, 2005). Using listwise deletion, I also explored the missing data, investigating if any one item had more missing data than other items.

Next, I conducted ordinary least squares (OLS) regression, which is a type of regression that has the ability to estimate the relationship between one or more
independent variables and one dependent variable (Fox, 2015). I chose to run multiple (three) OLS regressions, using STATA 15 software, to explore this part of the first research question given its ability to control for students’ demographics and academic characteristics while exploring students’ opportunity to learn about sustainability. 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 demographics and academic characteristics (gender, race/ethnicity, domestic/international status, major discipline, admittance status, parental education, class year, and GPA). Before running the OLS regressions, I checked assumptions, including normality, linearity, and homoscedasticity (Heck, Thomas, & Tabata, 2013; Mertler & Reinhart, 2016; Mertler & Vannatta, 2005). Using listwise deletion, I also explored the missing data, investigating if any one item had more missing data than other items.

**Research question 2.** Building upon the first research question, the second research question explored the extent to which students whom had the opportunity to learn about sustainability experienced promising practices of teaching and learning about sustainability. In order to respond to this research question, I first filtered out the student responses from the post-survey dataset that indicated that students did not have an opportunity to learn about sustainability in their coursework during the semester. Next, for the students who had an opportunity to learn about sustainability, I coded characteristics of the course they indicated where they had the most opportunity to learn. I used the MSU course catalog to code the course titles the students entered by course level (100-level – 800-level), number of credits the course was worth (1-4), and how many students were enrolled (the smallest class size was 1 student and the largest class size was 502 students). I also categorized these courses according to Biglan’s (1973) disciplinary paradigm.
Next, I ran initial descriptive analyses to explore the data employed in the second research questions. Based on frequencies, if items had less than 5% of respondents selecting responses across all response options, due to insufficient variance, I collapsed categories. Once the data were sufficiently clean, I analyzed means and frequencies of the course characteristics, as well as the questions that asked students about the kinds of teaching practices on sustainability, namely, cognitively responsive teaching and teaching for sustainability, they experienced during the semester.

Moving forward, I conducted exploratory factor analyses (EFA) to determine what, if any, underlying structure existed for the construct of promising practices of teaching and learning about sustainability (cognitively responsive teaching and teaching for sustainability). The goal of EFA is “to describe and summarize data by grouping together variables that are correlated” (Mertler & Vanatta, 2005, p. 347). I ran separate factor analyses for each construct. I tested the assumptions of the factors, including the Kaiser-Meyer-Olkin Measure (KMO) and Bartlett’s test of sphericity. Following, I consolidated the variables and created scales for each of PPOT&LAS. Using the newly created scales, I calculated means on the presence of each PPOT&LAS in the course where participants reported sustainability was most present, in order to explore the extent to which students experienced PPOT&LAS.

The second part of the second research question explored the extent to which promising practices of teaching and learning about sustainability differed across disciplines and course contexts. To examine this, I conducted multiple OLS regressions. As with the procedures for the first research question, I first engaged in pre-analysis data screening (Mertler & Vannatta, 2005). Next, I ran five OLS regressions to explore the extent to which promising practices of teaching and learning about sustainability occurred within disciplines and course contexts. The dependent variables were continuous variables on the extent to which students perceived presence of cognitively responsive teaching (subject matter, prior knowledge, and supporting changing views).
used to teach them about sustainability, as well as their perceived presence of teaching for sustainability (sustainability core ideas and sustainability teaching practices) used to teach them about sustainability. I ran a regression model for each of these five dependent variables. The independent variables were the course characteristics of course type, course format, course level, number of credits, class size, as well as discipline as per Biglan (1973).

**Structural Equation Modeling**

The second part of this study analyzed the structural relationships between having the opportunity to learn about sustainability and experiencing promising practices of teaching and learning surrounding sustainability with students’ sustainability learning outcomes. To analyze these structural relationships, data were analyzed using Structural Equation Modeling (SEM) using MPlus 8 software, estimated by using weighted least squares (WLS) estimation (Byrne, 2012, 2013). SEM can be defined as “a class of methodologies that seeks to represent hypotheses about the means, variances and covariances of observed data in terms of a smaller number of ‘structural’ parameters defined by a hypothesized underlying model” (Kaplan, 2000, p. 1). SEM is a statistical approach that integrates a number of multivariate techniques, such as confirmatory analysis, multiple regression analysis, and path analysis. The marriage of these techniques is used to analyze structural relationships (Byrne, 2013, 2016; Kaplan, 2000; Mueller & Hancock, 2008).

There were several benefits to using SEM in the present study. SEM is a process that allows for the assessment of hypothesized theories to explain the characteristics of measured variables (Hancock & Mueller, 2013; Mueller & Hancock, 2008). As such, one benefit is for the present study is that it is a confirmatory method that allows for testing a posited model (both the measurement and structural models). With regard to the measurement model, SEM has the ability to confirm the reliability of latent constructs as
well as construct validity (Hancock & Mueller, 2013; Kaplan, 2000; Kline, 2015). A latent construct is a construct for which there are no direct measures, such as students’ sustainability attitudes (Bandalos & Finney, 2001). However, we can use approaches to measure latent constructs using variables that we can measure directly and believe to be caused by the underlying latent construct. In this context, SEM has the ability to estimate how much variation in the survey items is explained by the latent construct. Therefore, instead of measuring students’ sustainability attitudes directly, the pre- and post- survey measured students’ self-report of their perceptions about sustainability attitudes (Byrne, 2016; Hancock & Mueller, 2013; Hox & Bechger, 2007). In this vein, SEM allowed me to assess the reliability and validity of latent constructs. Reliability is the consistency or stability of scores. If an assessment finds reliable scores, the scores will be similar on every occasion, and across different people and different items (Johnson & Christensen, 2008). SEM also allows us to gather evidence on the construct validity, in ways such as exploring whether the factor structure matches what we expect (for example, three correlated factors). With regard to the measurement model, SEM allowed me to confirm the validity of a latent construct (Byrne, 2016; Hancock & Mueller, 2013).

Furthermore, the procedures of estimating the measurement model were imperative for the present study because some of the scales in the survey had not been previously validated. The following scales had been validated: ASK (Zwickle et al., 2014) and the SAS (Zwickle & Jones, 2018). The cognitively responsive teaching scales had been validated in the context of college teaching and learning across disciplines (Michel et al., 2018b), but not in the specific sustainability context. The teaching for sustainability and sustainability behaviors scales had not been validated, and these scales were critical to the study. Therefore, estimating the validity of a latent construct was essential for carrying out the study. It is worth noting here that other exploratory methods, such as principal components analysis, do not have the ability to confirm pre-established, theory-driven scales, such as the ones in the survey, which is why SEM was so beneficial here.
Structural Equation Modeling is appropriate to use in situations when the main constructs that interest a researcher involve complex, multi-faceted constructs, like the ones in the present study. These complex, multi-faceted constructs are usually difficult to measure and are often measured erroneously. Therefore, one of the useful aspects of SEM is its ability to model errors of measurement. For instance, SEM was able to analyze a survey of perceptions (like the one in this study) due to its ability to estimate and account for measurement error. This is important because surveys that are perceptual in nature, like the ones in this study, are susceptible to bias errors, like those of social desirability and memory recall (Fowler, 2013; Fowler & Cosenza, 2009; Groves et al., 2011; Johnson & Christensen, 2008). Some of the variability in answers was also due to the true variability in people’s response to the particular question, but there were other factors that also caused variability, possibly to do with the questionnaire design, or even the room temperature where the participant was taking the survey. Although these factors do not interest me for the particular purpose of this study, they can still cause variability. As such, some of the variability might have been due to the latent construct I was trying to measure, while some were due to other factors, called errors (Byrne, 2016; Hancock & Mueller, 2013; Hox & Bechger, 2007). As noted, SEM accounts for measurement errors and estimates the proportion of variation that is attributed to such errors versus the construct of interest.

With regard to the structural model, SEM has the ability to confirm theoretically driven, hypothetical relationships (Byrne, 2016; Hancock & Mueller, 2013). For example, the Framework for Teaching and Learning for Sustainability in Higher Education posited that there are factors that influence students’ opportunity to learn, exposure to promising practices of teaching and learning, and learning outcomes. Based on this theoretical model, after I determined what the structural paths were, SEM allowed me to determine the magnitude of these paths. For example, SEM helped me understand the strength of the relationships between opportunity to learn and promising practices of
teaching and learning. Other methods, like multiple regression, do not start with pre-established relationships and can thus lead repeatedly to using trial and error, where multiple independent variables are tested and rejected based on exploratory estimates (Byrne, 2016; Nachtigall, Kroehne, Funke, & Steyer, 2003).

In addition, another benefit of using SEM in the present study was that it allows for the study of multiple endogenous, or dependent, variables (Byrne, 2013; Hancock & Mueller, 2013; Kaplan, 2000; Kline, 2015). This was advantageous for the present study, which investigated multiple endogenous variables of student demographics and academic characteristics, opportunity to learn about sustainability, cognitively responsive teaching, and teaching for sustainability. Using another method, such as multiple regression, would not allow for simultaneously investigating relationships between multiple exogenous and endogenous variables. As well, there are times when a researcher is interested in a single dependent variable as well as several independent variables or predictor variables. For instance, a researcher might be curious about the extent to which cognitively responsive teaching influences students’ sustainability knowledge. To explore this interest, the researcher could run an OLS regression. However, in the present study, I was interested in “systems” of relationships rather than a dependent variable and a set of predictors. SEM can have numerous different outcomes on dependent variables, each of which is affecting other dependent variables in a more complex system (Byrne, 2016; Hancock & Mueller, 2013; Hox & Bechger, 2007).

In sum, I chose to use SEM to respond to the third and fourth research questions because this statistical method allowed me to analyze a system of latent variables and their relationships with one another, which in turn enabled me to analyze the dependencies of constructs without measurement errors. SEM permitted me to map the posited framework for the data. This mapping provided me with fit statistics that assessed the matching of the model and the data. If the fit is acceptable, the assumed relationships between the latent and observed variables (measurement model) as well as the assumed
dependencies between the latent variables (structural model) were understood as being supported by the data (Nachtigall et al., 2003). Below, I describe how the third and fourth research questions explored the structural, or path, and measurement models, respectively.

**Factor analyses.** Before running the SEM, I conducted factor analyses, which are “a method of modeling the covariation among a set of observed variables as a function of one or more latent constructs” (Bandalos & Finney, 2010, p. 93). The purpose of factor analysis is to identify the nature of the latent constructs underlying the variables of interest (Bandalos & Finney, 2001). In particular, I conducted two types of factor analytic methods: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The specific purpose of EFA was to identify the latent constructs in order to generate hypotheses about their possible structures (Bandalos & Finney, 2001; Pett, Lackey, & Sullivan, 2003). Given that I already ran EFAs for the PPOT&LAS for the second research question, here, I ran EFAs with no rotation on the opportunity to learn variables, and on the sustainability learning outcome variables.

Moving forward, before running SEM, the researcher must ascertain the psychometric properties by running CFA for each latent construct (Byrne, 2013). CFA is useful because the factor analysis method allows for the testing of a priori specified theoretical models relating latent to measured variables (Bandalos & Finney, 2001; Byrne, 2013; Hancock & Mueller, 2013; Kline, 2015; Pett et al., 2003). As such, based on the findings of the EFAs, I next conducted CFA on the constructs of interest in order to confirm their factor structures and determine the strength of the influence of each survey item on its corresponding factor (Bandalos & Finney, 2001; Byrne, 2013; Hancock & Mueller, 2013; Kline, 2015; Pett et al., 2003). In each CFA model, I allowed the item loadings and error terms to be freely estimated and then constrained the factor variances to one. I also reported the Coefficient H, which is a value of reliability for latent constructs (Hancock & Muller, 2001). If CFA models did not hold, I consulted
with the Lagrange Multiplier (LM) test and made decisions about moving forward that were both statistically and theoretically defensible. This allowed me to make modifications to the constructs to ensure fit and reveal the error among the construct’s items and the reliability of the latent construct.

**Measurement model.** Once all the latent constructs were validated as per the series of CFAs, I next conducted a second order CFA to ascertain the intercorrelations among the latent constructs. This process revealed preliminary relationships among the latent constructs, and also had the capacity to draw attention to potential collinearity problems. Here, I ran a CFA model that allowed the remaining constructs to correlate freely. Additionally, I constrained the loadings of the pre- and post-items to be equal as they were exactly the same, given to the exact same participants, at two different points in time. As such, I expected that the measure was behaving in the same way at both time points, and therefore, the loadings should be constrained to be equal (Byrne, 2013; Hancock & Mueller, 2013; Kline, 2015). I created the equation for the intercorrelated CFAs, also recognized as my measurement model.

**Criteria for analyses/fit indices.** Kline (2005) suggests that the SEM literature has been discussing the best ways to assess model fit for at least 40 years, and to date, there is no single statistical framework we can clearly distinguish as “correct.” As such, prominent SEM scholars, including Kline (2005), as well as Byrne (2006), and Hu and Bentler (1999), advise considering multiple forms of fit indices as critical to having a full understanding of model fit. Therefore, in the present study, I relied on three measures of fit to evaluate the CFA and SEM models. These indices include: the Root Mean Square Error of Approximation (RMSEA), the comparative fix index (CFI), and the standardized root mean residual (SRMR).

The RMSEA, which takes into account the parsimony of the model, is “an absolute fit index scaled as a badness-of-fit statistic where a value of zero indicates the best result” (Kline, 2005, p. 273). RMSEA values ≤.06 would signify an excellent fit, and values ≤.08
would signify an appropriate fit. SRMR is an absolute fit index that is a badness-of-fit statistic, which evaluates the overall discrepancy between observed and implied covariance (Hancock & Muller, 2013; Kline, 2015). SRMR values ≤.08 would signify an excellent fit, and values ≤.1 would signify an appropriate fit. CFI is an incremental fit index that is a goodness-of-fit statistic. It evaluates a model’s absolute or parsimonious fit relative to a baseline model. CFI values of ≥.95 would signify an excellent fit, and values ≥.90 would signify an appropriate fit.

Structural model. After determining the psychometric properties of the model, as well as determining adequate model fit, I moved forward with testing the posited structural model. Proceeding forward, I created the structural equation for the posited structural model. A structural equation is a regression-type equation that expresses each endogenous variable as a function of all elements having a direct structural effect on it (Mueller & Hancock, 2008). After running the model, I then consulted with the Lagrange Multiplier (LM) test in order to assist with model re-specification.

Use of Conceptual Framework for Structural Equation Modeling

Figure 4 illustrates the operationalization of the conceptual model and shows how I used the Framework for Teaching and Learning for Sustainability in Higher Education in the present study, particularly to respond to the third and fourth research questions. The relationships posited in this conceptual model were based on prior literature, as discussed in the aforementioned literature review. I used the Bentler-Weeks notational conventions in the model: rectangles represent observed variables, ellipses represent latent factors,
Figure 4. Operationalization of *Framework for Teaching and Learning for Sustainability in Higher Education* in Present Study
single-headed arrows represent directional, hypothesized structural/causal bearing relationships, and double-headed arrows represent non-directional, hypothesized non-structural/non-causal covariation or variation (Byrne, 1994).

As seen in the figure, I posited that student demographics (gender and race/ethnicity), academic characteristics (field of study), and pre-surveys of the learning outcomes (sustainability-related knowledge, attitudes, and behaviors) co-varied with each other. I also posited that the pre-surveys on the learning outcomes, plus each student demographic and academic characteristic, directly influenced OTL and learning outcomes.

I postulated that OTL could directly influence the learning outcomes, bypassing the cognitively responsive teaching and teaching for sustainability, because it is possible that the sustainability-related subject matter was present without being delivered to students by way of PPOT&LAS. I also posited that OTL could directly influence PPOT&LAS, because it would be impossible to experience teaching practices on a particular subject matter without having the opportunity to learn about that subject matter. As such, OTL, which was influenced by student demographics, academic characteristics, and pre-surveys of learning outcomes, could influence each of the PPOT&LAS (cognitively responsive teaching subject matter, prior knowledge, and supporting changing views; teaching for sustainability core ideas, and teaching practices) and then indirectly influence the learning outcomes (e.g., OTL having a mediated influence on learning outcomes).

In terms of promising practices of teaching and learning about sustainability, I suggested that each facet of cognitively responsive teaching (subject matter, prior knowledge, and cognitive dissonance), and each facet of teaching for sustainability (sustainability core ideas and sustainability teaching practices), co-varied with each other. Additionally, PPOT&LAS, which were directly influenced by OTL, could directly
influence learning outcomes. Lastly, I suggested that the post-surveys on the learning outcomes (knowledge, attitudes, and behaviors) co-varied with each other.

**Research question 3.** Next, I turned to the results for the third research question, which asked: Does opportunity to learn influence cognitively responsive teaching and teaching for sustainability? And, do opportunity to learn, cognitively responsive teaching, and teaching for sustainability influence learning outcomes? To answer this question, I tested two parts of the posited structural model (opportunity to learn and promising practices of teaching and learning).

First, I examined if opportunity to learn influenced promising practices of teaching and learning (cognitively responsive teaching and teaching for sustainability). I examined the direct effects of opportunity to learn on cognitively responsive teaching and teaching for sustainability by looking at the standardized betas, which isolate one portion of the structural model. Next, I examined direct effects of opportunity to learn on learning outcomes, as well as direct effects of promising practices of teaching and learning on learning outcomes, also by looking at the standardized betas.

I then examined the effects of opportunity to learn on post-attitudes and post-behaviors via the promising practices of teaching and learning practices. There are several methods that can be used to test indirect effects. The Sobel method (Sobel, 1982, 1986) involves calculating the product of the two path and conducting a z-test. This method is not advisable because the indirect effect is not normally distributed, so critical z-values are inappropriate. An alternative method is getting the empirical sampling distribution via bootstrapping (Bollen, 1989; Shrout & Bolger, 2002). Bootstrapping is a non-parametric method in which the sample data are resampled with replacement many times, e.g., 500. The indirect effect is computed for each of these new samples. In this way, the sampling distribution of the indirect effect can be empirically generated. The standard deviation of this sampling distribution is then taken as the standard error of the indirect effect. The average of the bootstrapped indirect effects will not exactly equal the
true indirect effect value. Consequently, a bias-correct approach was developed to account for this discrepancy. However, the non-bias-corrected bootstrap approach is recognized for producing preferable confidence limits and standard errors for the indirect effect test (Fritz, Taylor, & MacKinnon, 2012). As the purpose of the bootstrapping here was to test the indirect effect for significance, the non-bias-corrected bootstrap method was used to create confidence intervals and determine whether the indirect effect is significant. Following, I examined the direct, indirect, and total effects of opportunity to learn, cognitively responsive teaching, and teaching for sustainability on sustainability learning outcomes.

**Research question 4.** The fourth research question explored if the whole model, the model of *Teaching and Learning for Sustainability in Higher Education*, held in one public, large-sized, four-year institution. Unlike the third research question, in exploring the path model for this fourth research question, I explored the whole structural model (including student demographics and academic characteristics). Here, I presented the full equation. I explored the model fit (RMSEA, CFI, and SRMR). In addition, I explored the strength of the paths in the model by analyzing standardized betas for those paths.

**Conclusion**

In this chapter, I outlined the methodological design of this dissertation study. I explained how I used the conceptual framework to guide the present study, introduced the site, sample, and data recruitment and administration methods, as well as the survey items. I explained my rationale for the decisions I made during data analysis, such as choosing to analyze the data with regressions and SEM, as well as decisions about cleaning the data. In the next chapter, I report the results of this methodological design.
Chapter IV
RESULTS

Introduction

This chapter describes the results of this dissertation study. I present results of the research questions that guided this study, which were:

1. To what extent, if at all, do higher education students have the opportunity to learn about sustainability throughout their coursework? 
   a. To what extent does this differ across student demographics and academic characteristics (e.g., gender, race/ethnicity, domestic/international status, major, class year)?

2. For students who have the opportunity to learn about sustainability, to what extent do they experience promising practices of teaching and learning about sustainability? 
   a. To what extent does this differ across disciplines and course contexts (e.g., class type, class level, class size)?

3. Does the opportunity to learn influence cognitively responsive teaching and teaching for sustainability? And, does the opportunity to learn, cognitively responsive teaching, and teaching for sustainability, influence sustainability learning outcomes?
4. Does a model of Teaching and Learning for Sustainability in Higher Education hold in one public, large-sized, four-year institution?
   
a. If not, what modifications can be made?

Results for Research Question 1

Results for the first research question are presented below. I provide frequencies of students’ opportunity to learn about sustainability by course contexts (including both course types and course formats). Next, to facilitate a more in-depth analysis, I present regression results from analyses that examine the extent to which student demographics differ in students’ opportunity to learn about sustainability.

Descriptive Statistics of Students’ Opportunity to Learn about Sustainability

The first research question examined the extent to which students had the opportunity to learn about sustainability throughout their coursework. Table 1 presents frequencies of opportunity to learn variables. Out of the 748 participants, 432 (64.2%) reported that they had exposure to sustainability-related content in at least one of their courses throughout the duration of the fall 2017 semester, while 241 (35.8.2%) of students did not.

Next, I investigated the particular course contexts for which students had the opportunity to learn about sustainability. As illustrated in Figure 5, I examined how often students had the opportunity to learn about sustainability by the course types of major, general education, and elective. The most frequent sites for learning about sustainability were in major coursework and in general education coursework. Seventy-three percent of students reported learning about sustainability in their major coursework, with 22.5% learning about it many times, and 9.8% learning about it all the time. In terms of general education coursework, 67.5% of students reported learning about sustainability, with
Table 11. Descriptive Statistics of Opportunity to Learn Variables (N=748)

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

16.0% learning about it many times, and 7.1% learning about it all the time. In addition, students reported on having the least opportunity to learn about sustainability in their elective courses, as nearly half (43.0%) had never had exposure to sustainability subject matter in their elective coursework. Additionally, responses to the elective course type were consistently lower than major and general education coursework. Overall, students reported on having access to sustainability subject matter across all three course types, with varying degrees of its presence.
As seen in Table 11, and as illustrated in Figure 6, I also examined how often students had the opportunity to learn about sustainability by the course formats of lectures, labs, recitations, and practicums. The trend seen by these frequencies is that students reported on having the most opportunity to learn in lectures, followed by labs, then in recitations, and the least opportunity to learn in practicums. Overall, students reported on having access to sustainability subject matter across all four course formats, with varying degrees of its presence.

Lastly, I investigated the frequency with which students had the opportunity to learn about sustainability throughout their coursework. As seen in Table 11, I examined how many individual class sessions within one course students had exposure to sustainability-related content. Of the 432 students who reported that they had exposure the sustainability-related subject matter, 260 (60.2%) learned about it in one class session in one course. There was an inverse relationship between the number of classes and the amount of students who had the opportunity to learn: as the number of classes went up, the number of students went down. In addition, in terms of learning about sustainability
in many class sessions, 20% learned about it across multiple class sessions in one course. However, the pattern continues: there was still is an inverse relationship between the number of classes and the amount of students who have the opportunity to learn. Only 8.3% of the participants had the opportunity to learn in many class sessions in more than one course.

**Univariate Analysis Results on the Influence of Students’ Demographics and Academic Characteristics on Their Opportunity to Learn about Sustainability**

The second part of the first research question explored the extent to which the opportunity to learn about sustainability differed across students’ demographics and academic characteristics. Initially, I conducted a logistic regression on the binary variable that explored if students had the opportunity to learn (yes or no), particularly in the context of exploring the extent to which this differed across student demographics and academic characteristics. Subsequently, I conducted multiple ordinary least squares regressions on whether the amount of opportunity to learn varied by students’
demographics and academic characteristics. I investigated these opportunity to learn variables by: gender, race/ethnicity, domestic/international status, parental education, major (as per Biglan’s, 1973, disciplinary paradigms), class year, GPA, and admission status.

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. As such, due to insufficient variance, I omitted the part-time versus full-time student variable (3.9% versus 96.0%, respectively). Additionally, this variable was not especially meaningful for examining opportunity to learn about sustainability—part-time students, for example, have less chance to learn across the board. In terms of race and ethnicity, I also removed students who identified as other or race/ethnicity unknown because there were only 12 students (1.7%) who self-selected this racial category. This presents a limitation, as this marginalized group of students who do not identify with a dominating racial group were not included in the analysis due to the limited statistical power.

**Data exploration for logistic regression.** Before conducting the logistic regression analysis, I conducted a specific set of pre-analysis data screening on the variables used in this analysis. I checked assumptions of linearity and homoscedasticity, and found that data were approximately linear and homoscedastic. Multicollinearity was not a concern, as evidenced by the variance inflation factor (VIF) ≤ 2.5 (Mertler & Vannatta, 2005). Using listwise deletion, I also explored the missing data, and I was unable conclude any specific pattern to explain the missing values.

**Logistic regression.** In order to investigate whether having the opportunity to learn about sustainability differed across student demographics and academic characteristics, I ran a logistic regression, which is a type of regression analysis that provides a modeling strategy for the analysis of binary data in the form of dichotomous outcomes (O’Connell & Amico, 2010). Logistic regression was useful here because the outcome variable was
binary, as it indicated whether students had the opportunity to learn about sustainability during the fall 2017 semester. The results of this logistic regression respond to this question: broadly, across all of their coursework, did students have any opportunity to learn about sustainability?

Table 12 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 (Menard, 2002; O’Connell & Amico, 2010; Peng et al., 2002). It is worth noting here that, as seen in the table, the predicted probabilities are not strong in predicting those who did not have the opportunity to learn, while they are very strong for predicting those that did learn about sustainability. However, given that I did not run this logistic regression model with the intention of being able to predict, I note this limitation while accepting this model. I am interested in the relationship between demographics characteristics and outcome of interest, which is opportunity to learn.

Table 12. Classification Table

<table>
<thead>
<tr>
<th>Predicted During the Fall 2017 semester, did you learn about the environment or sustainability in at least one class?</th>
<th>No</th>
<th>Yes</th>
<th>Percentage Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed: During the Fall 2017 semester, did you learn about the environment or sustainability in at least one class?</td>
<td>No</td>
<td>36</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>29</td>
<td>286</td>
</tr>
<tr>
<td>Overall Percentage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 13 shows predictors comparing students who did and did not have the opportunity to learn about sustainability. 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 student demographics, students whose parents have higher levels of education have higher opportunity to learn. In other words, the higher the level of parental education, the higher the odds of opportunity to learn (Exp(b)=1.219, \( p \leq 0.05 \)). The other student demographics, including gender, race, and domestic/international status, did not influence students’ opportunity to learn (\( p \geq 0.05 \)).

Table 13. Results of Opportunity to Learn (Binary) Regressed on Demographics

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

Note: * \( p \leq 0.05 \), ** \( p \leq 0.01 \), *** \( p \leq 0.001 \)
In terms of students’ academic characteristics, GPA and admittance status did not influence students’ opportunity to learn \((p \geq .05).\) In terms of discipline, students with hard versus soft majors did not influence students’ opportunity to learn \((p \geq .05).\) However, students in applied discipline majors were more likely to learn about sustainability than students in pure majors. Applied majors have 1.677 the odds of pure majors to have the opportunity to learn about sustainability \((p \leq .05).\) Additionally, life majors have a higher probability to learn about sustainability than non-life majors. Students who have non-life majors have .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 opportunity to learn \((\text{Exp}(b) = .829, p \leq .05).\)

Data exploration for ordinary least squares regression. Before conducting the OLS regression analyses, I conducted pre-analysis data screening on the variables used in these three regression models. I tested assumptions of linearity, normality, and homoscedasticity using the following analyses: scatter plot of unstandardized residuals and predicted values, Q-Q plot, and the Kolmogorov-Smirnov test (Heck et al., 2013; Mertler & Reinhart, 2016; Mertler & Vannatta, 2005). Data were approximately linear and homoscedastic. Multicollinearity was not a concern, as evidenced by the VIF \(\leq 2.5\) (Mertler & Vannatta, 2005). I closely examined missing data, and was unable conclude a specific pattern to explain the missing values.

Ordinary least squares regressions. Moving forward, I ran three Ordinary Least Squares (OLS) regressions in order to investigate more granular demographic differences in how much exposure to sustainability students had within particular course types. The three dependent variables were how often sustainability subject matter was present in major, general education, and elective coursework. The independent variables were the same as the logistic regression (gender, race, domestic/international status, parental education, discipline, class year, GPA, and admittance status). Table 14 presents results
from the OLS regressions that explored the extent to which student demographics and academic characteristics influenced students’ opportunity to learn by course type.

Table 14. Standardized Coefficients of Opportunity to Learn about Sustainability on Student Demographics and Academic Characteristics

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

Note: *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$
As demonstrated by the results, very few demographics influenced students’ opportunity to learn about sustainability. It is worth noting here that all of the reported effects are 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’ opportunity to learn about sustainability \((p ≥ .05)\), nor did any of the racial minorities compared with the reference group of students who identified as White \((p ≥ .05)\). Interestingly, though, students’ domestic/international status did influence their opportunity to learn about sustainability.

International students had higher exposure to sustainability subject matter in all three types of coursework: major coursework \((β = .136; p ≤ .01)\), general education coursework \((β = .158; p ≤ .05)\), and elective coursework \((β = .170; p ≤ .05)\). These significant results, albeit small effect sizes, together serve as an interesting finding, as prior literature shows that citizens, and students, in other countries have higher endorsement of sustainability-related issues than American citizens and students (Capstick, Whitmarsh, Poortinga, Pidgeon, & Upham, 2015; O’Connor, Bord, & Fisher, 1998; Stephens et al., 2008; Weber & Stern, 2011).

Given the demographic data I had access to, I attempted to uncover some indicator of socioeconomic status, by looking at levels of parental education, in terms of its influence on students’ opportunity to learn about sustainability. Across all three course types, parental education did not significantly influence students’ opportunity to learn about sustainability \((p ≥ .05)\). This provides evidence that the results of the logistic regression in which students whose parents have higher levels of education have higher opportunity to learn \((p ≤ .05)\) could thus be a spurious finding.

Next, I explored student academic characteristics, first by looking at discipline by way of Biglan’s (1973) disciplinary paradigms. In terms of major coursework, students in hard majors had more exposure to sustainability subject matter than students in soft majors \((β = -.140; p ≤ .01)\). Students in applied majors had more exposure to sustainability
subject matter than students in pure majors ($\beta = .150; p \leq .01$). Students in life majors had more exposure to sustainability subject matter than students in nonlife majors ($\beta = -.239; p \leq .001$). In terms of general education coursework, students in soft majors had more exposure to sustainability subject matter than students in hard majors ($\beta = .124; p \leq .05$). There was no difference in exposure to sustainability subject matter 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 report a significant difference in opportunity to learn in major or elective coursework, transfer students did report lower OTL in their general education coursework ($\beta = .110; p \leq .05$). This may be a result of their having completed general education courses before transferring to MSU, and because after they transferred, they were mostly engaged in major coursework. There were no differences with regard to class year nor with GPA ($p \geq .05$).

**Results for Research Question 2**

Results for the second research question are presented below. The second research question explored, for students who had the opportunity to learn about sustainability, the extent to which they experienced promising practices of teaching and learning about sustainability. I present descriptive statistics on their exposure to promising practices of teaching and learning. I also present OLS regression results on the extent to which exposure to promising practices of teaching and learning differed across disciplines and course contexts (course type, format, level, credits, and size) in order to better understand in what types of courses students had access to the promising practices.
Data Exploration

The second research question examined promising practices of teaching and learning about sustainability. In order to gather data about teaching practices, the post-survey prompted students to respond to questions about teaching practices employed by their instructors in the course that taught them the most about sustainability during the fall 2017 semester. Students were asked to enter what type of course this was (major, general education, or elective), as well as what format this course was (lecture, lab, practicum, or recitation). During data cleaning, I used the MSU course catalog to code the courses students entered by course level (100-level – 800-level), number of credits the course was worth (1-4), and how many students were enrolled (the smallest class size was one student and the largest class size was 502 students). I also coded these courses as per Biglan’s (1973) disciplinary paradigms.

Next, I conducted pre-analysis data screening. I ran initial descriptive analyses to explore the data. With regard to where students had the opportunity to learn about sustainability, based on descriptive frequencies, four items had less than 5% of respondents selecting responses across all response options: course format, course level, number of credits, and class size. Because of insufficient variance, I recoded the course format to lecture or non-lecture. The new “non-lecture” category consisted of the responses that had less than 5%, these being labs, practicums, and recitations. This variable was categorized as dichotomous in the subsequent analyses. Next, I recoded course level. Less than 5% of the students were enrolled in advanced-level coursework (above 400-level), so I collapsed 400 and higher into one group. Given that only 4.1% of the courses were worth one credit, I combined courses that were worth one and two credits. Additionally, I chose to treat class size as categorical because I was interested in observing patterns across enrollment sizes. I grouped class size into buckets (1-24, 25-29, 50-74, 75+ students). Lastly, I used listwise deletion to treat the missing data. 423 of the
432 participants who reported that they had the opportunity to learn were retained in the descriptive analyses.

**Descriptive Statistics for Where Students Learned the Most about Sustainability**

For the students who had the opportunity to learn about sustainability, descriptive statistics on the course contexts regarding where they had the most opportunity to learn are reported in Table 15.

Table 15. Descriptive Statistics and Coding of Courses Where Students Had the Most Opportunity to Learn about Sustainability (N=423)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coding/Frequency</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biglan (1973) disciplinary paradigms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard versus soft</td>
<td>Hard</td>
<td>183</td>
<td>44.2%</td>
</tr>
<tr>
<td></td>
<td>Soft</td>
<td>231</td>
<td>55.8%</td>
</tr>
<tr>
<td>Pure versus applied</td>
<td>Pure</td>
<td>100</td>
<td>24.2%</td>
</tr>
<tr>
<td></td>
<td>Applied</td>
<td>314</td>
<td>75.8%</td>
</tr>
<tr>
<td>Life versus nonlife</td>
<td>Life</td>
<td>278</td>
<td>67.1%</td>
</tr>
<tr>
<td></td>
<td>Nonlife</td>
<td>136</td>
<td>32.9%</td>
</tr>
<tr>
<td>Course Characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course type</td>
<td>Major</td>
<td>222</td>
<td>52.6%</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>81</td>
<td>19.2%</td>
</tr>
<tr>
<td></td>
<td>General education</td>
<td>119</td>
<td>28.2%</td>
</tr>
<tr>
<td>Course Format</td>
<td>Lecture</td>
<td>357</td>
<td>84.8%</td>
</tr>
<tr>
<td></td>
<td>Non-Lecture</td>
<td>64</td>
<td>15.2%</td>
</tr>
<tr>
<td>Course level</td>
<td>100 level</td>
<td>117</td>
<td>28.3%</td>
</tr>
<tr>
<td></td>
<td>200 level</td>
<td>165</td>
<td>39.9%</td>
</tr>
<tr>
<td></td>
<td>300 level</td>
<td>80</td>
<td>19.3%</td>
</tr>
<tr>
<td></td>
<td>400 and higher levels</td>
<td>52</td>
<td>12.6%</td>
</tr>
<tr>
<td>Course credits</td>
<td>1 or 2 credits</td>
<td>41</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>3 credits</td>
<td>290</td>
<td>70.0%</td>
</tr>
<tr>
<td></td>
<td>4 credits</td>
<td>83</td>
<td>20.0%</td>
</tr>
<tr>
<td>Number of students enrolled in class</td>
<td>1-24 students</td>
<td>220</td>
<td>52.0%</td>
</tr>
<tr>
<td></td>
<td>25-49 students</td>
<td>91</td>
<td>21.5%</td>
</tr>
<tr>
<td></td>
<td>50-74 students</td>
<td>42</td>
<td>9.9%</td>
</tr>
<tr>
<td></td>
<td>75+ students</td>
<td>70</td>
<td>16.5%</td>
</tr>
</tbody>
</table>
Exploratory Factor Analyses of Promising Practices of Teaching and Learning about Sustainability

Moving forward, I conducted exploratory factor analyses (EFA) to determine what, if any, underlying structure exists for measures of promising practices of teaching and learning about sustainability (cognitively responsive teaching and teaching for sustainability). I ran separate factor analyses, with no rotation, for each construct. I tested the assumptions of the factorability, using the Kaiser-Meyer-Olkin Measure (KMO) of sampling adequacy. The KMO was sufficient as it was above .9 for four of the five factors, and above .7 for the one factor. Bartlett’s test of sphericity was significant for all five factors. As seen in Table 16, loadings across all constructs were greater than .608, and Cronbach’s alphas were greater than .889, indicating good scale reliability. Given the strength of the assumptions and loadings, no items were removed. Three factors for the cognitively responsive teaching constructs (subject matter, prior knowledge, and supporting changing views) were retained, along with two factors for the teaching for sustainability factors (core ideas and teaching practices). Following, I created scales for each of the five promising practices of teaching and learning about sustainability retained by the exploratory factor analysis.

Table 16. Exploratory Factor Analysis Item Descriptions, Factor Loadings, and Cronbach’s Alphas

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Factor Loading</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitively Responsive Teaching Factor 1: Subject Matter</strong></td>
<td></td>
<td>.947</td>
</tr>
<tr>
<td>The instructor introduced, in-depth, a concept related to sustainability.</td>
<td>.879</td>
<td></td>
</tr>
<tr>
<td>The instructor explained the sustainability-related concept in a few different ways.</td>
<td>.887</td>
<td></td>
</tr>
<tr>
<td>The instructor introduced how sustainability is connected to course content.</td>
<td>.875</td>
<td></td>
</tr>
<tr>
<td>The instructor taught sustainability in a logical order.</td>
<td>.897</td>
<td></td>
</tr>
<tr>
<td>The instructor taught me how to think about sustainability.</td>
<td>.881</td>
<td></td>
</tr>
</tbody>
</table>
### Table 16 (continued)

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Factor Loading</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitively Responsive Teaching Factor 2: Prior Knowledge</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructor helped me use what I know from…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My own personal experiences to help me learn about sustainability.</td>
<td>.758</td>
<td>.889</td>
</tr>
<tr>
<td>My high school coursework to help me learn about sustainability</td>
<td>.639</td>
<td></td>
</tr>
<tr>
<td>My other college coursework to help me learn about sustainability</td>
<td>.627</td>
<td></td>
</tr>
<tr>
<td>My social roles and culture (e.g., race, socioeconomic status, gender, sexuality,</td>
<td>.751</td>
<td></td>
</tr>
<tr>
<td>ethnicity, religion) to help me learn about sustainability.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My family to help me learn about sustainability.</td>
<td>.795</td>
<td></td>
</tr>
<tr>
<td>My friends to help me learn about sustainability.</td>
<td>.789</td>
<td></td>
</tr>
<tr>
<td>The media to help me learn about sustainability.</td>
<td>.761</td>
<td></td>
</tr>
<tr>
<td><strong>Cognitively Responsive Teaching Factor 3: Supporting Changing Views</strong></td>
<td></td>
<td>.905</td>
</tr>
<tr>
<td>The instructor helped me realize the differences or similarities between</td>
<td></td>
<td></td>
</tr>
<tr>
<td>what I knew about sustainability before the class and what I learned</td>
<td>.894</td>
<td></td>
</tr>
<tr>
<td>about sustainability in the class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructor helped me work through differences between what I knew about</td>
<td>.955</td>
<td></td>
</tr>
<tr>
<td>sustainability before the class and what I learned about sustainability in the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructor supported me if and when I felt challenged by the sustainability</td>
<td>.772</td>
<td></td>
</tr>
<tr>
<td>content.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Teaching for Sustainability: Core Ideas</strong></td>
<td></td>
<td>.933</td>
</tr>
<tr>
<td>Defining Sustainability</td>
<td>.817</td>
<td></td>
</tr>
<tr>
<td>Environmental Crises</td>
<td>.799</td>
<td></td>
</tr>
<tr>
<td>Future Generations</td>
<td>.801</td>
<td></td>
</tr>
<tr>
<td>Economic sustainability</td>
<td>.746</td>
<td></td>
</tr>
<tr>
<td>Resource Management</td>
<td>.721</td>
<td></td>
</tr>
<tr>
<td>Challenging human-centered views of the environment</td>
<td>.835</td>
<td></td>
</tr>
<tr>
<td>Valuing all living things</td>
<td>.696</td>
<td></td>
</tr>
<tr>
<td>Valuing the ecological system</td>
<td>.746</td>
<td></td>
</tr>
<tr>
<td>Environmental justice</td>
<td>.752</td>
<td></td>
</tr>
<tr>
<td>Relating oppression of subordinate human groups to the oppression of nature</td>
<td>.745</td>
<td></td>
</tr>
<tr>
<td>Eliminating poverty</td>
<td>.641</td>
<td></td>
</tr>
</tbody>
</table>
Table 16 (continued)

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Factor Loading</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching for Sustainability: Teaching Practices</strong></td>
<td></td>
<td>.917</td>
</tr>
<tr>
<td>In the context of the area I live in (like Michigan)</td>
<td>.772</td>
<td></td>
</tr>
<tr>
<td>In the context of my school (like MSU)</td>
<td>.790</td>
<td></td>
</tr>
<tr>
<td>In the context of current events (like the Flint, Michigan water crisis)</td>
<td>.758</td>
<td></td>
</tr>
<tr>
<td>In a way that made me feel empowered to be more sustainable</td>
<td>.834</td>
<td></td>
</tr>
<tr>
<td>Case study</td>
<td>.608</td>
<td></td>
</tr>
<tr>
<td>Group discussion</td>
<td>.704</td>
<td></td>
</tr>
<tr>
<td>Debate</td>
<td>.676</td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>.770</td>
<td></td>
</tr>
<tr>
<td>Learning who I am in relation to the larger purpose of life</td>
<td>.774</td>
<td></td>
</tr>
</tbody>
</table>

**Descriptive Statistics of Promising Practices of Teaching and Learning about Sustainability**

Using the newly created scales, for students who had the opportunity to learn about sustainability, I began to examine to what extent they experienced promising practices of teaching and learning about sustainability. Table 17 presents descriptive statistics of the promising practices of teaching and learning scales. On average, students neither agreed nor disagreed (the neutral survey response option) that cognitively responsive teaching was employed to teach them about sustainability. Additionally, on average, students reported that they experienced the teaching for sustainability facet (both core ideas and teaching practices) a few times throughout the semester in the course that taught them the most about sustainability.
Table 17. Descriptive Statistics and Coding of Promising Practices of Teaching and Learning Scales (N=404)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coding/ Frequency</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitively Responsive Teaching</td>
<td>0=strongly disagree</td>
<td>2.434</td>
<td>1.158</td>
</tr>
<tr>
<td></td>
<td>1=disagree</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2=neither agree nor disagree</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3=somewhat agree</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4=strongly agree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subject Matter</td>
<td></td>
<td>2.097</td>
<td>1.057</td>
</tr>
<tr>
<td>Prior Knowledge</td>
<td></td>
<td>2.205</td>
<td>0.936</td>
</tr>
<tr>
<td>Supporting Changing Views</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching for Sustainability</td>
<td>0=never</td>
<td>1.300</td>
<td>0.926</td>
</tr>
<tr>
<td></td>
<td>1=a few times</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2=sometimes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3=many times</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4=all the time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainability Core Ideas</td>
<td></td>
<td>1.239</td>
<td>0.970</td>
</tr>
<tr>
<td>Sustainability Teaching Practices</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Univariate Analysis Results on the Influence of Discipline and Course Contexts on Promising Practices of Teaching and Learning

The second part of the second research question explored the extent to which promising practices of teaching and learning differed across disciplines and course contexts (course type, format, level, and size, and number of credits). I chose to run OLS regressions to explore this part of the second research question given their ability to control for particular course contexts while looking at other courses contexts.

**Data exploration.** Before conducting the OLS regression analyses, I conducted pre-analysis data screening. I tested assumptions of linearity, normality, and homoscedasticity using the following analyses: scatter plot of unstandardized residuals and predicted values, Q-Q plot, and the Kolmogorov-Smirnov test (Heck et al., 2013; Mertler & Reinhart, 2016; Mertler & Vannatta, 2005). Data were approximately linear and homoscedastic. Multicollinearity was not a concern, as evidenced by VIF ≤ 2.5.
Additionally, listwise deletion was used in the analyses; of the 423 participants who reported that they had the opportunity to learn and were retained in the descriptive analyses, 388 were retained for the ensuing OLS regressions. I was unable to discern a pattern for the missingness and deemed the missing values as random.

**Cognitively responsive teaching.** I explored the extent to which cognitively responsive teaching practices differed across disciplines and course contexts by running OLS regressions. I ran three regressions—each with the dependent variable being one of the cognitively responsive teaching scales (subject matter, prior knowledge, and supporting changing views). The independent variables were discipline (each of Biglan’s (1973) disciplinary paradigms), course type (major, elective, and general education), course format (lecture and non-lecture), course level (100, 200, 300, 400 and higher levels), number of credits (1 or 2, 3, and 4), and course size (1-24 students, 25-49 students, 50-74 students, and 75+ students).

Standardized coefficients from these three OLS regressions are presented in Table 18. The reported effects are for the independent variable of interest after controlling for the other independent variables in the model. First, I explored the extent to which cognitively responsive teaching practices differed across disciplines. The first cognitively responsive teaching construct, introducing in-depth subject matter ideas, here, sustainability-related ideas, was higher in applied disciplines than in pure disciplines ($\beta=.207; p \leq .001$) and in life disciplines than in non-life disciplines ($\beta=-.131; p \leq .05$). The second cognitively responsive teaching construct, tapping students’ prior knowledge, here, specifically prior knowledge about sustainability, was higher in soft disciplines than in hard disciplines ($\beta=-.120; p \leq .05$), and in life disciplines than in non-life disciplines ($\beta=-.147; p \leq .01$). Finally, the third cognitively responsive teaching construct, supporting students’ changing views, was higher in applied disciplines than in pure disciplines ($\beta=.155; p \leq .01$). Although the effect sizes were small, a pattern emerges showing that
cognitively responsive teaching about sustainability was present in some disciplines more than others (mainly more present in applied and life disciplines).

Table 18. Standardized Coefficients of Discipline and Course Context Variables on Cognitively Responsive Teaching Practices (N=388)

<table>
<thead>
<tr>
<th>Discipline</th>
<th>CRT1: Subject Matter</th>
<th>CRT2: Prior Knowledge</th>
<th>CRT3: Supporting Changing Views</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard versus soft (hard is the reference group)</td>
<td>.064</td>
<td>.120*</td>
<td>.070</td>
</tr>
<tr>
<td>Pure versus applied (pure is the reference group)</td>
<td>.207***</td>
<td>.095</td>
<td>.155**</td>
</tr>
<tr>
<td>Life versus nonlife (life is the reference group)</td>
<td>-.131*</td>
<td>-.147**</td>
<td>-.091</td>
</tr>
<tr>
<td>Course Type (major is reference group)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>.101</td>
<td>.032</td>
<td>.086</td>
</tr>
<tr>
<td>General Education</td>
<td>.114*</td>
<td>.059</td>
<td>.108</td>
</tr>
<tr>
<td>Course Format (lecture is reference group)</td>
<td>.033</td>
<td>-.039</td>
<td>-.071</td>
</tr>
<tr>
<td>Course Level (reference group is 100-level courses)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 level</td>
<td>-.012</td>
<td>-.114</td>
<td>-.086</td>
</tr>
<tr>
<td>300 level</td>
<td>-.052</td>
<td>-.118</td>
<td>-.073</td>
</tr>
<tr>
<td>400 and higher levels</td>
<td>-.065</td>
<td>-.077</td>
<td>-.101</td>
</tr>
<tr>
<td>Number of Credits (1 or 2 credits is the reference group)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 credits</td>
<td>.126</td>
<td>.051</td>
<td>.255**</td>
</tr>
<tr>
<td>4 credits</td>
<td>-.039</td>
<td>-.012</td>
<td>.105</td>
</tr>
<tr>
<td>Class Size (1-24 students is the reference group)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-49 students</td>
<td>.134</td>
<td>.098</td>
<td>.154*</td>
</tr>
<tr>
<td>50-74 students</td>
<td>-.017</td>
<td>-.092</td>
<td>.045</td>
</tr>
<tr>
<td>75+ students</td>
<td>-.055</td>
<td>-.081</td>
<td>.105</td>
</tr>
<tr>
<td>adj. $R^2$</td>
<td>.013</td>
<td>.086</td>
<td>.117</td>
</tr>
</tbody>
</table>

Note: *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$
Next, I explored the extent to which cognitively responsive teaching practices differed across course contexts. The first cognitively responsive teaching construct, subject matter, was higher in general education courses than in major courses ($\beta=.114; p\leq.05$). The third cognitively responsive teaching construct, supporting students’ changing views, was higher in courses that were worth 3 credits than courses that were worth 1 or 2 credits ($\beta=.255; p\leq.01$). Supporting changing views was also higher in courses that had 25-49 students enrolled when compared with courses that had 1-24 students enrolled ($\beta=.154; p\leq.05$). Given that both of these findings on the third cognitively responsive teaching construct lack consistent patterns within the data, they could be spurious findings. Alternatively, perhaps, these findings could be due to the effect after controlling for the other variables in the model. The second cognitively responsive teaching construct, prior knowledge, was not influenced by any of the course contexts I explored here ($p\geq.05$). Additionally, neither course level, nor course format, was significant across any of the three cognitively responsive teaching scales ($p\geq.05$).

**Teaching for sustainability.** Next, I explored the extent to which teaching for sustainability differed across disciplines and course contexts. I ran two regressions—each with the dependent variable being one of the teaching for sustainability scales (core ideas and teaching practices). The independent variables were the same as the prior set of regressions on the cognitively responsive teaching models (discipline and course contexts). Results are reported in Table 19.

Like all the cognitively responsive teaching scales, there were patterns respecting the extent to which teaching for sustainability differed across disciplines. Soft courses had higher presence of sustainability-specific core ideas ($\beta=.147; p\leq.01$) and sustainability-related teaching practices ($\beta=.138; p\leq.01$) than hard courses. Applied courses had higher presence of sustainability-specific core ideas ($\beta=.150; p\leq.01$) and sustainability-related teaching practices ($\beta=.138; p\leq.01$) than pure courses. Life courses had higher presence of sustainability-specific core ideas ($\beta=-.181; p\leq.001$) and
sustainability-related teaching practices ($\beta = -0.185; p \leq 0.001$) than nonlife courses. Although the effect sizes are small, across the entire teaching for sustainability facet (core ideas and teaching practices), soft (versus hard), applied (versus pure), and life (versus nonlife) disciplines had higher presence.

Table 19. Standardized Coefficients of Discipline and Course Context Variables on Teaching for Sustainability (N=388)

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Teaching for Sustainability: Core Ideas</th>
<th>Teaching for Sustainability: Teaching Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard versus soft (hard is the reference group)</td>
<td>.147**</td>
<td>.138*</td>
</tr>
<tr>
<td>Pure versus applied (pure is the reference group)</td>
<td>.150**</td>
<td>.138**</td>
</tr>
<tr>
<td>Life versus nonlife (life is the reference group)</td>
<td>-.181***</td>
<td>-.185***</td>
</tr>
<tr>
<td>Course Type (major is reference group)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>.138**</td>
<td>.069</td>
</tr>
<tr>
<td>General Education</td>
<td>.216***</td>
<td>.156**</td>
</tr>
<tr>
<td>Course Format (lecture is reference group)</td>
<td>-.020</td>
<td>-.081</td>
</tr>
<tr>
<td>Course Level (reference group is 100-level courses)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 level</td>
<td>.080</td>
<td>.054</td>
</tr>
<tr>
<td>300 level</td>
<td>.020</td>
<td>.010</td>
</tr>
<tr>
<td>400 and higher levels</td>
<td>.078</td>
<td>.019</td>
</tr>
<tr>
<td>Number of Credits (1 or 2 credits is the reference group)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 credits</td>
<td>.139</td>
<td>.094</td>
</tr>
<tr>
<td>4 credits</td>
<td>-.054</td>
<td>-.115</td>
</tr>
<tr>
<td>Class Size (1-24 students is the reference group)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-49 students</td>
<td>.116</td>
<td>.135</td>
</tr>
<tr>
<td>50-74 students</td>
<td>-.286</td>
<td>-.059</td>
</tr>
<tr>
<td>75+ students</td>
<td>-.012</td>
<td>-.017</td>
</tr>
<tr>
<td>adj. $R^2$</td>
<td>.218</td>
<td>.185</td>
</tr>
</tbody>
</table>

Note: *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$
In terms of course contexts, compared with courses that are required for students’ majors, elective courses had higher presence of sustainability-specific core ideas ($\beta=.138; \ p \leq .01$). Additionally, compared with courses that are required for students’ majors, general education courses had higher presence of sustainability-specific core ideas ($\beta=.216; \ p \leq .001$) and sustainability-related teaching practices ($\beta=.156; \ p \leq .01$). In sum, it seems like students experience OTL slightly more in major coursework, but general education courses that have OTL have better teaching practices than major courses. Neither course level, nor course format, nor course size, nor number of credits was significant in either of the teaching for sustainability scales ($p \geq .05$).

**Structural Equation Modeling**

The next part of this study analyzed the structural relationships between opportunity to learn about sustainability, experiencing promising practices of teaching and learning, and transformative sustainability learning outcomes. Structural Equation Modeling (SEM) was advantageous to the present study because it allowed for the testing of a posited model, provided the ability to confirm theoretically driven, hypothetical relationships, and allowed for the study of multiple endogenous variables (Byrne, 2013; Hancock & Mueller, 2013; Hox & Becher, 2007; Kaplan, 2000; Mueller & Hancock, 2008). In the subsequent sections, I detail the specific SEM process (including rationales for decisions and equations), as well as the results.

**Data Exploration**

In addition to the variables I have used thus far, moving forward into the SEM section of this study, I also used the transformative sustainability learning outcome variables. By conducting analysis of frequencies, I found a problem in the response distribution in the attitude learning outcome items, which was that there was not 5% of
responses spread across each response option. This could be because all participants have strong sustainability attitudes, or more likely, that these items fell privy to social desirability bias. It is worth noting here that given the high response on the sustainability attitude items, ensuing analyses may suffer from truncated range, or a ceiling effect, given that responses were so high and had little room for improvement. A ceiling effect can be defined as “a measurement limitation that occurs when the highest possible score or close to the highest score on a test or measurement instrument is reached, thereby decreasing the likelihood that the testing instrument has accurately measured the intended domain” (Taylor, 2010, p. 133). Moving forward, though, in order to better distribute responses, I collapsed the “strongly disagree, disagree, and somewhat disagree” responses into one category called “disagree,” thereby leaving responses in a four-point scale (disagree, somewhat agree, agree, and strongly agree). It is worth noting here that unlike the analysis for research question 2, I included all participants here (including both those who did, and those who did not, have the opportunity to learn about sustainability).

**Factor Analyses**

Before running the SEM, I conducted two types of factor analytic methods: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

**Exploratory factor analyses.** I conducted EFAs before running CFAs to explore the factor structure using my theoretically driven model (Bandalos & Finney, 2001; Pett et al., 2003). Given that I already ran EFAs for the promising practices of teaching and learning for the second research question, here I ran EFAs with no rotation on the opportunity to learn variables and on the sustainability learning outcome variables.

With regard to the OTL items, I ran an EFA, which demonstrated that all five items about course contexts for which students had the opportunity to learn (major, general education, electives, lectures, and non-lectures) held as one factor, and as such, all five items were retained. The opportunity to learn variables had strong loadings (from .711 to
and Cronbach’s alphas of .873. The percent of variance explained in item response in each construct, for a one-factor solution, ranged from 34.6% to 59.8%.

Next, I ran two EFAs on the sustainability attitude learning outcomes, one on the 11 items in the pre-survey responses and one on the 11 items in the post-survey responses. Given the acceptable to strong factor loadings (from .432 to .734) and strong Cronbach’s alphas (.856 and .886) in both the pre- and post-survey results, all 11 items were retained in the attitude learning outcome constructs.

Following, I ran EFAs on the sustainability-related behaviors. Guided by prior literature that distinguishes between private and public behaviors (Hadler & Haller, 2011, 2013; Hunter et al., 2004; Stern, 2000; Yates et al., 2015), I first examined the five private behavior items in the surveys. However, in neither the pre-survey data, nor the post-survey data, did the five private behaviors hold together with strong loadings. Because I did not want to immediately remove these private behavior items, I decided to run an EFA with all of the behavior items, including both the private and the public behaviors. Interestingly, two of what I had previously classified as “private” behaviors loaded with the “public” behaviors. When I looked at these two items (limit meat consumption and limit water use), it became clear that these two previous “private” behaviors were connected with what I previously called “public” behaviors. In common among all of these behaviors is a deep commitment to sustainability, beyond such simplistic behaviors as turning off the lights. Instead, these behaviors require connecting sustainably-related thoughts to actions, engaging in activist-like behaviors, taking part in behaviors that potentially have implications on society, and are not “easy,” but require some work. Taken together, these nine behavior items had strong factor loadings (from .471 to .754) and strong Cronbach’s alphas (.820 and .821) in both the pre- and post-survey results of these nine behavior items. As such, given the theoretical and statistical evidence, these nine items were retained as one construct.
The four factors for sustainability learning outcomes (pre-attitudes, post-attitudes, pre-behaviors, and post-behaviors) and one opportunity to learn factor were retained. All the items had loadings above .4. In fact, only three factor loadings were below .5. Cronbach’s alphas were all greater than .763, indicating good scale reliability. The Kaiser-Meyer-Olkin Measure (KMO) of sampling adequacy was sufficient. The KMO was above .695 for all factors. Bartlett’s test of sphericity was significant for all factors.

It is worth noting here that I did not run EFAs on the knowledge items because they are dichotomous (yes=the question was responded to correctly, no= the question was responded to incorrectly), and EFA is not appropriate to run on dichotomous variables.

**Confirmatory factor analyses.** Subsequently, I conducted CFAs because this factor analysis method allows for the testing of a priori specified theoretical models relating latent to measured variables (Bandalos & Finney, 2001; Brown, 2006; Byrne, 2013; Kline, 2015). Hence, based on the findings of the EFAs reported in the previous section, I conducted CFA on the constructs of interest in order to confirm their factor structures and determine the strength of the influence of each survey item on its corresponding factor. In each CFA model, I allowed the item loadings and error terms to be freely estimated and constrained the factor variances to one.

I fit individual CFA models for each of the constructs of interest (1) pre-attitudes, (2) post-attitudes, (3) pre-behaviors, (4) post-behaviors, (5) opportunity to learn, cognitively responsive teaching, (6) subject matter, (7) prior knowledge, and (8) supporting changing views, and teaching for sustainability, (9) core ideas, (10) teaching practices, (11) pre-knowledge, and (12) post knowledge). CFA results indicated that all constructs of interest held with strong model fits (ranging from RMSEA=.073 to .036, CFI= .889 to .990, SRMR=.051 to .022), and factor loadings with the exception of 3 constructs (teaching for sustainability subject matter, pre-knowledge, and post-knowledge).
The results of the CFA for the teaching for sustainability core ideas construct indicated that an adjustment needed to be made for a better model fit. The RMSEA was greater than 1, and the Lagrange Multiplier test indicated intercorrelated items among three survey items (environmental justice, relating oppression of subordinate human groups to the oppression of nature, and eliminating poverty). When I investigated the wording of these three items, they seemed to tap the same idea—the social, or equity, dimension of the sustainability concept. The intercorrelation revealed that these constructs had high correlations and would lead to multicollinearity problems in the model. As a result, two items (relating oppression of subordinate human groups to the oppression of nature, and eliminating poverty) were removed to improve fit. This important idea, central to the concept of sustainability, is still present in the construct, albeit through the “environmental justice” item.

Furthermore, in running the EFAs, I omitted the pre- and post-survey knowledge items because they were binary variables coded as 0=incorrect and 1=correct. Because Zwickle et al. (2014) had previously validated this construct, I felt comfortable running CFAs on these items without having first run the EFAs. Thus, I ran a CFA model on the full set of 12 sustainability knowledge items; unfortunately, the full set of 12 items was not useable to include in the model because the individual item loadings were very low (below .4). Moving forward, I tried to run a variety of CFA models with combinations of items guided by theory and results of Lagrange Multiplier tests that were theoretically defensible. For instance, I fit a model including only the items that were environmentally focused with strong loadings, and a model including only items that were about

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1Due to the fact that sustainability-related knowledge is critical for student learning, and because it did not hold in a CFA, I summed the correct number of answers (out of a total of 12 survey items). Instead of a scale, I treated knowledge as a composite, as it was the sum of correct responses. Ad hoc analyses testing sustainability knowledge learning outcomes can be found in Appendix H.
definitions of key sustainability terms that had strong loadings. Neither model had adequate fit.

After fitting several additional models on the knowledge items, I realized that a small subset of questions was not truly tapping into the full idea of knowledge as previously hoped. I concluded that these items were not reliable enough to produce a factor structure with adequate fit as loadings were not approaching the .5 cutoff. Accordingly, I updated my posited structural model in order to remove the pre-knowledge construct, post-knowledge construct, and all associated paths. After removing the knowledge paths, the updated model that I tested is presented in Figure 7. Removing the knowledge learning outcomes from this study does, though, present a limitation, as the literature (Chalkley, 2006; Sipos et al., 2008; Svanström et al., 2008) has previously stipulated that sustainability outcomes are knowledge, attitudes, and behaviors. Per se, future research ought to investigate sustainability-specific knowledge learning outcomes.

Figure 7. Revised Structural Model
Measurement Models

Moving forward, I next ran a CFA model that allowed the 10 remaining constructs to correlate freely. Additionally, I constrained the loadings of the pre- and post-attitudes, and the pre- and post-behaviors, to be equal. I constrained the pre- with the post- items because they were the exact same items, given to the exact same participants, at two different points in time. As such, I expected that the measure was behaving in the same way at both time points, and therefore, the loadings should be constrained to be equal (Byrne, 2013; Hancock & Mueller, 2013; Kline, 2015). The system of equations for the intercorrelated CFAs, also recognized as my measurement model, can be seen in Equation 1. In addition to what is shown in these equations, all factors were allowed to correlate as seen in Figure 8.

This measurement model had acceptable model fit (RMSEA=.032, CFI=.912, SRMR=.057). Additional evidence of a model with good psychometric properties lies in the loadings. The model had standardized loadings that range from .413 to .934. Only four items had loadings less than .5. All four of these loadings below .5 were dispersed across the learning outcome constructs, and not all located in same construct. Thirty-seven out of the 78 items had loadings that were greater than .7. Coefficient H values also indicated strong factor reliability, ranging from .83 to .95. The individual items, standardized loadings, and factor reliabilities can be found in Table 20.
Figure 8. Measurement Model
Equation 1. Measurement Equations
1 = \( b_{F1A1} \times F1 + E1 \)
A2 = \( b_{F1A2} \times F1 + E2 \)
A3 = \( b_{F1A3} \times F1 + E3 \)
A4 = \( b_{F1A4} \times F1 + E4 \)
A5 = \( b_{F1A5} \times F1 + E5 \)
A6 = \( b_{F1A6} \times F1 + E6 \)
A7 = \( b_{F1A7} \times F1 + E7 \)
A8 = \( b_{F1A8} \times F1 + E8 \)
A9 = \( b_{F1A9} \times F1 + E9 \)
A10 = \( b_{F1A10} \times F1 + E10 \)
A11 = \( b_{F1A11} \times F1 + E11 \)
1 = \( b_{F2B1} \times F2 + E1 \)
B2 = \( b_{F2B2} \times F2 + E2 \)
B3 = \( b_{F2B3} \times F2 + E3 \)
B4 = \( b_{F2B4} \times F2 + E4 \)
B5 = \( b_{F2B5} \times F2 + E5 \)
B6 = \( b_{F2B6} \times F2 + E6 \)
B7 = \( b_{F2B7} \times F2 + E7 \)
B8 = \( b_{F2B8} \times F2 + E8 \)
B9 = \( b_{F2B9} \times F2 + E9 \)
1 = \( b_{F3O1} \times F3 + E1 \)
O2 = \( b_{F3O2} \times F3 + E2 \)
O3 = \( b_{F3O3} \times F3 + E3 \)
O4 = \( b_{F3O4} \times F3 + E4 \)
O5 = \( b_{F3O5} \times F3 + E5 \)
1 = \( b_{F4CS1} \times F4 + E1 \)
CS2 = \( b_{F4CS2} \times F4 + E2 \)
CS3 = \( b_{F4CS3} \times F4 + E3 \)
CS4 = \( b_{F4CS4} \times F4 + E4 \)
CS5 = \( b_{F4CS5} \times F4 + E5 \)
1 = \( b_{F5CP1} \times F5 + E1 \)
CP2 = \( b_{F5CP2} \times F5 + E2 \)
CP3 = \( b_{F5CP3} \times F5 + E3 \)
CP4 = \( b_{F5CP4} \times F5 + E4 \)
CP5 = \( b_{F5CP5} \times F5 + E5 \)
CP6 = \( b_{F5CP6} \times F5 + E6 \)
CP7 = \( b_{F5CP7} \times F5 + E7 \)
1 = \( b_{F6CC1} \times F6 + E1 \)
CC2 = \( b_{F6CC2} \times F6 + E2 \)
CC3 = \( b_{F6CC3} \times F6 + E3 \)
1 = \( b_{F7SM1} \times F7 + E1 \)
SM2 = \( b_{F7SM2} \times F7 + E2 \)
SM3 = \( b_{F7SM3} \times F7 + E3 \)
SM4 = \( b_{F7SM4} \times F7 + E4 \)
SM5 = \( b_{F7SM5} \times F7 + E5 \)
\[ \begin{align*}
SM6 &= b_{F7SM6} F7 + E6 \\
SM7 &= b_{F7SM7} F7 + E7 \\
SM8 &= b_{F7SM8} F7 + E8 \\
SM9 &= b_{F7SM9} F7 + E9 \\
1 &= b_{F8TP} F8 + E1 \\
TP2 &= b_{F8TP2} F8 + E2 \\
TP3 &= b_{F8TP3} F8 + E3 \\
TP4 &= b_{F8TP4} F8 + E4 \\
TP5 &= b_{F8TP5} F8 + E5 \\
TP6 &= b_{F8TP6} F8 + E6 \\
TP7 &= b_{F8TP7} F8 + E7 \\
TP8 &= b_{F8TP8} F8 + E8 \\
TP9 &= b_{F8TP9} F8 + E9 \\
1 &= b_{F9PA} F9 + E1 \\
PA2 &= b_{F9PA2} F9 + E2 \\
PA3 &= b_{F9PA3} F9 + E3 \\
PA4 &= b_{F9PA4} F9 + E4 \\
PA5 &= b_{F9PA5} F9 + E5 \\
PA6 &= b_{F9PA6} F9 + E6 \\
PA7 &= b_{F9PA7} F9 + E7 \\
PA8 &= b_{F9PA8} F9 + E8 \\
PA9 &= b_{F9PA9} F9 + E9 \\
PA10 &= b_{F9PA10} F9 + E10 \\
PA11 &= b_{F9PA11} F9 + E11 \\
1 &= b_{F10PB} F10 + E1 \\
PB2 &= b_{F10PB2} F10 + E2 \\
PB3 &= b_{F10PB3} F10 + E3 \\
PB4 &= b_{F10PB4} F10 + E4 \\
PB5 &= b_{F10PB5} F10 + E5 \\
PB6 &= b_{F10PB6} F10 + E6 \\
PB7 &= b_{F10PB7} F10 + E7 \\
PB8 &= b_{F10PB8} F10 + E8 \\
PB9 &= b_{F10PB9} F10 + E9
\end{align*} \]
Table 20. Confirmatory Factor Analysis Factor Loadings and Reliabilities

<table>
<thead>
<tr>
<th>Construct</th>
<th>Survey Item</th>
<th>Factor Loading</th>
<th>Coefficient H</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sustainability Learning Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pre-Survey: Attitudes</strong></td>
<td>Equal rights for all people strengthen a community.</td>
<td>.621</td>
<td>.87</td>
</tr>
<tr>
<td></td>
<td>Community cooperation is necessary to solve social problems.</td>
<td>.692</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generally speaking consumerism is not sustainable.</td>
<td>.435</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access to clean water is a universal human right.</td>
<td>.609</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I am willing to put forth a little more effort in my daily life to reduce my environmental impact.</td>
<td>.676</td>
<td></td>
</tr>
<tr>
<td></td>
<td>An unsustainable economy values personal wealth at the cost of others.</td>
<td>.515</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I believe that many people can work together to solve global problems.</td>
<td>.619</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clean air is part of a good life.</td>
<td>.622</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our present consumption of natural resources will result in serious environmental challenges for generations.</td>
<td>.686</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The well-being of others affects me.</td>
<td>.577</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biological diversity in itself is good.</td>
<td>.586</td>
<td></td>
</tr>
<tr>
<td><strong>Post-Survey: Attitudes</strong></td>
<td>Equal rights for all people strengthen a community.</td>
<td>.721</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Community cooperation is necessary to solve social problems.</td>
<td>.698</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generally speaking consumerism is not sustainable.</td>
<td>.413</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access to clean water is a universal human right.</td>
<td>.612</td>
<td>.89</td>
</tr>
<tr>
<td></td>
<td>I am willing to put forth a little more effort in my daily life to reduce my environmental impact.</td>
<td>.686</td>
<td></td>
</tr>
<tr>
<td></td>
<td>An unsustainable economy values personal wealth at the cost of others.</td>
<td>.544</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I believe that many people can work together to solve global problems.</td>
<td>.653</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clean air is part of a good life.</td>
<td>.695</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our present consumption of natural resources will result in serious environmental challenges for generations.</td>
<td>.664</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The well-being of others affects me.</td>
<td>.583</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biological diversity in itself is good.</td>
<td>.664</td>
<td></td>
</tr>
<tr>
<td>Construct</td>
<td>Survey Item</td>
<td>Factor Loading</td>
<td>Coefficient H</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Sustainability Learning Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Survey: Behaviors</td>
<td>Sign a petition.</td>
<td>.569</td>
<td>.83</td>
</tr>
<tr>
<td></td>
<td>Take part in a protest or demonstration.</td>
<td>.564</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Participate in a community or environmentally-focused club or organization.</td>
<td>.521</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoid companies with harmful practices.</td>
<td>.722</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoid using or buying certain products.</td>
<td>.691</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Choose locally-owned businesses over larger chains.</td>
<td>.542</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Try to convince a friend not to buy bottled water.</td>
<td>.602</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limit meat consumption.</td>
<td>.478</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limit water use.</td>
<td>.527</td>
<td></td>
</tr>
<tr>
<td>Post-Survey: Behaviors</td>
<td>Sign a petition.</td>
<td>.528</td>
<td>.84</td>
</tr>
<tr>
<td></td>
<td>Take part in a protest or demonstration.</td>
<td>.509</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Participate in a community or environmentally-focused club or organization.</td>
<td>.522</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoid companies with harmful practices.</td>
<td>.724</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoid using or buying certain products.</td>
<td>.712</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Choose locally-owned businesses over larger chains.</td>
<td>.562</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Try to convince a friend not to buy bottled water.</td>
<td>.617</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limit meat consumption.</td>
<td>.496</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limit water use.</td>
<td>.583</td>
<td></td>
</tr>
<tr>
<td>Opportunity to Learn</td>
<td>Major Courses</td>
<td>.735</td>
<td>.89</td>
</tr>
<tr>
<td></td>
<td>General Education Courses</td>
<td>.709</td>
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</tr>
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<td></td>
<td>Electives</td>
<td>.755</td>
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<td></td>
<td>Lectures</td>
<td>.884</td>
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</tr>
<tr>
<td></td>
<td>Non-lectures</td>
<td>.726</td>
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</table>
### Table 20 (continued)

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<thead>
<tr>
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<th>Factor Loading</th>
<th>Coefficient H</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sustainability Learning Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitively Responsive Teaching 1: Subject Matter</td>
<td>The instructor introduced, in-depth, a concept related to sustainability.</td>
<td>.886</td>
<td>.95</td>
</tr>
<tr>
<td></td>
<td>The instructor explained the sustainability-related concept in a few different ways.</td>
<td>.895</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The instructor introduced how sustainability is connected to course content.</td>
<td>.873</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The instructor taught sustainability in a logical order.</td>
<td>.897</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The instructor taught me how to think about sustainability.</td>
<td>.893</td>
<td></td>
</tr>
<tr>
<td>Cognitively Responsive Teaching 2: Prior Knowledge</td>
<td>My own personal experiences to help me learn about sustainability.</td>
<td>.771</td>
<td>.90</td>
</tr>
<tr>
<td></td>
<td>My high school coursework to help me learn about sustainability</td>
<td>.630</td>
<td></td>
</tr>
<tr>
<td></td>
<td>My other college coursework to help me learn about sustainability.</td>
<td>.667</td>
<td></td>
</tr>
<tr>
<td></td>
<td>My social roles and culture (e.g., race, socioeconomic status, gender, sexuality, ethnicity, religion) to help me learn about sustainability.</td>
<td>.766</td>
<td></td>
</tr>
<tr>
<td></td>
<td>My family to help me learn about sustainability.</td>
<td>.785</td>
<td></td>
</tr>
<tr>
<td></td>
<td>My friends to help me learn about sustainability.</td>
<td>.795</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The media to help me learn about sustainability.</td>
<td>.770</td>
<td></td>
</tr>
<tr>
<td>Cognitively Responsive Teaching 3: Supporting Changing Views</td>
<td>The instructor helped me realize the differences or similarities between what I knew about sustainability before the class and what I learned about sustainability in the class.</td>
<td>.913</td>
<td>.93</td>
</tr>
<tr>
<td></td>
<td>The instructor helped me work through differences between what I knew about sustainability before the class and what I learned about sustainability in the class.</td>
<td>.934</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The instructor supported me if and when I felt challenged by the sustainability content.</td>
<td>.794</td>
<td></td>
</tr>
</tbody>
</table>
Table 20 (continued)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Survey Item</th>
<th>Factor Loading</th>
<th>Coefficient H</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sustainability Learning Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching for Sustainability: Core Ideas</td>
<td>Defining Sustainability</td>
<td>.842</td>
<td>.94</td>
</tr>
<tr>
<td></td>
<td>Environmental Crises</td>
<td>.828</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Future Generations</td>
<td>.809</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Economic sustainability</td>
<td>.802</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resource Management</td>
<td>.744</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Challenging human-centered views of the environment</td>
<td>.849</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valuing all living things</td>
<td>.701</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valuing the ecological system</td>
<td>.805</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental justice</td>
<td>.657</td>
<td></td>
</tr>
<tr>
<td>Teaching for Sustainability: Teaching Practices</td>
<td>In the context of the area I live in (like Michigan)</td>
<td>.785</td>
<td>.93</td>
</tr>
<tr>
<td></td>
<td>In the context of my school (like MSU)</td>
<td>.795</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In the context of current events (like the Flint, Michigan water crisis)</td>
<td>.766</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In a way that made me feel empowered to be more sustainable</td>
<td>.851</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Case study</td>
<td>.630</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group discussion</td>
<td>.720</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Debate</td>
<td>.672</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mindfulness</td>
<td>.775</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learning who I am in relation to the larger purpose of life</td>
<td>.789</td>
<td></td>
</tr>
</tbody>
</table>

In Table 21, I report the intercorrelations among the 10 constructs. It is worth mentioning here that several constructs had high correlations including the pre- and post-responses for the attitudes (.805) and behaviors (.847); these high correlations make sense though, as they are the exact same items asked at two points in time. The two teaching for sustainability constructs, sustainability core ideas and sustainability teaching practices, also had a high correlation (.886), but I chose to keep them as distinct given that they are tapping the different concepts of core ideas and pedagogies. Even with these three relatively high correlations, considering the strength of the model fit, and the absence of linearity in the model, I accepted this as the final measurement model. Investigation of
<table>
<thead>
<tr>
<th></th>
<th>CRT1</th>
<th>CRT2</th>
<th>CRT3</th>
<th>TFS: CI</th>
<th>TFS: TP</th>
<th>OTL</th>
<th>Pre-Attitudes</th>
<th>Post-Attitudes</th>
<th>Pre-Behaviors</th>
<th>Post-Behaviors</th>
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</thead>
<tbody>
<tr>
<td>CRT1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRT2</td>
<td>.563</td>
<td>1</td>
<td></td>
<td>.647</td>
<td>.517</td>
<td>.592</td>
<td>.592</td>
<td>.520</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRT3</td>
<td>.716</td>
<td>.669</td>
<td>1</td>
<td>.610</td>
<td>.569</td>
<td>.628</td>
<td>.628</td>
<td>.580</td>
<td>.520</td>
<td></td>
</tr>
<tr>
<td>TFS: CI</td>
<td>.647</td>
<td>.517</td>
<td>.592</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFS: TP</td>
<td>.610</td>
<td>.569</td>
<td>.628</td>
<td>.886</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>OTL</td>
<td>.498</td>
<td>.423</td>
<td>.390</td>
<td>.580</td>
<td>.520</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Attitudes</td>
<td>.097</td>
<td>.036</td>
<td>.026</td>
<td>.051</td>
<td>.048</td>
<td>.065</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Attitudes</td>
<td>.087</td>
<td>.053</td>
<td>.028</td>
<td>.033</td>
<td>.031</td>
<td>.026</td>
<td>.805</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Behaviors</td>
<td>.066</td>
<td>.201</td>
<td>.129</td>
<td>.207</td>
<td>.231</td>
<td>.271</td>
<td>.435</td>
<td>.343</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Post-Behaviors</td>
<td>.129</td>
<td>.276</td>
<td>.153</td>
<td>.275</td>
<td>.310</td>
<td>.305</td>
<td>.359</td>
<td>.317</td>
<td>.847</td>
<td>1</td>
</tr>
</tbody>
</table>
the intercorrelations among the benchmarks suggests that the 10 constructs in the model while related, were in fact distinct.

**Structural Models**

After determining the psychometric properties of the model, as well as determining adequate model fit, I moved forward with testing the posited structural model (Figure 7) in order to respond to the third and fourth research questions.

Proceeding, I created the structural equation for the posited structural model. A structural equation is a regression-type equation that expresses each endogenous variable as a function of all elements having a direct structural effect on it (Mueller & Hancock, 2008). Below, in Equation 2, I present the system of structural equations for the present study. In the structural model, I allowed errors to correlate to account for the dependency in item responses for the pre- and post- resulting from the same sample being asked identical questions at two time points. These error correlations do not appear in the equations. However, examples of the correlated paired errors are A1 pre-survey with A1 post-survey, and A2 pre-survey with A2 post-survey, and so on. Further, it is worth noting that it was not necessary to allow any errors to correlate in the measurement models because we are only looking at one point in time, so there is not a two-time issue.

Equation 2. Structural Equations

\[
\begin{align*}
F3 &= b_{F3F1}*F1 + b_{F3F2}*F2 + b_{F3V1}*V1 + b_{F3V2}*V2 + b_{F3V3}*V3 + D3 \\
F4 &= b_{F4F3}*F4 + D4 \\
F5 &= b_{F5F3}*F5 + D5 \\
F6 &= b_{F6F3}*F6 + D6 \\
F7 &= b_{F7F3}*F7 + D7 \\
F8 &= b_{F8F3}*F8 + D8 \\
F9 &= b_{F9F1}*F1 + b_{F9F2}*F2 + b_{F9F3}*F3 + b_{F9F4}*F4 + b_{F9F5}*F5 + b_{F9F6}*F6 + b_{F9F7}*F7 + b_{F9F8}*F8 + b_{F9V1}*V1 + b_{F9V2}*V2 + b_{F9V3}*V3 + D9 \\
F10 &= b_{F10F3}*F3 + b_{F10F2}*F2 + b_{F10F3}*F3 + b_{F10F4}*F4 + b_{F10F5}*F5 + b_{F10F6}*F6 + b_{F10F7}*F7 + b_{F10F8}*F8 + b_{F10V1}*V1 + b_{F10V2}*V2 + b_{F10V3}*V + D10
\end{align*}
\]
First, I ran the structural model with the paired pre-post correlated items. This model had a borderline-acceptable model fit (RMSEA= .031, CFI=.903, SRMR=.076). As such, I then consulted with the Lagrange Multiplier (LM) test in order to assist with model re-specification. The LM test found that additional error correlations of individual items could increase the fit, which I did because this deals with the measurement model rather than the structural model, so the questions regarding the structural model still held. As such, I added the following error correlations among individual items: A3 with A6, PA1 with PA8, PA1 with PA11, PA2 with PA7, PA3 with PA6, PB7 with PB8, OTL1 with OTL4, TP1 with TP3, and TP6 with TP7. When I ran this re-specified SEM, the results showed a stronger model fit (RMSEA= .028, CFI=.918, SRMR=.072). According to Hu and Bentler (1999), ideal fit indices are RMSEA ≤.06 and SRMR ≤.008, which this model falls into. In terms of CFI, Hu and Bentler advise ideally ≥.95, but ≥.90 indicates appropriate fit. The CFI for this model is slightly greater than .90. As such, although not a perfect fit, this model is certainly a good fit. Results will be discussed below, in responding to the third and fourth research questions.

Results of Research Question 3

Next, I turned to the results for the third research question, which asked: Does opportunity to learn influence cognitively responsive teaching and teaching for sustainability? And, do opportunity to learn, cognitively responsive teaching, and teaching for sustainability influence learning outcomes? To answer this question, I tested two parts of the posited structural model (opportunity to learn and promising practices of teaching and learning) using SEM. First, I examined the paths between opportunity to learn and cognitively responsive teaching, and the paths between opportunity to learn and
teaching for sustainability. Second, I tested the paths between opportunity to learn, cognitively responsive teaching, and teaching for sustainability with learning outcomes.

**Direct Effect Between Opportunity to Learn and Promising Practices of Teaching and Learning**

First, I examined if opportunity to learn influence d promising practices of teaching and learning. I examined the direct effects of opportunity to learn on cognitively responsive teaching and teaching for sustainability by looking at the standardized betas, which isolate one portion of the structural model, highlighted in red in Figure 9. Standardized betas of the paths between opportunity to learn and each of the promising practices of teaching and learning are presented in Table 22.

All five of these paths under investigation were statistically significant ($p \leq 0.001$), and had strong effect sizes (ranging from .507 to .674). In other words, opportunity to learn about sustainability did influence promising practices of teaching and learning about sustainability. More specifically, opportunity to learn about sustainability influenced all three cognitively responsive teaching constructs, and opportunity to learn influenced both teaching for sustainability constructs. These results indicate that the more students have the opportunity to learn about sustainability, the more the one course that had the most sustainability content also had the most promising practices of teaching and learning. These results reveal that the more opportunity to learn about sustainability students have, the more likely they are to experience promising practices of teaching and learning around the sustainability-related core ideas. On the whole, the influence of opportunity to learn on practices of teaching and learning is strong.
Figure 9. Highlighted Structural Model for Paths Between Opportunity to Learn and Promising Practices of Teaching and Learning
Table 22. Direct Effects of Opportunity to Learn on Cognitively Responsive Teaching and Teaching for Sustainability

<table>
<thead>
<tr>
<th></th>
<th>Standardized Betas (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitively Responsive Teaching: Subject Matter</td>
<td>.586***</td>
</tr>
<tr>
<td>Cognitively Responsive Teaching: Prior Knowledge</td>
<td>.523***</td>
</tr>
<tr>
<td>Cognitively Responsive Teaching: Supporting Changing Views</td>
<td>.507***</td>
</tr>
<tr>
<td>Teaching for Sustainability: Core Ideas</td>
<td>.674***</td>
</tr>
<tr>
<td>Teaching for Sustainability: Teaching Practices</td>
<td>.638***</td>
</tr>
</tbody>
</table>

Note: *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001

**Direct Effect Between Opportunity to Learn and Learning and Learning Outcomes, and between Promising Practices of Teaching and Learning and Learning Outcomes**

Next, I examined direct effects of opportunity to learn on learning outcomes, as well as direct effects of promising practices of teaching and learning on learning outcomes. As seen in Table 23, opportunity to learn did not influence either the attitude learning outcomes or the behavior learning outcomes (p≥.05). Additionally, neither of the two teaching for sustainability constructs influenced attitude learning outcomes nor the behavior learning outcomes (p≥.05). None of the three cognitively responsive teaching constructs influenced attitude learning outcomes (p≥.05). However, while the first and third cognitively responsive teaching constructs did not influence behavior learning outcomes (p≥.05), when students’ teachers tapped their prior knowledge about sustainability (cognitively responsive teaching construct 2), students increased their pro-sustainability behaviors between the beginning and end of the semester (β=.116, p≤.05). For a one standard deviation increase in the second cognitively responsive teaching construct, there is an expected .116 standard deviation increase in students’ pro-sustainability behaviors. Neither of the teaching for sustainability constructs had a significant influence on learning outcomes. Overall, as seen here, whether or not students had the opportunity to learn about sustainability, and the extent to which they...
experienced promising practices of teaching and learning, largely did not influence their learning outcomes, except in the case of the second cognitively responsive teaching construct and pro-sustainability behavior learning outcomes.

Table 23. Direct Effects of Opportunity to Learn on Cognitively Responsive Teaching and Teaching for Sustainability on Learning Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Attitudes</th>
<th>Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opportunity to learn</td>
<td>-.081</td>
<td>.045</td>
</tr>
<tr>
<td>Cognitively Responsive Teaching 1 (subject matter)</td>
<td>.070</td>
<td>-.008</td>
</tr>
<tr>
<td>Cognitively Responsive Teaching 2 (prior knowledge)</td>
<td>.055</td>
<td>.116*</td>
</tr>
<tr>
<td>Cognitively Responsive Teaching 3 (supporting changing views)</td>
<td>-.039</td>
<td>-.110</td>
</tr>
<tr>
<td>Teaching for Sustainability Core Ideas</td>
<td>.006</td>
<td>-.053</td>
</tr>
<tr>
<td>Teaching for Sustainability Teaching Practices</td>
<td>-.022</td>
<td>.157</td>
</tr>
</tbody>
</table>

Note: *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001

**Direct Effects, Indirect Effects, and Total Effects on Learning Outcomes**

Next, I examined the effects of opportunity to learn on post-attitudes and post-behaviors via the promising practices of teaching and learning practices (cognitively responsive teaching and teaching for sustainability), as illustrated by the highlighted portion of the model in Figure 10, and presented in Table 24. Here, I studied the direct, indirect, and total effects. I used the non-bias corrected boot-strap method to test for indirect effects.

First, I examined the influence of opportunity to learn on post-attitudes. Results indicated that opportunity to learn did not significantly directly affect post-attitudes (p ≥ .05). Next, I examined the combined indirect effect of opportunity to learn on post-attitudes via the promising practices of teaching and learning. Like the direct effect, results indicated that opportunity to learn did not significantly indirectly affect post-attitudes (p ≥ .05). Finally, I examined the total influence (combining the direct and indirect effects) of opportunity to learn on post-attitudes and found that the total effect
Figure 10. Highlighted Structural Model for Paths Between Opportunity to Learn, Promising Practices of Teaching and Learning, and Learning Outcomes
Table 24. Direct, Indirect, and Total Effects of Opportunity to Learn, Cognitively Responsive Teaching, and Teaching for Sustainability on Sustainability Learning Outcomes

<table>
<thead>
<tr>
<th>Construct</th>
<th>Attitude Learning Outcomes</th>
<th>Behavior Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct</td>
<td>Indirect</td>
</tr>
<tr>
<td>OTL</td>
<td>-0.081</td>
<td>0.040</td>
</tr>
<tr>
<td>CRT1</td>
<td>0.070</td>
<td>0.041</td>
</tr>
<tr>
<td>CRT2</td>
<td>0.055</td>
<td>0.029</td>
</tr>
<tr>
<td>CRT3</td>
<td>-0.039</td>
<td>-0.020</td>
</tr>
<tr>
<td>TfS SM</td>
<td>0.006</td>
<td>0.004</td>
</tr>
<tr>
<td>TfS TP</td>
<td>0.022</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Note: *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001

was not significant (p≥.05). Overall, here, I found that opportunity to learn did not influence post-attitudes.

Subsequently, I examined the influence of opportunity to learn on post-behaviors. Results indicate that opportunity to learn did not significantly directly affect post-behaviors (p≥.05). I then examined the combined indirect effect of opportunity to learn on post-behaviors via the promising practices of teaching and learning. Results once again indicated that opportunity to learn did not significantly indirectly affect post-behaviors (p≥.05). Next, I examined the total influence (combining the direct and indirect effects) of opportunity to learn on post-behaviors and found that the total effect was significant (β=110**, p≥.05).

In terms of pro-sustainability behavior learning outcomes, the direct influence of opportunity to learn on behaviors was not significant; additionally, the indirect influence was not significant. However, when looking at the direct and indirect effects combined, the total effect was significant. This can be construed as unusual because neither the direct nor indirect effect was significant when looked at on their own. As such, in order to investigate this further, I examined the five individual indirect effects between
opportunity to learn and behavior learning outcomes and found that only one was statistically significant, which was the second cognitively responsive teaching construct (the indirect effect was $\beta=.061$, $p\leq.01$). The significance of the second cognitively responsive teaching construct is perhaps contributing to the significant total effect in the influence of opportunity to learn on behavior learning outcomes. In addition to likely contributing to the overall influence of opportunity to learn on behavior learning outcomes, the indirect effect of the second cognitively responsive teaching construct on behavior learning outcomes is also important to note, as it is the only significant path, and thus the strongest path.

Table 25 provides the means and standard deviations of students’ pre- and post-learning outcomes of attitudes and behaviors. Using paired-sample t-tests (since the same set of students and the same set of survey items were being compared), I found that change between the pre- and post-survey was not significant ($p\geq.05$). Overall the learning across the semester was insignificant. The fact that the growth is minimal can help explain the lack of significant effect of the teaching practices on sustainability learning outcomes in a semester—perhaps this kind of learning takes longer than a semester.

Table 25. Pre- and Post-Attitude and Behavior Learning Outcomes (N=644)

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Coding</th>
<th>Survey</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitudes</td>
<td>1=Disagree</td>
<td>Pre-</td>
<td>3.2992</td>
<td>.502</td>
</tr>
<tr>
<td></td>
<td>2=Somewhat agree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3=Agree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4=Strongly agree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-</td>
<td></td>
<td>3.3049</td>
<td>.518</td>
</tr>
<tr>
<td>Behaviors</td>
<td>1=Never</td>
<td>Pre-</td>
<td>3.1348</td>
<td>.736</td>
</tr>
<tr>
<td></td>
<td>2=Rarely</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3=Sometimes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4=Often</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lastly, I tested the whole model, consisting of both the posited measurement and structural models in order to answer the fourth research question which investigated if a model of *Teaching and Learning for Sustainability in Higher Education* adequately fits the data in one public, large-sized, four-year institution. The full system of equations for this model can be found in Equation 3. Given the acceptable model fit (RMSEA= .028, CFI=.918, SRMR=.072), the answer is yes, this model fits the data well. As such, this analysis reveals that a model of *Teaching and Learning for Sustainability in Higher Education* holds in one public, large-sized, four-year institution. However, not all paths in this model were significant, and although the model fits, certain parts of the model, were more meaningful than other parts of the model.

Equation 3. Measurement & Structural Equations

\[
1 = b_{F1A1} * F1 + E1 \\
A2 = b_{F1A2} * F1 + E2 \\
A3 = b_{F1A3} * F1 + E3 \\
A4 = b_{F1A4} * F1 + E4 \\
A5 = b_{F1A5} * F1 + E5 \\
A6 = b_{F1A6} * F1 + E6 \\
A7 = b_{F1A7} * F1 + E7 \\
A8 = b_{F1A8} * F1 + E8 \\
A9 = b_{F1A9} * F1 + E9 \\
A10 = b_{F1A10} * F1 + E10 \\
A11 = b_{F1A11} * F1 + E11 \\
1 = b_{F2B1} * F2 + E1 \\
B2 = b_{F2B2} * F2 + E2 \\
B3 = b_{F2B3} * F2 + E3 \\
B4 = b_{F2B4} * F2 + E4
\]
B5 = bF2B5*F2 + E5
B6 = bF2B6*F2 + E6
B7 = bF2B7*F2 + E7
B8 = bF2B8*F2 + E8
B9 = bF2B9*F2 + E9
1 = bF301*F3 + E1
O2 = bF3O2*F3 + E2
O3 = bF3O3*F3 + E3
O4 = bF3O4*F3 + E4
O5 = bF3O5*F3 + E5
1 = bF4CS1*F4 + E1
CS2 = bF4CS2*F4 + E2
CS3 = bF4CS3*F4 + E3
CS4 = bF4CS4*F4 + E4
CS5 = bF4CS5*F4 + E5
1 = bF5CP1*F5 + E1
CP2 = bF5CP2*F5 + E2
CP3 = bF5CP3*F5 + E3
CP4 = bF5CP4*F5 + E4
CP5 = bF5CP5*F5 + E5
CP6 = bF5CP6*F5 + E6
CP7 = bF5CP7*F5 + E7
1 = bF6CC1*F6 + E1
CC2 = bF6CC2*F6 + E2
CC3 = bF6CC3*F6 + E3
1 = bF7SM1*F7 + E1
SM2 = bF7SM2*F7 + E2
SM3 = bF7SM3*F7 + E3
SM4 = bF7SM4*F7 + E4
SM5 = bF7SM5*F7 + E5
SM6 = bF7SM6*F7 + E6
SM7 = bF7SM7*F7 + E7
SM8 = bF7SM8*F7 + E8
SM9 = bF7SM9*F7 + E9
1 = bF8TP1*F8 + E1
TP2 = bF8TP2*F8 + E2
TP3 = bF8TP3*F8 + E3
TP4 = bF8TP4*F8 + E4
TP5 = bF8TP5*F8 + E5
TP6 = bF8TP6*F8 + E6
TP7 = bF8TP7*F8 + E7
TP8 = bF8TP8*F8 + E8
TP9 = bF8TP9*F8 + E9
1 = bF9PA1*F9 + E1
PA2 = bF9PA2*F9 + E2
PA3 = bF9PA3*F9 + E3
Figure 11 provides the standardized betas for the paths in the model. None of the explored student demographics nor academic characteristics significantly influenced students’ opportunity to learn, or attitude or behavior learning outcomes ($p \geq 0.05$). This is aligned with, and even reinforces, the findings from the first two research questions. In addition, in this model, pre-attitudes did not influence opportunity to learn ($p \geq 0.05$). Interestingly, though, pre-behaviors did influence students’ opportunity to learn about sustainability ($\beta = 0.325$, $p \leq 0.001$). In other words, students with higher pre-survey behavior scores were more likely to enroll in classes with presence of sustainability-related subject matter.
As explained in the section discussing research question 3, opportunity to learn did influence each of the five promising practices of teaching and learning. However, when looking at the full model, we can also see that the three cognitively responsive teaching constructs, and the two teaching for sustainability constructs, significantly covaried with each other. Additionally, as explained in the results of research question 3, opportunity to
Figure 11. Standardized Betas for Paths
learn did not influence either the attitude learning outcomes or the behavior learning outcomes \((p \geq .05)\). Neither of the two teaching for sustainability constructs (core ideas and teaching practices) influenced either set of learning outcomes (attitudes and behaviors; \(p \geq .05\)). None of the three cognitively responsive teaching constructs influenced attitude learning outcomes \((p \geq .05)\). However, when teachers surfaced students’ prior knowledge about sustainability (cognitively responsive teaching construct 2), students increased their pro-sustainability behaviors between the beginning and end of the semester \((\beta = .116, p \leq .05)\). Knowing that not much change happens during just one semester, and given this small amount of change, cognitively responsive teaching construct 2 is a promising way to teach students about sustainability.

Overall, certain parts of the model are stronger than other parts, as evidenced by the fact that there were several non-significant paths. For instance, opportunity to learn did not significantly affect the post-attitudes, nor the post-behaviors, beyond the indirect effect through the cognitively responsive teaching second construct. As such, Figure 12 shows all significant paths highlighted in red in order to accentuate the significant parts of the model. Strong parts of the model were the correlations between the student demographics and academic characteristics. The paths between the pre- and post-learning outcomes (both attitudes and behaviors) were large \((\beta = .812)\), providing a good validation check. Additionally, as seen here, the outcome is almost entirely explained by the pre-survey. This is likely due to the short duration of the study—one semester, when learning complex content about sustainability may take longer. In terms of the other causal paths, pre-behaviors influenced opportunity to learn. Opportunity to learn strongly influenced each of the five promising practices of teaching and learning. Additionally, the three cognitively responsive teaching constructs correlated, as did the two teaching for sustainability constructs. Tapping prior knowledge had a strong influence on post-survey behaviors.
Figure 12. Model with Significant Paths
Although the model held, it is worth noting that the study was constrained to only one academic semester. Prior research has found that there is little change over the course of one semester (Downey, 2004; Martins, Mata, & Costa, 2006; Sterling, 2004). Thus, the model likely held due to the strong correlation between the pre- and the post-survey, and due to the strong influence of OTL on the PPOT&LAS. The many insignificant paths, therefore, probably point to a measurement issue (lack of ample time to see change), rather than a theoretical one. Another potential reason we did not see change is due to the truncated range of the ceiling effect because there was little room for growth after students’ scored so highly on the pre-survey.

**Limitations**

The dissertation study has several noteworthy limitations. One limitation is that it is narrow in scope, as it only included one HEI. This HEI, MSU, has a largely homogenous student population, and therefore one major limitation is that many minoritized groups, such as students of color, were underrepresented in the sample. Therefore, although these results may be applicable to other HEIs that are similar in institutional type to MSU, as well as being identified as a sustainability exemplar, care should be used when generalizing results to other HEIs. However, this research lays preliminary groundwork to expand this study to a multi-institutional study in order to explore patterns more broadly across higher education. Additionally, with regard to the sample, because the pre-survey was pre-existing data, I did not have input in the stratification of the sampling process. Although sampling was done randomly, there was a low response rate, and therefore, it could be that only participants with particularly strong views on sustainability participated, which could again limit the generalizability.

In terms of EfS content, a limitation of the present study is that it only explored students’ formal in-class learning about sustainability. However, higher education
literature (e.g., Astin, 1984; Kuh, 2001, 2009) explains that students’ co-curricular learning is important for their overall learning. In the context of sustainability learning, co-curricular experiences are valuable because they move students beyond awareness and toward engaging with environmentalism in their everyday lives (Beringer et al., 2008; Walton et al., 2009). As such, the lack of exploration of students’ co-curricular learning, in tangent with their curricular learning, is deemed a limitation.

Furthermore, in terms of data collection, prior research has critiqued students’ self-reporting of their educational experiences as a way to understand teaching practices (Campbell, 2015; Porter, 2011). Although there are limitations associated with surveys, such as weak validity, because this study is exploratory in nature, surveying was a helpful way to collect data as a first step in this process. While pre- and post-surveys are not as good as testing, longitudinal gains are better proxies than self-reported cross-sectional gains (Bowman, 2010). Surveys remain a useful way to gather data on the quantity and quality of students’ exposure to EfS because they allow for measuring many kinds of characteristics, like their thoughts, feelings, attitudes, beliefs, values, perceptions, and behavioral intentions related to sustainability (Fowler, 2013; Fowler & Cosenza, 2009; Groves et al., 2011).

In addition, with regard to surveys, particular reporting biases may be present in students’ survey responses, such as social desirability bias and memory bias. Social desirability bias is the tendency of survey participants to answer questions in a way they think is seen as more favorable and can result in over-reporting positive behaviors and under-reporting negative behaviors. This type of response is particularly prevalent in ethical and moral topics, like sustainably (Cronbach & Meehl, 1955; Nederhof, 1985), and was likely evident in students’ attitudes, as they all reported very high. Additionally, memory biases can also be present in survey data. Memory errors are incorrect recall of a detail or event (Porter, 2011). This could have been evident in the behavior responses, as they asked students to rely on remembered behaviors.
Although student surveys are limited in the biases they can fall privy to, the pre- and post-survey design of the present study aims, to some extent, to overcome these limitations. While students may have social desirability bias, the same students were surveyed at the beginning and end of the semester. Because one of the main goals of the present study was to measure change over time, social desirability did not truly color the results. Furthermore, although memory bias is a concern, the survey took place during the last week of the semester so that students’ semester experiences were still fresh in their minds. In addition, an important strength of SEM is its ability to estimate and account for measurement error, which is crucial in a survey of perceptions. Surveys that are perceptual in nature, as noted, are open to a number of error possibilities and biases, such as social desirability and memory biases (Fowler, 2013; Fowler & Cosenza, 2009). SEM accounts for these measurement errors and estimates the proportion of variation that is attributed to error versus the construct of interest (Byrne, 2016; Hancock & Mueller, 2013). One of the biggest weaknesses of SEM is that mathematically equivalent models provide equal model fit (Shah & Goldstein, 2006). That is, any structural equation model fit to these data with the same number of paths will have the same RMSEA, CFI, and SRMR.

Additionally, in terms of time, this study was bounded by one academic semester. Prior research has found that there is little change over the course of a semester (Downey, 2004; Martins, Mata, & Costa, 2006; Sterling, 2004); future research should replicate this study, perhaps at the beginning and end of students’ college experiences, to see if, overall, college influences students’ sustainability knowledge, attitudes, and behaviors. This limitation may particularly explain why results of my model, in terms of paths that influence the outcomes, were insignificant. Furthermore, given that I removed the knowledge learning outcome items, teaching and learning on knowledge-specific learning outcomes warrants further study. Finally, future research could build off the findings of
this study by a more in-depth exploration of the teaching of EfS, perhaps through classroom observations or faculty and student interviews.

**Conclusion**

This chapter presented the findings of the present study. Results found that approximately two-thirds of student participants reported that they had the opportunity to learn about sustainability over the fall 2017 semester. On average, neither cognitively responsive teaching, nor teaching for sustainability, pedagogical approaches were employed to teach sustainability. Interestingly, though, when instructors surfaced students’ prior knowledge about sustainability while teaching the subject, students’ sustainability behaviors increased over the course of the semester. These results, along with the less protuberant while equally important results, will be discussed in the following chapter.
Chapter V

DISCUSSION AND CONCLUSION

The past few decades have witnessed a widespread expansion of research exploring what constitutes good teaching in well-established and traditional academic disciplines. Consequently, this developing body of research has become a sub-field in the broader study of higher education, often identified as “teaching and learning.” Throughout this time, scholars have considered ways to understand college teaching, with active learning as a central focus in the literature (Campbell et al., 2016; Carroll 1963; McKeachie and Kulik 1975). More recently, scholars have begun to advance learning theory in this domain by investigating the confines of prior research (Hora & Ferrare, 2014; Neumann, 2014) and assessing more innovative approaches to teaching students in the higher education context (Campbell et al., 2016). However, what good teaching looks like in emerging interdisciplinary fields remains largely uncharted territory. Increasingly, global problems reflect overlaps between traditional disciplines, and should be situated in an interdisciplinary setting. In response, higher education has indeed become more interdisciplinary in nature. However, we still do not have a clear picture of good teaching of interdisciplinary subject matter.

Therefore, this dissertation explored how to better instruct higher education students about culturally sensitive, socially conscious, politically charged subject matter, using the case of sustainability. As noted throughout this dissertation, when viewed through the lens of race and lower socio-economic status, it is our weakest populaces
who suffer the greatest peril from climate change. Therefore, the exploration of promising practices of teaching and learning about sustainability-related subject matter must address the catastrophic environmental consequences—intensified storms, pollution, and water contamination—through an interdisciplinary social justice focused lens. As such, in this final chapter of my dissertation, I discuss the four research questions, as well as the implications from this study for policy, practice, and research. In the penultimate section, I suggest areas for future research, after which I finish the chapter with concluding remarks.

**Discussion of Research Question 1**

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 Education for Sustainability (EfS) is expanding beyond the disciplinary confines of natural science (Azar et al., 1996; Hopkinson & James, 2010), little is known about the prevalence of EfS throughout an entire higher education curriculum. Therefore, the first research question aimed to capture a bird’s eye view of the presence of sustainability-related subject matter at one higher education institution, Michigan State University, recognized as an exemplar on the sustainability forefront, during one academic semester.

**Opportunity to Learn about Sustainability**

Opportunity to Learn (OTL) was employed to guide an exploration of the presence of sustainability-related subject matter across the curriculum. The finding uncovered by the OTL analyses showed that nearly two-thirds of the student participants reported that they had exposure to sustainability-related subject matter during the course of the
semester. In other words, well over half of the students were exposed to sustainability-related subject matter in the context of their formal classroom learning. This was a surprising finding given the multitude of obstacles (such as limited expertise and perceived irrelevance by faculty members) that have heretofore been documented as preventing EfS from infiltrating the already-existing curriculum (Borg et al., 2012; Christie et al., 2013; Reid & Petocz, 2006). While the scope of the first research question lacked the bandwidth to contradict, let alone challenge, the body of literature from which it stemmed, it did provide a glimmer of hope in its evidence that more students than expected were exposed to sustainability within their studies.

As two-thirds of the student participants had at least some exposure to sustainability-related subject matter, it begged the question as to how much time they were actually exposed to it. Of the students who reported that they did have OTL, most of them only learned about sustainability at one point in time—e.g., in just one class session in only one course. 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 who reported on learning about sustainability did not spend appreciable time with the subject matter, most frequently being exposed to it only once.

Higher education learning theory deems such lack of repetition inadequate. Many studies have found that the amount of time students devote to learning activities influences their acquisition of knowledge (Astin, 1993; Kuh, 2003; Kuh, Kinzie, Schuh, Whitt, & Associates, 2005; Tinto, 1997). 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. As noted, while nearly two-thirds of the student participants indicated that they did have the opportunity to learn about sustainability, an examination of how much time they spent learning about it proved to be insufficient.
Furthermore, the literature customarily considers EfS as a recurring set of instances, such as a course that integrates sustainability subject matter throughout the semester (Gough & Scott, 2003; Wals & Blewitt, 2010; Wals & Jickling, 2002). However, since policymakers have called for EfS to be infused throughout the whole curriculum, not just in closely-related disciplinary classes (Gough & Scott, 2008; Jones et al., 2010), I counted any instance where students were exposed to sustainability-related subject matter in the classroom as having the opportunity to learn about sustainability. The benefit of classifying EfS so broadly was that I was able to see each instance where students had exposure to sustainability-related subject matter. The downside to this broad definition, as evidenced by this finding, was that, while it illuminated EfS’s presence, it also demonstrated that it was not happening enough. As per the analyses for this part of the research question, I, in unison with prior scholars like Orr (1991, 2004, 2013), argue that the current state of EfS is insufficient and not happening at the frequency necessary to cultivate the interrelated environmental, economic, and social changes that we so desperately need. The issue with learning about a topic in only one instance is that it does not satisfy the benchmarks for deep learning, let alone the ability to transfer learning (Biggs, 1989; Marton & Säaljö, 1976; Warburton, 2003), which is so important for sustainable engagement.

Nearly half a century of policy initiatives across the globe have pointed toward educating students about sustainability in higher education as a mechanism for rectifying the current problems we are facing. EfS scholars have, as noted previously, advocated for sustainability-related subject matter to be included in all classes, rather than isolated in natural science courses (Dobson, 2011; Edwards, 2012; Orr, 1991; Sterling, 2004). While the first part of this research question found that nearly two-thirds of students were in fact having exposure to sustainability-related subject matter, the later parts reveal that, although it was happening, it was usually just happening once. Inadequate time is being devoted to educating students about sustainability, especially the amount needed to
transform students’ learning. Perhaps this leads to the question of whether breadth has been emphasized at the expense of depth. Moreover, given that two-thirds of students had OTL only once, contextualizing this finding at MSU, where EfS happens more frequently than at other less sustainably-engaged HEIs, begs a question. What about students’ exposure to sustainability-related subject matter at less sustainably-engaged HEIs, particularly those with higher enrollments of racial minorities and students of low socioeconomic status? This would include community colleges, where very little research on EfS has been done.

Where Students are Learning about Sustainability

After finding that most students had at least some OTL, it leads one to wonder where in the curriculum exposure to sustainability-related subject matter was occurring. The overall finding was that many students who reported having OTL learned about sustainability at least one time across all course types. Sustainability subject matter was most present in major coursework, followed by general education courses, and then by elective courses, with 73%, 64.8%, and 57% of participants, respectively, who reported having at least one exposure to sustainability in these types of coursework. Overall, the trend seen here is that of sustainability subject-matter emerging from the curricular periphery and becoming actively integrated throughout its entirety.

Of the students at MSU who had OTL, nearly three-fourths of them reported learning about sustainability in their major coursework during the Fall 2017 semester. Such prominence of EfS was auspicious for several reasons. Primarily, students’ majors prepare them for their future careers. This then indicated that learning about what sustainability meant in their major coursework, as well as understanding the sustainability-related issues likely to arise within their chosen fields, provided promise that these students would have the capacity to consider and act upon anticipated sustainability issues in their future careers (Colby et al., 2003).
Second, students declare majors in disciplines that they are passionate about (Colby et al., 2003). As such, sustainability learning in the context of their major is important because it could resonate more deeply when they see its connection to topics they are invested in. As well, conversing with their close peers, and faculty members, could also further connect sustainability learning in the context of their majors. This, in turn, teaches them how to think across disciplines, since students who reported having the opportunity to learn about sustainability in major coursework came from a wide variety of majors in the present study, including marketing, psychology, political science, history, criminal justice, nursing, education, neuroscience, mathematics, astrophysics, environmental geosciences, and mechanical engineering. However, although sustainability was present throughout all disciplinary majors, it was students in soft, applied, and life majors who had the greater exposure to it. This makes sense, as the traditional conceptions of sustainability that underpin the ethos of the subject matter are soft, applied, and life (Biglan, 1973). Withal, this finding demonstrates that the call for sustainability to be embedded throughout the curriculum, beyond traditional “sustainability-related” disciplines, is largely unfinished and in need of further expansion to hard, pure, and non-life disciplines.

One prominent barrier to incorporating EfS into nontraditional disciplinary courses, well documented throughout the literature, is that majors are defined in terms of discrete disciplinary categories, and sustainability-related real-life contexts are inherently interdisciplinary. Thus, the disciplinary structure of the curriculum is not well suited to facilitate the kind of integrative thinking these complex problems require (Colby et al., 2003; Schneider & Schoenberg, 1999). As such, another important reason for EfS to be present in major coursework is the need for bringing interdisciplinary subject matter into traditional disciplinary classrooms. This would support students in coming to terms with the complexity of current world problems (Colby et al., 2003; Schneider & Schoenberg, 1999). Given the plethora of reasons for the absence of EfS infusion throughout
coursework, this study revealed that, although it might not appear to be a natural or easy fit, it is nonetheless happening.

In addition, of the students who had OTL, 64.8% of them indicated that they learned about sustainability in general education coursework. This is noteworthy for several reasons. Given the strong presence of general education in students’ higher education learning, it becomes fertile ground for sowing sustainability learning. Second, general education courses are among the first classes in which college students enroll (Lattuca & Stark, 2009; Tinto, 1993). As these courses commence early in the higher education experience, at a time when students are confronting the academic and emotional challenges of transitioning into the college community (Shulman, 1987; Tinto, 1993), it can be said that they set the foundation for students’ higher education learning. As such, it is in this context that learning about sustainability comes into its own as the base for all ensuing scholarship. 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 (Gamson, 1984; Levine, 2006; Nussbaum, 1997). In this view, general education prepares students for conscientious citizenship, exercising their knowledge not just for higher salaries, but for the betterment of humankind and for our world (Gamson, 1984). Additionally, of the students who had the opportunity to learn, 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.

**Opportunity to Learn by Students’ Demographics and Academic Characteristics**

The second part of the first research question explored the extent to which OTL differed across student demographics and academic characteristics. Results responding to this part of the research question found that very few demographics, including gender,
race, and socioeconomic status, influenced students’ sustainability learning opportunities.

There are very few places in higher education where all students have equal access to subject matter, but in the case of sustainability, this is especially urgent. Climate change has a higher likelihood to affect people from vulnerable populations, such as communities of color and low socioeconomic status. These people already endure disproportionately high exposure to pollution and toxins, with resultant economic and health consequences (Agyeman et al., 2003; Brainard et al., 2009; Bullard et al., 2008).

Additionally, relating to access to learning about sustainability, many marginalized groups (e.g., low SES) often have high demands outside the classroom, such as working to help earn their college tuition and other economic commitments (Titus, 2006; Walpole, 2003). As such, at having OTL in the classroom is important to their having equal access to learn about sustainability.

The finding that race, gender, and SES did not influence opportunity to learn at MSU during the fall 2017 semester, while indeed edifying, compels further investigation, as it contradicts the literature stating that White people from higher SES have higher sustainability literacy (Agyeman et al., 2003; Brainard et al., 2009; Bullard et al., 2008). This contradiction to the overall theme throughout the literature is conceivably due to the way I frame students’ opportunity to learn about sustainability, as I include all instances in which it occurs. It may be that the literature points to the fact that marginalized students are less likely to take EfS-specific courses. Essentially, perhaps marginalized students are being exposed to this subject matter throughout their coursework, even if they are in enrolled in an unrelated major and do not actively seek sustainability courses. However, student demographics ought to be further explored because environmental discrimination is 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 HEI? As seen, higher education is not yet doing enough—but what more can or should be done? Perhaps this harks back to the first part of the research question in
that more time needs to be spent on EfS 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 the present study, international students displayed higher exposure to sustainability subject matter. These significant results, albeit in small effect sizes, were interesting, as they supported prior literature, which promulgates that students in other countries have greater concern about sustainability than their US higher education counterparts (Gambro & Switzky, 1996; Sammalisto & Lindhqvist, 2008).

Regarding the extent to which academic characteristics influenced students’ opportunity to learn about sustainability, the theme of sustainability as a largely equal access subject endured. Overall, neither class year nor GPA affected students’ exposure to sustainability subject matter. With regard to admittance status, although transfer and first-time students did not report a substantial difference in opportunity to learn in major or elective coursework, transfer students did report lower opportunity to learn in their general education coursework. However, since general education courses tend to be among the first classes students take when enrolled in postsecondary education (Lattuca & Stark, 2009; Tinto, 1993), this may be a result of their having completed general education courses before transferring to MSU and because, after they transferred, they were primarily engaged in major coursework. Additionally, because MSU is an exemplar on sustainability in higher education, wherever they transferred from may not have had such a sustainability focus. Taken together, sustainability can reliably be termed an equal access subject matter in higher education.

**Opportunity to Learn and the Civic Mission**

As long ago as Plato and Aristotle, the role of education in developing citizenship has been deemed necessary to the well-being of a society (Carr, 2011; Curren, 2010;
Nussbaum, 1998, 2010; O’Neill, 2002; Stonehouse et al., 2011). Education in a variety of
disciplines was at the heart of the Ancient Greeks’ learning theory. In that way, students
would be stimulated to contribute to society’s overall good. An important element was
education about the natural environment (Tsevreni, 2018). Therefore, environmental
teaching has long been a fundamental component to good citizenship. These primitive
educational roots about the environment are today paramount to the contemporary
sustainability education discourse, evidencing sustainability education’s unique place
within the civic mission of education. Indeed, they ground the argument that
sustainability belongs in higher education, which has a duty to provide students with the
opportunity to learn about it. Despite the current political climate undermining its
importance, it remains more than ever a pathway to cultivating a sustainable future for
our society, and our world. In various degrees, it has been occurring, as seen by the
analyses of the extent to which students had the opportunity to learn about sustainability
throughout their higher education coursework. As seen by these analyses, despite
challenges, sustainability is present throughout the curriculum, providing students with
exposure to this subject matter.

**Discussion of Research Question 2**

Charting if, for how long, and where students have the opportunity to learn about
sustainability is important because it offers insight into quantifying students’ exposure to
sustainability-related subject matter. However, the mere presence of sustainability-related
subject matter, simply imbued into a pre-existing course structure, is inadequate. In order
for EfS to truly have a transformative impact upon students, instructors must artfully
guide them in their learning. Thus, building off the first research question, the second
research question more deeply explored the learning experiences of students who had
OTL at MSU by investigating the extent to which they encountered promising practices of teaching and learning about sustainability.

**Promising Practices of Teaching and Learning about Sustainability**

In order to explore the extent to which students experienced promising practices of teaching and learning about sustainability, I isolated students who had indicated that they did have this particular learning opportunity in the post-survey. I then asked these students to think about the course where they had the most opportunity to learn about sustainability. This ensured that the teaching practices they were questioned on related to that one particular course. Such seclusion of a particular course was important in order to measure whether exposure to particular teaching methods (which I term promising practices of teaching and learning about sustainability—PPOT&LAS) led to specified learning outcomes. I posit that PPOT&LAS is the composite of the two arms of the overall framework (cognitively responsive teaching and teaching for sustainability), which I suggest converge to characterize good EfS teaching.

The first facet of PPOT&LAS was Neumann’s (2014) cognitively responsive teaching. Therefore, I examined the students who had had the opportunity to learn about sustainability, and in particular about their exposure to cognitively responsive teaching practices. On average, students chose the mid-point on the scale (within the “neither-agreed-nor-disagreed” area), indicating that each of the three cognitively responsive teaching constructs was somewhat employed when their instructors taught them about sustainability. It is also worth noting that, although there was only slight variation in the averages among these three scales, and despite students’ average responses to the presence of all three practices, it was the subject matter teaching practice that scored the highest. Then came prior knowledge, followed by supporting changing views. Interestingly, this pattern aligned with prior findings on cognitively responsive teaching research. For instance, several prior CEQ studies have found that faculty score higher on
subject matter than on prior knowledge, which exceeds supporting changing views (e.g., Michel et al., 2018a). It is seen in the CEQ studies that explore teaching and learning across disciplines that, as the teaching practice becomes increasingly complex, it happens less frequently. This seems to ring true for teaching EfS, as well.

In addition, because EfS does not necessarily mirror the structure of its traditional disciplinary counterparts (Jones et al., 2010; Pizmony-Levy, 2011; Smyth, 1995; Sterling, 1992), good teaching here might look different from what good teaching looks like in more established disciplines. Therefore, the second arm of PPOT&LAS was teaching for sustainability, which aimed to identify the nuances of EfS that might otherwise be missed. In the present study, teaching for sustainability, in which students experienced both core ideas and teaching practices, occurred on average between a few times and sometimes, although closer to a few times, during the course of the semester. The credence here is evidence that instructors are not merely dropping the subject matter into their courses, but instead are taking steps toward teaching it well.

Together, I suggest that employment of cognitively responsive teaching and teaching for sustainability would provide students with a “promising” EfS learning experience. On the whole, though, I found that the degree to which students experienced promising practices of teaching and learning about sustainability (comprised of both cognitively responsive teaching and teaching for sustainability) was rarely happening.

Increasingly, we occupy a planet where there is less food for us to eat and fewer places for us to live. Greenhouse gases are infiltrating the atmosphere, glaciers are melting, and sea levels are rising (Allen et al., 2000; Etheridge et al., 1996; Rosenzweig et al., 2008). Higher education has been designated as an auspicious mechanism for ameliorating problems to our future. And while it is worth commemorating the inroads that promising practices of teaching and learning are making, they are not being incorporated with the necessary forcefulness to effect meaningful
social change. This finding, about the lack of good teaching occurring in EFs, resonated with prior literature (Jensen, 2014; Orr, 2013).

To date, policy initiatives have pushed EFs into many courses, but these initiatives mainly advocate for OTL, and, due to that, practice and policy taper off simultaneously. Little if any policy has advocated for, or allocated funds toward, the needed professional development, curriculum development, or workshops for instructors that educate them on how to teach EFs. In turn, there has been little attempt to provide faculty with professional development to equip them with the pedagogical tools essential to teach sustainability-related subject matter. These limited efforts have obstructed good EFs teaching—resulting in high insecurity of EFs teaching, low levels of sustainability understanding, lack of knowledge on how to translate sustainability concepts into subject matter, and lack of educational strategies for teaching in the context of EFs (Denby & Rickards, 2016; Forbes & Davis, 2008). In fact, prior research has established that many faculty members struggle with incorporating EFs into their traditional disciplinary courses (Borg et al., 2012; Christie et al., 2013; Lemkowitz et al., 1996; Reid & Petocz, 2006). Therefore, along with the benefits of expanding EFs throughout the curriculum come concerns with how well it is actually being taught—suggested by some scholars as the primary challenge (Leal Filho & Pace, 2016). As seen in the present study, while OTL is frequently happening at MSU, a site where we know EFs is happening more than at most other HEIs, it is not often being taught well enough. Overall, instructors are not really engaging in “good” teaching about sustainability. Consequently, this second research question underscores the fact that policymakers and administrators must devote more resources to sound EFs teaching practices.

**Influence of Discipline and Course Contexts on Promising Practices of Teaching and Learning**

The second part of the second research question investigated the degree to which PPOT&LAS differed across disciplines and course contexts. While students’ exposure to
such practices of teaching and learning did not vary much by course type, course format, course level, number of credits, or course size, discipline did influence their exposure to the teaching practices under investigation. Overall, the trend seen here was that PPOT&LAS, in common with the findings for research question 1, were higher in soft, applied, and life courses. This was an anticipated finding: sustainability as a topic is soft, applied, and life, and thus most naturally falls within the confines of these disciplinary boundaries. Therefore, the faculty in these disciplines may better understand the teaching practices that are particularly supportive of sustainability learning.

Additionally, this finding echoes prior literature, which has found substantial differentiation of disciplinary experiences in higher education (Becher, 1987, 1994; Braxton & Hargens, 1996; Clark, 1987; Michel, Campbell, & Dilsizian, in press). This idea has prominently been summarized by Clark’s (1987) landmark characterization of discipline as “small worlds, different worlds.” Many studies, in fact, have found that discipline particularly influences teaching practices (e.g., Michel et al., 2018a; Umbach, 2007). The consensus from the literature that includes discipline as a context for understanding teaching practices has found that soft disciplinary courses hold promise for better teaching practices than their hard discipline counterparts. For instance, using Biglan’s (1973) framework, Laird, Shoup, Kuh, and Schwarz (2008) found that faculty in soft, pure, and life disciplines scored higher in their self-reported practices that facilitate deep approaches to learning for students. In another example, Braxton (1995) found that faculty members in the soft disciplines integrated good principles of teaching to a greater degree than those in hard disciplines. Braxton, Olsen, and Simmons’s (1998) explanation for the difference surfaced by Braxton (1995) was the disproportionate level of pressure for faculty members across the two paradigms. Faculty in the hard sciences, under more pressure to conduct research, are less likely to adopt effective teaching practices. In turn, the present study’s finding that PPOT&LAS were higher in soft, applied, and life courses
is aligned with prior literature where disciplines (particularly soft) have been found to offer better teaching practices.

**Discussion of Research Question 3**

In the first part of this study, the initial two research questions mapped out the extent to which students had the opportunity to learn about sustainability and the pedagogical practices they experienced during this learning. From there, the next part of the study analyzed the structural relationships between having the opportunity to learn about sustainability and experiencing promising practices of teaching and learning, and their influence on students’ sustainability learning outcomes. The third research question explored if the opportunity to learn influenced cognitively responsive teaching and teaching for sustainability, and if the opportunity to learn, cognitively responsive teaching, and teaching for sustainability, influenced sustainability learning outcomes.

**Influence of Opportunity to Learn on Promising Practices of Teaching and Learning about Sustainability**

By examining the structural paths between opportunity to learn and cognitively responsive teaching, and the paths between opportunity to learn and teaching for sustainability, I found that students who had more opportunity to learn about sustainability were more likely to have exposure to all promising practices of teaching and learning under investigation. In other words, when students had more classes where they were exposed to sustainability-related subject matter, the more chances they had for it to happen well. This finding was not that more opportunity to learn in one class had better teaching, but rather, more opportunity to learn across more classes indicated a better chance for students to encounter good teaching about sustainability. As such, this finding supports the calls for sustainability to be infused in all courses throughout the curriculum (Azar et al., 1996; Hopkinson & James, 2010; Orr, 2013), because by
providing students more opportunities to learn about sustainability, they have more changes to experience promising practices of teaching and learning when learning about sustainability. Optimally, EfS is done frequently (students have a lot of opportunities to learn about sustainability across many of their courses) and well (students learn about sustainability through promising practices of teaching and learning). However, on the contrary, if students are not having much opportunity to learn, they also are not likely to experience it well, and as such, there is a compounding effect here.

**Influence of Opportunity to Learn about Sustainability on Learning Outcomes**

Next, I explored if opportunity to learn influenced students’ sustainability-related learning outcomes and found that it did not, demonstrating that the mere presence of sustainability-related subject matter did not lead to increased sustainability-related attitudes or behaviors. This finding, aligned with decades of research in learning science and socio-cultural studies that have explored how to teach well, concluded that simply placing subject matter into a curriculum is not enough (Biggs, 1989; Marton & Säljö, 1976). Such prior research suggests that, in addition to adding a particular subject matter into a curriculum, it ought to be imparted upon students in ways that help effectively shape student learning (Campbell, Cabrera, Michel, & Patel, 2016; Hora & Ferrare, 2014; Neumann, 2014).

Results from the first research question found that most students were experiencing OTL about sustainability at least once, in various places in the curriculum (across majors and general education coursework). From there, however, analysis of the third research question found that, while sustainability-related subject matter was present, OTL did not lead directly to increased sustainability learning outcomes. Thus, as seen by the relationship between these research questions, mere exposure to the subject matter did not translate to learning—a result that resonates with established learning theory (e.g., Biggs, 1989; Marton & Säljö, 1976). Additionally, prior research has found that
transformative change in sustainability-related learning takes longer than one semester to occur (Downey, 2004; Martins, Mata, & Costa, 2006; Sterling, 2004), and therefore, repeated teaching over the course of a semester, for several semesters, warrants future study.

**Nonsignificant Influence of Teaching Practices on Learning Outcomes**

In terms of the influence of promising practices of teaching and learning on learning outcomes, none of the five constructs influenced students’ sustainability-related attitude learning outcomes—such as increasing the belief that “access to clean water is a universal human right” or that “the well-being of others affects me.” Four of the five constructs did not influence behavior learning outcomes (such as limiting meat consumption and water use)—namely, the two cognitively responsive teaching constructs (subject matter and supporting changing views), along with the two teaching for sustainability teaching constructs (sustainability-related core ideas and teaching practices). One of the five promising practices of teaching and learning constructs exerted a positive influence on the behavior learning outcomes (prior knowledge), to be discussed in the next section. However, the majority pattern showed an insignificant influence between promising practices of teaching and learning about sustainability and students’ sustainability learning outcomes. There are several potential practical reasons for this, which I discuss below.

Cognitively responsive teaching was the first arm of the promising practices for teaching and learning facet of the framework. Since Anna Neumann first shared cognitively responsive teaching in her 2012 Presidential Address for the Association of the Study of Higher Education (ASHE), it has been used in several ways, such as framing part of the CEQ study (Campbell, 2015, 2017; Campbell et al., 2016), as well as studies on faculty learning (Baker, Terosky, & Martinez, 2017; O’Meara, Rivera, Kuvæva, & Corrigan, 2017). Cognitively responsive teaching has provided strong conceptual
grounding for the study of higher education teaching and learning, pushing exploration of practices beyond the binary ones of lecture and non-lecture (Campbell et al., 2016) to more nuanced, complex teaching and learning practices, albeit not to an analysis of learning outcomes. As such, the largely insignificant influence of cognitively responsive teaching practices on students’ sustainability-related learning outcomes, as found in the present study, may point to the need to further investigate how to bridge the three claims into EfS-specific practice. Additionally, it could be that this is the first time cognitively responsive teaching was applied specifically to sustainability-related subject matter across the curriculum, and that it has traditionally been intended to be understood within disciplines, whereas this study is interdisciplinary in nature.

The second arm of the promising practices for teaching and learning facet was teaching for sustainability, composed of core ideas and teaching practices. As with two of the three cognitively responsive teaching practices, the teaching for sustainability teaching practices did not lead to learning outcomes either. This insignificant finding can be understood in the context of Campbell et al.’s (2016) exploration of college teaching practices, where data from 587 classroom observations were used to understand patterns of teaching practices within courses, with five distinct clusters of teaching practices being identified. One category of courses was entitled “active only,” which included courses that were classified by “[enacting] active learning by getting students engaged in class activities, but … not organized around either in-depth subject matter expertise or the students’ prior knowledge” (p. 597). In other words, this cluster of classes was taught by instructors who did engage students in active learning practices, but they refrained from

1The five categories of courses found in this study were: comprehensive (courses that enacted many teaching practices, including both active learning and traditional lecture), traditional lecture (courses that mainly lectured on subject matter), active learning (courses that had a combination of lecture and active learning practices), integrated discussion (courses that enacted active learning by using class discussion, but not activities or student questions), and active only (courses that only had active learning) (Campbell et al., 2016).
employing these pedagogical practices in order to teach students new subject matter ideas. By the same token, it is possible that instructors in the present study taught students about sustainability through popular pedagogies (e.g., debates or connecting to local community), but neglected to use them as a bridge for meaningful teaching about sustainability.

Regardless of whether the insignificant influence between promising practices of teaching and learning about sustainability, and students’ sustainability learning outcomes, was due to necessary modifications when putting these theorized facets into practice, or whether faculty had limited exposure to higher education-specific research, either could perhaps be remedied with professional development. As mentioned previously, while some policy initiatives have promoted sustainability in the classroom, efforts have generally stopped there (Dobson, 2011; Edwards, 2012; Orr, 1991; Sterling, 2004). Few, if any, efforts have aimed to instruct faculty how to teach about sustainability. Therefore, it could be that these practices fail simply due to faculty members’ lack of exposure to resources, like professional development, and time to study how to better teach EfS.

Further, even if faculty could access the resources in learning how to better teach sustainability, would they take advantage of them? Would they attend workshops and conferences? While ideally, yes, they would, the opposite is also possible. The current reward structure for higher education faculty does not compensate them for teaching about sustainability well (Rowe, 2002; Svanström et al., 2008). Rather, faculty are mainly rewarded on research productivity, not just teaching well (Boyer, 1990; Tien & Blackburn, 1996; Toutkoushian & Bellas, 1999), especially regarding subject matter outside of their discipline, like sustainability (Rowe, 2002; Svanström et al., 2008). Without this financial incentive, they may not feel inspired to devote their time (when, say, they could be engaging in research that would earn them a salary raise) to better learn how to teach about sustainability. Therefore, lack of resources, and specific
incentives to teach EfS well, could be the reason we do not see the influence of teaching practices on learning outcomes.

**Significant Influence of Surfacing Prior Knowledge on Learning Outcomes**

None of the five PPOT&LAS constructs influenced attitude learning outcomes, while four of the five PPOT&LAS constructs did not influence behavior learning outcomes. However, when all else was held constant, one of the five PPOT&LAS constructs did influence behavior learning outcomes, even given the little learning that took place over one single semester. The second cognitively responsive teaching construct (when an instructor surfaced students’ learning to prior knowledge and experiences) influenced sustainability-related behavior learning outcomes—i.e., when instructors employed the pedagogical technique of guiding students to encounter new ideas by surfacing their prior sustainability-related knowledge, there was then an increase in students’ sustainability-related behavior learning outcomes. This finding resonates with prior research, as earlier studies have found that EfS increases students’ sustainability-related behavior (Ryu & Brody, 2006; Smith-Sebasto, 1995). These studies are limited, though; in addition to being outdated, they also neglect to look at the particular teaching practices that may contribute to the increase in behaviors. Additionally, these studies do not to consider prior knowledge, which is a noteworthy limitation given the influence the present study found that surfacing prior knowledge has on students’ EfS learning.

Though exploratory, the present study provides preliminary evidence that supports the pedagogy of using students’ prior knowledge of sustainability-specific subject matter to teach them new sustainability-related ideas, practices, and skills. Previous research, as seen, has already demonstrated the benefit of revealing and utilizing students’ prior knowledge to teach them new ideas (Bransford et al., 2000; Castillo-Montoya, 2017; Neumann, 2014). However, this finding reveals that surfacing students’ prior knowledge,
steeped in K-12 education research (González et al., 2005; Lee, 2007), the learning sciences (Bransford et al., 2000), and, more recently, higher education coursework in the liberal arts (Neumann, 2014) and sociology (Castillo-Montoya, 2017), can in fact be applied to sustainability subject matter. Furthermore, the finding that the second cognitively responsive teaching construct influenced sustainability-related behavior learning outcomes can be contextualized in a recent argument by Fullan (2016), drawing on the work of Dewey (1902, 1916), who posited that people do not necessarily learn just by doing, but by also contemplating their new actions. Fullan’s point is that, oftentimes, changes in behaviors precede changes in attitudes, as he argues that “the stimulation comes from new experiences that give us something new to think and learn about” (p. 39). He states further, “This accounts for the related but counterintuitive findings that behaviors and emotions often change before beliefs—we need to act in a new way before we get insights and feelings related to new beliefs” (p. 39). In the case of change, particularly social change for increased sustainability competence, this makes sense, as behaviors are easier to change than deeply ingrained attitudes. Students perhaps need to act a certain way, in this case more sustainably, before their attitudes can follow suit and, ideally, their future track would then be aligned with Fullan (2016) and Dewey (1902, 1916). In thinking deeply about what they are doing, they perhaps will ultimately re-shape their attitudes.

Moreover, the specific relationship between tapping prior knowledge and behaviors is worthy of investigation. The post-survey items asked students if their instructors tapped their prior knowledge about sustainability by way of personal experiences, high school coursework, college coursework, social roles and culture, family, friends, and media. The behaviors that hung together for the behavior learning outcome construct were: signed a petition, took part in a protest or demonstration, participated in a community or environmentally-focused club or organization, avoided companies with harmful practices, avoided using or buying certain products, chose locally-owned
businesses over large chains, tried to convince a friend not to buy bottled water, and limited meat and water consumption. Intrinsic in these two sets of survey items there is perhaps a link. For example, the types of prior knowledge (their personal lived experiences and experiences seeing how their family and friends might act) are bound to impact how they behave. If a student grew up with a father specifically altering the way he washed the dinner dishes each night to limit his water use, and the instructor tapped that memory and used it to teach a student about the waste associated with buying goods from large chain stores, they might increase that particular behavior. The predominant finding stemming from the research question 3 analysis is that the second cognitively responsive teaching construct (an instructor surfaced students’ learning to prior knowledge and experiences) influenced sustainability-related behavior learning outcomes. While only one path of many, this finding is promising when considered in the context of scholars (e.g., Chase et al., 2012) who have suggested that HEIs have the greatest force, and most unique impact, within the education domain, by way of their ability to instill sustainability behaviors in students.

**Discussion of Research Question 4**

For the purpose of this study, I developed a new theoretical framework entitled the *Framework for Teaching and Learning for Sustainability in Higher Education*. In the fourth research question, I tested this framework as a whole in order to help consider whether the framework fits the data and whether it needs modifications. Overall, I found that yes, the whole model (consisting of both the posited measurement and structural models) for the framework adequately fit the data. However, several modifications, which I discuss below, had to be made to ensure this fit. Additionally, although the model did fit, there were several insignificant parts of the model, also addressed below.
Knowledge Learning Outcomes

Although my posited conceptual framework, along with the corresponding structural model, included sustainability-related learning outcomes in forms of knowledge, attitudes, and behaviors (Chalkley, 2006; Sipos et al., 2008; Svanström et al., 2008), one necessary modification was the removal of the knowledge learning outcomes. Statistically, the previously validated knowledge learning outcome items (Zwickle et al., 2014) should have hung in one construct. Theoretically, the set of knowledge items made sense for inclusion because the items were all about the three interrelated dimensions of sustainability (environmental, economic, and social) and because prior research has suggested that formal EfS should increase students’ sustainability knowledge. However, in the present study, the knowledge items did not hang together as one construct, and therefore I was unable to include them in the full model. I was able to obtain satisfactory model fit of the full model only after removing this important part of the model. While the model fits without the knowledge learning outcome construct, it is vital to note that this modification had to be made, as well as the implication for this change: that students’ acquisition of sustainability-related knowledge was not included in the present study.

It is also worth noting that, given the important role of knowledge in helping students understand the reasoning behind their decision, leading to increased attitudes and behaviors, this study is thereby limited in that it was unable to assess this crucially important construct. However, while OTL and PPOT&LAS did not largely influence attitudes and behaviors, they may possibly have influenced knowledge. Thus, had I been able to include knowledge in the model, I might have been able to cite research that shows that awareness (knowledge) is a first step toward change (e.g., Leiserowitz et al., 2006) and that attitudes and behaviors often follow after knowledge increases (e.g., Fullan, 2016). Sustainability knowledge is important, as failure to understand the environment and its broader relationship with sustainability is correlated with poor attitudes, negative values, and lack of participation in sustainable behaviors (Leiserowitz
et al., 2006; Peattie, 2010). I did, as previously noted though, engage in ad hoc testing of the knowledge items given their importance to students’ learning (as presented in Appendix H), but they were not included in the SEM model.

**Teaching for Sustainability Core Ideas Construct**

Another modification I made to the original posited model was the removal of two items from the teaching for sustainability core ideas construct. Because EfS does not necessarily resemble its traditional disciplinary counterparts (Jones et al., 2010; Pizmony-Levy, 2011; Smyth, 1995; Sterling, 1992), good teaching might look different. Therefore, the second facet pointing to promising practices of teaching and learning was teaching for sustainability, which aimed to identify the nuances of EfS that might otherwise have been missed. Based on a literature review, I posited that the core ideas of the interdisciplinary field of EfS were: defining sustainability, environmental crises, eliminating poverty, future generations, environmental justice, economic sustainability, resource management, anthropocentrism, biocentrism, ecocentrism, and ecofeminism. However, three items (environmental justice, ecofeminism—relating oppression of subordinate human groups to the oppression of nature, and eliminating poverty) did not hold in the analysis, which made theoretical sense, as they seemed to tap the same overarching idea of environmental justice.

Altogether, after this one adjustment, I found that this facet (teaching for sustainability core ideas) of the framework held. While this adjustment assisted the model in holding, the limitation of using one umbrella equity item, instead of the three more specific equity items, cannot be overlooked. Given that I had to remove two of three equity-oriented items, I was unable to see whether the teaching of equity-related sustainability ideas would have influenced learning outcomes. This argues for further investigation, as equity is critical to a deep understanding of sustainability. Figure 13, below, illustrates the revised teaching for sustainability facet of the framework.
Figure 13. Revised Teaching for Sustainability Framework

**Significant Paths**

Although all paths in the *Teaching and Learning for Sustainability in Higher Education* model were not significant, the model highlighted several important paths that in fact were significant. I posited that student demographics (gender and race/ethnicity), academic characteristics (field of study), and pre-survey of the learning outcomes (sustainability-related attitudes and behaviors) co-varied with each other, which indeed they did. I also posited that cognitively responsive teaching constructs covaried together and that the teaching for sustainability constructs covaried together, as they both did. The fact that these covariations were significant meant that the factors and/or constructs were related and, as such, should be investigated together in the future because they significantly influence each other and omitting some of them in future models would mean missing part of the story.

Additionally, I posited that pre-attitudes would influence post-attitudes, and the pre-behaviors would influence the post-behaviors—as they were the same set of questions asked before and after the semester—which they both did. These significant effects were found after controlling for all the other paths leading to post-attitudes and
post-behaviors, indicating that, after taking into account a students’ opportunity to learn and exposure to cognitively responsive teaching and teaching for sustainability, pre-survey scores were still significantly predicting post-scores. This could have some implications for practice, such as the importance of reaching students as early as possible because the ideas they come with into the pre-survey seem to still be there in the post-survey, even with their opportunity to learn about sustainability between. Or, perhaps, attitudes on this topic could be deep-seated beliefs that are difficult to change at all.

Furthermore, I posited that opportunity to learn influenced all five of the promising practices of teaching and learning, which it did, which makes sense because good teaching practices cannot happen unless there is formal learning about sustainability taking place. While not all paths in the model were significant, it is worth recognizing these significant paths because these paths were likely not attributed to chance, but these particular paths were in fact likely happening. The significant paths are especially important because they are significant after controlling for the other paths leading to that same dependent variable.

**Insignificant Paths**

While overall, a model of *Teaching and Learning for Sustainability in Higher Education* adequately fits the data, it was surprising that many of the paths were not significant, indicating that some were more meaningful than others. The paths between the student demographics and academic characteristics did not significantly influence opportunity to learn about sustainability. These findings provided an interesting contradiction to prior literature, which has found that some populations have more exposure to EfS than other populations, based on race and socioeconomic status (Agyeman et al., 2003; Brainard et al., 2009; Bullard et al., 2008; Garibay, Ong, & Vincent, 2016). Also nonsignificant was the path between pre-test attitudes and opportunity to learn, after controlling for pre-behavior and demographics. None of the
paths between the promising practices of teaching and learning and attitude learning outcomes were significant. Four of the five promising practices of teaching and learning constructs were insignificant on influencing behaviors, after controlling for pre-attitudes, pre-behaviors, opportunity to learn, student demographics, and academic characteristics. This could be signaling that tapping students’ prior knowledge was playing the largest role in affecting students’ sustainability-related behaviors.

The series of aforementioned insignificant paths led to a few conjectures. First, prior research has found that change takes longer than one semester to occur (Leiserowitz et al., 2006; Sterling, 2004), and as such, perhaps this full model should be tested, say, over the course of students’ entire college careers, typically a four- to six-year span. Second, it may be that certain items in the survey were not pertinent. For instance, is it actually likely for a student to increase their attitudes on “access to water is a universal right,” and really work to change this in a trigonometry class? Or a phonetics class? While this is the ultimate (some might say utopian) goal of EfS, perhaps it would be more realistic to ask questions better aligned with what could likely happen. For instance, it would not be out of place for a class on Latin American culture to discuss the serious effects of deforestation in parts of that continent in a way that could encourage students to save paper (such as using double-sided printing and borrowing textbooks instead of buying them). Perhaps these insignificant paths are results of either the limited time of study or the inability of the items in the survey to capture course-level attitudes and behaviors. In other words, I am suggesting that every semester, in each course, students might be making more granular changes in their attitudes and behaviors that, over time, could result in the broader and more robust attitudes and behaviors measured in my one-semester study timeline.

There are several potential reasons for these insignificant paths. One potential reason is that perhaps we do not yet know how to truly teach EfS well—what scholars such as Campbell (2015) have referred to as the “black box” of higher education—or
address the questions of what quality teaching actually looks like. More specifically, we know the inputs (students’ level of sustainability competency before the semester) and the outputs (students’ level of sustainability competency after the semester), but perhaps our knowledge of the teaching and learning processes between them is still not quite understood. Over time, research has explored the characteristics of traditional disciplines in order to better understand good teaching practices in other areas, for one example, mathematics (Ball, 1988, 1993). Unlike these more established disciplines, however, it remains to be seen what good teaching looks like in the interdisciplinary field of sustainability. While I called on prior literature to suggest what I thought good teaching would look like, perhaps these are not truly the best practices for teaching EfS content. It may be that there are better ways to teach this subject matter, which we have yet to discover.

Even with these insignificant paths, this model contributes to the literature because it had good fit. While all paths were not significant within the model, perhaps the effects differ by some variable that is outside the scope of my study, like co-curricular experiences. Or, perhaps in comparing these paths I thought would be significant to previous studies that found that these kinds of relationships were significant, maybe there is something different about the group of students that participated in this study and the ones in other studies that did find significant paths. Alternatively, the previous studies I based this model on looked at smaller parts of this large model that I created. Maybe, if they had included all the variables similar to the way I did, they would not have had so many significant results because they would be controlling for more variables.

**Staking a Claim on Teaching and Learning for Sustainability in Higher Education**

Taken together, based on both the insignificant and significant paths in the *Teaching and Learning for Sustainability in Higher Education*, at this time I stand by this model. I justify this decision based on the theory behind it, and now the acceptable
statistical model fit to support it. As such, I would not revise this model because, although there were several insignificant paths, statistically the model still held with acceptable model fit indices indicating that it did in fact fit the data. Although not all paths were significant, I believe each path represents an important relationship in the model, so even though not all paths were significant, I still believe in keeping all of the paths in this model.

This model theoretically makes sense as it is steeped in decades of K-12 education policy, higher education teaching and learning, and EfS literature. The profusion of validated, dependable individual theories extend to one another and do, in fact, cohere. Therefore, because this idea is based on decades of theory and it statistically still holds, I would not change the model. I would, though, continue to examine nonsignificant paths, which will be discussed in the subsequent section on future research. My statement on this theory is that opportunity to learn about sustainability (in all coursework, not just in traditional science classes) influences exposure to promising practices of teaching and learning about sustainability, which ultimately leads to students’ increased sustainability learning in the forms of knowledge, attitudes, and behaviors. If promising practices of teaching and learning about sustainability were happening more frequently, as evidenced by this model, I hypothesize that there would be more of an influence on the sustainability-related learning outcomes. As such, this model posits that there ought to be more focus on how this subject matter is imparted upon students.

**Implications**

This dissertation study explored the amount, and the effectiveness, of EfS in an HEI and examined whether EfS was related to students’ sustainability learning. To my knowledge, there are no other higher education scholars studying such teaching and learning, specifically in the case of sustainability. This research, therefore, has
implications for the field in several important ways, namely, policy, practice, and research.

**Policy Implications**

As mentioned in this dissertation, the past three decades have seen a rise in policy initiatives that have driven sustainability into higher education (Dobson, 2011; Edwards, 2012; Saylan & Blumstein, 2011; Sterling, 2004). This study found that, likely in response to these initiatives, most student participants did in fact have the opportunity to learn about sustainability throughout their coursework. This learning occurred in classes where, years ago, this subject matter would not have been present. However, while these policy initiatives have promoted sustainability throughout the higher education curriculum, efforts have generally stopped there (Dobson, 2011; Edwards, 2012; Orr, 1991; Sterling, 2004).

Few, if any, policies have advocated for instructing faculty how to teach about sustainability, a problem which was reflected in the poor scores on students’ exposure to promising practices about teaching and learning found in the present study. As such, this study implies that policymakers ought to extend their call for infusing sustainability throughout the curriculum to include teaching faculty on *how* to educate students about sustainability—through ways such as professional development initiatives, which can result in excellent sustainability instruction, as opposed to just teaching about it to fulfill a requirement.

One problem that may arise in attracting instructors’ interest in attending such professional development initiatives is that higher education faculty are not incentivized toward this teaching about sustainability. In fact, they should be compensated for adjusting their syllabi to include this additional teaching (Rowe, 2002; Svanström et al., 2008). Without any incentive, it seems unlikely that they will feel inspired to work on better learning how to teach about sustainability—especially when they could engage in
more lucrative research. Given this need, another policy implication from this study is allocating incentives (financial or time) to support faculty to learn how to teach about sustainability. These policy implications are important: we cannot expect faculty to educate students without first being educated themselves.

Practice Implications

Furthermore, this study was positioned to have implications for practice in terms of teaching, civic mission, and equity.

Teaching practice implications. While this study found that many students did have the opportunity to learn about sustainability, these students most frequently learned about it only once. As such, an implication for instructors’ practice is to integrate EfS throughout the semester, as opposed to just once, in order for its repeated presence to more meaningfully integrate students’ learning process. Prior higher education studies (e.g., Astin, 1993; Kuh, 2003; Tinto, 1997) have found that the amount of time students devote to learning activities influences their acquisition of knowledge. Supported by this body of prior research, this study implies that for students to truly learn about EfS well, their instructors ought to teach about it regularly, weaving the content into the already existing coursework throughout the semester.

Additionally, perhaps the reason that instructors only mention sustainability once is because they struggle to incorporate it into their traditional disciplinary courses (Borg et al., 2012; Christie et al., 2013; Lemkowitz et al., 1996; Reid & Petocz, 2006). Daunted by their limited expertise in teaching specific sustainability-related subject matter, they neglect to bring EfS into their classrooms (Dawe et al., 2005; Saylan & Blumstein, 2011; Smyth, 1995; Sterling, 1992). As was seen in this study, when instructors tapped students’ prior sustainability knowledge and leveraged it to teach them more about the subject, students’ sustainability behaviors increased over the course of one semester. From this perspective, the present study can provide instructors with specific pedagogical
strategies that effectively facilitate students’ EfS learning, namely, by guiding students to encounter new ideas through surfacing their prior knowledge.

In addition, the other four teaching practices (cognitively responsive teaching subject matter and supporting changing views, and teaching for sustainability core ideas and teaching practices) did not influence students’ learning over the course of the semester. However, students largely did not perceive these teaching practices as being frequently employed. Accordingly, implications from this study are that these practices ought to be used more frequently when teaching students about sustainability.

**Equity practice implications.** Marginalized racial groups, along with those of low socioeconomic status, are disproportionately affected by climate change and its economic and social implications (Agyeman et al., 2003; Brainard et al., 2009; Bullard et al., 2008). However, this study found that very few demographics, including race and socioeconomic status, influenced students’ sustainability learning opportunities. But as seen here, regardless of race and SES, such students did have the ability to learn about sustainability. Thus, this study shows the importance of higher education engaging in equitable work. Furthermore, within higher education, students from underrepresented races do not always have equal access to all kinds of subject matter (e.g., Garibay, Ong, & Vincent, 2016; Garibay & Vincent, 2016). However, in this study, I found that such students did have equal access to sustainability-related subject matter. In that regard, in an interdisciplinary field that matters so deeply for equity, equal access to sustainability-related subject matter shows great promise. Consequently, if more students from marginalized groups had access to higher education, they would have an avenue to learn about sustainability.

**Civic mission practice implications.** The original colonial colleges, the first HEIs in America, were founded within the context of civic mission, with the purpose of perpetuating the public good through a learned citizenry (Altbach et al., 2011; Bowen et al., 2005). Although American higher education has undergone many changes since
then, its commitment to contributing to the public good (Altbach et al., 2011) remains intact, despite a hostile political climate where many people, having lost sight of its roots in the well-being of a society, question the value of higher education. The case for educating students about sustainability, however, evidences the civic mission’s ongoing and strong presence, enacting its role in educating students to become sustainably aware citizens. Perhaps then, implications from this can contribute to a larger conversation about the purpose of higher education in a world that increasingly fails to value it. For instance, with the sharp rise of technical schools (and reduction of the liberal arts), many students are likely missing out on important lessons regarding their future roles as sustainably engaged citizens. As seen in this study, higher education can serve as a site for cultivating a better world by educating students to be part of a social movement, in this case, with regard to sustainability.

**Research Implications**

In addition to its policy and practice implications, the present study also has implications for research in order to expand scholarship on EfS. First, given that the central focus of this dissertation, EfS, is grounded in the environmental and sustainability education literature base, this study formally brings EfS into the study of higher education, providing the field with a new content area.

Most prior studies of EfS have examined the interdisciplinary field of EfS through the diffusion model, specifically focusing on a particular EfS course. However, because policy initiatives have called for sustainability to be infused across the curriculum, future research, like this study, ought to mirror policy initiatives and investigate EfS beyond just a traditionally labeled EfS course. For example, students of color are less likely to enroll in sustainability-specific coursework, but in this study, we saw that they had equal access to it throughout the curriculum. Hence, without exploring this topic throughout the curriculum we would miss such important opportunities of it—additional evidence that
future research studies should examine EfS across the curriculum. Furthermore, because policy initiatives have pushed EfS into many courses without providing insight into how to teach it, much remains to be known on how to teach EfS well. Therefore, OTL should not be studied without also examining teaching practices used to deliver sustainability content to students.

This study validated the survey instrument I created for examining students’ EfS coursework experiences. Given that EfS is understudied in higher education, this study contributes a survey instrument for students’ sustainability learning. If scholars, as well as practitioners such as sustainability officers in HEIs, use this survey to measure their students’ EfS coursework experiences, we can together build a richer understanding of teaching and learning about sustainability in higher education. In turn, we can offer the field better ways to increase students’ sustainability learning, and strengthen their pathways to becoming more sustainably engaged citizens.

**Theoretical Implications**

To date, higher education frameworks for teaching and learning are not designed to focus on highly politicized subject matters, like sustainability. As such, for the present study, I created the first higher education theoretical framework for teaching and learning about sustainability. Implications from this study offer a way to frame sustainability-specific subject matter and teaching practices. Additionally, scholars can continue to examine which facets of the *Framework for Teaching and Learning about Sustainability* are most important and continue to fine-tune the framework as it develops.

**Future Research**

This dissertation study offered insight on EfS in higher education. In particular, I found that, while most student participants had some exposure to sustainability-specific
subject matter throughout their coursework, far fewer had access to promising practices of teaching and learning when learning about sustainability. Additionally, of the five constructs for promising practices of teaching and learning, only one (tapping prior knowledge) proved to significantly increase students’ sustainability behaviors over the course of one semester. Given these findings, below I discuss recommendations for future research that can expand upon the present dissertation study in order to fortify this line of research, including modifications to the replication of and expansion of the present study.

**Modifications to Replication of Present Study**

There are several modifications I propose for strengthening future iterations of the present study to enhance its breadth and depth. First, I advise testing the *Framework of Teaching and Learning for Sustainability in Higher Education* with the incorporation of knowledge learning outcomes. In particular, I suggest using a revised set of knowledge outcomes for a reliable measure of students’ sustainability knowledge. Given that knowledge is the foundation for understanding our environmental beliefs, and our behavior around sustainability-related problems (Leiserowitz et al., 2006; Peattie, 2010), its inclusion is essential to more fully understand students’ learning about sustainability. Furthermore, as EFS is still a maturing interdisciplinary field and often lacks the credibility of its more well-established disciplinary counterparts (like history and geography), it is important—in its quest to become established—to measure students’ traditional ways of learning, such as knowledge acquisition.

Additionally, in terms of the learning outcomes (in all three forms of knowledge, attitudes, and behaviors), the items should perhaps be better aligned with students’ coursework in either one of two ways. On the one hand, the survey questions could be broader such as to be applicable to essentially any discipline. Or, on the other hand, perhaps they could be narrower such that they reflect what can realistically be covered in
a specific discipline. Either way, be it by broader or narrower survey questions, future research ought to explore how to better measure students’ EfS learning.

Moreover, this research was based on EfS at one public, large-sized, four-year research university. Future research ought to replicate this study at other institutional types in order to see if, practically, the findings would remain consistent, and conceptually, that this model would hold. I am particularly interested in how this model would act in tribal colleges (where postsecondary practices act in accordance with the indigenous communities they are embedded in), as well as at community colleges, historically Black colleges and universities, Hispanic-serving institutions, and other forms of minority-serving institutions (where most students are racial minorities from low SES backgrounds and communities hit hard by sustainability-related problems).

**Expansion of Present Study**

There are several possible directions, building off the present study, for expanded research on EfS across the higher education curriculum. For one, this study’s most promising finding was the benefits of employing students’ prior knowledge of sustainability-specific subject matter in teaching them sustainability-related behaviors, practices, and skills. Given this potential, future research ought to further investigate this sustainability-specific prior knowledge, such as whether or not all prior knowledge behaves similarly in students’ learning. Do certain types of prior knowledge (e.g., knowledge learned in previous years of formal schooling) act the same way in fostering students’ learning as what is read in the news? Seen on social media? Experienced from living through a climate disaster like the spreading wildfires in California? Does a students’ political ideology play a role in their learning of contentious interdisciplinary subject matter? A better understanding of the types of prior knowledge that most support students’ learning could strengthen this construct’s effect on students’ sustainability learning.
Also, in the present study, the intervention between the pre- and post-surveys was formal classroom learning experiences. However, higher education scholarship (Astin, 1984; Kuh, 2001, 2009), in conjunction with EfS literature (Halfarce et al., 2013), posits the importance of students’ co-curricular engagement for their learning. As such, perhaps other kinds of learning were taking place during the semester, such as participating in a sustainability-related club or organization. Since this study only examined what happened in the classroom, future research ought to explore the possible advances in learning outcomes that may result from important co-curricular learning.

Furthermore, is it not preemptive to expect faculty to teach about sustainability before knowing their comprehension of it? Future research should distribute to faculty the same survey instrument of sustainability knowledge, attitudes, and behaviors supplied to students. Additionally, although prior studies have pointed to the limited opportunities for faculty to participate in professional EfS development, and although I advocate for increasing faculty development for training instructors in how to teach sustainability, we first need a basic understanding of faculty’s sustainability knowledge, attitudes, and behaviors—which can be done through administering a survey similar to the one distributed to students in the present study.

Finally, I suggest the incorporation of additional data collection methods in future EfS research. The present study measures students’ perception of their exposure to sustainability-related subject matter, as well as teaching practices employed to teach that subject matter. To complement students’ perceptions, future research should employ EfS experts to examine EfS teaching as it unfolds in the classroom by way of classroom observation. This would enable a more nuanced investigation of what is actually taking place in EfS (Campbell, 2017).
Conclusion

Although the majority of scientists agree that we are facing unprecedented climate crises, prior literature suggests that higher education’s engagement with environmental and sustainability problems is sorely lacking. As such, policymakers have deemed higher education classrooms a promising site for equipping future generations of citizens to engage with sustainability (Chase et al., 2012; Crossley, 2018). However, EfS is not being incorporated into the higher education curriculum with either the quantity or quality necessary to steer society toward social change (Jensen, 2014).

Therefore, the purpose of this dissertation study was to explore the amount of, and the effectiveness of, EfS in an institution of higher education and to analyze whether EfS was related to students’ sustainability learning outcomes. Data collection took place at Michigan State University, a public, large-sized, four-year institution. Students were surveyed at both the beginning and end of the Fall 2017 semester to measure changes over the course of one academic semester. Guided by the operative frames of opportunity to learn, cognitively responsive teaching, teaching for sustainability, and transformative sustainability learning outcomes, data were analyzed with logistic and ordinary least squares regression, and Structural Equation Modeling (SEM).

Results showed that of the 748 participants, approximately two-thirds reported having the opportunity to learn about sustainability-related content in at least one of their courses. On average, neither cognitively responsive teaching nor teaching for sustainability pedagogical approaches were employed to teach sustainability-related subject matter. Interestingly, though, when instructors surfaced students’ prior knowledge about sustainability while teaching the subject, students’ pro-sustainability behaviors increased over the course of the semester. Accordingly, this study contributes to the broader field of higher education by illuminating the importance of the pedagogical
technique of utilizing students’ prior knowledge when teaching them about culturally sensitive, politically charged subject matter.
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Appendix A

List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ACUPCC</td>
<td>American College and University Presidents’ Climate Commitment</td>
</tr>
<tr>
<td>CRT</td>
<td>Cognitively Responsive Teaching</td>
</tr>
<tr>
<td>HEIs</td>
<td>Higher Education Institutions</td>
</tr>
<tr>
<td>EE</td>
<td>Environmental Education</td>
</tr>
<tr>
<td>EfS</td>
<td>Education for Sustainability</td>
</tr>
<tr>
<td>IPPC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>MSU</td>
<td>Michigan State University</td>
</tr>
<tr>
<td>OTL</td>
<td>Opportunity to Learn</td>
</tr>
<tr>
<td>PPOT&amp;LAS</td>
<td>Promising Practices of Teaching and Learning about Sustainability</td>
</tr>
<tr>
<td>SEM</td>
<td>Structural Equation Modeling</td>
</tr>
<tr>
<td>SHE</td>
<td>Sustainability in Higher Education</td>
</tr>
<tr>
<td>TfS</td>
<td>Teaching for Sustainability</td>
</tr>
<tr>
<td>TSL</td>
<td>Transformative Sustainability Learning Outcomes</td>
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<tr>
<td>UN</td>
<td>United Nations</td>
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<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
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</table>
Appendix B

Michigan State University IRB Approval

MICHIGAN STATE UNIVERSITY

September 5, 2017

To: Adam Zwackle
502 Baker Hall

Re: IRB # 2017-1144a Category: Exempt 2
Approval Date: September 5, 2017

Title: Fall 2017 Campus Sustainability Survey

The Institutional Review Board has completed their review of your project. I am pleased to advise you that your project has been deemed as exempt in accordance with federal regulations.

The IRB has found that your research project meets the criteria for exempt status and the criteria for the protection of human subjects in exempt research. Under our exempt policy the Principal Investigator assumes the responsibilities for the protection of human subjects in this project as outlined in the assurance letter and exempt educational material. The IRB office has received your signed assurance for exempt research. A copy of this signed agreement is appended for your information and records.

Renewal: Exempt protocols do not need to be renewed. If the project is completed, please submit an Application for Permanent Closure.

Revisions: Exempt protocols do not require revisions. However, if changes are made to a protocol that may no longer meet the exempt criteria, a new initial application will be required. If the project is modified to add additional sites for the research, please note that you may not begin your research at those sites until you receive the appropriate approvals/permissions from the sites.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects and change the category of review, notify the IRB office promptly. Any complaints from participants regarding the risk and benefits of the project must be reported to the IRB.

Follow-up: If your exempt project is not completed and closed after three years, the IRB office will contact you regarding the status of the project and to verify that no changes have occurred that may affect exempt status.

Please use the IRB member listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

C: Bruno Takahashi, John Besier, Mark Gibson, Jessica Michel
Appendix C
Teachers College IRB Approval

Ostrow, Jessica <jo2317@tc.columbia.edu>

Exemption Notification - IRB ID: 18-060
Curt Nasar <naesar@axcomedu.com>
Reply-To: Curt Nasar <curtn@axcomeducation.com>
To: jo2317@ts.columbia.edu

Thu, Oct 12, 2017 at 01:07 PM

Teachers College IRB

To: Jessica Ostrow  
From: Curt Nasar, TC IRB Administrator  
Subject: IRB Approval: 18-060 Protocol  
Date: 10/12/2017  

Thank you for submitting your study entitled, "An Assessment of Sustainability Teaching and Learning across the Higher Education Curriculum"; the IRB has determined that your study is Exempt from committee review (Category 1) on 10/12/2017.

Please keep in mind that the IRB Committee must be contacted if there are any changes to your research protocol. The number assigned to your protocol is 18-060. Feel free to contact the IRB Office by using the “Messages” option in the electronic Mentor IRB system if you have any questions about this protocol.

As consent is conducted online, no stamped copy of the consent form is provided with this approval. You can retrieve a PDF copy of this approval letter from the Mentor site.

Best wishes for your research work.

Sincerely,
Curt Nasar, Ph.D.
TC IRB Administrator
Appendix D

Language for Email and Reminders

Language for Email and Reminders for Pre-Survey

Initial Email – 7am Tues, 9/12
Subject: Make Your Voice Heard!
Dear ${m://FirstName},
I am writing to ask you for your help with the fourth annual Michigan State University Sustainability Survey. The annual Sustainability Survey is an important way for Spartan students to let their voices be heard about sustainability issues on campus and around the world. We greatly appreciate your help with this year’s survey, which you can begin by clicking the link below:
Take the survey
We have many exciting sustainability initiatives happening on campus, thanks in large part to students like yourself. Thank you for taking the time to share your thoughts with me, and…GO GREEN!

Sincerely,
Ann Erhardt
Director of Sustainability
Michigan State University

Reminder 1,2&3 – 7am Thurs, 9/14; 12pm Sat, 9/16; 12pm Mon, 9/18
Wed: 7am
Fri: noon
Sunday: noon

Dear ${m://FirstName},
Earlier this week I sent an e-mail to you asking for your help in the fourth annual Michigan State University Sustainability Survey. The annual Sustainability Survey is an important way for Spartan students to let their voices be heard about sustainability issues on campus and around the world. We greatly appreciate your help with this year’s survey, which you can begin by clicking the link below:
Take the survey
We have many exciting sustainability initiatives happening on campus, thanks in large part to students like yourself. Thank you for taking the time to share your thoughts with me, and…GO GREEN!

Sincerely,
Ann Erhardt
Director of Sustainability
Michigan State University
Reminder 4 – 5pm Wednesday, 9/20

Dear ${m://FirstName},

I am writing to follow up on the e-mail I sent last week asking for your help in the fourth annual Michigan State University Sustainability Survey. We ask for your participation just one last time and to tell you that the survey will close on XXXXX.

Take the survey

We have many exciting sustainability initiatives happening on campus, thanks in large part to students like yourself. Thank you for taking the time to share your thoughts with me, and…GO GREEN!

Sincerely,
Ann Erhardt
Director of Sustainability
Michigan State University

Language for Email and Reminders for Post-Survey

Subject: Make Your Voice Heard!
Dear ${m://FirstName},

At the beginning of the semester, we asked you some questions about social and environmental issues. We would love to hear from you again on some of these issues. I am writing to ask you for your help with a follow-up Sustainability Survey. The annual Sustainability Survey is an important way for Spartan students to let their voices be heard about sustainability issues on campus and around the world. We greatly appreciate your help with this survey, which you can begin by clicking the link below:

Take the survey

We have many exciting sustainability initiatives happening on campus, thanks in large part to students like yourself. Thank you for taking the time to share your thoughts with me, and…GO GREEN!

Sincerely,

Ann Erhardt
Director of Sustainability
Michigan State University
Appendix E

Informed Consent for Pre-Survey

We need your help understanding what students think and do about social and environmental issues. This is an annual survey and you were randomly selected from MSU’s student body. We would like to hear from you regardless if you have strong feelings about sustainability or not. Thanks for your help.

Because this is a university-based research study, we are obligated to inform you of the following:

1. Your participation in this survey is voluntary. You must be 18 years or older in order to participate. You may choose not to participate at all, or you may refuse to answer certain questions or discontinue your participation at any time without consequences.

2. Your participation in this study is not expected to cause you any risk greater than those encountered in everyday life. Your answers will not harm you in any way. If you feel any discomfort in answering any question, you can withdraw from the study without any consequences.

3. If you have any questions about your rights as a participant, please contact Dr. Adam Zwickle by email at skastudy@msu.edu. Further, if you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University’s Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or email irb@msu.edu or regular mail at 408 W. Circle, 207 Olds Hall, MSU, East Lansing, MI 48824.

By clicking next at the bottom of this screen, you indicate that you have voluntarily agreed to participate in this study.
Informed Consent for Student Post-Survey

Protocol Title: An Assessment of Sustainability Teaching and Learning across the Higher Education Curriculum
Principal Investigator: Jessica Ostrow Michel, Doctoral Candidate, Teachers College, Columbia University  
   jo2317@tc.columbia.edu

INTRODUCTION
You are being invited to participate in this research study called “An Assessment of Sustainability Teaching and Learning across the Higher Education Curriculum.” You may qualify to take part in this research study because you are a college student over 18 years of age, and you expressed your willingness to take a follow-up survey when you filled out the Fall 2017 Sustainability Survey. Approximately five hundred people will participate in this study and it will take 15 of your time to complete.

WHY IS THIS STUDY BEING DONE?
This study is being done to determine what teaching and learning about sustainability in higher education looks like.

WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY?
If you decide to participate, you will be asked to do one survey (approximately 15 minutes).

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY?
This is a minimal risk study, which means the harms or discomforts that you may experience are not greater than you would ordinarily encounter in daily life while taking routine physical or psychological examinations or tests. However, there are some risks to consider. You might feel discomfort in speaking about some of your class experiences. However, you do not have to answer any questions. You can stop participating in the study at any time without penalty.

You might feel concerned that your responses might get back to instructors or administrators. The principal investigator is taking precautions to keep your information confidential and prevent anyone from discovering or guessing your identity, such as using a code instead of your name and keeping all information on a password protected computer. The principal investigator is taking steps to ensure that your individual responses will never be seen by anyone outside of the research team.

WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY?
There is no direct benefit to you for participating in this study. Participation may benefit the field of higher education to better understand college teaching about sustainability.
WILL I BE PAID FOR BEING IN THIS STUDY?
You will not be paid to participate.

WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS?
The study is over when you have completed the survey. However, you can leave the study at any time even if you haven’t finished.

PROTECTION OF YOUR CONFIDENTIALITY
The PI will keep all survey responses on a computer that is password protected. The information that identifies who you are (e.g. your name, email address) will be kept separate from your responses. There will be a code (a number) that links your name and other identifying information to your survey responses. This code will be kept by only the PI and lead researchers. Regulations require that research data be kept for at least three years.

HOW WILL THE RESULTS BE USED?
The results of this study will be published in journals and presented at academic conferences. Your name or any identifying information about you will never be published.

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?
If you have any questions about taking part in this research study, you should contact the principal investigator, Jessica Ostrow Michel at jo2317@tc.columbia.edu. You can also contact the faculty advisor, Dr. Corbin Campbell at campbell2@tc.columbia.edu or 212-531-5182.
If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 1002. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.
PARTICIPANT’S RIGHTS

- I have read and discussed the informed consent with the researcher. I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty to future student status.
- The researcher may withdraw me from the research at his or her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.

By clicking “YES” below, you are stating that you are over 18 years old and agree to participate in this study:
YES
NO
To: Dr. Adam Zwickle, Assistant Professor  
From: Jessica Ostrow Michel, Doctoral Candidate  
Date: September 19, 2017  

Subject: Data Sharing and Usage Agreement  
This agreement establishes the terms and conditions under which Jessica Ostrow Michel of Teachers College, Columbia University will acquire data from Dr. Adam Zwickle of Michigan State University (MSU).

Period of agreement
- Dr. Zwickle and Mr. Mark Gibson will distribute the 2017 Fall Sustainability Survey to a random sample of ideally 50% of MSU students in September 2017.
  - Dr. Zwickle will share the data with Jessica by mid-October (earlier if possible).
- Dr. Zwickle will distribute a follow-up study to participants of the 2017 Fall Sustainability Survey who agree to be contacted for a post-survey in late-November to mid-December.
  - Dr. Zwickle will share the data with Jessica by late-December (earlier if possible).
- After all data has been collected, and both Jessica and Dr. Zwickle have access to the data they need (by mid-January 2017), the period of agreement will be terminated.

Constructs under agreement
- Dr. Zwickle will share the following data with Jessica from 2017 Fall Sustainability Survey
  - Student demographics
  - Assessment of Sustainability Knowledge
  - Sustainability Attitudes Scale
  - Sustainability Behavior Questions
- Jessica will have access to ask the following sets of questions in her follow-up study
  - Student demographics
  - Assessment of Sustainability Knowledge
  - Sustainability Attitudes Scale
  - Sustainability Behavior Questions
  - Opportunity to Learn
  - Cognitively Responsive Teaching
  - Teaching for Sustainability
  - Transformative Sustainability Learning Outcomes
Constraints on use of the data

- Jessica will use the data to map where and how sustainability is being taught to students throughout the MSU curriculum, and will analyze the structural relationships between students who have the opportunity to learn about sustainability and experiencing promising practices of teaching and learning surrounding sustainability with students’ sustainability learning outcomes.
- Jessica retains the right to own the measurement tool (survey items) and framework developed for the post-survey.
- Jessica can generate, publish or disseminate data findings and reports related to her dissertation research without approval of Dr. Zwickle.
- Jessica will not share the data with any further parties.

Data confidentiality

- Because some data may contain information that can be linked to individuals, when Jessica receives the data, she will store all data in a password-protected computer in a locked office.
- Personal information of survey participants will remain confidential and will not be disclosed verbally or in writing to any unauthorized third party.

Methods of data-sharing

- Data will be shared electronically, though email.

Financial costs of data-sharing

- There are no monetary costs for the sharing of data for either party.

Jessica Ostrow Michel, Doctoral Candidate
Higher and Postsecondary Education Program
Teachers College, Columbia University

Dr. Corbin M. Campbell
Dissertation Sponsor
Higher and Postsecondary Education Program
Teachers College, Columbia University

Signature: Jessica Ostrow Michel
Date: 9/26/2017

Dr. Adam Zwickle, Assistant Professor
School of Criminal Justice and Environmental Science and Policy Program
Michigan State University

Signature: Adam Zwickle
Date: 9/19/2017
Student Demographics

What is your current academic status?
- Freshman
- Sophomore
- Junior
- Senior

Are you a full- or part-time student?
- Full-time student
- Part-time student

Did you enter into MSU as a first-time or transfer student?
- First-time student
- Transfer student

What is your current GPA, to the best of your recollection?
- [text box]

What is your college?
- College of Agriculture and Natural Resources
- College of Arts and Letters
- Eli Broad College of Business
- College of Communication Arts and Sciences
- College of Education
- College of Engineering
- James Madison College
- Lyman Briggs College
- College of Music
- College of Natural Science
- College of Nursing
- Residential College in the Arts and Humanities
- College of Social Science
- College of Veterinary Medicine
- Don’t Know
What is your major?
Display logic will follow the previous question so that only majors attached to the particular college will show

College of Agriculture and Natural Resources
- Agribusiness Management
- Agriculture and Natural Resources
- Agriculture, Food and Natural Resources Education
- Animal Science
- Construction Management
- Crop and Soil Sciences
- Dietetics
- Entomology
- Environmental Economics and Management
- Environmental Economics and Policy
- Environmental Studies and Sustainability
- Fisheries and Wildlife
- Food Industry Management
- Food Science
- Forestry
- Horticulture
- Interior Design
- Landscape Architecture
- Nutritional Sciences
- Packaging
- Sustainable Parks, Recreation and Tourism
- Technology Systems Management
- Other

College of Arts and Letters
- Apparel and Textile Design
- Apparel and Textiles
- Arabic
- Art Education
- Art History and Visual Culture
- Arts & Letters-General
- Chinese
- Classical Studies
- English
- Experience Architecture
- Film Studies
- French
- German
- Global Studies in the Arts and Humanities
- Humanities - Prelaw Program
- Interdisciplinary Humanities
- Japanese
- Linguistics
- Philosophy
- Professional Writing
- Religious Studies
- Russian
- Spanish
- Studio Art - Bachelor of Arts
- Studio Art - Bachelor of Fine Arts
- Theatre - Bachelor of Arts
- Theatre - Bachelor of Fine Arts
- Women’s and Gender Studies
- Other

Eli Broad College of Business
- Accounting
- Finance
- General Management
- Hospitality Business
- Human Resource Management
- Marketing
- Supply Chain Management
- Other

College of Communication Arts and Sciences
- Advertising
- Communication
- Journalism
- Media and Communication Technology
- Media and Information - Bachelor of Arts
- Media and Information - Bachelor of Science
- Media Arts and Technology
- Other

College of Education
- Athletic Training
- Education
- Kinesiology
- Special Education-Learn Disabilities
- Other
College of Engineering
- Applied Engineering Sciences
- Biosystems Engineering
- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Computer Science
- Electrical Engineering
- Engineering-No Major
- Environmental Engineering
- Materials Science and Engineering
- Mechanical Engineering
- Other

James Madison College
- Comparative Cultures and Politics
- International Relations
- Political Theory and Constitutional Democracy
- Social Relations and Policy
- Other

Lyman Briggs College
- Biology
- Computer Science
- Earth Science
- Environmental Sciences and Management
- History, Philosophy and Sociology of Science
- Physical Science
- Other

College of Music
- Composition
- Jazz Studies
- Music
- Music Education
- Music Performance
- Other

College of Natural Science
- Actuarial Science
- Astrophysics
- Biochemistry and Molecular Biology
- Biochemistry and Molecular Biology/Biotechnology
- Biological Science-Interdepartmental
• Biomedical Laboratory Science
• Chemical Physics
• Chemistry - Bachelor of Arts
• Chemistry - Bachelor of Science
• Clinical Laboratory Sciences
• Computational Chemistry
• Computational Mathematics - Bachelor of Arts
• Computational Mathematics - Bachelor of Science
• Diagnostic Molecular Science
• Earth Science - Interdepartmental
• Environmental Biology/Microbiology
• Environmental Biology/Plant Biology
• Environmental Biology/Zoology
• Environmental Geosciences
• Genomics and Molecular Genetics
• Geological Sciences
• Human Biology
• Mathematics - Bachelor of Arts
• Mathematics - Bachelor of Science
• Mathematics, Advanced - Bachelor of Arts
• Mathematics, Advanced - Bachelor of Science
• Microbiology
• Natural Science-No Major
• Neuroscience
• Physical Science - Interdepartmental
• Physics - Bachelor of Arts
• Physics - Bachelor of Science
• Physiology
• Plant Biology
• Predental
• Premedical
• Preoptometry
• Statistics - Bachelor of Arts
• Statistics - Bachelor of Science
• Zoology - Bachelor of Arts
• Zoology - Bachelor of Science
• Other

**College of Nursing**
• Nursing
• Nursing - Accelerated Second Degree Program
• Nursing (Online Program) - RN license required
• Prenursing
• Other
Residential College in the Arts and Humanities
- Arts and Humanities
- Other

College of Social Science
- Anthropology - Bachelor of Arts
- Anthropology - Bachelor of Science
- Child Development - Bachelor of Arts
- Criminal Justice
- Early Care and Education
- Economics - Bachelor of Arts
- Economics - Bachelor of Science
- Environmental Geography
- Geographic Information Science
- Geography - Bachelor of Arts
- Geography - Bachelor of Science
- Global and Area Studies- Social Science (Bachelor of Arts)
- Global and Area Studies- Social Science (Bachelor of Science)
- History
- History Education
- Human Development and Family Studies - Bachelor of Arts
- Human Development and Family Studies - Bachelor of Science
- Human Geography
- Interdisciplinary Studies in Social Science - Bachelor of Arts
- Interdisciplinary Studies in Social Science - Bachelor of Science
- Interdisciplinary Studies in Social Science: Social Science Education
- Political Science - General
- Political Science - Prelaw
- Psychology - Bachelor of Arts
- Psychology - Bachelor of Science
- Public Policy
- Social Work
- Sociology - Bachelor of Arts
- Sociology - Bachelor of Science
- Urban and Regional Planning
- World Politics
- Other

College of Veterinary Medicine
- Preveterinary
- Veterinary Technology
- Other
Don’t Know
- [text box]

What is your current living arrangement?
- I live on campus
- I live off campus
- I live in a sorority or fraternity house

Did you choose to live on or near campus in order to limit the amount of times you need to drive?
Display logic will follow the previous question so that only students who live on campus or in a sorority or fraternity house will receive this question
- Yes
- No, I chose to live here for different reasons
- No, I did not have a choice

What is the highest level of education your father completed?
- Less than high school
- High school/GED
- Vocational/technical degree or some college
- Bachelor’s degree
- Master’s degree
- PhD or equivalent degree
- Don’t know/Not applicable

What is the highest level of education your mother completed?
- Less than high school
- High school/GED
- Vocational/technical degree or some college
- Bachelor’s degree
- Master’s degree
- PhD or equivalent degree
- Don’t know/Not applicable

When it comes to paying for university tuition and living costs, which of the following are true.
My parents pay most of the costs
I need to have a part-time job during the school year
I need financial aid
I need to take out loans

Response options for this set of questions are:
- Yes
- No
Which of the following describes the area you come from?
- Large urban (over 100,000 residents)
- Medium urban (25,000 -- 100,000 residents)
- Small urban (2,500 - 24,999 residents)
- Rural town (< 2,500 residents)

In general, would you describe your views about economic issues as ...
- Very conservative
- Conservative
- Moderate
- Liberal
- Very liberal Don’t know

In general, would you describe your views about social issues as ...
- Very conservative
- Conservative
- Moderate
- Liberal
- Very liberal
- Don’t know

In politics today, do you consider yourself a Republican, Democrat or Independent
- Republican
- Independent leaning Republican
- Independent
- Independent leaning Democrat
- Democrat

In what year were you born?
- [text box]

To which gender identity do you most identify?
- Male
- Female
- Not listed

Were you born in the United States?
- Yes
- No

In what country were you born?
*Display logic will follow the previous question so that only students who said no will receive this question*
- [text box]
How long have you been in the United States (In years)?
Display logic will follow the previous question so that only students who said no will receive this question
- [text box]

Do you consider yourself Latino or Hispanic?
- Yes
- No

Which of the following describes your race? You may select as many as apply.
- White
- Black or African American
- American Indian or Alaska Native
- Asian Indian
- Japanese
- Chinese
- Filipino
- Korean
- Vietnamese
- Guamanian or Chamorro
- Samoan
- Native Hawaiian
- Other Asian [text box]
- Other Pacific Islander [text box]
- Other [text box]

What is your present religion, if any?
- Protestant
- Roman Catholic
- Mormon
- Orthodox, such as Greek or Russian Orthodox
- Jewish
- Muslim
- Buddhist
- Hindu
- Atheist
- Agnostic
- Spiritual, but not religious
- Something else [text box]

In an effort to understand how students grow and change in their perspectives during their time at MSU, we will contact a few selected students with some follow-up questions in the future.
Would you agree to be contacted again at the end of the semester?

- Yes
- No

**Learning Outcomes: Knowledge**

The first group of questions is meant to assess what people know about science and environmental issues. Please answer to the best of your ability.

What is the most common cause of pollution of streams and rivers in the U.S.?

- Dumping of garbage by cities
- *Surface water running off yards, city streets, paved lots, and farm fields*
- Litter near streams and rivers
- Waste dumped by factories

Ozone forms a protective layer in the earth’s upper atmosphere. What does ozone protect us from?

- Acid rain
- Climate change
- Sudden changes in temperature
- *Harmful UV rays*

Which of the following is an example of sustainable forest management?

- Setting aside forests to be off limits to the public
- *Never harvesting more than what the forest produces in new growth*
- Producing lumber for nearby communities to build affordable housing
- Putting the local communities in charge of forest resources

Which of the following is the most commonly used definition of sustainable development?

- Creating a government welfare system that ensures universal access to education, health care, and social services
- Setting aside resources for preservation, never to be used
- *Meeting the needs of the present without compromising the ability of future generations to meet their own needs*
- Building a neighborhood that is both socio-demographically and economically diverse

---

1Correct answer is italicized.
Over the past 3 decades, what has happened to the difference between the wealth of the richest and poorest Americans?

- The difference has increased
- The difference has stayed about the same
- The difference has decreased

Which of the following countries passed the U.S. to become the largest emitter of the greenhouse gas carbon dioxide?

- China
- Sweden
- Brazil
- Japan

Many economists argue that electricity prices in the U.S. are too low because...

- They do not reflect the costs of pollution from generating the electricity
- Too many suppliers go out of business
- Electric companies have a monopoly in their service area
- Consumers spend only a small part of their income on energy

Which of the following is the most commonly used definition of economic sustainability?

- Maximizing the share price of a company’s stock
- Long term profitability
- When costs equal revenue
- Continually expanding market share

Which of the following is a leading cause of depletion of fish stocks in the Atlantic Ocean?

- Fishermen seeking to maximize their catch
- Reduced fish fertility due to genetic hybridization
- Ocean pollution
- Global climate change

Which of the following is the best example of environmental justice?

- Urban citizens win a bill to have toxic wastes taken to rural communities
- The government dams a river, flooding Native American tribal lands to create hydro-power for large cities
- All stakeholders from an indigenous community are involved in setting a quota for the amount of wood they can take from a protected forest next to their village
- Multi-national corporations build factories in developing countries where environmental laws are less strict.
Of the following, which would be considered living in the most environmentally sustainable way?

- Recycling all recyclable packaging
- *Reducing consumption of all products*
- Buying products labeled “eco” or “green”
- Buying the newest products available

Put the following list in order of the activities with the largest environmental impact to those with the smallest environmental impact:

A. Keeping a cell phone charger plugged into an electrical outlet for 12 hours
B. Eating one McDonald’s quarter-pound hamburger
C. Eating one McDonald’s chicken sandwich
D. Flying in a commercial airplane from Washington D.C. to China

- A, C, B, D
- D, A, B, C
- D, C, B, A
- D, B, C, A

**Learning Outcomes: Attitudes**

For the next group of questions, please indicate how much you agree or disagree with each statement.

- Equal rights for all people strengthen a community.
- Community cooperation is necessary to solve social problems.
- Generally speaking consumerism is not sustainable.
- Access to clean water is a universal human right.
- I am willing to put forth a little more effort in my daily life to reduce my environmental impact.
- An unsustainable economy values personal wealth at the cost of others.
- I believe that many people can work together to solve global problems.
- Clean air is part of a good life.
- Our present consumption of natural resources will result in serious environmental challenges for generations.
- The well-being of others affects me.
- Biological diversity in itself is good.

**Response options for this set of questions are:**

- Strongly disagree
- Disagree
- Somewhat disagree
- Somewhat agree
- Agree
- Strongly agree
**Learning Outcomes: Behaviors** (Private)

The next group of questions is meant to assess what you do to live more sustainably. Some actions have big impacts, and some have small impacts. Some actions are easy to do, and some are hard to do.

We are interested in what YOU do, in your own, everyday life.

- Limit your meat consumption?
- Use a reusable drinking bottle instead of disposable plastic water bottles?
- Switch off your electronics when they are not in use?
- Limit water use?
- Practice double-sided printing?

**Response options for this set of questions are:**
- Always
- Often
- Sometimes
- Rarely
- Never

**Learning Outcomes: Behaviors** (Public)

Since the beginning summer\(^2\), how often did you make a special effort to...

- Sign a petition?
- Take part in a protest or demonstration?
- Participate in a community or environmentally-focused club or organization?
- Avoid companies with harmful practices?
- Avoid using or buying certain products?
- Choose locally-owned businesses over larger chains?
- Try to convince a friend not to buy bottled water?

**Response options for this set of questions are:**
- Always
- Often
- Sometimes
- Rarely

\(^2\)In the post-test, this question said: Since the beginning of the Fall 2017 semester, how often did you make a special effort to…
Learning Outcomes: Knowledge, Attitudes, & Behaviors
Replicated set of questions from pre-test

Opportunity to Learn (Co-curricular)

During the past semester, how often did you attend…
- A university-sponsored club or organization that focused on sustainability?
- A university-sponsored event, activity, or lecture (not part of an academic class) that focused on sustainability?
- An off-campus club or organization that focused on sustainability?
- An off-campus event, activity, or lecture (not part of an academic class) that focused on sustainability?

Response options for this set of questions are:
- Never
- A few times
- Sometimes
- Many times
- Every chance I got

Opportunity to Learn (Curricular)

The next few sections of this survey will focus on your learning about sustainability during the Fall 2017 semester.

Sustainability refers to the idea that human activity ought to be guided by the consideration of the health and well-being of the environment and future generations of humans. Acting sustainably, for example, could mean acting responsibly about the products we consume in order to be able to support the billions of people on this planet forever.

During the past semester, how often did your instructor mention sustainability-related topics in…
- Courses that are required for your major
- General education courses
- Elective courses
- Lectures
- Labs
- Recitations
- Practicums
- Another type of course [text box]
Response options for this set of questions are:

- Never
- A few times
- Sometimes
- Many times
- All the time
- Not applicable (I did not take this kind of course)

During the past semester, in how many of your courses did you see a visual of sustainability similar to the image below?

- 0 (this was not mentioned in any course)
- 1 course
- 2 courses
- 3 courses
- 4+ courses
During the past semester, in how many of your courses did you see a visual of sustainability similar to the image below?

- 0 (this was not mentioned in any course)
- 1 course
- 2 courses
- 3 courses
- 4+ courses

An ecological footprint tells you the impact that a person or community has on the environment, as expressed by the amount of land required to sustain their use of natural resources.

During the past semester, in how many of your courses did you complete an ecological footprint?
- 0 (this was not mentioned in any course)
- 1 course
- 2 courses
- 3 courses
- 4+ courses

During the past semester, in how many courses were the following kinds of sustainability-related current events mentioned?

- **National events** (like the United States’ withdrawal from the Paris Climate Accord)
- **Regional events** (like the Flint Michigan Water Crisis or Lake Erie Algae Bloom)
- **Local MSU events** (like the power plant to stop using coal or the solar array over the parking lot)
Response options for this set of questions are:
- 0 (this was not mentioned in any course)
- 1 course
- 2 courses
- 3 courses
- 4+ courses

During the past semester, in how many of your courses did you...
- Learn about sustainability in at least one class session?
- Learn about sustainability in a semester-long theme or project?

Response options for this set of questions are:
- 0 (this was not mentioned in any course)
- 1 course
- 2 courses
- 3 courses
- 4+ courses

Promising Practices of Teaching and Learning

During the Fall 2017 semester, did you learn about environmental or sustainability issues in at least one class?
- Yes
- No

Display logic will follow the previous question for participants who responded with no.

Would you have liked to learn about sustainability in your current coursework?
- Yes
- No
- Unsure

How likely are you to benefit from learning about sustainability coursework in the following ways?
- In your future coursework
- In your future career
- In your role in your local community
- In your role in the global community
Response options for this set of questions are:
- Extremely unlikely
- Somewhat unlikely
- Neither likely nor unlikely
- Somewhat likely
- Extremely likely

Display logic will follow the previous question for participants who responded with yes.

Think about the course that taught you the most about sustainability during the past semester. Please answer the following questions for this particular course.

What is the full name of the course? (like Introduction to Cultural Anthropology, or College Algebra)
- [text box]

Which college was this course in?
- College of Agriculture and Natural Resources
- College of Arts and Letters
- Eli Broad College of Business
- College of Communication Arts and Sciences
- College of Education
- College of Engineering
- James Madison College
- Lyman Briggs College
- College of Music
- College of Natural Science
- College of Nursing
- Residential College in the Arts and Humanities
- College of Social Science
- College of Veterinary Medicine
- Don’t Know

Which kind of course was this?
- Major
- Elective
- General education
- Other [text box]

What form was this course?
- Lecture
- Lab
- Recitation
- Practicum
- Other [text box]
Across the semester, how much time in this course was devoted to sustainability?
- 0-24%
- 25-49%
- 50-74%
- 75-100%

Teaching for Sustainability (Core Ideas)

Think about this same course that taught you the most about sustainability. Please answer the following questions for this particular course.

How often did this course cover the following content?

Note: you can hover over each item to read examples of the concept.

- Defining sustainability
  o Hover text: For example, the instructor provided you with a definition of “sustainability” to help you understand the meaning of the term.

- Environmental crises
  o Hover text: For example, the instructor discussed environmental crises such as climate change, global warming, pollution, ozone depletion, deforestation, extinction, etc.

- Future generations
  o Hover text: For example, the instructor talked about sustainability in the context of meeting our own needs without compromising the ability of future generations to meet their needs.

- Resource management
  o Hover text: For example, the instructor discussed renewing resources at a rate equal to or greater than the rate at which they are consumed.

- Economic sustainability
  o Hover text: For example, the instructor discussed the value of economic systems that have the ability to support a defined level of economic production indefinitely.

- Challenging human-centered views of the environment
  o Hover text: For example, the instructor challenged human-centered views of the environment, like the view that human beings are the central or most significant entities in the world.

- Valuing all living things
  o Hover text: For example, the instructor discussed valuing all living things (like animals and plants), and/or the concept that nature does not exist to be consumed by humans but that humans are one species among many to consume natural resources.

- Valuing the ecological system
  o Hover text: For example, the instructor discussed that the ecological system is the most significant and consequential aspect of earth.
• Environmental justice
  o Hover text: *For example, the instructor discussed how marginalized racial communities are subjected to disproportionate exposure to pollution, or limited access to clean drinking water.*

• Relating oppression of subordinate human groups to oppression of nature
  o Hover text: *For example, the instructor related the oppression and domination of subordinate groups (women, people of color, children, low-income communities, etc.) to the oppression and domination of nature (animals, land, water, air, etc).*

• Eliminating poverty
  o Hover text: *For example, the instructor explained how low-income communities depend most on natural resources for their livelihoods, and they are also the ones who suffer most from the impacts of environmental problems.*

**Response options for this set of questions are:**
• 0 class sessions
• Less than half of the class sessions
• About half of the class sessions
• More than half of the class sessions
• Nearly every class session

**Teaching for Sustainability (Teaching Practices)**

Think about this same course that taught you the *most* about sustainability. Please answer the following questions for this particular course.

How often was sustainability taught in the following ways?

• In the context of the *area I live in* (like Michigan)
• In the context of *my school* (like MSU)
• In the context of *current events* (like the Flint, Michigan water crisis)
• In a way that made me feel empowered to be more sustainable (like motivating me to think about my water consumption)
• Case Study
• Group Discussion
• Debate
• Mindfulness
• Learning who I am in relation to the larger purpose of life
Response options for this set of questions are:

- Never
- A few times
- Sometimes
- Many times
- All the time

**Cognitively Responsive Teaching** (Subject Matter)

Think about this same course that taught you the most about sustainability. Please answer the following questions for this particular course.

Note: you can hover over the term “sustainability” in each item to read a fictitious example of how this might look in the classroom.

- **The instructor introduced, in-depth, a concept related to sustainability.**
  - Hover text: *For example, when an American history teacher mentioned the Dust Bowl of the 1930s, she went beyond mentioning the event and explained it thoroughly with special focus to the environmental and health hazards it had on people.*

- **The instructor explained the sustainability-related concept in a few different ways.**
  - Hover text: *For example, when explaining the economic impact of organic farming, the instructor explained how it might impact individual consumers, local farmers, and the local economy.*

- **The instructor introduced how sustainability is connected to course content.**
  - Hover text: *For example, when reading Shakespeare’s “A Midsummer Night’s Dream,” the instructor pointed out the reference to the time period’s unusually volatile weather, and he drew a connection between ecological awareness in Shakespearian times and in our current times.*

- **The instructor taught sustainability in a logical order.**
  - Hover text: *For example, instead of just stating that the MSU power plant is becoming coal-free, the instructor discussed the step-by-step plan of becoming coal-free.*

- **The instructor taught me how to think about sustainability.**
  - Hover text: *For example, the instructor used an analogy to help me think about sustainability by saying: imagine you have a magic candy jar that refills itself. The candy in the jar is sustainable because you can use it for a long time without it running out. In the real world, we don’t have a magic candy jar. If you keep taking candy out of a jar and never put more back in, the jar will become empty. This is similar to the concept of sustainability.*
Response options for this set of questions are:

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Strongly Agree

**Cognitively Responsive Teaching** (Prior Knowledge)

Think about this same course that taught you the most about sustainability. Please answer the following questions for this particular course.

Note: you can hover over the term “sustainability” in each item to read a fictitious example of how this might look in the classroom.

The instructor helped me us what I know from…

- **My own personal experiences to help me learn about sustainability.**
  - Hover text: For example, the instructor equated how the social norm of picking up after my dog is similar to large corporations divesting from fossil fuel companies to help me understand this abstract concept in a way I can relate to.

- **My high school coursework to help me learn about sustainability.**
  - Hover text: For example, the instructor made reference to ideas I learned in my high school courses (like a natural science class where I learned about plate tectonics, or erosion and deposition) to help me understand the sustainability-related idea (s)he was teaching.

- **My other college coursework to help me learn about sustainability.**
  - Hover text: For example, the instructor made reference to ideas I learned in my other MSU courses (like a women’s studies class where I learned about ecofeminism) to help me understand the sustainability-related idea (s)he was teaching.

- **My social roles and culture (e.g., race, socioeconomic status, gender, sexuality, ethnicity, religion) to help me learn about sustainability.**
  - Hover text: For example, the instructor examined how some religions and cultures sacrifice animals for symbolic reasons, and challenged me to think about how my social and cultural roles may have sustainable implications.

- **My family to help me learn about sustainability.**
  - Hover text: For example, the instructor used family situations, like a dynamic conversation around the Thanksgiving table, to depict the complexity of converging views about sustainability.
• My friends to help me learn about sustainability.
  o Hover text: For example, the instructor used social situations, like sharing a bathroom in the college dorm, to show how conversations with friends about how the length of a shower can be used to make sense of water management.

• The media to help me learn about sustainability.
  o Hover text: For example, the instructor mentioned an example I knew about from the media, like the wildfires in California, to help explain a sustainability-related idea.

Response options for this set of questions are:
- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Strongly Agree

Cognitively Responsive Teaching (Supporting Changing Views)

Think about this same course that taught you the most about sustainability. Please answer the following questions for this particular course.

Note: you can hover over the term “sustainability” in each item to read a fictitious example of how this might look in the classroom.

• The instructor helped me realize the differences or similarities between what I knew about sustainability before the class and what I learned about sustainability in the class.
  o Hover text: For example, at the beginning of the course I thought that using energy efficient light bulbs was being sustainable but the instructor pushed me to think about reduction of resources instead of just consumption of “better” resources.

• The instructor helped me work through differences between what I knew about sustainability before the class and what I learned about sustainability in the class.
  o Hover text: For example, coming into the class, I believed that the Lake Erie toxic algae bloom was solely an environmental issue. I did not understand how this was a broader sustainability issue because it is an environmental problem. In one class discussion in early November, a peer offered that he was voting for a particular candidate because he/she supported investing in research and practices that would limit the toxic algae from blooming, and resources to protect local communities from the devastating effects of the toxic algae. Using this peer’s insight, the instructor then guided me in thinking about how this could be seen as an environmental issue, how this could be seen as a political issue, how this could be seen as an economic issue, and how this could be seen as a social
issue. Then, the instructor helped me understand how this is a broader sustainability issue, not just an environmental issue.

- The instructor supported me if and when I felt challenged by the sustainability content.
  - Hover text: For example, this past summer I visited SeaWorld. This semester, in my Documentary Filmmaking class, I watched “Blackfish.” I felt conflicted by my recent visit to SeaWorld. I felt comfortable about sharing my conflicting feelings in a class conversation, and the instructor helped me feel supported. The instructor built on what I experienced at SeaWorld to help me feel challenged about what I saw there in a way to become empowered to be a critical, reflective thinker about my ways of knowing.

Response options for this set of questions are:
- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Strongly Agree
Appendix H
Ad Hoc Testing of Sustainability Knowledge Learning Outcomes

Due to the fact that sustainability-related knowledge is critical for student learning, and because it did not hold in a CFA, I engaged in ad hoc descriptive testing of a composite of the sustainability-related knowledge items. First, I reduced the sample to only the participants who responded to all twelve knowledge items during both the pre- and post-surveys (N=352). Next, as seen in Table 1, I ran frequencies of the number of correct responses to each of the twelve knowledge items during the two time points of this study, the pre- and post-surveys.

Table 1. Percentage of Correct and Incorrect Individual Sustainability Knowledge Survey Items in Pre- and Post- Surveys (N=352)

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Pre-Survey</th>
<th>Post-Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the most common cause of pollution of streams and rivers in the U.S.?</td>
<td>Correct: 259 (73.6%)</td>
<td>Correct: 276 (78.4%)</td>
</tr>
<tr>
<td></td>
<td>Incorrect: 93 (26.4%)</td>
<td>Incorrect: 76 (21.6%)</td>
</tr>
<tr>
<td>Ozone forms a protective layer in the earth’s upper atmosphere. What does ozone protect us from?</td>
<td>Correct: 336 (95.5%)</td>
<td>Correct: 339 (96.3%)</td>
</tr>
<tr>
<td></td>
<td>Incorrect: 16 (4.5%)</td>
<td>Incorrect: 13 (3.7%)</td>
</tr>
<tr>
<td>Which of the following is an example of sustainable forest management?</td>
<td>Correct: 310 (81.1%)</td>
<td>Correct: 319 (90.6%)</td>
</tr>
<tr>
<td></td>
<td>Incorrect: 42 (11.9%)</td>
<td>Incorrect: 33 (9.4%)</td>
</tr>
<tr>
<td>Which of the following is the most commonly used definition of sustainable development?</td>
<td>Correct: 303 (86.1%)</td>
<td>Correct: 323 (91.8%)</td>
</tr>
<tr>
<td></td>
<td>Incorrect: 49 (13.9%)</td>
<td>Incorrect: 29 (8.2%)</td>
</tr>
</tbody>
</table>
Moving forward, I summed the correct number of answers for each participant (out of a total of 12). I treated knowledge as a composite (unlike a scale, which I used for the
attitude and behavior learning outcomes), as it was the sum of correct responses. The average of pre- and post- sustainability-related sums can be seen in Table 2.

Table 2. Pre- and Post- Knowledge Learning Outcomes (N=352)

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Coding</th>
<th>Survey</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitudes</td>
<td>Number of correct survey responses (ranging from none (0) correct to all 12 correct)</td>
<td>Pre-</td>
<td>9.10</td>
<td>1.932</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-</td>
<td>9.52</td>
<td>1.898</td>
</tr>
</tbody>
</table>

Given that the same set of questions were dispersed to the same participants, I ran paired-sample t-tests, and found significant differences between the pre- and post-surveys (p≤.001). Overall, the trend here, albeit slight, was that knowledge did increase over the course of one academic semester. In order to explore the extent to which the promising practices of teaching and learning analyzed in the present study (i.e., cognitively responsive teaching subject matter, prior knowledge, supporting changing views, and teaching for sustainability core ideas and teaching practices) influenced sustainability-related learning outcomes, I conducted ordinary least squares regression. None of the five teaching practices, nor the opportunity to learn construct, significantly influenced sustainability-related knowledge over the course of the semester (p≥.05). As such, although there was a slight increase in sustainability-related knowledge over the course of one academic semester (p≤.001), the teaching practices under investigation did not influence this change.