Curriculum Improvement in Education for Sustainable Development: Measuring Learning Outcomes in an Introductory Urban Planning Course.

By

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ABSTRACT

Education for sustainable development (ESD) is an academic goal for many courses in higher learning. ESD encompasses a specific range of learning outcomes, competencies, skills and literacies that include and exceed the acquisition of content knowledge. Methods and case studies for measuring learning outcomes in ESD is absent from the literature. This case study of an undergraduate course in urban sustainability examines the processes, curriculum, pedagogies, and methods to explore whether or not learning outcomes in education for sustainable development are being reached. Observations of the course, and the statistical analysis of student surveys from course evaluations, are explored to help identify the relationships between learning outcomes in ESD and the processes of learning and teaching in the case study. Recommendations are made for applying the lessons of the case study to other courses, and for continuing further research in this area.

DEDICATION

To my wife, Olga. You were there.

ACKNOWLEDGEMENTS

Thank you, Dr. Pijawka. You are the geatest advisor a student could have.

TABLE OF CONTENTS

Page

CHAPTER Page

CHAPTER Page

LIST OF TABLES

Table Page

Table Page

LIST OF FIGURES

Figure Page

CHAPTER ONE: INTRODUCTION

The years of 2005-2014 have been named by the United Nations as the "Decade of Education in Sustainable Development (DESD). Institutions of higher education across the United States are increasingly accepting the call towards integrating Education for Sustainable Development (ESD) into their curricula (Arima, 2009). Well-funded centers focused on the inquiry into issues around sustainability are on nearly every major campus of higher learning. Well over a hundred universities throughout the United States and across the world have adopted academic majors and minors in ESD; and many more promise to emerge (AASHE, 2011). Nearly all established disciplines, including urban planning, architecture, and design have incorporated some level of ESD into their curricula. Similarly, a multitude of classes focused on or related to sustainability have been incorporated into university curricula. The integration of sustainability into higher education occurs at various levels (e.g. student life, campus organization, public policy), across multiple scales (e.g. student, classroom, discipline), and continues to develop.

Statement of the Problem

Many individual disciplines have made considerable internal efforts towards identifying the discipline-specific goals (e.g. learning outcomes) in ESD. Engineering, for example has explored sustainability as ethical approach for decision-making (El-Zein, Airey, Bowden, & Clarkeburn, 2007; Goudie, 2009), and urban planners have long adopted an education that understands democratic values as being central to sustainable communities (Campbell, 2004; Jepson, 2001). In addition to specific discipline-related goals, broad educational competencies and literacies in ESD have also been identified for

nearly all students as a part of their basic university education (McKeown, 2004; OECD, 2005), and many suggestions are available for incorporating sustainability into informal learning areas such as campus living, such as David Orr's Living Center, or the Second Nature Program at Northern Arizona University (Bardaglio, 2007; Cortese, 2003).

However, not enough research has been done on how instructors might achieve these goals in ESD at the classroom level, at which level of education particular learning outcomes should be sought, or what the effect of widespread ESD will have on society and how to measure it (Colucci-Gray, Camino, Barbiero, & Gray, 2006; Lozano-Garcia, Kevany, & Huisingh, 2006). Less literature has been published that suggests how to determine if individual discipline-specific goals are being reached, and what effect the disciplines themselves have on learning ESD within those disciplines (Reid, Petocz, & Taylor, 2009). Finally, no discussion has been opened on how to specifically measure these learning outcomes and particular competencies within sustainability. This lack of discussion points to a troubling inability to verify claims towards achieving ESD learning outcomes in higher education.

Research Question

This thesis is an exploration into the question, "Are we achieving our desired learning outcomes in education for sustainable development?" First, we will review the literature in ESD to find out what exactly those outcomes are, and then adopt a robust theoretical framework that we can use to determine which of those outcomes are appropriate at the introductory, undergraduate level of education. This thesis then carefully gathers and analyzes research data from an "exemplifying case study" (Bryman, 2010) focused on an undergraduate urban planning course at Arizona State University. From the results of the mixed methods analysis, we investigate whether or not the course

is achieving the desired learning outcomes in ESD, and identify the core strengths and weaknesses of the particular course under study. Through the results of the research, we determine how instructors might achieve those outcomes, and finally, conclude with suggestions for how we might measure them.

Methods

This thesis explores its central question by employing mixed methods research into a large freshman-level urban planning and sustainability course at Arizona State University titled "Sustainable Cities." The case study is a suitable method for investigating this form of research question and will provide, through observational and documentary evidence, a sufficient context from where to begin addressing the central question (Yin, 1994). As Yin states, a case study is defined as an inquiry that "investigates a contemporary phenomena within its real-life contexts; when the boundaries between phenomena and context are not clearly evident; and in which multiple sources of evidence are used." However, in the process of investigating this question, additional sub-questions need to be addressed through a structured exploration of three related concerns:

- What are the expected learning outcomes for a freshmen-level introductory ESD courses in urban sustainability?
- How can these learning outcomes best be achieved?
- How can we measure or assess these learning outcomes?

Yin affirms that the last of these forms of research questions can be successfully addressed through the use of the survey technique. Therefore, in addition to the case study observations, this thesis utilizes secondary sources in the form of three classroom surveys: one before the course began (to assay students' competencies and literacies in

ESD before they engaged with the learning environment and activities of the class), one in the middle of the course (to assess pedagogical methods), and one after the course had concluded (to discern to what degree these competencies and literacies have been developed). Relationships that exist between the individual variables of the case study (e.g. students, assignments, et. al.) will be identified and compared to the relationships found in the statistical analysis of the student survey responses. Various pedagogic styles will also be evaluated for their relationship to the development of student learning outcomes in ESD.

There are three additional, interconnected propositions to consider. First, "the outcome of the individual acquisition process is always dependent on what has already been acquired" (Illeris, 2004). This is important for the realization that, at the college level, a student's first course in sustainability is important for laying a positive groundwork for their continued interest in sustainability. Second, certain topics facilitate the learning of certain concepts (Bassok & Holyoak, 1989). This proposition is central to the notion that some curricular progressions of topics and concepts in an education in urban sustainability might be more efficacious than others. Also, the introductory course necessitates a broad spectrum of topics (Doan & Ali, 2006; Simpson-Beck, 2011; van der Hoeven Kraft, Srogi, Husman, Semken, & Fuhrman, 2011; Vann, Pacheco, & Motloch, 2006) Assuming these three premises, a substantive issue can be raised:

- What is the most efficacious step-wise progression of concepts and topics for an introductory ESD course in urban sustainability?

Finally, if this education is intended to be developed over the course of an undergraduate career, then the goal of a freshman level ESD course should also be to lay the foundation for a future transformation to occur. In addition to discussing how to lay the foundation for further transformative development to satisfy the requirements of ESD,

we discuss the learning outcomes specifically in the domain of urban sustainability at the introductory level. We begin this thesis with a brief discussion of the background, the justification, and contribution of this research.

Importance of the Research

This thesis opens the discussion of how to measure learning outcomes in ESD. As this research is in the form of a case study, it is not generally transferable to all conditions. However, "moderate generalizations … can, will, and should be made" (Bryman, 2010) from case study research. By providing an example of how this researcher proceeded with measuring and assessing learning, an extremely important addition to the scholarly record with immediate, practical implications, and lessons for instruction in ESD will have been made. This is for three reasons. First, this research is important because regular intervals of assessing the learning outcomes of professorial instruction are central to the ability to progress and improve the education of students. Second, the survey research herein, which was used to assess learning outcomes, can provide a template on which further research can improve upon.

Measuring learning outcomes is an opportunity for student learning and for the ongoing professional development of educators (Accordino, 1991). Measuring learning outcomes gives educators a sense of direction, correction, and validation (Stassen, Doherty, & Poe, 2001). In addition, with increasing frequency, many employers across the United States and the world, including organizations centered on urban planning, routinely suggest that well-developed competencies in sustainable development in their new hires are a main consideration (Ferreira, Lopes, & Morais, 2006). The ability for educators to validate their work is central to the continuing presence of competencies in SD as a skill set that is sought-after by employers.

Definitions

Because the dialogue around ESD was developed from various discipline-specific and vernacular sources, the meanings of the terminology around sustainability, educational learning outcomes, and assessments can introduce a lack of clarity (El Ansari, 2009). Now we will provide some definitions for the basic terms that we will use throughout the case study and survey.

Sustainable Development.

One common discussion found among the literature around sustainable development and ESD concerns the exact definition of ESD, indeed, of sustainability itself. First, this thesis establishes the central premise that, despite any theoretical controversy, because of the immanent and dramatic threats confronting human society, the work of sustainability should nonetheless be promoted (Porter & Córdoba, 2009). We will define the concept of sustainable development as put forth by the 1987 Brundtland Commission Report: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". This definition includes:

- “the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given;
- and the idea of limitations imposed by the state of technology and *social organization* on the environment's ability to meet present and future needs." (emphasis added)

Education for Sustainable Development.

This thesis adopts the position that ESD is explicitly an education "for" sustainable development, as opposed to merely "about" sustainability (Tilbury, Stevenson, Fien, & Schreuder, 2003). We need to further recognize that "…the task of education for sustainable development is … to contemplate how to maintain global sustainability while continuing development" (Arima, 2009). Furthermore, this thesis assumes with President Arima that "development" refers not only to the technological or economic sectors, but also to the social sectors, including culture (UNESCO, 2007).

This assumption brings us to a major premise regarding ESD: that an education for sustainable development is necessarily a holistic endeavor (Warburton, 2003; UNESCO, 2007). In the academic sense, this implies a need for interdisciplinary cooperation and transdisciplinary approaches to problem solving and research. The practice of holism is advanced by understanding that singular, isolated disciplines are unable to 'capture the complexities of sustainability,' and recognizes that "No one discipline can or should claim ownership of ESD" (McKeown, 2002). Academic instruction should be structured to support the development of "… general competencies [that] include making reasoned decisions in unfamiliar situations, adapting to change, adopting a holistic approach to problem solving and collaborating and empathising with colleagues" (Karol, 2005; Lozano-Garcia, Kevany, & Huisingh, 2006). Far beyond the mere introduction of systems thinking, holism requires an ongoing and reflective investigation of values (Porter & Córdoba, 2009). Embedded in the idea of a holistic education towards a more just and sustainable society is the value of empathy. One central realization in ESD is that individual and cultural values regarding sustainability will be in conflict, consensus will therefore be incomplete, and dialogue will necessarily be ongoing (Ratner, 2004). In order to address conflicting values in a participatory and

democratic manner required of sustainable development, competency and literacy in empathy is an essential part of ESD, and to society as a whole (Rifkin, 2010). Because social and environmental justice will remain integral components in a more sustainable society, "Evolving meaningful strategies to create awareness and develop skills in people struggling for their daily existence requires a sensitivity and empathy for the human situation to help catalyse changes" (Tilbury, Stevenson, Fien, & Schreuder, 2003)

Learning Outcomes.

This thesis intends to be interdisciplinary research into the measuring of student learning outcomes (including affective capacity development) in ESD, but does not intend to be authoritative on educational and developmental theory. It is important to adopt the idea that higher education is primarily, but not exclusively, about acquiring knowledge in discrete academic disciplines. While "sustainable development needs to be located in all educational and disciplinary domains" (Reid & Petocz, 2006), developing expertise in academic disciplines remains the recognized purpose of higher education. This is not a hindrance to ESD; in fact, academic expertise in distinct intellectual domains facilitates ESD (McKeown, 2002). In addition to developing expertise in among academic fields, this thesis adopts the perspective that an education in sustainability also necessarily be a personally transformative experience for the student. As an academic goal in education for sustainable development, in addition to acquiring and generating disciplinary knowledge, we need to train for competency in a particular set of general learning outcomes that includes, but is not limited to,

> *"skills for creative and critical thinking, oral and written communication, collaboration and cooperation, conflict management, decision-making, problem-solving and planning, using appropriate information and communication technologies, and practical citizenship."*(UNESCO, 2004).

Critical thinking is described as, "*the act of challenging ideas and considering alternatives based on developing valid and plausible premises through sound logic and reasoning*" (Matthews & Lowe, 2011). These basic learning outcomes in an education for sustainable development exist for all graduates of higher education, including the case study example of this thesis, and nominally encompass:

- Subject-based outcomes which subsume learning objectives and which are complex discipline-based outcomes which are capable of being assessed;
- Personal transferable outcomes, including: acting independently; working with others; using information technology, gathering information; communicating effectively; organizational skills; and generic academic outcomes.
- Making use of information; thinking critically; analyzing; synthesizing ideas and information.

One recurring theme in this thesis is that traditional subject-based outcomes are already being measured directly, if imperfectly, through tests and other graded work in the classroom. In addition, the generic learning outcomes necessary for all organized learning (e.g. library searches, presentation skills) are measured indirectly through normative expectations of the quality of those skills at a certain academic level. It is the long-term retention of that knowledge outside of the classroom which is difficult to assess. The final behaviorally-oriented outcomes, as they relate to ESD, are the concern of this thesis.

Competency and Literacy.

ESD at the university level is an adaptive education (UNESCO, 2007) that facilitates the transformation of college graduates into global citizens who perceive sustainable development as a positive and necessary outcome, and have the skills, and propensity, to adjust to meet new emerging issues and uncovered information. These

graduates should not only understand what sustainability is, but they should be able to access the skills and personal capacity to implement it, and the ability to adapt their assessments to changing circumstances. Finally, the implementation of policies towards sustainable development is insufficient in a society where those policies are not acted upon. Indeed, some propose that ESD itself is insufficient, unless we mean educating for a 'sustainable life' to necessarily include, "personal responsibility, commitment to other people and a spiritual life … related to the options that people take in daily living" (Otto & Wohlpart 2009). Transforming society means transforming our future global citizens. This transformation can occur when we train people,

> *"… to not only acquire and generate knowledge, but also to reflect on further effects and the complexity of behavior and decisions in a future-oriented and global perspective of responsibility."* (Barth, Godemann, Rieckmann, & Stoltenberg, 2007)

Understanding (i.e. having literacy in) the idea of complexity as being central to an education for sustainable development is described as an appreciation of "the interconnections and interdependences between natural processes and human ways of living" (Colucci-Gray, Camino, Barbiero, & Gray, 2006). Being able to recognize connections is a central component to attaining literacy in SD. Being literate in sustainability means going beyond merely recognizing interconnections, but adopting an epistemology of interconnectedness. How, then, do we assess a student's tendency towards recognizing connections over the course of a semester?

Assessment.

Most academic programs have an accreditation process by which a national agency authenticates the ability of the program to equip graduates with the competencies and skills required of the field. In addition, most universities have internal auditing systems as well, to ensure that basic skills are being taught effectively. Finally, most

states, and the federal government, have legislated mandates for measuring learning outcomes at the institutional level, usually in the form of statistics related to graduation rates, and standardized test scores. The processes, examinations, and rubrics for measuring learning outcomes are generally referred to as assessments (Accordino, 1991). Most of these assessments are beyond the scope of this thesis. However, instructors also have a range of classroom-level techniques to draw on in their efforts to measure the efficacy of their pedagogy and curriculum as it pertains to knowledge (Simpson-Beck, 2011).Similar to the barriers found in assessing sociology courses (Cappell & Kamens, 2002), ESD as a topic does not lend itself to assessment. This thesis is concerned only with those techniques that apply to the scale of the classroom, and realizes that we will observe a "less than ideal design, under numerous constraints."

Limitations of Study

What will not be included in this thesis is an exhaustive account of how this research is to be applied beyond the confines of the case study at Arizona State University. Each learning environment is unique, and has a specific set of goals and changing circumstances. The "how" of what constitutes a proper reaction to the changing of curricula by individual institutions is, by then, an emergent and local concern. Therefore, this case study should not be advanced as a model, but only as a point of reference.

While recognizing that university pedagogy is a whole system comprised of curricular content, institutional context, and cultural syntax, this thesis focuses on the formal learning environment ('direct pedagogy') and instructional processes limited to "faculty and students … curricular content, teaching/learning practices … programs and

courses" (Timmerman & Metcalf, 2009); particularly those of the large, undergraduate lecture-type learning environment.

Lastly, this thesis focuses on a large, lecture-style course, and considers the pedagogies and curricula that might be applied to such large courses. Therefore the instructional components discussed herein should not necessarily be considered as transferrable to seminar or capstone type courses. While smaller courses, higher level courses might share some general elements of ESD, as they are under a different set of environmental parameters, with different goals and different set of learning outcomes.

Chapter Outline

The second chapter focuses on a literature review that identifies learning outcomes in education for sustainable development. We establish ESD as a transformational experience, with that transformation also including the development of competencies for change agency. We will then review the discussion of how academia can pursue the skills and competencies that allow for change agency, while at the same time avoiding prescriptive indoctrination (Wals & Jickling, 2002). Finally, we review the research and theory of programs, pedagogies and methods that suggest ways to achieve ESD goals and student transformations. From these we will establish a theoretical framework essential to the development of the case study (Yin, 1994).

Chapter 3, 'Methods,' describes the object of the research: the "Sustainable Cities" course at Arizona State University. In chapter three we apply the theoretical framework for investigating and exploring the embedded constituent elements within the single case study (Yin, 1994), such as the students, the instructors, and the learning environment. We also review the survey instrument, and propose a number of hypotheses and observations that might help develop a measurement of success.

Chapter 4, ‘Findings,’ identifies outcomes of our hypotheses through analysis of assignments, surveys, and other considerations. The chapter explores the meaning of the descriptive frequencies of phenomena found in the case study, and supports the findings with empirical observations from the case study.

Chapter 5, ‘Recommendations,’ concludes by exploring possible meaning the case study has for achieving ESD learning outcomes at the freshman level, makes suggestions for how to best interpret the statistical analysis, and suggests further areas of research.

CHAPTER TWO: LITERATURE REVIEW

"The real change that we face in embracing a more sustainable future rests with our ability to educate students differently." – David Orr

Introduction

The underlying logic for ESD, sustainable development, is an evolving concept that continually adapts to new information, emerging theory, and changing circumstances (Jepson 2001; McKeown 2002). It is also a contested conceptual terrain, subject to the continuing tensions between normative ethics, social goals and democratic values (Clarkeburn 2002; Wals & Jickling, 2008). Education and learning are likewise complex issues. We recognize that learning is shaped by physical space, with formal, informal, and non-formal learning environments, and student relationships with those environments all having an effect on learning outcomes in general (Ball & Lai, 2006; Holden, et al., 2008; Timmerman &Metcalf, 2009; Wesch, 2008,). Additionally, not only do students come to the course with differing levels of acumen (Cole, Kennedy, & Ben-Avie, 2009), there are significant cognitive and affective considerations unique to each student, as well as the different learning strategies they employ (e.g. performance vs. mastery) (Brown, Collins, & Duguid, 1989; Chi, De Leeuw, Chiu, & Lavancher, 1994). When the two are combined, sustainable development and education create a dynamic and intricate system. Not only does ESD necessarily occur at all three levels of educational formality (UNESCO, 2010), it also contains both disciplinary and transdisciplinary knowledge-based content which influences students with different disciplinary backgrounds in different ways (Reid, Petocz, & Taylor, 2009). Furthermore, ESD outcomes add yet another dimension of complexity by manifesting in students' beliefs, values, and behaviors (Murray, Brown, & Murray, 2007; Myers & Beringer, 2010). The ethical goals

of adopting particular learning outcomes in ESD are also contested for a host of other reasons: political, practical, conceptual and more (Wals & Jickling, 2008). The topic of learning outcomes in ESD is therefore extremely complex and often times hard to pinpoint (P. Murray, personal communication, March 22, 2012).

Learning as Action and Interaction

According to John Dewey's well-known statement that students learn by doing (praxis), central to the relationship between learners and their changing beliefs are the actions they execute and practice. The topic of precisely how people learn (e.g. performance-oriented or mastery-oriented, recall and memory, etc.) is beyond the scope of this literature review. However, to lay a foundation of validity for the theoretical framework that we will adopt regarding the development of competencies, we will assume Gale Sinatra's (2005) position that lasting conceptual change is a function of the interaction between the learner, including their motivations and beliefs, and the taught message.

Additionally, the learning environment and the student have a level of interaction, as well, and with substantive effects on the learner's motivation (Wesch, 2008). Understanding the context of the large lecture hall as a learning environment, and the limitations it places on available, actionable teaching methods, is essential to identifying appropriate strategies for delivering an education in ESD. Indeed, educator Michael Wesch (2011) asks, "If students learn by doing, what are they learning by sitting in a large lecture hall?" Since, for a number of practical reasons, the large lower-division lecture hall will remain a fixture in university education for the foreseeable future, how are we to effectively educate in that context?

Finally, several authors and scholars have suggested that learning is effective when it is interest-led, and motivation pays a key role (Dole & Sinatra, 1998). Students are only likely to retain the information long-term and incorporate it into their daily processes if the knowledge is interesting, relevant, or inspiring (Gregoire, 2003; Orr, 1990; Wesch, 2010). While this might not be exclusive to all learning, as there are other motivations for incorporating various skills and competencies into one's daily life (e.g. work, duty, cultural norms), this might be true of literacies in ESD.

Sustainability Literacy as Change Agency

Our modern society needs citizens able to cope with a plethora of threats that are dangerous to human society. Some of these coping mechanisms are disciplinary in nature, while others are transdisciplinary. Central to both types of mechanisms, however, is the establishment of sustainability literacy.

The history of ESD literacy is rooted in ecological literacy. While literacy itself "is often used in a careless and imprecise way to signify particular desired consequences of education, or curriculum goals" (Gough & Scott 2001), David Orr (1989) outlined a relatively manageable list of ecological topics that students needed to have a conversational and conceptual grasp of in order to facilitate positive change in those areas. This basic capacity for a relevant vocabulary remains central to developing and applying more complex competencies. In addition to containing specific knowledge areas needed for the social discussion over ecology, a host of other skills and competencies have also been added for discussing human society as nested within ecology (Cronon, 1995). Literacy in ESD has since evolved beyond both ecological literacy and the discussion of humans as a component of nature, into the realm of attitudes, values, and behavior. Dale and Newman (2005) recognize that "Sustainable development literacy

builds upon a progression of environmental and ecological literacies" and suggest that understanding human-environmental inter-actions is a salient departure from those disciplinary literacies towards a more holistic social literacy.

Those earlier conversations have become broader and more general in the process: "the trajectory has been for definitions of the new form of 'literacy' to become less specific and more general in scope" (El Ansari, 2009). Sustainability literacy is, in the end, about the total project of human flourishing on a planet with finite resources, and this will require changing our current processes, especially our processes of education which produce citizens who perpetuate unsustainable practices. How to achieve this without explicitly advocating for a particular moral agenda is a concern for many academics (Thomas, 2009).

Higher education is already seen to be in a binary state of tension between fostering social reproduction and creating transformative autonomy. ESD has been suggested as a means to create a more sustainable society through the adjustment of students' behaviors. Wals and Jickling (2008) are concerned with this, saying it risks our capacity to educate students to be able to critique social norms. Additionally, if done improperly, ESD might be seen as repressive, transmissive, and authoritarian ("Big Brother Sustainability"), and threatens to undermine the democratic principles necessary to create a more sustainable society. Henriikka Clarkeburn (2010) similarly sees behaviors and values as unacceptable objectives for the creation of change agents. She suggests that values and social actions are only modestly correlated; even in the unlikely event that consensus in values could be established. She also suggests that education towards virtue and character are also untenable: "authentic convictions" born of independent reflection is what strengthens democratic society, but education towards a particular character implies supporting a "certain type of personality ideal" that eschews

plurality of thought. Clarkeburn suggests instead educating for "two aspects of a skill-based moral development: ethical sensitivity and moral reasoning skills."

Whatever the risks regarding moral advocacy, because of the time-sensitive nature of the ecological and social threats facing us, most academics agree that some effort should be initiated, even if imperfect (Porter & Córdoba, 2009). So, in addition to understanding the human-environment relationship, education *for* sustainable development is by definition *for* change; in particular, the education of change agents (El Ansari, 2009; McKeown, 2002; Myers & Beringer 2010; Orr, 2008). "However, equipping individuals with the appropriate knowledge and skills does not guarantee that they will be fully utilized" (Murray & Cotgrave, 2007). The question, then, is how to produce change agents through the development of competencies and skill sets.

Competencies and Skills

Particular competencies and skills are required for the education of change agents (Orr, 1989) and for transformative growth. However, despite being the focus of scholarly interest, there is no consensus for a strict definition of competencies in ESD (Barth, Godemann, Rieckmann, & Stoltenberg, 2007). To avoid ambiguity, this thesis adopts a distinction between skills and competencies. Competencies will refer to the both knowledge (cognitive) and affective (emotive) capacity for particular actions. For the purposes of this thesis, competencies can be considered as the actionable aspects of literacies (e.g. the capacity for "giving back to the community" – El Ansari, 2009) Skills, on the other hand, will refer to the 'toolbox' of methods and techniques by which those capacities are executed (Runhaar, Dieperink, & Driessen, 2006; S. Brem, personal communication, March 15, 2012). We also acknowledge that some skills might require the presence of a particular knowledge and/or affect in order to execute the skill.

It is important to mention that skills and competencies are not the same as habits. While personal growth includes the improvement of positive, beneficial habits (Ralston, 2011), literacy in ESD recognizes a difference between habits and cognitive or affective skills. The development of individual habits is not quite the domain of higher education, and few authors have mentioned the development of habits as a goal for higher education: Not only are habits developed earlier in life, they are not academic or social. Dyer, Selby, & Chalkley make a clear distinction:

> "*Students entering higher education probably studied recycling, waste management and energy saving at primary school … instead they should be challenged with issues of sustainability commensurate with the rigour of their courses and a curriculum that both enhances their career prospects and enables them to become well informed and responsible members of society*" (Dyer, Selby, & Chalkley, 2006).

Some European educators have adopted a "Gestaltungskompetenz" model (de Haan 2006, in Barth, Godemann, Rieckmann, & Stoltenberg, 2007) for competencies, which are listed here:

- competency in foresighted thinking;
- competency in interdisciplinary work;
- competency in cosmopolitan perception, transcultural understanding and co-operation;
- participatory skills;
- competency in planning and implementation;
- capacity for empathy, compassion and solidarity;
- competency in self-motivation and in motivating others; and
- competency in distanced reflection on individual and cultural models.

Brundiers, Wiek, & Redman (2010), suggest three "clusters" with which to categorize these competencies: strategic knowledge cluster (content and methodological knowledge/competencies), practical knowledge cluster (implementation skills as a

component of "Gestaltungskompetenz"), and the collaborative cluster (affective and technical skills for working in teams and across different knowledge communities). The intersection of these competencies with freshman-level coursework is established through two reorientations of university pedagogy: an "orientation towards interdisciplinarity" and "strengthening self-reliance and self-direction in the learning process" (Barth, Godemann, Rieckmann, & Stoltenberg, 2007). Therefore, the freshman-level ESD course, while not excluding the development of habits, is challenged by augmenting those habits with substantive opportunities for transformative change, while simultaneously increasing motivation, affinity and relevance, all through a change in processes at the university classroom level.

Disciplinary skills play a role in the development of sustainable actions (Reid et al. 2009). For example, Runhaar, Dieperink, & Driessen (2006) describe five tools for environmental social scientist: Reconstruction of policy theory; Stakeholder analysis; Impact assessment; Cost-benefit analysis; and Discourse analysis. While exploring the myriad specific disciplinary skills is beyond the scope of this literature review, the effect of disciplines on the learning process as it pertains to developing literacy in ESD will be investigated.

Pedagogy and Curriculum

Several pedagogical theories have been asserted as frameworks for ESD. An exhaustive account of pedagogical theory is beyond the scope of this literature review, so three related and mutually supporting examples will be briefly examined to provide a conceptual framework for the case-study.

Problem-based learning (PBL) is one such pedagogy, and it is already an acknowledged methodology in professional education and architectural (*project*-based)

design studios (Forsyth, Albrechts, Teitz, & Myers, 1999; Karol, 2006). While not asserted as a method specifically *for* ESD, PBL shares many similarities with ESD: transformative learning; interdisciplinary learning and team working; and critical thought are central goals. The operative difference between PBL and traditional answer-based learning is that students are challenged to "learn to think, specifically 'how to think' rather than 'what to think," with the goal of increasing problem-solving competencies, as opposed to manipulating skills designed for structured and well-circumscribed problems. (Thomas, 2009). Competencies in PBL include "making reasoned decisions in unfamiliar situations, adapting to change, adopting a holistic approach to problem solving and collaborating and empathizing with colleagues" (Karol, 2005). Therefore, PBL is well suited to ESD because the approach to problems mimics the real world's emergent and unanticipated circumstances, thus preparing students for future events (Ferreira, Lopes, & Morais, 2006), and "the complexities of sustainable development" (Dale & Newman 2005).

> "*Since inquiry and growth are open-ended, evolutionary processes guided by human intelligence, it is tempting to conclude that realizing educative growth means engaging in successful inquiries. However, by definition, the inquirer does not know in advance where an inquiry is headed, whether it will deliver good outcomes or run off the rails. Still, through repeated involvement in problem-solving activity, the experienced inquirer learns to recognize guideposts in successful inquiries, an ability that itself signals an unfolding process of growth*." (Ralston, 2011)

Student-centered learning (SCL) is another such methodology seen as a possible method for the transformative and motivational ESD. Student-centered learning is founded on social constructivist theory, which contends that knowledge is context-specific: the learner is involved in the production of the knowledge instead of being a passive receiver of fixed truths, thereby increasing motivation and identification with topics (Moulding, 2009). SCL maintains a preference for analysis and critique over memorization. While students might briefly participate in the development of

vocabularies, theories and concepts used to explore the curriculum topics through lecture-based formats, they then shift to activities where they brainstorm, reflect, and communicate their experiences with one another. Other approaches to SCL include short multimedia aids, humor, real-world examples, and energetic lecture styles punctuated with frequent questions and other interactions.

Another methodology used for ESD, with its emphasis on curiosity, better questions over rigid answers, and personal relevance, is "Deep-Learning" (Smith & Colby 2007; Warburton 2003). Deep-Learning incorporates PBL and SCL into a pedagogical approach that provides a robust framework for observing this case study.

The substantive question for Warburton (2003) is "How then do we provide students with the conceptual tools to move across disciplines to recognize patterns and causal relationships between economic, environmental and equity issues?" He suggests the following to be integrated by instructors at the pedagogical and classroom level:

- provide a wide range of conceptual and material content;
- illustrate interconnections and interdependence;
- stress dynamic rather than fixed structures and processes.

More specifically, Warburton also identifies several specific principles for curricular strategies in the classroom (titles adapted):

- Principle 1: *Balance between mastery learning and exploratory learning.* Attention towards essential content that is effectively matched to particular learning materials and source formats (e.g. journal articles, videos, guest speakers, documentaries, web instruments such as myfoorprint.org, etc.) and at the same time balanced with opportunities for discovery learning, independent investigation, and the development of personal meaning with the content matter. We should realize that "such that an open environment encouraging independent

discovery tends to favor low anxiety learners, but high anxiety learners do better in a more structured setting" (Warburton, 2003).

- Principle 2: *A direction towards relevance*

  A curriculum narrative initially rooted in foundational concepts that relate to the students personal experience, with continuing material delivered in a logical progression. Importantly, "surprises, problems, and variety should also be built in so as to appeal to intuitive holists as well as serialists" (Warburton, 2003). The introduction of surprise material and topics maps onto real-life uncertainty, setting the stage for learners to appreciate adaptive and anticipatory approaches.

- Principle 3: *Extract relevant meaning from concepts*

  Provide a process in which the introduction of key concepts and the interpretation of those concepts are one in the same. The interactions of the concepts and interpretations are to be approached from the three spheres of economy, environment and society, with hands-on or regionally relevant case-study examples. Furthermore, the key concepts should be returned to at periodic intervals of increasing detail and abstraction (a "spiral curriculum").

- Principle 4: *Articulate relationships*

  Support problem-based learning, enquiry, and discussion with conceptual frameworks and concept mapping that encourages the visualization of relationships.

- Principle 5: *Thoughtfully support scientific dialogues*

  Create active, cooperative learning environments for (e.g. through interactive question sessions, make predications, create explanations), and contextually scaffold (Puntambekar & Hübscher, 2005) scientific aspects of sustainability education.

- Principle 6: *Questions over answers*

  Issues in SD should be expressed as emergent and systems-related, to be explored through investigating questions as opposed to answers. "… the pedagogical process should be presented as a revelatory activity that builds individual awareness, rather than as one where pre-packaged information is to be absorbed. Through problem-based learning tasks, students can be encouraged to clarify assumptions, choose analytic techniques and examine value judgments." (Warburton, 2003)

- Principle 7: *Curriculum-action research*

  Curriculum-action research (e.g. McKernan, 1994, in Warburton, 2003) should be employed as a means of providing students with another avenue of learning, and has a myriad of other benefits. However, fully exploring curriculum-action research goes far beyond the scope of this thesis.

- Principle 8: *Education for change agency*

  Remember that the goals of ESD are to encourage the sort of reflection which leads to behavioral change, and evolving attitudes and values. Students must be equipped with the conceptual, analytical, investigative, and personally relevant skills that encourage self-reflection and the clarity that it brings.

"In summary, it is suggested that a critical awareness of key concepts and the scope, limitations and complementarity of different disciplinary paradigms is a desirable outcome of environmental education. Such an awareness is best developed within an integrated, interdisciplinary framework and requires the student to engage in comparative and synthetic thinking at diverse levels." (Warburton, 2003)

If ESD is a process, and not a single event that occurs over one course, then deep learning might also best be conceived as a step-wise process with outcomes that are to be developed over the period of the entire undergraduate experience. However, Warburton

suggests three key considerations for implementing the eight principles stated above into the individual classroom. These include:

- *Varied content*: "… a priority for educators must be to provide an environment where students develop a strong personal interest in sustainability issues. Ensuring that learning is made relevant, and that the content and teaching styles are varied, can help here."
- *Realistic workloads:* "It may also be a result of an excessive workload: in many ways traditional teaching pushes students towards superficial levels of engagement with material, even as it hopes to do the opposite."
- *Multiple topics:* "It is clear that learning is strategic, so that both (Warburton, 2003) deep and surface learning strategies can be used at different times by the same student in response to perceived requirements and assessment criteria. The existence of such flexibility is a positive factor, but it puts the onus on educators to ensure that the learning environment is conducive to the use of deep learning skills."

Learning Outcomes in Education for Sustainable Development

Because the threats to the sustainability of human societies are myriad and need to be addressed from an equally diverse set of responses, the learning outcomes in ESD that equip students to make those responses are equally multitudinous. According to the OECD (2005) learning outcomes in ESD can be broadly defined by students who show the following propensities:

- "have[ing] acquired various skills (critical and creative thinking, communication, conflict management and problem solving strategies, project assessment) to take an active part in and contribute to the life of society,

- Be[ing] respectful of the Earth and life in all its diversity,
- Be[ing] committed to promoting democracy in a society without exclusion and where peace prevails." (OECD, 2005)

Brundiers, Wiek, & Redman (2010) identify outcomes vis-à-vis the transdisciplinary case study (TCS) to include critical-thinking, "boundary-crossing", implementation skills, and value-adaptation. The building blocks of this skills-based approach are the ideas of interdisciplinarity, participatory fieldwork and service learning, and reengaging theory with praxis. (Bacon, et al., 2011; Bridge 2001; Hansmann, Mieg, Crott, & Scholz, 2003; Lehmann & Fryd 2008) Steiner & Posch have three hallmarks for the TCS: Interdisciplinarity, Transdisciplinarity, and Self- regulated learning that embeds knowledge at three levels: Understanding (including empathy), Conceptualization, and Explaining (2006). In the urban context, what is needed is to create in students a realization of our dependence on ecosystem services (Rowe, 2011) and an appreciation the obstacle of our general inability to assess fees to them. In addition, while all of these skills, abilities and literacies must be kept in a holistic perspective, this thesis is focused on those topics and vocabularies that specifically deal with the introduction of the city as a subject of sustainability study.

Many urban issues are extremely challenging. One goal of the introductory course then is to ensure that a) the objects of study are solvable, and b) the student is not disheartened by the scale and magnitude of urban issues. Considering that ESD is to instill a sense of ownership in the student, separation of the student from the issues can be avoided through assignments that involve personal inventories. Showing the student their connection to the issue through such exercises as the Ecological Footprint, and giving them a chance for self-reflective work is a step towards personal resilience, is one way to

avoid cynicism (Rowe, 2011). Specific attention to the concept of externalities, and a larger discussion on values and the ethics needs to engage in that discussion.

However, with a few exceptions (Runhaar, Dieperink, & Driessen, 2006), little has been written on what specific topics tend to facilitate particular desired learning outcomes in ESD, and nowhere in the literature is the relationship between topics, delivery, and student interest examined in detail. Also missing from the literature is the efficacy of particular topics in the generation of learning outcomes.

It is important to mention that the strategies identified in this literature review tend to focus on transformative learning in classroom sizes in the studio, seminar, or small-lecture seating range (under 100 seats); and they mostly focus on strategies for upper classmen or even graduate students. Moreover, many of these strategies assume that the student has a personal interest or direction in the coursework content that has been developed over time, but many students take introductory courses merely to fill requirements. Finally, while the large freshman-level lecture is not the ideal classroom setting (Wesch, 2011), two- to four-hundred seat lectures will remain a fixture in American higher education for years to come, as they tend to be cost-effective: the student-teacher ratio are quite small.

While some attempts have been made towards a broad discussion of how ESD can be integrated into the curricula of higher education (Baum, 1997; Gunder, 2006; Jucker, 2002; Jepson, 2001; Thomas 2009; Wright 2003), how specifically ESD needs to be integrated at the various educational levels with respect to the entire educational experience in order to be successful is missing from the literature.

This thesis takes the perspective that "*learning is understood as a continuous process where an individual constructs and reconstructs his/her conception of the world*" (Ferreira, Lopes, & Morais, 2006). The freshman-level introductory course in education

for sustainable development can thus be assumed to be the first in a series. What then is the contribution of the undergraduate lecture in the total student experience in ESD? This, of course, is predicated on what *can* be taught. With respect to what is being taught, by the end of the freshman-level course in urban sustainability ("Sustainable Cities"), a student is expected to be able to:

- Define sustainable development, sustainability concepts, and principles such as resiliency.
- Define the environmental, socio-economic, cultural, and structural problems of contemporary cities and their consequences on natural systems and on built communities.
- Identify sustainable alternatives and mechanisms in current and future urban structures and dynamics.
- Identify technological, social and cultural innovations for sustainable cities, including the ecological footprint analysis, green and regenerative design, energy alternatives, and environmental justice.
- Apply basic knowledge of approaches, applications, and practices in sustainability.
- Identify urban systems in a global to local context.
- Connect concepts and theories to the practice of urban sustainability.
- Understand connections between individual behavior and sustainability outcomes.

These goals were identified by Arizona State University Senior Sustainability Scientist Dr. K. David Pijawka in the "Sustainable Cities" course syllabus.

Measuring Learning Outcomes

While there are assessment strategies for all levels: from classroom assessments, to program assessments (e.g. accreditation reviews), and up to institutional and state-wide assessments (e.g. standardized tests), this thesis focuses on strategies at the classroom and student level. ESD is a transformative education intended to be established over the course of the higher education experience (even, from some perspectives, over a lifetime), and while this thesis appreciates the freshman introductory course in such a context as important, such long-term learning outcomes are far beyond the scope of this thesis.

"Classroom Assessment Techniques" (CAT's) are of two basic varieties: summative and formative (Simpson-Beck, 2011; UNESCO, 2010). Summative CAT's (e.g. tests) focus on what has been learned: they are evaluative, typically being administered at the conclusion of a course, and are ostensibly given to measure the degree to which the information from the class has been retained. Formative CAT's are, on the other hand, reflective and student-centered and focus more on how information has been learned, and how to improve learning (Simpson-Beck, 2011). The assessment is observed through the student's meta-cognitive (thinking about learning) skills and critical reflection of the learning materials. CAT's have not been definitively researched and assessed themselves in academia regarding the improvement of learning outcomes, *per se*, although they may have many other positive influences in student-learning (Simpson-Beck, 2011).

What is of central importance is how we can measure either affect-oriented outcomes, ethics-based outcomes, or learning outcomes that manifest in behavior, such as those found in ESD, in addition to the more traditional knowledge-based and skills-based learning outcomes alone (Clarkeburn, 2003).

Measuring Outcomes in ESD

How to apply CAT's in ESD is problematic. It should be noted that learning outcomes in ESD differ significantly from traditional learning outcomes in that ESD outcomes are ethical in nature, and "… coverage of environmental ethics and sustainability in planning curricula would seem essential… Planning schools must begin to foster in future planning professionals and educators a more respectful earth ethic and the ability to effectively convey such perspectives to others." (Martin & Beatley, 1993).

However, one framework for the creation of learning outcome assessments in ESD comes from UNESCO. It recommends that schools "Develop an action plan and align it with existing curriculum, teacher education, evaluation and assessment review processes" (UNESCO, 2010). This is what Thomas refers to as "the bolt-on" approach (Thomas, 2009), where ESD topics are attached to existing curricula. For example, regarding the measurement of outcomes, the document asks, "How can Education for Sustainable Development enhance quality learning outcomes?" This does not address the measurement of actual student knowledge production implicit in student-centered learning. For achieving personal transformation necessary for ESD, UNESCO suggests evaluation on the following criteria, by asking if the student has:

- Contributed to identification of a problem or issue that needs to be addressed?
- Investigated the issue using a range of different knowledge resources?
- Found up-to-date, relevant information on the issue?
- Developed a vision of what an alternative future might look like in relation to the issue?
- Proposed realistic strategies for what needs to be done?
- Helped with decision-making on what to do next?
- Been able to work co-operatively with colleagues?

- Contributed activity to the dialogue and discussions on the issue?
- Identified social, economic, environmental and cultural aspects of the issue/topic?
- Identified why and how these different aspects are contributing to the issue/topic?
- Been able to decide what aspect of the issue/topic requires the most attention in the problem-solving process? (UNESCO, 2010)

Yet questions remain such as, "How do you grade and/or evaluate these criteria? What combination of these criteria is necessary to establish competency?" And perhaps most importantly, "How do we educate in ESD without being prescriptive, and without sacrificing a critical approach to learning?" (Wals & Jickling, 2002)

One possible answer to the last question is that education in the ethical component of ESD should take a skills-based approach (Clarkeburn, 2002; Jickling & Wals, 2002). Here the emphasis is on improving the students' skills in evaluating moral and ethical questions by introducing them to ethical quandaries on a routine basis, and provide them with the range of arguments and reasoning provided by philosophical studies. The measure may simply be whether or not the student identifies, from an array of possible outcomes, those strategies that foster sustainability in a given situation. Survey-type methods have been used to discern ethical development in the biosciences (Clarkeburn, 2003) and affective motivation in the geosciences. Van der Hoeven Kraft, et. al. (2011) suggest a new instrument to be created from several related surveys that have already been validated, including Pintrich's Motivated Strategies for Learning Questionnaire (MSLQ), and Bandura's Self-Efficacy Questionnaire (SEQ). Surveys might also be developed to measure choice recognition in the context of sustainability, but as of yet, none have been validated.

Summary

"*In an introductory course for sustainability, there should be a balance between breadth and depth of coverage. There is a need for breadth that provides an understanding of the complexity and system's nature of sustainability tempered by the realization that a full understanding of each of the issues that is a part of that complexity cannot be developed in one course.*"
(Vann, Pacheco, & Motloch, 2006)

All of the above-mentioned goals in ESD can be sought simultaneously, and some skills, competencies, and literacies can be achieved at the same time. While viewing a student's education as a complex system is a necessity, it should not be unreasonable to expect that certain competencies can only be established after certain literacies have been developed. "Actually, one of Piaget's (1952) most basic assumptions is that to learn something means to mentally structure something, namely, to incorporate it in a mental scheme" (Illeris, 2006). It is important to discern what should be taught regarding ESD at the various levels of higher education.

Competencies and skills in ESD are broad at the transdisciplinary level and quite specific at the disciplinary level. This presents issues for interdisciplinary, introductory courses. In addition to providing a substantive learning experience in an academic discipline, because there is an assumption that knowledge retention is partially related to interest and relevance, these courses also have the additional objectives of continuing student interest in sustainability, and laying the groundwork for a transformative education.

The theoretical landscape for teaching behavioral change is contested terrain. Because education is caught between the tensions of social reproduction and personal transformative production, the process and rationale for behavioral change should be approached carefully in order to avoid prescription or indoctrination. One answer for teaching ethics in ESD is to use a skill-based approach.

Classroom assessment techniques can be effective for measuring content knowledge, but they are not easily applied to measuring learning outcomes in courses in ESD, which go far beyond content knowledge. Measuring learning outcomes in ESD is an unexplored area of scholarly research. This thesis hopes to provide a point of reference for other researchers.

CHAPTER THREE: METHODS

Introduction: A Mixed Methods Design

The insights from the case study method and the use of surveys combine to provide a robust foundation from where to address the central question and its sub-questions. A case study is defined as an inquiry that "investigates a contemporary phenomena within its real-life contexts; when the boundaries between phenomena and context are not clearly evident; and in which *multiple sources* of evidence are used" (Yin, 1989, p. 23). Learning outcomes occur within such a real-life context, and the boundaries wherein the learning occurs are "not clearly evident" and contain far more points of interest than there are data to study them. The survey establishes a connection between these points of interest through an analysis of quantifiable data.

Site Selection

Arizona State University is one of the largest institutions of higher learning in the world, with nearly 60,000 undergraduates, over 12,000 graduate students, and 3,000 academic instructors on 3 campuses across the Phoenix metro area covering about 1,500 acres. It is fairly representative of major North American research universities.

This course was chosen as the subject of this holistic (Yin pg. 39) case study research for several reasons. First, it is what University of Leicester School of Management Professor and author Alan Bryman (2010 pt. 4) might call an "exemplifying case." This is because ASU's *Sustainable Cities* course in many ways typifies the large, undergraduate, and introductory lecture course common to the modern, major research university: it is primarily directed towards lower division students; it is designed to cover

a broad variety in subject matter; it establishes a vocabulary necessary for further study; and it is delivered in a large, traditional lecture hall.

Sustainable Cities is a flagship introductory course in urban sustainability at Arizona State University (ASU) where such learning outcomes in ESD are embodied in the stated course objectives, and where solid survey data already exists through which to consider them and the factors that influence them. The course is interdisciplinary in its conception, being cross-listed in both the School of Geographical Sciences and Urban Planning as "Urban Planning 190", and the School of Sustainability as "Sustainability 111", and is co-taught with instructors from different fields of study. There are no prerequisites for this course, and it is open to enrollment by the entire undergraduate university population, but is geared towards the incoming freshman student. The specific section being observed was in the Fall semester of 2011. All data related to the class itself are collected from this one section alone.

Another reason this course was chosen for the case study was the researcher's proximity to it. As the lead teaching assistant, the researcher had the unique opportunity to study a course such as this in extreme detail, and already possessed thorough experience with it. While not technically "participant observation" (PO), some of the fundamentals of what makes PO research robust (e.g. proximity, detail, insight [Yin pg. 80]) were able to be leveraged by the researcher. Additionally, three other factors that usually impede Direct Observation (DO) methods were mitigated: time-consumption, cost, and reflexivity.

Strengths. Time-consumption constraints usually suffered by researchers of case studies were lessened considerably, because the researcher was already on-hand as the lead teaching assistant, and naturally, costs were negligible. The actual time spent

performing the duties of the lead teaching assistant (TA) helped inform the research to a level of detail much greater than could be expected from an outside researcher. In fact, the time spent on both research and assisting in the course provided for a unique and intimate view into the course. This "inside look" is the heart, and prevailing strength, of this study.

Reflexivity of the course was not a major concern. The operations of the classroom were largely, although not entirely, unaffected by the presence of an outside researcher. Bias from manipulation may have occurred from the TA/researcher's increased interest in the course. Being personally invested in the outcome might have increased time spent being available to students and to the material. One suggestion for future researchers might be to include additional observers with a more objective perspective. However, the researcher had been a TA for the course twice prior in the capacity of a TA alone, and the course proceeded as much as it had in the earlier semesters. The notes that were taken in class by the researcher were in the manner of a TA preparing lecture notes for exam questions. While the surveys might have had some affect on the outcome of the class, "surveys as educational" was not a goal of the survey, and the surveys were not designed to that effect. All in all, the effects of reflexivity were minor.

Weaknesses. Some of the weaknesses associated with PO and DO methods were magnified: Selectivity (Yin pg 80) perhaps reached the upper limit. Selectivity is also known as selection bias. Because regression analysis rests on the presumption of random selection, selectivity is a major concern for that family of tests in survey statistics. However, in this study, regressions are not used, and selectivity is less of a concern. If regressions are a goal of future researchers, they might employ multiple case studies, or

embedded case studies (Yin pg 39) as a means for increasing the internal validity necessary for regression.

Another weakness is in how the course is *not* "exemplifying." This includes the fact that the course employs a robust online component that constitutes half its content delivery. This "hybrid" form of course design is not as common as the more traditional lecture that is exclusively in-class. Future researchers investigating the assessment of learning outcomes in ESD may not have a similar course available for study. The absence of an online component may preclude any comparisons. While this case study does not help further research into learning outcomes in purely online courses, the course does permit the testing of whether or not including an online component provides a benefit towards learning outcomes in ESD.

Finally, the course also draws on a significant number of guest lecturers. Most lecture-type courses maintain the same faculty instructor throughout, and the stability and possible rote familiarity they bring may have an effect on learning outcomes. With guest lecturers, the student has no strong pre-conceived notions of the lecture content. Again, future researchers might not have access to a course with this design, and the presence of guest lecturers might give the class a unique feel, making the course non-representative of all introductory sustainability courses, to some degree.

Case Study Profile – Documentary Evidence

Documentation (Yin, pg. 80) will play a key role in the analysis of this case study. For example, one of the central components to the case study is the analysis of written documentation in the form of the students' answers to one homework question, that is, "Do people have the right to consume?" given in the context of an assignment focused on the Ecological Footprint. There may be several reasons as to why student

responses to this question might contain some type of bias, so while not definitive, the usefulness of this documentation is still recognized to provide insight into the outcomes for this course. Another documentary data set was in the survey question included in the before course and after course surveys, "What is your definition of sustainability?" We will code the responses to these questions, and see what role the lesson and assignment had, if any, on the students' responses.

Case Study Profile – Direct Observation

One of the strengths of this case study is the immersion and proximity of the researcher to the case study environment. Sometimes formally, sometimes casually (Yin pg. 86), DO methods include the detailed notes which are taken in each class that inform several broad categories of case study elements and survey variables that have effects on the course according to the theoretical framework. From these notes it can be discerned as to which in-class lectures had particularly positive effects on class participation, the students' overall affect and, theoretically, learning outcomes. General classroom reactions to lecture styles (save the direct observation of any online lectures – however, important empirical data of students' preferences towards lecture delivery methods are obtained from the survey records) are identified and weighed against the framework.

Also, DO method allows the researcher to more carefully consider the environment in which the learning takes place. The ability to research *in situ* allows for a bridge between the case study environment and the survey research by providing a somewhat less-interpretive account of the context from where to interpret the survey responses. Again, while not technically participant observation, as an expected element in the learning environment by virtue of a teaching assistant's job duty, the researcher is

able to directly participate in the observation of the interaction between the learner and the formal structure of the course.

Case Study Elements Outside of the Scope of Research.

This section briefly describes the constituent elements of the case study that are not considered in the analysis. The case study must have a manageable scope (Yin pg), and so the particular elements that do not lend themselves to investigation through the case study are discussed. This is not an exhaustive list of what is not studied, but it helps to establish that the researcher is aware of some of the items being excluded. First, the two examinations (e.g. mid-term and final exam) are not explored. They are of the scan-tron variety, with forty questions presented as either true or false, or as multiple-choice with either four or five possible responses. Also, the syllabus is a simple, typical .pdf posted to the online class management server. While in some cases examinations and syllabi can be instructive, and may have an effect on learning outcomes, the influence on ESD learning outcomes from these two elements are considered beyond the scope of the case study.

Neither the lecture hall itself, nor the course's time allocation is subject to analysis in either the case study or survey. The class is on Mondays and Wednesdays from 5pm until 6:15pm, and is conducted in a large (468 seat), modern lecture hall with six double-door entries and a 30ft ceiling. The audio/visual equipment is up-to-date and versatile with many quality speakers, a myriad of lighting options, three large projection screens and advanced climate controls. In learning environments, it is one of the latest, most state-of-the-art lecture halls at ASU. Subtle inferences and outright rejections of the large lecture hall as an appropriate learning environment run throughout the literature on ESD. However, while Warburton (2003) says that Deep Learning is "not well served by

packed timetables or large class sizes", he does not say it is impossible. Again, while it may have substantial effects on the learning environment, this thesis does not study this effect.

Course Structure and Environment

The course is a hybrid, with in-class lectures on Mondays, and online content on Wednesdays. Exams and other events typically occur on Wednesdays, with Mondays being devoted to lectures. Online content is accessed through a campus-wide server, and usually is in one of two distinct forms: a PowerPoint with voice-over narration, or in the form of a documentary movie, TED Talk, or other multi-media platform. Various readings are assigned through traditional paper textbooks, other written materials available through the online server, and online readings. There were four written class assignments, five extra credit movie assignments, mid-term and final examination.

Students come from all over campus, but most are concentrated in four large groups: urban planning and architecture/design students; sustainability majors; business students with the business sustainability minor; and students representing a variety of majors from across the campus. About half of the students are required to take this course; the remainder of the students took it to meet graduation requirements for an elective, or for personal reasons such as time availability, general credit requirements, or simple curiosity. The participants in this course were those who chose to take this course for a variety of reasons. With a size of 448 students that semester, there were many different reasons for taking this course related to each student's individual goals and circumstance.

Among the many academic majors offered are the Bachelors in Sustainability and the Bachelors in Urban Planning. There are minors in sustainability as well,

including the extremely popular minor in business sustainability. Several centers on campus have sustainability-related research underway, and it is home of the Global Institute of Sustainability (GIOS). Many sustainability-related extra-curricular programs and clubs regularly conduct activities on campus, such as …. Recycling initiatives and other related programs maintain high visibility on campus. In short, sustainability has a major presence at Arizona State University, both formally and informally.

Sample Selection

Total starting enrollment for the course was 444 students. The *combined survey sample* was comprised of the students who took all three surveys (one before the course, one mid-semester, and one after the course): a total of 349 students. All comparative data that show before and after changes in average mean are from the students who took part in all three surveys. Some questions are reflective of the responses from a single survey. The sample sizes for each of the three surveys were 400, 389, and 406 respectively (see Table 1). Exceptionally high response rates over the three surveys shows a solid level of participation.

Table 1

Response Rates of 444 Students per Survey

Survey	Student Responses	Response Rate
Before Course	395	88.9%
Mid-Semester	383	86.3%
After Course	391	88.1%
Combined	349	78.6%

In the combined surveys results, there were four categories of academic major which each contained over 10 percent of the students in the class. Almost a third of the course was comprised of students from an additional eleven categories of academic major

(see Table 30 in Appendix IV), including undecided, with two disciplinary areas being unrepresented (education and languages). Sustainability and Urban Planning majors are required to take the course. Students taking the business sustainability minor are also required to take the course, although not all business majors necessarily take the minor. Other students may be taking the course to fulfill requirements of minors in sustainability, to fulfill other graduate requirements, or are taking the class to fill a convenient time slot in their schedule. The class is geared towards lower division students, and they consist of the bulk of the class enrollment.

Survey Instrument

No instrument, survey-based or otherwise currently exists to measure learning outcomes in ESD. The instrument in this thesis was created as an exploratory tool. The survey was tested for construct validity with 9 undergraduate students from a previous semester. At the conclusion of the pilot period, the following changes were made to the questions and the format:

- The scale was changed from 1-10, to 1-7. Pilot respondents voiced concern that the 1-10 interval range was "a bit overwhelming", and contained "too many choices."
- The question identifying race was removed from the survey. Four respondents wondered what race had to do with sustainability, and three of those students independently commented that they would refuse to answer a question that they felt was irrelevant to the issue. Furthermore, two more students, for a total of six (two-thirds of the total) responded to the question of "If you had to remove one question, what would it be?" with the question on race.

- Finally, the labeling of the Likert scale was limited to the lowest choice (1), and the highest choice (7). Respondents commented that the "field was too populated" and "we get it." When asked about labeling the middle choice, five students said it was unnecessary, with one comment expressed as, "four is clearly in the middle."
- Respondents agreed that the question regarding "environmental consciousness" needed more than the highest and lowest choices to be labeled. They cited a unfamiliarity with what constituted environmental conscientiousness as it pertained to behavior e.g. "what is average?")

The three survey instruments (the before course survey, the middle survey – regarding assignments and lectures – and the after course survey) therefore consisted of 18, 10 and 18 questions, respectively. The Likert-type scale ranges from 1-7 for most of the closed questions; this range being supported in the literature as having the best balance between qualities of precision and user friendliness. Other closed questions had choices of between three and six categories. The use of SurveyMonkey.com allowed for a number of options in the construction of the instrument that keep response mistakes to a minimum. In all of the three surveys, only six respondents were eliminated based on obviously insincere reporting; therefore, all of the respondents are now valid. Tests of survey reliability can be found in appendix III.

Survey One. The first survey was administered during the week prior to the start of the course. There were three main objectives of the first survey. First, key student independent variables were identified, such as the students' year of education, previous exposure to sustainability instruction, and academic major. These variables are important

in that they might have an effect on the dependent variables related to learning outcomes. For example, senior year architects may have a greater interest in transportation than sophomore planners to a degree beyond that which can be explained by random error. Another survey question captures whether or not a student had a taken a class in sustainability before; this is another key independent categorical variable.

The second objective was to have students rate their sense of three key variables that students rated were on three distinct scales of *Knowledge*, *Interest*, and *Importance*:

- *Knowledge of Topics In Sustainability Before the Course* (i.e. the *Knowledge Before* scale)
- *Interest in Topics in Sustainability Before the Course* (i.e. the *Interest Before* scale)
- *Importance of Topics in Sustainability Before the Course* (i.e. the *Importance Before* scale)

Each area of Knowledge, Interest and Importance contained ten different lecture subjects in urban sustainability that were rated on a scale of 1 to 7, with a score of 1 being the lowest and 7 being the highest:

- personal values and lifestyle
- ancient civilizations and their collapse
- history of environmentalism
- increasing global urbanization
- energy: production, consumption and alternatives
- global climate change
- environmental justice
- architectural and landscape design
- water consumption
- transportation

These topics in urban sustainability were chosen for specific reasons. First, they are sufficiently distinct from each other, and also because they were already secured in the syllabus. In addition, the terms were sufficiently understandable in layman's terms, with perhaps a few exceptions (e.g. environmental justice).

Finally, the survey gathers an open-ended response regarding the students' conception of sustainability (i.e. "What is your definition of sustainability?") to be later coded and compared to the same question asked after the course. They will be compared to identify substantive changes, if any exist.

Survey Two. The second survey had two main objectives, and was conducted just after the mid-term. It was geared more towards the specific mechanics of the classroom. First, we asked the students to rate the specific lecture deliveries (e.g. online, guest lecture) and the subjects of those lectures (e.g. Urban Heat Island Effect, the history of environmentalism) regarding how beneficial they were in learning about sustainability. Second, we wanted to measure which topics were facilitated by specific delivery methods most effectively. Further relationships are analyzed between the independent variables of the first survey and the preferences and perceived efficacy of the dependent variables of the second survey (e.g. preference in assignment types).

Survey Three. The third survey had three main objectives. First was to observe changes in the students own conception of sustainability, discovered through the responses to the same open-ended question as the first survey "What is your definition of sustainability?" Next, we defined the students' broader preferences in classroom mechanics and curriculum structure (e.g. variety of topics, source materials, flexibility in meeting assignment instructions) through a series of questions related to those issues.

The last objective was to observe any changes from the results of the first study regarding students' change from before the class in any of the sustainability topics in any of the three domains of *knowledge*, *interest* and of *importance*. As discussed above, the topics that students rated within each domain were the same in all three domains of

Knowledge, *Interest*, and *Importance*. The ten individual topics in urban sustainability were again aggregated into a single scale for each of the three domains, for a total of six scales: three domain-based scales before the course; and the same three domain-based scales after the course:

- *Knowledge of Topics In Sustainability After the Course* (i.e. the *Knowledge After* scale)
- *Interest in Topics in Sustainability After the Course* (i.e. the *Interest After* scale)
- *Importance of Topics in Sustainability After the Course* (i.e. the *Importance After* scale)

The independent variables (e.g. academic major) are to be analyzed for relationships with dependent variables, such as the lecture topics within each of the three "domains" (e.g. interest in transportation, importance of energy) both before and after the course.

Theoretical Framework

The thesis develops a hypothesis derived from several authors (Orr, Wesch, Gunder, et al.) discussed in the literature review who assert that classroom or course topics need to be "interesting, relevant, or inspiring" to students in order for them to learn in such a way as to ensure that they will continue to incorporate their education into their lives beyond their formal schooling. A course necessarily must transmit content knowledge in its academic domain. This thesis integrates these two propositions on to the theoretical framework of Deep Learning as a means to deliver an education for sustainable development. This theoretical framework explains how the processes and approaches utilized in the *Sustainable Cities* course might deliver an education for sustainable development: in order to ground our framework for learning outcomes, this thesis adopts the position of the UNESCO Chair for Higher Education for Sustainable

Development when he says, “A framework of educational psychology adds robustness to competence research and theory” (Myers & Beringer, 2010).

The individual elements of the case study (e.g. lectures, assignments, etc.) will be connected to the theoretical framework to establish whether or not ESD learning outcomes are being achieved, and what factors (e.g. pedagogies) are best at meeting those outcomes. Additionally, we should consider that two or more elements may combine to articulate a goal in the framework. Other goals in the framework, such as Curriculum Action Research, may not be utilized in the course at all, and it will be necessary to determine if all of the components necessarily need to be applied in order to deliver ESD outcomes, especially at the introductory level.

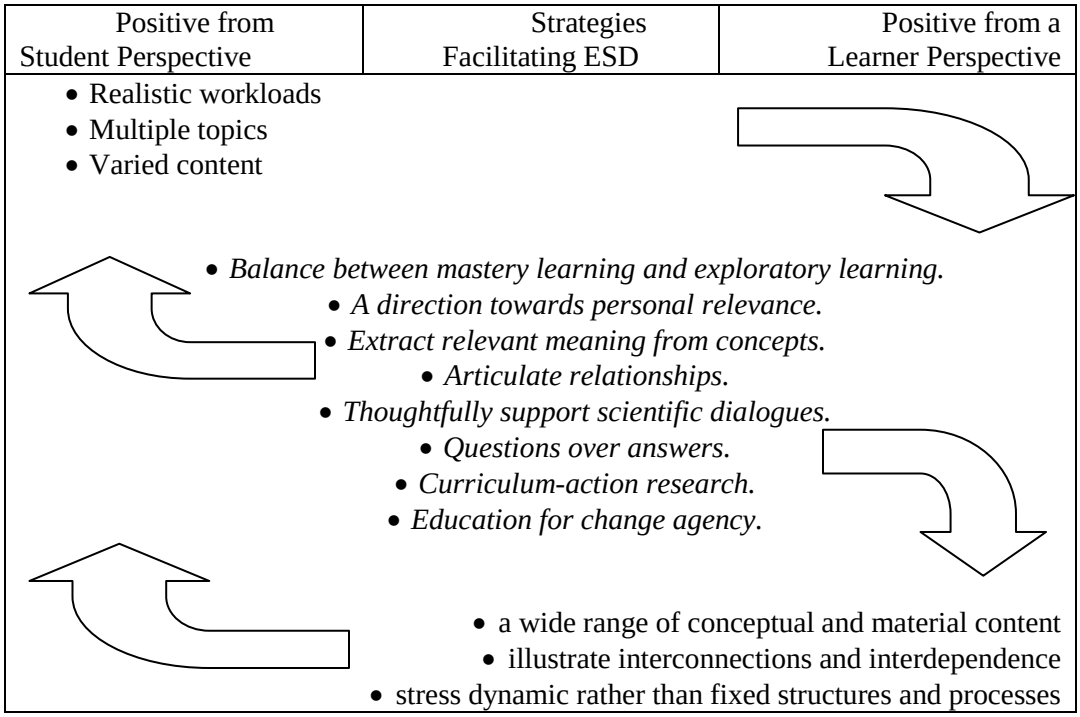

Figure 1. Deep Learning Conceptual Framework – these elements will be matched against the case study elements to validate an education in sustainable development.

Explorations and Hypotheses

This thesis uses a mixed-methods approach to answer the central research question: "Are we achieving our desired learning outcomes in education for sustainable development?" by connecting the theoretical framework to the data through three related sub-questions. These three sub-questions are approached in one of two ways. First, an issue related to the Subquestion is developed as a hypothesis, which can be analyzed with one or more statistical tests. Alternatively, a related issue might be presented as an exploration that does not lend itself to statistical tests. Instead, we will review such explorations with frequency descriptives, graphs and other figures.

Sub-Question One

"What are the expected learning outcomes for a freshmen-level introductory ESD course in urban sustainability?"

Various traditional methods of assessing content knowledge are addressed by the course in terms of graded assignments, exams, and the overall grade from an intuitional perspective. This thesis focuses instead on the achievement of outcomes necessary for ESD, and is observed from multiple perspectives, including from the students' perspectives. Accordingly, the survey is a measure of self-reported perceptions of literacy in content knowledge. This sub-question is concerned with what the students perceive their knowledge to be before the course begins, and what their perceived knowledge is after the course.

One of the objectives of the course is to learn the terms useful to carry on a discussion of sustainability issues (Orr, 1989). A level of familiarity with key concepts and terms is necessary to engage sustainable thinking (Orr, 2008), therefore the survey addresses the students' perceived ability in defining key terms, and asks students what

they perceive to be their knowledge of topics in urban sustainability to be. Consequently, a list of six terms was developed from the course material and then presented to the students in the first survey to identify their level of familiarity with those terms. In an effort to understand what would cause students to be familiar with certain terms, an additional variable was developed by asking if the students had taken a class in sustainability before. This is necessary to identify the level of influence that earlier coursework has on student familiarity with terms in sustainability. It would be informative to separate the freshmen from the rest of the students in order to see if freshmen with earlier coursework in sustainability had similar levels of term familiarity to other students.

In addition, students with prior coursework should also register higher sample means for topics in the domain of knowledge (i.e. *Knowledge Before* scale). Another important consideration that gets to the heart of whether the course delivers learning outcomes is if there is an initial difference between those students with prior coursework and those without, does the course bring the latter group up to the level of the former?

Four hypotheses, and two general areas for exploration, emerge to be tested that are related to the first sub-question:

Exploration One: Before the course, freshmen students with high school coursework in sustainability can define more terms in sustainability (e.g. ecological footprint, resilience) than can the other students.

Exploration One (a): After the course, freshmen students with high school coursework in sustainability can define more terms in sustainability (e.g. ecological footprint, resilience) than can the other students.

Hypothesis One: Before the course, upper division students will have a higher sample mean than lower division students on the *Total Knowledge Before* scale.

Hypothesis One (a): After the course, upper division students will have a higher sample mean than lower division students on the *Total Knowledge After* scale.

Hypothesis Two: Before the course, students with high school coursework in sustainability will have a higher sample mean than students without prior coursework on the *Total Knowledge Before* scale.

Hypothesis Two (a): After the course, students with high school coursework in sustainability will have a higher sample mean than students without prior coursework on the *Total Knowledge Before* scale.

Table 2

Subquestion 1

Observation	Independent Variable(s)/ Sample Mean(s)	Dependent Variable(s)/Sample Means(s)	Statistical Test(s)
Exploration 1	Sustainability Course in High School (Y/N) Academic Year (4 levels)	Number of Sustainability Terms Defined Before Course (Nominal)	Frequency Descriptives
Exploration 1a	Sustainability Course in High School	Number of Sustainability Terms Defined After Course	Frequency Descriptives
Hypothesis 1	Academic Year	Total Knowledge Before Course	Kruskal-Wallis (4)
Hypothesis 1a	Academic Year	Total Knowledge After Course	Kruskal-Wallis (4)
Hypothesis 2	Sustainability Course in High School	Total Knowledge Before Course	Mann-Whitney U Test
Hypothesis 2a	Sustainability Course in High School	Total Knowledge After Course	Mann-Whitney U

Sub-Question Two

"What factors best facilitate meeting ESD outcomes?"

The literature revealed that some lecture formats and pedagogic styles might be more helpful for acquiring ESD competencies. This thesis asks if those learning environments and methods are being delivered. Therefore, the surveys query students regarding the beneficence of lectures for learning about sustainability, both by the individual content topics within groupings of similar topics (e.g. ancient civilization in the topic group related to history), and by the larger topic groupings themselves (e.g. history, science). Also, questions are asked students about how helpful they perceived the various assignment types (e.g. analytic, reflective) to be for learning about sustainability; and what effect the level of detail of the assignment instructions (e.g. latitude/creativity in student response) had on their mental and affective state . Also, the survey investigated whether students found some lecture formats (e.g. online, in-class) more beneficial for learning about sustainability, and which types of source materials (e.g. TED Talks, peer-reviewed journals) were most effective.

It is possible that the students conceptions of what is most helpful for learning about sustainability will change over the course of the semester as they become more acquainted with both the definition of sustainability and the means by which to investigate topics in sustainability. ESD is learning for transformative change. Identifying students' changing perceptions of how to acquire ESD competencies tells us about a transformation in the student regarding their conception of sustainability. Therefore, ten hypotheses emerge when addressing the second sub-question:

Hypothesis Three: By the middle of the course, students generally believe some lecture topic groups to be more helpful in shaping their understanding of sustainability.

Hypothesis Three (a): By the middle of the course, students generally consider some individual lecture topics within lecture topic to be more helpful in shaping their understanding of sustainability.

Hypothesis Four: Before the course begins, students generally consider certain lecture delivery types (e.g. online, in-class) more beneficial than others for learning about sustainability.

Hypothesis Four (a): Before the course begins, certain students (e.g. freshmen, business majors) consider certain lecture delivery types (e.g. online, in-class) more beneficial than others for learning about sustainability.

Hypothesis Five: Generally, students' attitudes change about the beneficence of lecture formats (e.g. online, in-class) from before the course to after the course.

Hypothesis Five (a): After the course, certain students' (e.g. freshmen, business majors) attitudes differ than others regarding the beneficence of lecture formats (e.g. online, in-class).

Hypothesis Six: Before the course, students generally assume some assignment types more beneficial for learning about sustainability than others.

Hypothesis Six(a): Before the course, some students (e.g. freshmen, business majors) assume some assignment types more beneficial for learning about sustainability than others.

Hypothesis Six (b): After the course, students' preferences about assignment types for learning about sustainability have changed.

Hypothesis Six (c): Students generally prefer particular types of examinations for measuring ESD outcomes.

Hypothesis Six (d): After the course, students find certain source materials more effective for learning about sustainability than others.

Table 3

Subquestion 2

Observation	Independent Variable(s)/ Sample Mean(s)	Dependent Variable(s)/Sample Means(s)	Statistical Test(s)
Hypothesis 3		Beneficence of Lecture Subject Group (History, Science, Decision)	Frequency Descriptives
Hypothesis 3a		Topics in History Group	Frequency Descriptives
		Topics in Science Group	
		Topics in Decision Group	
Hypothesis 4		Beneficence – In Class	Frequency Descriptives
		Beneficence – Guest	
		Beneficence – Online	
		Beneficence – Movies	
Hypothesis 4a	Major	Beneficence – In Class	Kruskal Wallis (8)
	Year	Beneficence – Guest	
		Beneficence – Online	
		Beneficence – Movies	
Hypothesis 5	Before – In Class	After – In Class	paired-samples t-test (4) Wilcoxon Signed Rank (4)
	Before – Guest	After – Guest	
	Before – Online	After – Online	
	Before –Movies	After –Movies	
Hypothesis 5a	Major	After – In Class	Kruskal Wallis (8)
	Year	After – Guest	
		After – Online	
		After –Movies	

Table 3

Subquestion 2, con't

Observation	Independent Variable(s)/ Sample Mean(s)	Dependent Variable(s)/Sample Means(s)	Statistical Test(s)
Hypothesis 6		Before Crit Think	Frequency Descriptives
		Before Data Analysis	
		Before Personal Reflect	
		Before Field Work	
		Before Inter Personal Comm	
Hypothesis 6a	Major	Before Crit Think	Kruskal Wallis (10)
	Year	Before Data Analysis	
		Before Personal Reflect	
		Before Field Work	
		Before Inter Personal Comm	
Hypothesis 6b	Assign After Data Analysis		Wilcoxon Signed Ranks Test
	Assign After Personal Reflect		
Hypothesis 6c	Exam Format Preferences		Frequency Descriptives
Hypothesis 6d	Source Material Preferences		Frequency Descriptives

Sub-Question Three.

"How can we measure or assess these learning outcomes?"

A record exists of the students' learning of concepts and vocabulary in sustainability through the grades of assignments, scores on tests, and their final grade. These scores do not necessarily reflect that a groundwork for transformative change has been established. Also, while we have test scores and grades for homework assignments, those are imperfect measurements subject to influences stemming from non-classroom related phenomena. So, while those metrics are informative, they do not address whether

or not the students feel that their literacy in sustainable development has increased. To augment these traditional learning measures, and provide a more informed assessment of the development of outcomes, insights into the opinions and conceptions of sustainability can be recorded. Because ESD means a transformative cognitive and affective experience, student conceptions of sustainability also need to take a more nuanced, specific, or meaningful turn. To capture a sense of this, the before course survey asks for a definition of sustainability, which is then compared to a definition given in the after course survey. In addition, a question was retrieved from the homework assignments that inquired about peoples' rights to consume. We look at the responses to this question for a rough measure of the students' perspective on the ethics of consumption.

The literature review suggests that students' interest in, and their perception of the importance of topics in sustainability need to be developed in order to encourage continued learning in ESD, and to encourage integration of SD competencies into cognitive skill sets. To explore this, the survey compares self-reported interest and importance of SD topics from before and after the course. Another measure of positive ESD outcomes might be found in any increased environmental conscientiousness reported by the students. Finally, an indication of transformative change is measured by broadened student interests; identification with sustainability might be found in the students' consideration of adopting new academic majors or minors. Seven additional hypotheses therefore emerge:

Hypothesis Seven: Students generally feel that their knowledge of SD topics has increased from before the course to after the course.

Hypothesis Seven (a): Students generally feel that their interest in SD topics has increased from before the course to after the course.

Hypothesis Seven (b): Students generally feel that topics in SD are more important after the course.

Hypothesis Eight: Students' conceptions of sustainability become more nuanced, specific, or meaningful over the course of the semester.

Hypothesis Nine: In the middle of the course, students reject the notion that people have a "right to consume."

Hypothesis Ten: After the course, students consider themselves to be more environmentally conscientious than they were before the course.

Hypothesis Eleven: Students generally consider adopting new majors or adding additional minors as a result of the course.

An additional inquiry not entirely related to the case study, but interesting nonetheless, is also conducted. We wonder if students might have a greater perceived knowledge, interest, or importance in various topics that relate to their major. There are a few reasons why this might turn out to be a useful observation. Knowing the effect on learning that the relationships between students and their disciplines have might be instructional for providing a well-rounded curriculum, and might be advantageous in providing a more holistic, less silo-driven approach to ESD. Additionally, this might be helpful for considering what to include in a future course that will be cross listing between what might otherwise seem to be disparate academic disciplines.

Exploration Two: Students favor certain topics in sustainability regarding knowledge, interest, and importance according to their major. See appendices.

Table 4

Subquestion 3

Observation	Independent Variable(s)/ Sample Mena(s)	Dependent Variable(s)/Sample Means(s)	Statistical Test(s)
Hypothesis 7	Total Knowledge Before	Total Knowledge After	Paired-samples T-Test
			Wilcoxon Signed Rank Test
Hypothesis 7(a)	Total Interest Before	Total Interest After	Wilcoxon Signed Rank
Hypothesis 7(b)	Total Importance Before	Total Importance After	Wilcoxon Signed Rank
Hypothesis 8	Definition of Sustainability Before	Definition of Sustainability After	Frequency Descriptives
Hypothesis 10	Environmental Conscientiousness Before	Environmental Conscientiousness After	Wilcoxon Signed Rank
Hypothesis 11	Adopt new Major/Minor		Frequency Descriptives
Exploration 2	Major	Individual Domain Topics	Kruskal Wallis (10)
			One Way Between Groups ANOVA/Tukey HSD (3)

Case Study Elements

The following case study elements consist of documentary evidence and direct observational evidence with which connections to the conceptual framework can be identified. Most of these elements are cross-analyzed with the surveys' results, but they are equally important in their own right in that they provide detailed documentary- or observation-based case study information that helps shape our contextual understanding of the essential learning environment of the course. Assignments, source materials, lesson presentations and lectures, are all included in this category of evidence.

Source Materials.

One documentary case study element is the various source materials used in the course. They can be measured individually against the framework for contributing to learning outcomes, and also identified and rated for efficacy in exploring sustainability by the students in the third survey. The effect of the variety itself can also be explored, as a wide variety of materials were employed in diverse platforms (e.g. electronic, video, print). Preferences in materials are compared to independent survey variables such as major and year in school for preference, in an attempt to answer the question of whether or not particular students prefer particular source material mediums. The list of material types and the frequency of use in parenthesis:

- Sustainable Urban Design Reader (SUDR) Textbook (18)
- Peer-reviewed journal (PRJ) articles (6)
- 18 minute TED Talks (TED) (4)
- YouTube.com (YT) videos (2)
- 5- minute newscasts (News) (2)
- online encyclopedia (OE) readings (2)
- 25-minute cable shows (Hulu.com) (2)

Lessons and Lectures.

The analysis regarding the beneficence of individual pedagogic approaches and their connection to the conceptual framework will be established through the direct observations of the researcher and supported by the statistical analysis of the surveys, where applicable. In addition, the individual lessons (e.g. ancient civilizations and their collapse) will be measured against the other lectures in the lecture group (e.g. history lecture group) in the survey analysis.

Lectures are analyzed in two contexts: those that directly influence survey domains, and those that are not directly addressed. Further distinctions are made between those delivered by faculty, guest lecturers, and those found online, and the effects that they might have on survey outcomes. Case study analysis is employed to determine if particular topics and lecture styles were more effective at eliciting post-lecture discussions between the students and lecturer. Preferences in lecture delivery are looked at through survey variables such as major and year in school, in an attempt to answer the question of whether or not particular students prefer particular lecture delivery platforms.

Table 5

Lectures Directly Relating to Survey Subject Topics	Lectures Not Directly Relating to Survey Subject Topics
Values in Sustainability#	Sustainability Concepts
Environmental Justice@	Risk, Vulnerability, Resiliency#
Ancient Cities	Looking Forward (TED Talks)@
History of Environmentalism#	Measuring Sustainability#
Changes to Cities	Sustainability Indicators
Biophilic Cities*	Landscape Ecology*
Place and Urban Design	Phoenix's Urban Ecology
Sustainable Urbanism#*	Sustainable Agriculture#*
Sustainable Design – LEED#	Urban Farming*
Transportation#	Urban Agriculture*
Transportation*	Waste Cycles@
Energy and Alternatives#*	Urban Heat Island Effect#
Water Resources	
Global Climate Change*	

*Guest Lecturer, #Online Lecture, @Online Video

The Assignments.

The assignments are compared to the theoretical framework to assess whether their design in facilitates delivering learning outcomes in ESD. The assignments are shaped by two distinct approaches: the analytic, and the reflective. The analytic

assignments focus on data, while the reflective assignments focus on personal values and attitudes. None of the four assignments can be definitely excluded from either category, as the subjective and objective responses lay on a continuum. Nor is this distinction made explicit in the assignment instructions (e.g. "This assignment is reflective"). However, the basic approach is one of direction: is the response by the student an observation of particular measured qualities of the exterior world, or is it instead an inspection of interior qualities of the self?

The analytic approach is characterized by problem-based learning. It is expressed that there are no right or wrong answers, but rather answers that tend to include more considerations in reaching a conclusion, as those types of answers can be assumed to be subjected to less uncertainty. The student looks at specific empirical data about an issue in sustainability, objectively assessing the information, and drawing reasoned conclusions. Conclusions should integrate both scientific and democratic perspectives from the readings and lectures.

The reflective approach is instead focused on student-centered learning. Again, there is no right or wrong answer, but instead answers that more or less fully unpack the student's insight to the greater degree. Instead of looking at empirical data about an issue, this approach looks at an issue in sustainability and encourages the student to develop propositions about the issue from where to approach the development of solutions. One of the major components to the four essay-type assignments is a purposeful lack of strict parameters. Guidelines for answering the questions give students an enormous, almost unsettling amount of latitude. Preferences in assignment types are compared to independent survey variables such as major and year in school for preference, in an attempt to answer the question of whether or not particular students prefer particular assignment designs and guidelines. Additionally, one question posed to the students from

the first assignment is reviewed for insights into their perspectives on rights and consumption, and is compared to the theoretical framework and other forms of data in order to recognize any ESD learning outcomes if they can be identified.

Summary

The purpose of this study was to explore the central question, "Are we achieving our desired learning outcomes in education for sustainable development?" through an exploration of three sub-questions:

- What are the expected learning outcomes for a freshmen-level introductory ESD courses in urban sustainability?
- How can these learning outcomes best be achieved?
- How can we measure or assess these learning outcomes?

To investigate these sub-questions, an exploration of the relationships between the case study elements and the theoretical framework was initiated. To explore the relationships at work in the classroom, three separate sources of data were used to understand the dynamics of the class, and assess whether or not any of the desired learning outcomes in ESD were being achieved.

First, two forms of documentary evidence were used. One is in the form of the specific answers to a question from a class assignment, and the other is in the body of source materials, lectures and lessons, and characteristics of the class assignments applied to meet stated course objectives.

The second source of data is in the form of direct observation of the case study elements. The researcher observed and noted various useful occurrences in the course (e.g. student reactions to lectures and lesson, queries into assignment instructions, etc.)

The third source of data is in the form of a series of surveys. The surveys establish important categorical independent variables based on responses from students about their individual characteristics; and categorical, ordinal and interval dependent variables about their experience over the course of the semester.

CHAPTER FOUR: FINDINGS

Introduction

In this chapter, we review the findings of the statistical analysis of the surveys and the observations of the case study. The three relevant sub-questions are reviewed individually by an examination of each sub-question's hypotheses. First, we briefly discuss how each hypothesis connects the sub-question to the literature review in chapter two. Then we identify the variables or frequency descriptives (e.g. nominal categories, percentage of sample) to be examined, and state the appropriate statistical test(s) to be done. Then the test statistics themselves are explained (e.g. r^2, p-value), and each of the hypotheses outlined in the previous chapter will be accepted or rejected based on the findings of the statistical tests that are applied. Following each test, we discuss the status of the hypothesis in relation to observations of the course (i.e. the researcher's assessment) and the theoretical framework. Finally, we show how the result of the test might inform the answer to the sub-question before moving on to the next hypothesis.

Sub-Question One

"What are the expected learning outcomes for a freshmen-level introductory ESD course in urban sustainability?"

In the literature review we discovered that positive learning outcomes in education for sustainable development come in many ways. Included among these learning outcomes are literacies in ESD, both practical literacy and conceptual: content knowledge; transformative education; interdisciplinarity; critical-thinking; and more specifically:

- competency in foresighted thinking;

- competency in interdisciplinary work;
- competency in cosmopolitan perception, transcultural understanding and co-operation;
- participatory skills;
- competency in planning and implementation;
- capacity for empathy, compassion and solidarity;
- competency in self-motivation and in motivating others; and
- competency in distanced reflection on individual and cultural models.

These outcomes are broad and independent of one another. Strategies for achieving one will not necessarily facilitate another. Furthermore, some competencies might need to be developed before others can be approached. This level of research is beyond the scope of this thesis. Therefore, we will assume that a multiplicity of techniques and approaches are required to achieve them all, and that the establishment of these outcomes might be an objective that spans the course of the undergraduate experience, or beyond. To achieve these various competencies, skills, and literacies, our conceptual framework of "Deep Learning" suggests the following pedagogical tactics and strategies:

1) Balance between mastery learning and exploratory learning.
2) A direction towards personal relevance.
3) Extract relevant meaning from concepts.
4) Articulate relationships.
5) Thoughtfully support scientific dialogues.
6) Questions over answers.
7) Curriculum-action research.
8) Education for change agency.

We will refer back to these stated learning outcomes in ESD, and the eight recommendations of the conceptual framework when reviewing the several hypotheses related to the sub-questions.

Content Knowledge

One of the most fundamental learning outcomes upon which many others are enabled is the development of a working vocabulary in sustainable development. To establish whether or not the case study provides such a vocabulary is then a proper starting point for our investigation. To establish the effect of the course on student vocabulary we need to discern the students' ability in this area prior to the start of class. Knowing that some students have taken prior ESD coursework in high school prompted us to make the following proposition:

"Before the course, freshmen students with high school coursework in sustainability can define more terms in sustainability (e.g. ecological footprint, resilience) than can the other students."

We found through a simple observation of the survey results that freshmen students with prior coursework in sustainability recorded an average of 2.34 terms per student (n = 38), while freshmen without prior coursework recorded 1.26 terms per student (n = 102). Sophomores with prior coursework in sustainability recorded 1.76 terms (n = 17), while sophomores without recorded 1.44 (n = 67). Figures for juniors and seniors who had taken prior coursework in sustainability were too low (n = 5, n = 1, resp.). Juniors in both categories recorded 2.06 terms per student (n = 94), while seniors recorded 2.32 terms per student (n = 31), about the same as freshmen with prior coursework (See Figure 2). We can safely accept the veracity of this proposition in this case study.

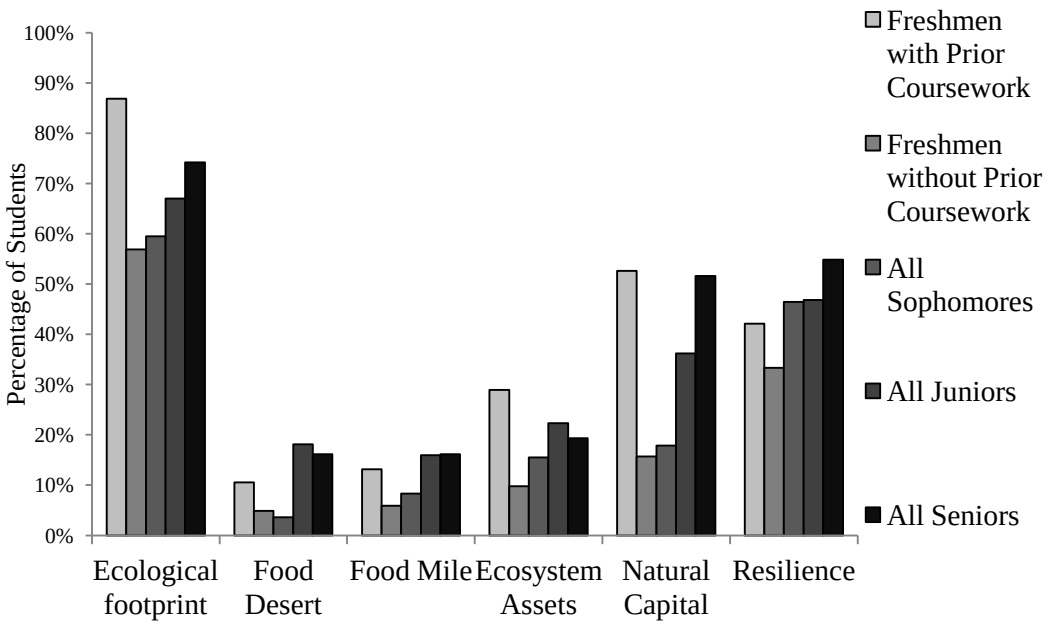

Figure 2. Before Course Familiarity with Terms by Prior Coursework and Academic Year.

Discussion: This is an important observation to make at the beginning of the semester for two reasons. First, it provides a general baseline of the strengths of the students according to year. The introductory course has a difficult balance to strike between meeting the needs of freshmen and sophomores, and being concurrently interesting and relevant to juniors and seniors. Secondly, it allows the researcher to judge the initial strengths and weaknesses in the vocabulary of the students, and measure the familiarity with individual terms against the amount of lecture time and source materials devoted to those terms, and thereby measure the efficacy of the combined curriculum when these figures are compared to the *After Course* responses. This exercise of comparing lecture content and source materials will provide an additional sense of the efficacy of those materials in later tests.

Of note is fact that freshmen students with prior coursework in sustainability seem very confident of their ability to define terms (see Figure 2). For example, they

reported greater familiarity with the terms "ecological footprint" and "ecosystem assets" than did the seniors. It is clear that prior coursework has a dramatic effect on the literacy in sustainable development of students.

Additionally, it appears that freshmen have had more opportunities to take a class in sustainability in high school than the other students (See Figure 3). This may be due to an increase in the spread of ESD in secondary education. The results of this exploration points to an area for further research, and suggest future adjustments for higher education instructors: as ESD becomes ubiquitous in secondary education, the incoming students to introductory courses in sustainable development-related topics will have greater literacies and more developed vocabularies. What an education in sustainable development means at the college level is related to the proficiencies that the students will bring with them in their first year.

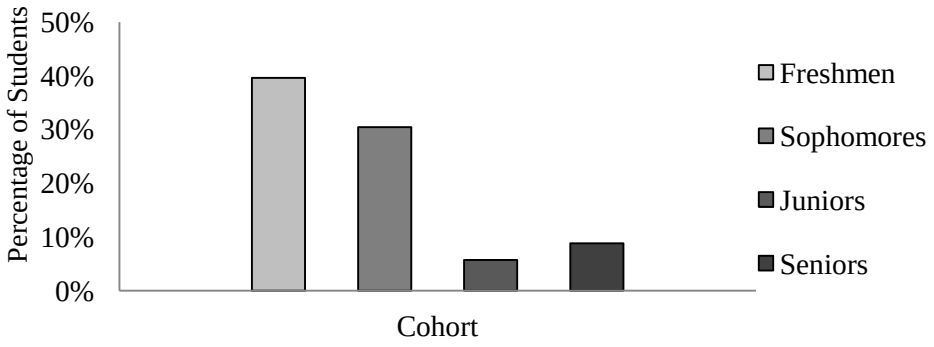

Figure 3. Frequency of the Answer "Yes" to the Question, "Was Sustainability ever the Focus of any of your High School Courses?"

We know now that students come into the course with different levels of familiarity with terms in sustainability. In measuring the effect of the course on vocabulary development, we assumed that prior coursework in ESD would retain the effect found above by proposing that:

"*After the course, freshmen students with high school coursework in sustainability can define more terms in sustainability (e.g. ecological footprint, resilience) than can the other students."*

However, we found that the discrepancies between students seem to become less marked, and even reversed in some cases on the *After Course* survey, with all freshmen registering the ability to define an average of 4.71 of our six sustainability terms (n = 140), sophomores registering 4.98 terms (n = 84), juniors registering 4.85 terms (n = 94), and seniors registering 5.19 terms (n = 31). We should reject the premise stated above, and instead assume that after the course students in this case study have similar levels of literacy in ESD-related vocabularies.

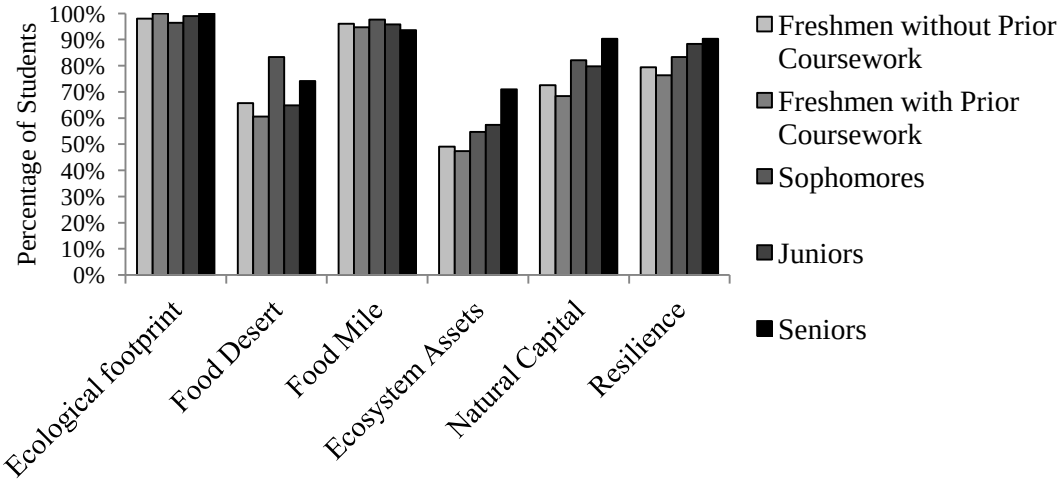

Figure 4. After Course Familiarity with Terms by Prior Coursework and Academic Year.

Discussion: In Figure 4, we can see that the differences between students' comfort in defining terms are not as dramatic, perhaps with the exception of the term "natural capital." This shows that the course acts as an equalizer: students without prior coursework in sustainability are able to catch up to those with prior coursework in the familiarity with conceptual terminology. This is extremely important, because although

students come to the class with disparities in educational backgrounds in sustainable development, they should be able to converse with the same level of literacy in SD after passing this course. This shows that the course provides a foundation for a positive discourse to occur among students across different academic levels regardless of their prior high school coursework in ESD.

Similarly, to the effect on outcomes stemming from prior coursework in ESD in high school, we suggested that there would be a discrepancy between higher division students and lower regarding content knowledge in general. We posited that:

"Before the course, upper division students will have a higher sample mean than lower division students on the Total Knowledge Before scale."

However, a Kruskal-Wallis Test revealed no statistically significant difference on the *Total Knowledge Before* scale between students in different years of study (Freshmen, $n = 140$, Sophomores, $n = 84$, Juniors, $n = 94$, Seniors, $n = 31$, χ^2 (3, n = 349) = 3.23, $p = .357$. These results suggest that there is no significant difference in *Total Knowledge Before* between students of different academic levels. We should therefore reject the proposition.

Discussion: This test measures the self-perception of knowledge in all ten topics combined, and it shows that students come to the class with similar perceptions about their overall awareness and proficiency in the ten aggregated topics in sustainability that we tested. This is different from having familiarity in vocabulary, and points to that fact that the wide diversity of topics in urban sustainability acts as a great equalizer. Academic year is not an indication of literacy in SD topics, broadly. This is extremely important as it suggests that, perhaps because SD is so new, we need not be overly concerned with providing seniors with more complex material in SD beyond that which

freshmen can master, when student distributions are in the proportions presented by the case study.

We know that the prior coursework in ESD in high school had no effect on the ability to define terms in sustainability. We also found that before the class that upper division students did not perceive themselves to be more knowledgeable about the aggregated topics in the *Knowledge Before Scale*. Despite this, we suggest that:

"After the course, upper division students will have a higher sample mean than lower division students on the 'Total Knowledge After' scale."

A Kruskal-Wallis Test revealed no statistically significant difference on the *Total Knowledge After* scale between students in different years of study (Freshmen, $n = 140$, Sophomores, $n = 84$, Juniors, $n = 94$, Seniors, $n = 31$, χ^2 (3, n = 349) = 2.20, $p = .533$. These results suggest that there is no significant difference in *Total Knowledge After* between students of different academic levels. We should reject the suggestion above.

Discussion: This is also extremely important in that it shows the material is not so complex that seniors perceive themselves as mastering it beyond that which the freshmen perceive. Students at every academic level perceive themselves as having similar knowledge competencies after the course. This reinforces the point made earlier that the course provides a basis for discourse among students of different academic levels. For this reason, we can assume that group projects in class can safely include students of various levels of academic advancement.

We have ascertained that students with prior coursework enter the class with a higher self-perceived familiarity with sustainability terms than the other students regardless of academic level. We also know that upper division students do not enter the class reporting a higher aggregated knowledge of the ten topics in the *Total Knowledge*

Before scale. Now we will suggest that the prior coursework in sustainability will have an effect on the *Total Knowledge Before* scale by stating the proposition that:

"Before the course, students with high school coursework in sustainability will have a higher sample mean than students without prior coursework on the Total Knowledge Before scale."

Corresponding to our earlier discovery about discrepancies regarding vocabulary, a Mann-Whitney U Test also revealed a significant difference on the *Total Knowledge Before* scale between students with prior high school coursework in sustainability (*Md* = 41, *n* = 61) and those without (*Md* = 36, *n* = 288). This suggests that *Total Knowledge Before* is higher in students who took a sustainability course in high school. We should accept the proposition.

*Discussio*n: Students with prior coursework in ESD do perceive themselves as having a significantly higher knowledge in aggregated topics before the course begins. This supports the result found earlier in the discussion of familiarity in vocabulary. However, as we found earlier, the next test shows that the course equalizes this difference. We complete this section with the proposition that:

"After the course, students with high school coursework in sustainability will have a higher sample mean than students without prior coursework on the Total Knowledge Before scale."

Similar to the equalization in vocabulary terms, a Mann-Whitney U Test revealed no significant difference on the *Total Knowledge After* scale between students with prior high school coursework in sustainability (*Md* = 41, *n* = 61) and those without (*Md* = 36, *n* = 288). This suggests that, after the course, *Total Knowledge After* is no higher in students who took a sustainability course in high school than that of those who did not. We should therefore reject the proposition.

Discussion: Again, the course is shown to provide a normalizing effect on student self-perception of literacy in SD. An introductory course in ESD should lay a foundation from where the student can pursue further interests in SD, and from where to develop richer competencies in SD. Therefore, in answering the question of, *"What are the expected learning outcomes for a freshmen-level introductory ESD course in urban sustainability?"* we can reply that the learning outcomes related to content knowledge stated in the syllabus for the course Sustainable Cities provide a model example. However, ESD goes far beyond content knowledge. To what extent the course provides opportunities to acquire those competencies that are not related to content knowledge will be examined in other areas of this chapter.

What can be safely suggested is that students come to class with different levels of exposure to topics and vocabularies in SD. They also bring different self-perceptions regarding knowledge in SD topics. However, there is substantial evidence that the course does provide sufficient opportunity to become nominally literate in content knowledge regardless of prior coursework in ESD, or levels of general academic advancement.

Sub-Question Two

"What factors best facilitate meeting ESD outcomes?"

What cannot be claimed is that there are any tests of the survey results that are able to directly measure learning outcomes in ESD that are non-content knowledge areas, such as transformative education, a capacity for empathy, or interdisciplinary thinking. To capture a sense of whether or not the course delivers such outcomes in ESD, we will therefore look one or more elements of the course structure and pedagogies, match them to the theoretical framework, and assess their efficacy in providing our stated outcomes. Again, the elements of the "Deep Learning" theoretical framework are as follows:

1) Balance between mastery learning and exploratory learning.
2) A direction towards personal relevance.
3) Extract relevant meaning from concepts.
4) Articulate relationships.
5) Thoughtfully support scientific dialogues.
6) Questions over answers.
7) Curriculum-action research.
8) Education for change agency.

Course Design for ESD

We will consider the presence of one or more of the stated elements of the theoretical framework in each of the hypotheses related to sub-question two. Several of these elements might be related to the students' beliefs regarding the efficacy of lecture topics in delivering ESD. Therefore, we proposed that:

"By the middle of the course, students generally believe some lecture topic groups to be more helpful in shaping their understanding of sustainability."

Students marked the design component as being most influential in shaping their current view of sustainability by a two-to-one ratio over the other components, and marked the history series as least helpful. While no statistical tests were completed on this hypothesis, the frequency descriptives for this data shows that we can safely accept the proposal above.

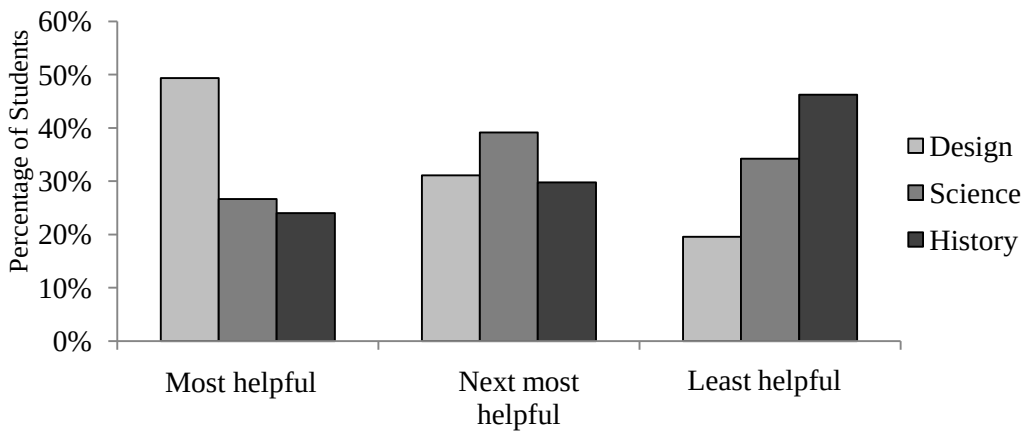

Figure 5. Most Helpful Lecture Series for Learning About Sustainability (*n* = 383).

Discussion: No tests were applied to this data. Half of the students offered that the design component of the course was the most helpful of the three queried sections. Both the science and history components shared the remainder of the distribution. In a similar fashion, the history component was rated as being least helpful by half of the students. What is important to note is that each of the three components had quest lectures, faculty lectures, and online material. However, one fact that skews this finding is that one of the main lecturers in the design component was Dr. Timothy Beatley, a well-known author and experienced presenter with a new and exciting lecture topic, "Biophilic Cities." It was widely known among the students that Dr. Beatley was visiting from out of state, and that his presence was a special treat. In fact, many professors from across the campus came to watch the lecture, and the presence of so many professors may have raised the level of excitement, and therefore the lectures impact. Furthermore, he was the author of their textbook. In addition, Dr. Nabil Kamel gave another outstanding lecture on the subject of urban design that spurred a great discussion afterwards and prompted many questions from the students.

However, another reason why history may have been represented so poorly among the three was one that the students expressed to the researcher: a sense that the

problems facing society today are different the problems faced by ancient civilization, and that new thinking was going to be necessary to overcome the current crises. In addition, a persistent theme, even among the lecturers discussing ancient history and the history of environmentalism, is that we will not be able to adjust to modern challenges with the current prevailing conception of those issues, and that a holistic thinking will be required to address the problems that linear thinking created.

It may also be important to discern at a finer scale of detail the elements within each lecture group. Therefore, we suggested that:

"By the middle of the course, students generally consider some of the lecture topics within lecture groups to be more helpful in shaping their understanding of sustainability."

In the "History" lecture series, students marked the in-class lecture 'Changes to Cities' as the most beneficial lecture topic by a three-to-one ratio over the online 'History of Environmentalism' lecture (n = 383), and two-to-one over the 'Earliest Cities' lecture. In the "Decision" lecture series, they choose the 'Concepts' lecture over the others by wide margins. Similarly, there was a clear favorite in the "Science" group. While no statistical tests were completed on this hypothesis, the frequency descriptives for this data shows that we can easily accept this null hypothesis.

Discussion: One consideration regarding the imbalance in the history component is that the researcher observed that students seemed to be more interested in current events in general. For example, many of the students were shocked to learn that there were riots in Los Angeles in 1993 that shut down the city for weeks, but were not similarly interested in any of the dramatic events described in the ancient civilization lecture. The pressing nature of our current crises seemed to hold greater relevance for

them. This personal relevance of the subject material is a key component to the theoretical framework.

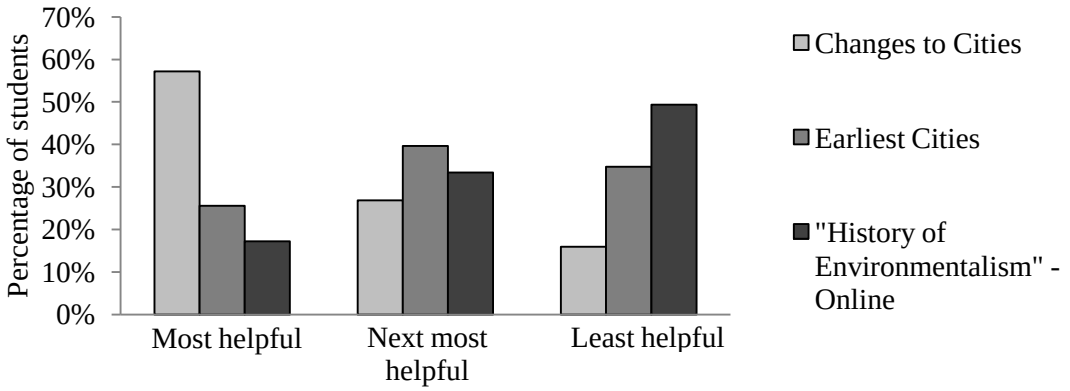

Figure 6. History Lecture Topics that Helped Students Learn about Sustainability.

It is no surprise that the online lectures did poorly in the survey: for the entire semester, constant technical issues plagued the Blackboard site which provided the platform from which students downloaded the lectures. This one factor must be considered when assessing this data: we will see later that attitudes towards online lectures did change because of the course.

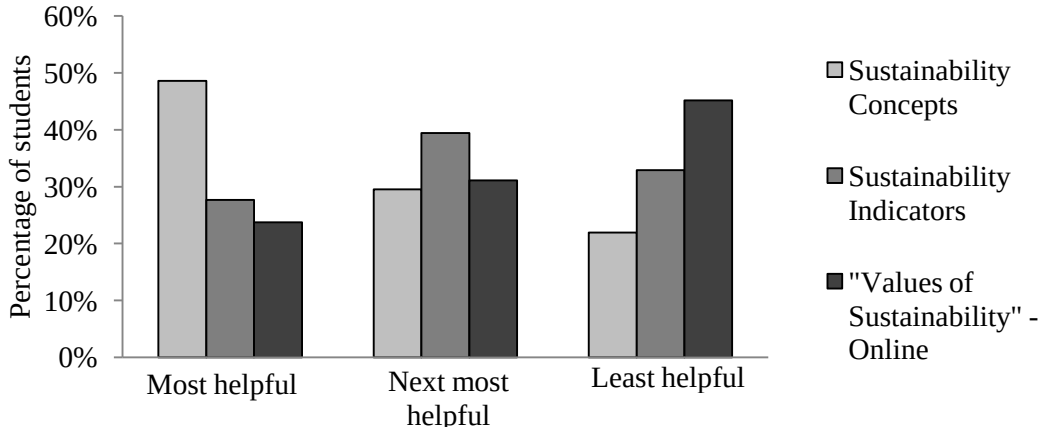

Figure 7. Decision Lecture Topics that Helped Students Learn about Sustainability.

When comparing the results of the survey, we can assume that the online platform hurt the response towards the values lecture. 'Sustainability Concepts' was also

the first lecture the students attended. This might skew the results. Science related topics and sustainability indicators being second would indicate that the students feel that science and technology is important for solutions, and there is a strong bent for technological answers to our problems. However, we can generally assume that the students perceive that the core issue is a conceptual, perceptual and cognitive one.

One reason why the in-class guest lecture might have received lower ratings was it tended to be on the technical side: one of the earlier slides in particular was a baffling array of formulas and acronyms that cast a sort pall over the lecture hall, even eliciting some exclamations of amused bewilderment. Still, there was a sense in the post-lecture questions and student discussion after that lecture that the issue of Urban Heat Islands was important: perhaps being in Phoenix may have skewed the results somewhat.

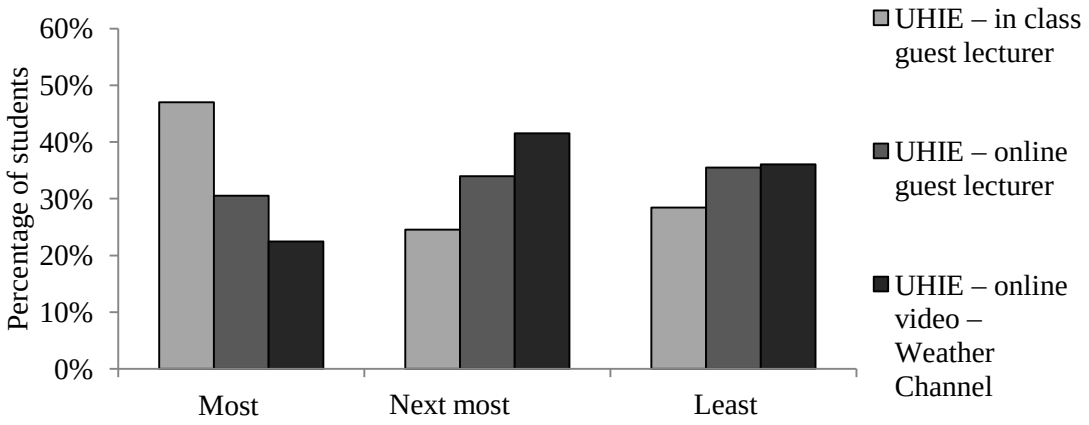

Figure 8. Science Lecture Topics that Helped Students Learn about Sustainability.

Students' recorded different lecture topics as providing differing levels of help in learning about sustainability. The theoretical framework suggests that a broad range of topics is helpful for delivering ESD, as this creates more opportunities for students of different interests to find personal relevance. A range of topics is also an opportunity to present the interdisciplinarity of SD.

Similarly, the methods by which these lecture topics are delivered will appeal to students with different approaches, styles, and goals towards learning. Therefore we made the proposition that:

"Before the course begins, students generally consider certain lecture delivery types (e.g. online, in-class) more beneficial than others for learning about sustainability."

Students assumed in-class lectures as being most helpful for learning about sustainability, (n = 349, M = 6.17, SD = 1.02), and online lectures the least helpful (M = 4.40, SD = 1.76). Observing the distribution of responses (see Figure 9), we can safely accept the stated proposition.

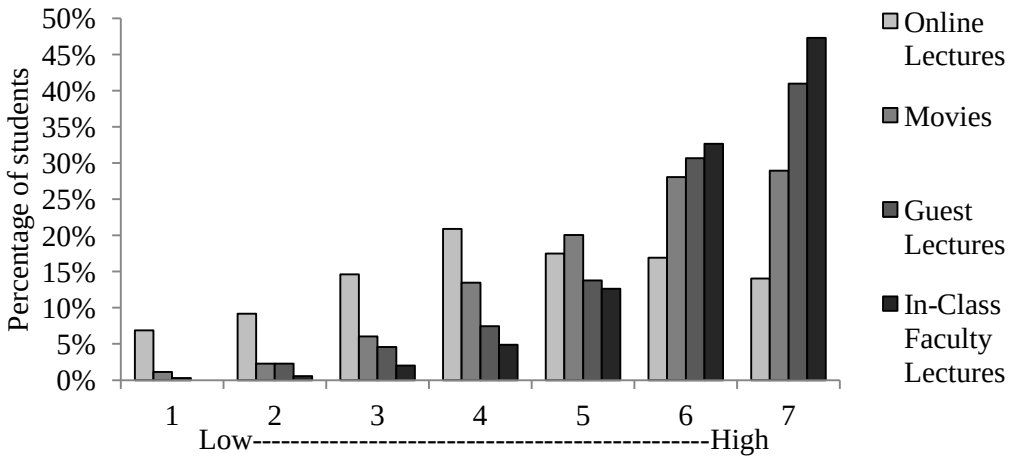

Figure 9. Lecture Types' Beneficence in Learning about Sustainability.

Discussion: No tests were applied to these before-course statistics. From Figure 9, we can clearly see that there are distinct and dramatic differences in which lecture types students feel will be most helpful for delivering an education in sustainable development. Naturally, they feel that faculty lectures are central. Importantly, the students also show a realization of the importance of guest lectures. Very few students (<5%) rated in-class lectures from faculty as having less-than-average beneficence.

They do not favor online lectures at all, and appear to prefer movies for at-home or away-from-class learning. However, the distribution for online lectures still nominally resembles a normal distribution. That is to say, more people ranked online lectures as having average value than people ranked it of low value. This might seem to indicate that online lectures have a place in learning about sustainability. We then need to ask, which students favor which delivery types, i.e. is there is any significant difference according to academic level or major. To approach this question we assumed that:

"Before the course begins, certain students (e.g. freshmen, business majors) consider certain lecture delivery types (e.g. online, in-class) more beneficial than others for learning about sustainability."

Table 6

Differences in Beneficence by Academic Major – Before Course Survey

	LP Before - In Class	LP Before - Guest	LP Before - Online	LP Before - Movie
Chi-Square	20.484	16.998	17.652	9.176
df	14	14	14	14
Asymp. Sig.	.116	.256	.223	.820

A Kruskal-Wallis Test revealed no statistically significant difference in students preference before the course for in class lectures for learning about sustainability based on major (Arch/Design, n = 37, Art, n = 3, Biological Sciences/Health, n = 7, Business, n = 95, Communications, n = 12, Math/Computing, n = 3, Engineering/Technology, n = 24, Environmental Sciences/Physical Sciences, n = 13, Interdisciplinary Studies, n = 5, Law, n = 4, Social Sciences, n = 11, Urban Planning, n = 36, Sustainability, n = 70, Other, n = 12, Undecided, n = 17), χ^2 (14, n = 349) = 20.48, p = .116; guest lectures, χ^2 (14, n = 349) = 16.98 p = .256; online lectures, χ^2 (14, n = 349) = 17.65, p = .223; or

movies, χ^2 (14, n = 349) = 9.18, p = .820. We should reject the null hypothesis based on differences among academic majors.

We also suggested that a difference in the beneficence of lecture type would be observed according to academic level.

Table 7

Differences in Beneficence by Academic Year – Before Course Survey

	LP Before - In Class	LP Before - Guest	LP Before - Online	LP Before - Movie
Chi-Square	2.485	6.092	1.831	4.645
df	3	3	3	3
Asymp. Sig.	.478	.107	.608	.200

However, a Kruskal-Wallis Test did not reveal statistically significant differences in student preference before the course for in-class lectures based on college year (Freshmen, n = 140, Sophomores, n = 84, Juniors, n = 94, Seniors, n = 31), χ^2 (3, n = 349) = 2.49, p = .478; the guest lectures, χ^2 (3, n = 349) = 6.10, p = .107; online lectures, χ^2 (3, n = 349) = 1.83, p = .608; or movies χ^2 (3, n = 349) = 4.64, p = .200. We should reject the null hypothesis assuming differences in the beneficence of lecture type stemming from levels of academic advancement.

Discussion: These results suggest that there is no significant initial difference in lecture preference based on college level or major. This suggests that the preferences from Figure 9 are universal. This is important in that it suggests that, when student academic majors and levels have distributions in similar proportions to those presented by this case study, we do not have to be overly concerned with tailoring the course to suit particular academic majors, or the minority of upperclassmen.

We wondered if the course had an effect on the perceived beneficence of lecture types among students. Therefore, we suggested that:

"Generally, students' attitudes change about the beneficence of lecture formats (e.g. online, in-class) from before the course to after the course."

Table 8

Changes in Attitudes About Lecture Type, Before and After Course Survey

		Mean	Std. Deviation	t	Sig. (2-tailed)
Pair 1	Before - In Class After - In Class	.244	1.652	2.753	.006
Pair 2	Before - Guest After - Guest	.103	1.883	1.023	.307
Pair 3	Before - Online After - Online	.292	2.551	2.141	.033
Pair 4	Before - Movie After - Movies	.086	2.142	.750	.454

A paired-samples t-test was conducted to evaluate the impact of the course on students' preferences in lecture type for learning about sustainability. There was a statistically significant decrease in the benefits of in class lecture from before the course (M = 6.17, SD = 1.02) to after the course (M = 5.92, SD = 1.23), t (348) = 2.75, $p < .01$ (two-tailed). The mean decrease in in-class lecture benefit was .24 with a 95% confidence interval ranging from .070 to .418. The eta-squared statistic (.02) indicated a negligible effect. There was also a statistically significant decrease in the benefits of online lecture from before the course (M = 4.40, SD = 1.76) to after the course (M = 4.11, SD = 1.80), t (348) = 2.75, $p < .01$ (two-tailed). The mean decrease in in-class lecture benefit was .29 with a 95% confidence interval ranging from .024 to .561. The eta-squared statistic (.01) indicated a negligible effect. These finding show a significant difference between students' perceived benefit of in-class faculty lectures and online lectures before and after the course regarding learning about sustainability. There was no statistical difference in students' perceived benefit from guest lecturers or movies in learning about

sustainability; but because of the change in opinion about in-class and online lectures, we should accept the null hypothesis.

Table 9

Changes in Attitudes About Lecture Type, Before and After Course Survey

	LP After In Class - LP Before - In Class	LP After Guest - LP Before - Guest	LP After Online - LP Before - Online	LP After Movies - LP Before - Movie
Z	-2.824[b]	-.959[b]	-2.086[b]	-.692[b]
Asymp. Sig. (2-tailed)	.005	.337	.037	.489

Because the distributions of the data are nonparametric, a Wilcoxon Signed Rank Test was also conducted; it revealed a statistically significant reduction in perceived benefit of in-class lectures, $z = -2.82$, $p < .05$ with a small effect size ($r = .11$), and online lectures, $z = 2.09$, $p < .05$ with a small effect size ($r = .08$) by students from before to after the course. There was no significant difference in either guest lecturers or movies for being beneficial in learning about sustainability. This supports the results of the earlier paired-samples t-test: students record less benefit from in-class lectures and online lectures for learning about sustainability.

Discussion: Students generally changed their minds about the importance of in-class guest lectures and online lectures. Both of these delivery systems were ranked lower by students regarding their beneficence towards learning about sustainability. We will discuss faculty lectures first.

One reason why this might be is that students initially (before the course) rated faculty lectures too high, because they did not have a sense of the interdisciplinary nature of sustainability. Once students understood that approaching SD issues necessitates the involvement of multiple disciplines, they placed less emphasis on the faculty lecturer.

Also, many of the students likely did not know before the course that the class is taught by professors from different disciplines; they might have assumed that, since sustainability is an academic program at ASU, that the 'answers' for SD problems are assumed to be tackled by the sustainability department. After the course, they realize that sustainability department itself is interdisciplinary. This finding is a validation of the basic structure of the course, and contributes to the assertion that the course conveys an understanding to the students that SD is a topic that requires a holistic, interdisciplinary approach.

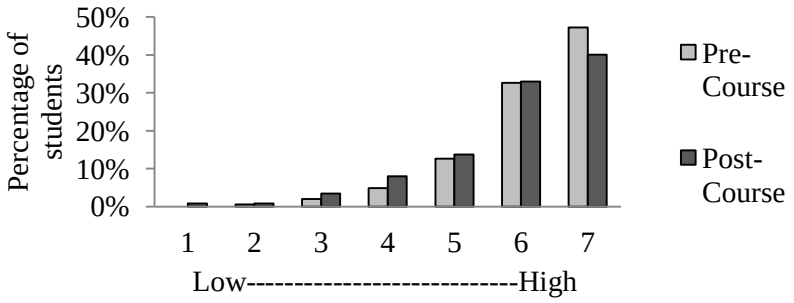

Figure 10. Beneficence of faculty lectures for learning about sustainability.

The online lectures may have suffered for different reasons. Because there were platform issues with the delivery of the online lectures, the ranking of online lectures may have suffered, and these results do not necessarily measure the construct. However, it might also be that the online lectures were not as beneficial as once thought.

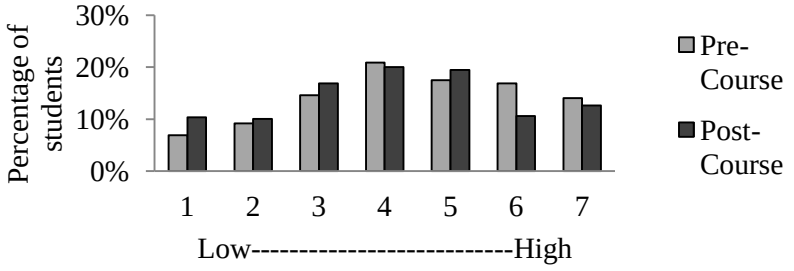

Figure 11. Beneficence of online lectures for learning about sustainability.

We also thought that changes in the perceived benefit of lectures types may be rooted in differences among academic level or major. We proposed that:

"After the course, certain students' (e.g. freshmen, business majors) attitudes differ from others regarding the beneficence of lecture formats."

Table 10

Lecture Type, After Course Survey, Beneficence by Academic Major

	LP After In Class	LP After Guest	LP After Online	LP After Movies
Chi-Square	15.908	21.321	14.184	9.584
df	14	14	14	14
Asymp. Sig.	.319	.094	.436	.792

However, a Kruskal-Wallis Test revealed no statistically significant difference after the course in students preference for in class lectures based on major (Arch/Design, n = 37, Art, n = 3, Biological Sciences/Health, n = 7, Business, n = 95, Communications, n = 12, Math/Computing, n = 3, Engineering/Technology, n = 24, Environmental Sciences/Physical Sciences, n = 13, Interdisciplinary Studies, n = 5, Law, n = 4, Social Sciences, n = 11, Urban Planning, n = 36, Sustainability, n = 70, Other, n = 12, Undecided, n = 17), χ^2 (14, n = 349) = 15.91, p = .319; guest lectures, χ^2 (14, n = 349) = 21.32, p = .256; online lectures, χ^2 (14, n = 349) = 14.18, p = .436; or movies, χ^2 (14, n = 349) = 9.58, p = .792

We also looked for differences in the perceived beneficence of lecture type according to academic level.

Table 11

Lecture Type, After Course Survey, Beneficence by Academic Year

	LP After In Class	LP After Guest	LP After Online	LP After Movies
Chi-Square	3.255	2.831	1.147	1.554
df	3	3	3	3
Asymp. Sig.	.354	.418	.766	.670

However, a Kruskal-Wallis Test revealed no statistically significant differences in students preference after the course for in class lecture based on college year for learning about sustainability (Freshmen, $n = 140$, Sophomores, $n = 84$, Juniors, $n = 94$, Seniors, $n = 31$), χ^2 (3, $n = 349$) = 3.26, $p = .354$; the guest lecture, χ^2 (3, $n = 349$) = 2.83, $p = .418$; online lecture, χ^2 (3, $n = 349$) = 1.15, $p = .766$; or movie χ^2 (3, $n = 349$) = 1.55, $p = .670$. This suggests that there is no significant post-course difference in lecture preference based on college level or major, so we should reject the null hypothesis.

Discussion: These results suggest that student perceptions of the beneficence of lecture types are universal in this case study. This is important in that, when student distributions of academic major and level are in the proportions presented by this case study, we do not have to be overly concerned with tailoring the course to suit particular academic majors, or the minority of upperclassmen.

Now that we have explored the relationship of academic major and year in the lecture types and lecture topics, we will investigate the assignments presented in the case study. We approach this by making the claim that:

"Before the course, students generally assume some assignment types more beneficial for learning about sustainability than others do."

We observed that students assumed fieldwork to be the most helpful for learning about sustainability ($n = 349$, $M = 6.08$, $SD = 1.14$), and rated personal reflection the

lowest (M = 5.34, SD = 1.35). We can safely accept that students generally regard particular assignment types to be more beneficial for learning about sustainability.

Discussion: No tests were applied to these before-course statistics. From Figure 12, we can clearly see that there are distinct and dramatic differences in which assignments students feel will be most helpful for delivering an education in sustainable development. Fieldwork and critical-thinking based assignments ranked highest, while personal reflection, interpersonal communication, and data analysis ranked the lowest. This is a strong indication that the importance of critical thinking and applied fieldwork already has a strong presence. Implied in this is that students already perceive sustainable development to be about thinking differently about what we do. If the idea that critical thinking and fieldwork is already established, this might mean that the curriculum would benefit from showing the importance of personal reflection, interpersonal communication, and data analysis as integral components of a whole education.

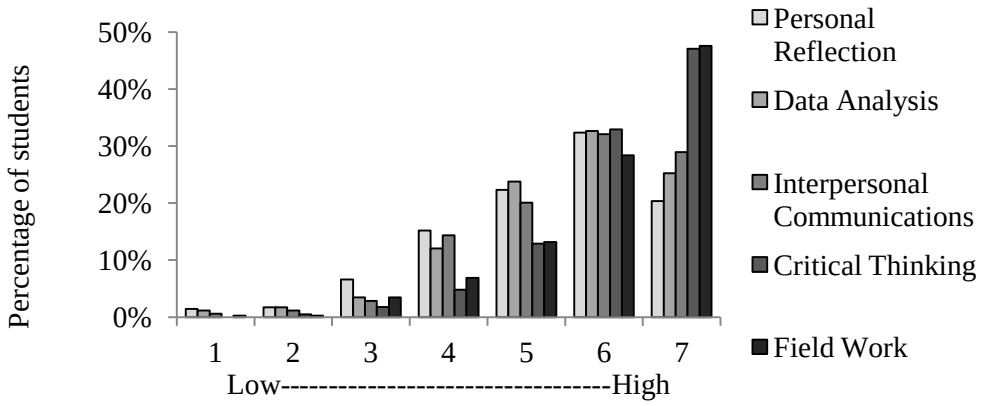

Figure 12. Beneficence of assignment types for learning about sustainability.

For various reasons, no fieldwork or interpersonal communication projects were assigned during the semester. Moreover, critical thinking was not assigned in one project, *per se*, but was instead a component of all of the assigned works. The four assignments for the semester covered the spectrum between personal reflection and data analysis.

It might be important to know which, if any, students perceived particular assignment types to be more beneficial for learning about sustainability before the class began; this question is addressed by the next two tests, with one addressing academic major and the other addressing academic year. We begin by positing that:

"Before the course, some students (e.g. freshmen, business majors) assume some assignment types more beneficial for learning about sustainability than others."

Table 12

Assignment Type, Before Course Survey, Beneficence by Academic Major

	Assign Before Crit Think	Assign Before Data Analysis	Assign Before Personal Reflect	Assign Before Field Work	Assign Before Inter Personal Comm
Chi-Square	11.725	15.220	15.123	13.879	27.773
df	14	14	14	14	14
Asymp. Sig.	.628	.363	.370	.459	.015

A Kruskal-Wallis Test revealed statistically significant differences before the course in students' preference for four of the assignments types based on major. No differences were found among the following: (Arch/Design, n = 37, Art, n = 3, Biological Sciences/Health, n = 7, Business, n = 95, Communications, n = 12, Math/Computing, n = 3, Engineering/Technology, n = 24, Environmental Sciences/Physical Sciences, n = 13, Interdisciplinary Studies, n = 5, Law, n = 4, Social Sciences, n = 11, Urban Planning, n = 36, Sustainability, n = 70, Other, n = 12, Undecided, n = 17), χ^2 (14, n = 349) = 11.73, p = .628; data analysis assignments, χ^2 (14, n = 349) = 15.22, p = .363; personal reflection assignments, χ^2 (14, n = 349) = 15.12, p = .370; and field work assignments, χ^2 (14, n = 349) = 13.88, p = .459. There was however, a significant difference regarding assignments based on interpersonal communication, χ^2 (3, n = 349) = 27.78, p = .015 with Communication, Interdisciplinary Studies, and Law students recording a higher median score (Md = 7), and Math, Engineering, and 'Other'

majors registering a low median score (*Md* = 5.0). We should accept the hypothesis based on academic majors, as it seems that certain majors perceive particular assignment types to be more beneficial for learning about sustainability.

Academic year may also play a role in perceived beneficence of assignment types. We tested this possibility as well.

Table 13

Assignment Type, Before Course Survey, Beneficence by Academic Year

	Assign Before Crit Think	Assign Before Data Analysis	Assign Before Personal Reflect	Assign Before Field Work	Assign Before Inter Personal Comm
Chi-Square	9.135	5.510	3.234	.400	2.576
df	3	3	3	3	3
Asymp. Sig.	.028	.138	.357	.940	.462

A Kruskal-Wallis Test reveal statistically significant difference in students preference before the course for assignments based on critical thinking for learning about sustainability by college year (Freshmen, $n = 140$, Sophomores, $n = 84$, Juniors, n = 94, Seniors, $n = 31$), χ^2 (3, $n = 349$) = 9.14, $p = .028$, with seniors registering a higher median score (*Md* = 7) than the other students (*Md* = 6). There were, however, no statistical differences for assignments based on data analysis, χ^2 (3, $n = 349$) = 5.51, $p = .138$; personal reflection, χ^2 (3, $n = 349$) = 3.23, $p = .357$; field work, χ^2 (3, $n = 349$) = .400, $p = .940$, or interpersonal communication, χ^2 (3, $n = 349$) = 2.58, $p = .462$. These results suggest that there are significant pre-course differences in assignment type preferences based on college level.

Discussion: Perhaps not surprisingly, before the course began, the students with communication/media, law, and interdisciplinary studies majors ranked interpersonal communication-based assignments as more beneficial than others did towards learning about sustainability to a significant degree more than math, engineering and 'other'

category of majors. This reflects an important bias that some academic majors have on the students' perception of what SD is, and how to best approach solving SD problems. If a choice had been available to include an assignment focused on technology, it would have been interesting to see if math and engineering students favored that type of assignment more than other disciplines.

Assignment preferences for learning about sustainability do not automatically translate into preferences for tackling real-world SD problems. Students might retain this predisposition to favor the assignments that correspond with their discipline as being more beneficial to learning about sustainability. This could prove problematic for meeting the criteria that students of all disciplines see SD issues as best solved with interdisciplinary means. There was no fieldwork or interpersonal communication assignment given, so we cannot test whether or not this predisposition changes.

Additionally, before the course, senior year students favored critical thinking assignments as being beneficial for learning about sustainability to a significantly greater degree than other students do. Again, we cannot test whether or not this changes, but it is a good sign that higher education does provide, over the course of an undergraduate career, a sense of the importance of critical thinking. If this is true, then critical thinking is an outcome that is reached through higher education in general.

The question remains as to the effect that the case study has on student attitudes towards assignment types. To uncover meaning in this area we proposed the following:

"After the course, students' preferences about assignment types for learning about sustainability have changed."

A Wilcoxon Signed Rank Test revealed a statistically significant difference between data analysis and personal reflection assignments, $z = -3.098$, $p = .002$ with a small effect size ($r = .11$). While students ranked data analysis higher than reflective

pieces when combined with three other assignment types, when ranked alone, reflection scored higher by two-to-one. Because the surveys are not entirely similar, no decision on the hypothesis should be made.

Discussion: This is not an entirely conclusive, and these results should be interpreted carefully. Since the other assignment types (e.g. fieldwork, interpersonal communication) were not subject to survey, before and after comparisons of data analysis and personal reflection are not valid from this data.

What can be said is that after the course, given the choice between personal reflection and data analysis, the students substantially favored personal reflection as a beneficial assignment type for learning about sustainability. The data for Figure 13 shows the two categories alone, in the before course survey, and are without the other assignment types that were part of the question. In this view, the difference between the two is far from clear, and may not be statistically significant.

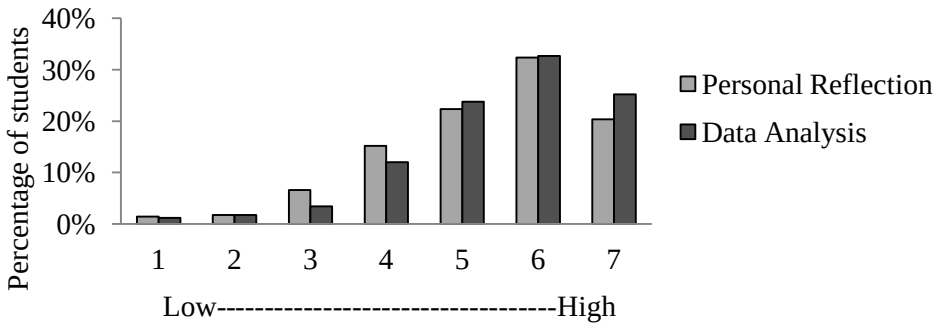

Figure 13. Before Course: Reflection vs. Analysis (when Isolated from Other Assignment Types).

However, after the course, when compared only with one another, the reflective assignments, (e.g. ecological footprint, imagine the sustainable city) were rated by students as being more beneficial for learning about sustainability by a ratio of nearly two-to-one. While we cannot test for certainty, it does suggest that students change their opinion of what assignments help to understand the nature of SD problems. These two

assignments focus on the role of personal behavior as being fundamental to the crisis of sustainability. Indeed, many students write in their assignments that they had no idea that their behavior and lifestyles were linked to global issues. For this reason, we can assume that the assignments in this class provide for the conditions for ESD.

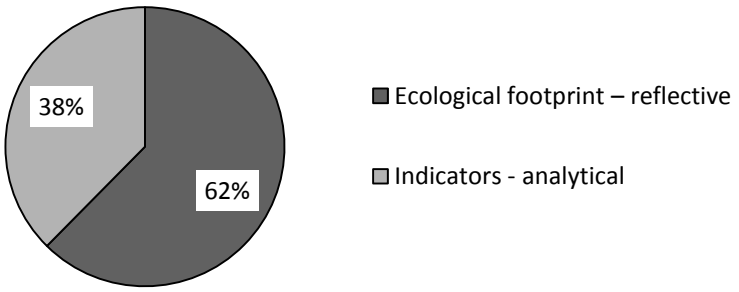

Figure 14. After Course: Reflection Assignments vs. Analysis Assignments

Students may feel that demonstrating literacy in SD is best approached by testing methods that favor expressing problem-based approach rather than an answer-based result. Knowing students' preferences for the testing and assessing of content knowledge in ESD shows an understanding of the complexity of SD topics. Therefore, we made the claim that:

"Students generally prefer particular types of examinations for measuring ESD outcomes."

After the course, students generally supported multiple-choice as an effective way of testing for student understanding in sustainability (n = 391). Over a third recommended adding an essay component to the exam format. Very few seemed to reject the multiple-choice format outright, so while no tests were applied, we can tentatively accept the null hypothesis.

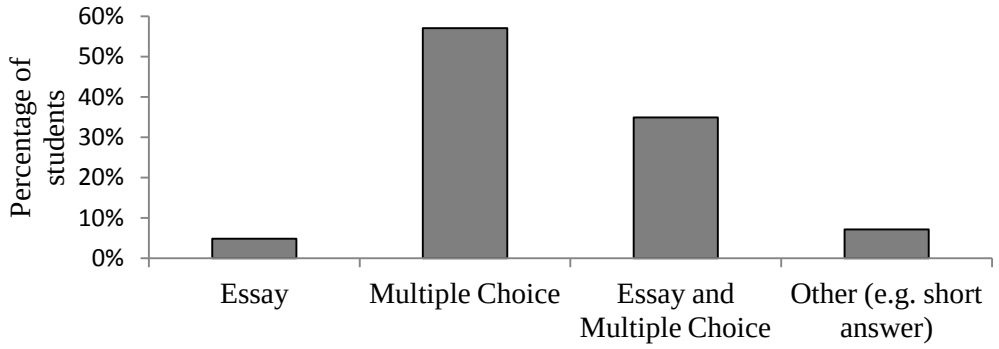

Figure 15. Exam Format Preferences

Discussion: Exams are not specifically discussed in the conceptual framework. Additionally, the exams in the course were not specifically designed to be instructional, as well as assessments of content knowledge. It is interesting to note, however, that nearly half of all students suggest including a more descriptive, explicatory component to the exam for assessing content-based learning outcomes in ESD, such as essays or short answers. This gets to the understanding that issues in ESD are too complex to address with multiple-choice questions. We might also consider the development of tests that assess non-content knowledge fundamentals of ESD, such as recognizing complex systems, and non-lateral thinking.

There was no corresponding question before the course to compare any shift to regarding this answer. In addition, students traditionally do not favor working harder, and many might assume that essays are more difficult. This assumption might skew the results to favor multiple choice test formats.

A wide variety in source materials is suggested as a means towards delivering learning outcomes in ESD. To investigate whether or not the case study provides this variety, and the benefit of such a variety, we adopted the stance that:

"After the course, students generally prefer particular types of source materials for learning about sustainability."

Discussion: While no tests were done of the data from this hypothesis, we can clearly see from Figure 16 that there are dramatic differences in which types of source material students feel are most effective for learning about sustainability (n = 349). TED Talks received the largest share of the top rankings, with YouTube videos also showing well. Online encyclopedia entries and peer-reviewed journal articles ranked the lowest.

The cable documentaries and textbooks both showed a very flat distribution, with a rankings of between 5% and 15% for every scoring bin. The brief newscasts showed ranking that resemble a normal distribution. The findings of this hypothesis are quite mixed. With some certainty we can say that students thought the TED Talks were effective, and that they did not find the online encyclopedia effective for learning about sustainability.

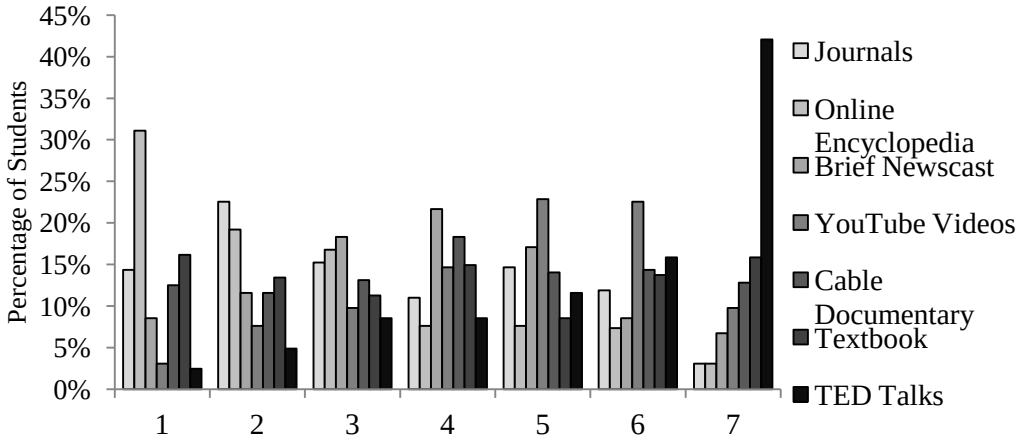

Figure 16. Source Material Efficacy for learning About Sustainability

After the course, students generally (about 75%) supported multiple source materials as an effective way of delivering understanding in sustainability (n = 349). This establishes that a major component of the conceptual framework is being provided by the course: a wide variety of source materials and media formats. It is also shown (Figure 17) that the variety does in fact help considerably towards learning about

sustainability, and the distraction from the presence of so many source materials is negligible. Variety alone might not be enough: the case study employed at least two types of media material for each lesson. Splitting up material types by lesson might not achieve the same results.

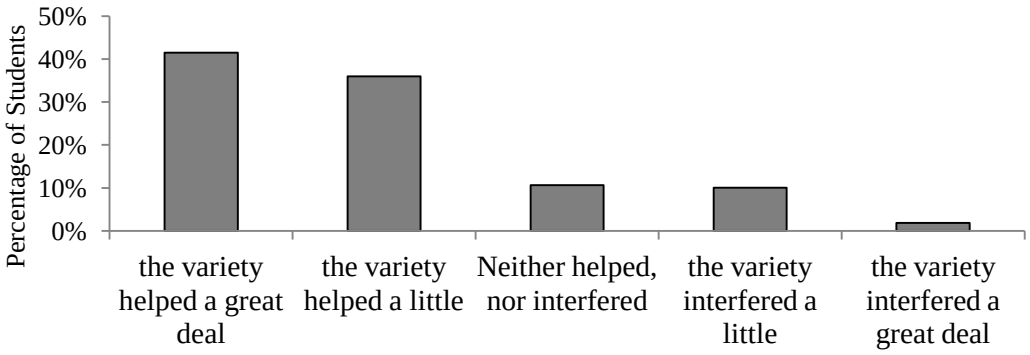

Figure 17. Preferences in Source Material Variety

Sub-Question Three

"How can we measure or assess these learning outcomes?"

As stated earlier, direct classroom assessment techniques (CAT's) for measuring learning outcomes in ESD have not been developed. We have seen in the previous sub-question that the case study utilizes certain methods and pedagogies that are conducive for the establishment of ESD outcomes. This next section attempts to discern if the presence of those methods and pedagogies deliver an education for sustainable development. While we cannot directly measure the presence of these outcomes we can, in some cases, detect their presence through student attitudes (e.g. position on the "right to consume"); shifts in the level of sophistication for abstract concepts (e.g. "the definition of sustainability); and students' self-identification with certain behavioral patterns (e.g. "environmental conscientiousness"). Throughout this next section, we will

attempt to deduce the presence of ESD learning outcomes through the triangulation of these attitudes and shifts.

Detecting ESD Outcomes Through Change

While there are a number of traditional assessments used in the case study to establish that content learning has been established among the students, such as assignment results, exams scores, and the final grades, it is important that students also feel they have a grasp of the underlying concepts. Answering a question correctly on an exam is different from feeling one has a grasp of the concepts; or, a mastery of the knowledge. To establish one corner of a triangulation to discover the presence of this feeling of mastery, we posit that:

"Students generally feel that their knowledge of SD topics has increased from before the course to after the course."

Table 14

Change in Perception of Knowledge, from Before to After

	Paired Differences				
	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Total Knowledge Before - Total Knowledge After	-15.539	12.778	-22.718	348	.000

A paired-samples t-test was conducted to evaluate the impact of the course on students' perceived *Total Knowledge* scale. There was a statistically significant decrease in the Total Knowledge scale from before the course (M = 36.93, SD = 9.84) to after the course (M = 52.47, SD = 9.07), t (348) = 22.72, p < .001 (two-tailed). The mean increase on the *Total Knowledge* scale was 15.54 (on a scale from 10 to 70) with a 95% confidence interval ranging from 16.88 to 14.19. The eta-squared statistic (.60) indicated

a large effect. This test suggests the students' perceived their *Total Knowledge* scale score to increase dramatically.

Table 15

Change in Perception of Knowledge, from Before to After

	N	Percentiles		
		25th	50th (Median)	75th
Total Knowledge Before	349	30.00	37.00	44.00
Total Knowledge After	349	47.00	54.00	59.00

Because these data are not parametric, a Wilcoxon Signed Rank Test was also conducted. This test also revealed a statistically significant increase in perceived increase on the *Total Knowledge* scale, $z = -14.68$, $p < .001$ with a large effect size ($r = .55$). This supports the results of the previous paired-samples t-test: students perceive a significant increase on the *Total Knowledge* scale. This suggests the presence of a feeling of mastery.

Discussion: These two tests show that student's perception of their knowledge in distinct topics in sustainable development increases because of the course. This is likely a good measure of an increase in content knowledge, as well as a measure of a feeling of mastery. It might also be the case that there were a number of students who thought that they had a good grasp of the content in a subject area, only to discover that there was a great deal more to the topic.

Academic grades alone do not necessarily convey that content has been learned. It is important that the students' feel that they have learned as well. When looked at alongside the overall grades for the semester (the average grade for the course was a high B, or 89.9%), the findings of these two statistical tests show that students not only learn content, but they also feel they have expanded their literacy, as well. Over all, this finding also supports the content knowledge aspect of the conceptual framework as being

delivered. Three representative figures of the shift in self-reported perception of knowledge in SD topics (Figures 18, 19, and 20) are presented below.

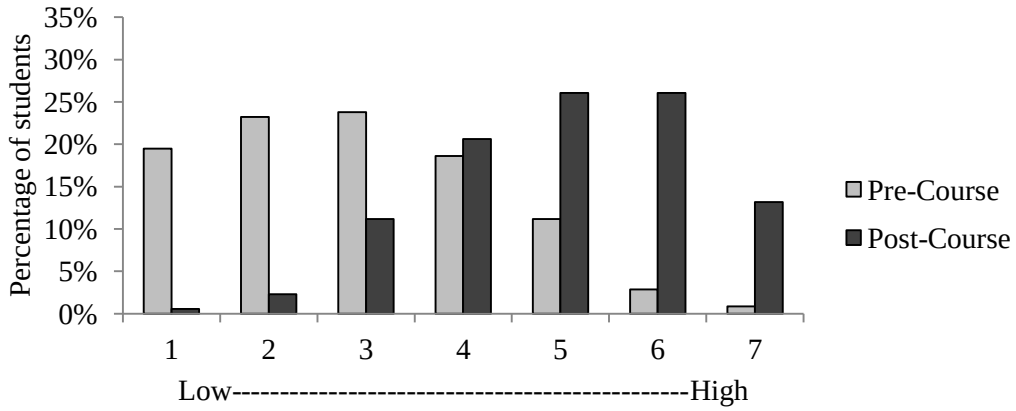

Figure 18. Total Knowledge: Environmental Justice, Before and After

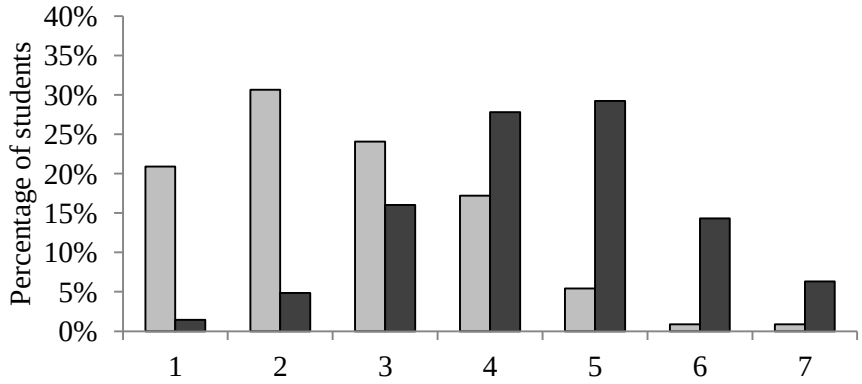

Figure 19. Total Knowledge: History of Environmentalism, Before and After

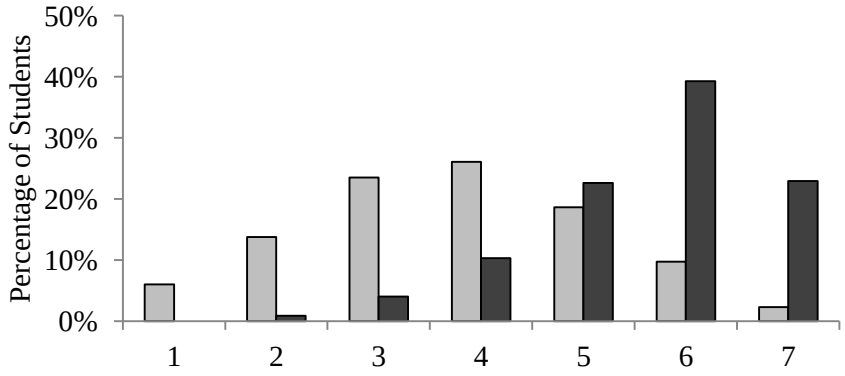

Figure 20. Total Knowledge: Water Consumption, Before and After

It has also been suggested that students find the content interesting in order for them to incorporate it long-term. Therefore, we suggested one hypothesis that reads:

"Students generally feel that their interest in SD topics has increased from before the course to after the course."

However, a Wilcoxon Signed Rank Test revealed no statistically significant increase in students' perceived score on the *Total Interest* scale, $z = -1.56$, $p > .05$. We reject the null hypothesis: students' perceived interest in SD topics has not increased.

Furthermore, it has been suggested that students need to find the information as being important in order for them to incorporate the learning for the long-term. Thus, an additional hypothesis is stated:

"Students generally feel that topics in SD are more important after the course."

However, a Wilcoxon Signed Rank Test was conducted and revealed no statistically significant increase in students' perceived score on the *Total Importance* scale, $z = -2.31$, $p > .05$. Again, we should reject the null hypothesis: students' overall perceived importance of SD topics has not increased.

Discussion: These results show that there is no significant change in the students' perception of aggregated *interest in,* or *importance of* scales. However, on closer inspection, we can see that some subject areas do indeed show significant differences between before the course and after the course. These outcomes in importance and interest might be related to the students' academic majors. This supports the suggestion that academic expertise in a field is important for pursuit of sustainable development.

Ancient Civilizations and their Collapse ($z = -2.18$, $p < .05$), and the History of Environmentalism ($z = -5.53$, $p < .05$) both show an increase in student interest, but critically, they do not show an increase in importance. This implies that students find history content-based lectures and materials more interesting than before the course, but

they do not consider them any more important for learning about sustainability. They also considered the topic Water Consumption as being more interesting, but less important for learning about sustainability. This is likely because before the course the students had already rated Water Consumption extremely high for importance.

Conversely, the topic of Personal Values is the only subject that increased in importance but not in interest. They students do not find it more interesting, but the course does indeed express to the students the idea that learning about behavior and personal lifestyles is extremely important to understanding SD issues. This is central to meeting the goals of the conceptual framework, and should not be understated. One reason this effect occurs at all is that there was a strong presence of the topic of personal values in the homework and the lectures.

The topics of Energy, Increased Urbanization, and Climate Change became neither more interesting nor more important. Energy is an interesting case in that is was rated extremely high in both categories before the course began, so it had little to gain. In addition, this lack of movement for these topics may be due, in part, to the fact that no homework assignments were related to either topic, and somewhat less attention was paid to climate change in the readings and other source materials than other topics. One of the multimedia sources that accompanied the reading on urbanization was a newscast, which is a type of source material that the students did not favor as being beneficial for learning about sustainability.

Transportation, Architecture and Design, Environmental Justice all increased in both interest and importance. It is likely that these topics surprised the students with how integral they were to learning about sustainability. Other factors might have been the impressive lectures on design by Dr. Beatley and Dr. Kamel, and the lecture on transportation given by Dr. Aaron Golub, which wove together seemingly disparate

issues (e.g. history, public participation, energy) into a comprehensible and coherent whole. Likewise, the TED Talk on Environmental Justice given by Majora Carter was remarked upon by students as being very moving. The individual shifts in the specific topics are found on Tables 16 and 17.

Table 16

Change in Perception of Interest, from Before to After, by Topic

	PV	AC	HE	IU	E	CC	EJ	AD	W	T
Z	-.528	-2.184	-5.534	-1.108	-.583	-.922	-2.070	-2.560	-2.702	-3.746
Sig.	.597	.029	.000	.268	.560	.357	.038	.010	.007	.000

PV = Personal Values, AC = Ancient Civilizations, HE = History of Environmentalism, E = Energy, CC = Climate Change, EJ = Environmental Justice, AD – Architecture and Design, W = Water Consumption, T = Transportation

Table 17

Change in Perception of Importance, from Before to After, by Topic

	PV	AC	HE	IU	E	CC	EJ	AD	W	T
Z	-3.050	-1.008	-.395	-.008	-1.793	-.294	-2.851	-4.180	-.289	-3.226
Sig.	.002	.313	.693	.994	.073	.769	.004	.000	.773	.001

PV = Personal Values, AC = Ancient Civilizations, HE = History of Environmentalism, E = Energy, CC = Climate Change, EJ = Environmental Justice, AD – Architecture and Design, W = Water Consumption, T = Transportation

One extremely important observation to make towards uncovering change in the students' literacies in SD is in their definitions of sustainability. Therefore, we proposed this statement from where to investigate this change:

"Students' conceptions of sustainability become more nuanced, specific, or meaningful over the course of the semester."

Discussion: A sample of 349 students wrote one or more sentences on what they perceived the definition of sustainability to be in both the before course survey and the after course survey. Interestingly, the word count dropped from 9,095 words in the before course survey to 7,997 in the after course survey. This shortening of the definition meant a drop in average words per response from 26 words to 23 words. This might be an

indication that students expressed the definition with more precision. There may be an influence from the position in the survey: the question was second to last in the after course survey; in the before course survey, it was the first.

Notably, the types of words used changed dramatically (see Table 18). Words and roots of words that reflected an ecological definition (e.g. words such as ‘resource,’ or roots such as ‘natur’ and ‘enviro’) dropped considerably. Conversely, words and roots that corresponded to a social or temporal aspect (e.g. ‘future’, ‘generation’, ‘social’, ‘socie’) increased substantially. The frequencies of ‘change,’ ‘consci,’ ‘action,’ and ‘lifestyle’ also showed considerable increase.

Other interesting shifts included a drop in certain words and roots, such as ‘energy,’ ‘green,’ ‘produc,’ ‘material,’ ‘tech,’ and ‘effici’ and we saw an increase in ‘plan,’ ‘econo,’ and ‘preserve.’ Overall, these results show a broadening of the definition of sustainability to include more nuanced, specific or meaningful definitions.

Supporting the development of transformative change is the presence of a value that is predicated on the realization that human society shares a limited amount of resources and ecosystem services. To determine if such a value is present in the students of the case study, we made the following proposition:

“In the middle of the course, students reject the notion that people have a “right to consume.”

Table 18

Words with an Frequency Count of 15 and Over

	Before		After	
	Count	Adj. Count[1]	Count	Percent Change
sustain*	311	276.79	239	-13.65%
resource	158	140.62	107	-23.91%
enviro*	123	109.47	84	-23.27%
future	*73*	*64.97*	*205*	*215.53%*
generation	*54*	*48.06*	*125*	*160.09%*
natur*	51	45.39	34	-25.09%
earth	51	45.39	41	-9.67%
world	*42*	*37.38*	*45*	*20.39%*
human	41	36.49	30	-17.79%
maint*	38	33.82	22	-34.95%
energy	36	32.04	9	-71.91%
effici*	33	29.37	17	-42.12%
*plan**	*32*	*28.48*	*32*	*12.36%*
*social**	*30*	*26.7*	*36*	*34.83%*
preserve	*26*	*23.14*	*29*	*25.32%*
*econo**	*23*	*20.47*	*21*	*2.59%*
renew*	22	19.58	2	-89.79%
system	21	18.69	14	-25.09%
impact	*20*	*17.8*	*19*	*6.74%*
planet	*20*	*17.8*	*22*	*23.60%*
green	20	17.8	11	-38.20%
produc*	18	16.02	8	-50.06%
health	17	15.13	14	-7.47%
action	*17*	*15.13*	*19*	*25.58%*
*conserve**	*16*	*14.24*	*16*	*12.36%*
tech	16	14.24	4	-71.91%
*socie**	*16*	*14.24*	*23*	*61.52%*
survive	*15*	*13.35*	*15*	*12.36%*
material	15	13.35	5	-62.55%
build	15	13.35	5	-62.55%
waste	15	13.35	4	-70.04%
change	*12*	*10.68*	*18*	*68.54%*
lifestyle	*8*	*7.12*	*15*	*110.67%*
*consci**	*8*	*7.12*	*19*	*166.85%*

[1]adjusted for equal net word count

Italicized words show an increase in usage of the word.

* partial word/root

Discussion: The data for this hypothesis is not derived from the surveys, and no statistical tests have been applied. Rather, this data stems from a question on one of the assignments, the Ecological Footprint. The assignment was the culmination of a discussion on rights and consumption that highlighted the disparity in resource usage among various societies. It is a "one-shot" source of data, and the results cannot be attributed to the lectures in the course. Another caveat is that the students answered this question immediately after completing a personal inventory and reading the results of a carbon footprint. It does however provide an interesting window into the moral landscape of the students. In the last question for this assignment, students are asked if people have a right to consume. Two-thirds of the students say "no" and some say this emphatically. Only 4% of the students take a "might-makes-right" approach. Over a quarter of the students suggested that people do have a right to consume as they please, but that such acts are foolish or detrimental, and that they should not exercise that right.

If these results are close to being accurate for the course, then it seems that the moral landscape of the class is in a relatively healthy condition. The course does investigate this area of ESD, so the conceptual framework is being satisfied in that respect.

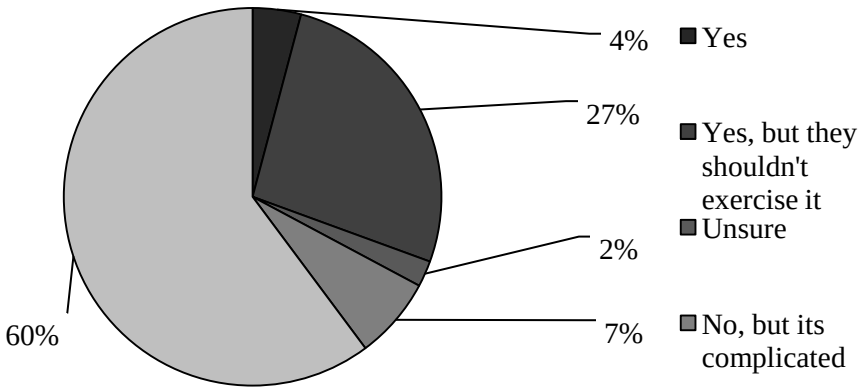

Figure 21. Students on "Do People have a Right to Consume?" in the context of producing a carbon footprint.

Another indication that the course lays a foundation for transformative change is in the increase of a self-reported identification with environmental conscientiousness from before the class to after. To measure an increase in environmental conscientiousness, questions were asked in the before and after course surveys. To test any shift in this attitude, we developed the following hypothesis:

"After the course, students consider themselves to be more environmentally conscientious than they were before the course."

Table 19

Change in Perceived Environmental Conscientiousness, from Before to After

		N	Mean Rank	Sum of Ranks
Environmental Conscientiousness After - Environmental Conscientiousness Before	Negative Ranks	103[a]	116.26	11974.50
	Positive Ranks	146[b]	131.17	19150.50
	Ties	100[c]		
	Total	349		

A Wilcoxon Signed Rank Test revealed a statistically significant increase in perceived environmental conscientiousness, $z = -3.286$, $p < .01$ from before the course started to after the course concluded. The stated hypothesis should be accepted.

Discussion: This finding certainly supports the course in meeting the conditions of the theoretical framework as it pertains to "education for change agency." The answers to the survey question were couched in terms of thought and action (e.g. thinking about the environment, consuming in a particular manner, shopping in particular places, being active in environmental organizations). The before course distribution of student responses was similar to a normal distribution, if perhaps showing slight kurtosis, and having a slight skew towards being environmentally conscientious. After the course, it does then shift significantly to the more environmentally aware. However, under many circumstances, it is likely that students over-estimated their environmental

conscientiousness before the course. Having found out over the course of the semester that they were not as environmentally conscientious as they had previously thought, they might have chosen to record a lower score on the after course survey.

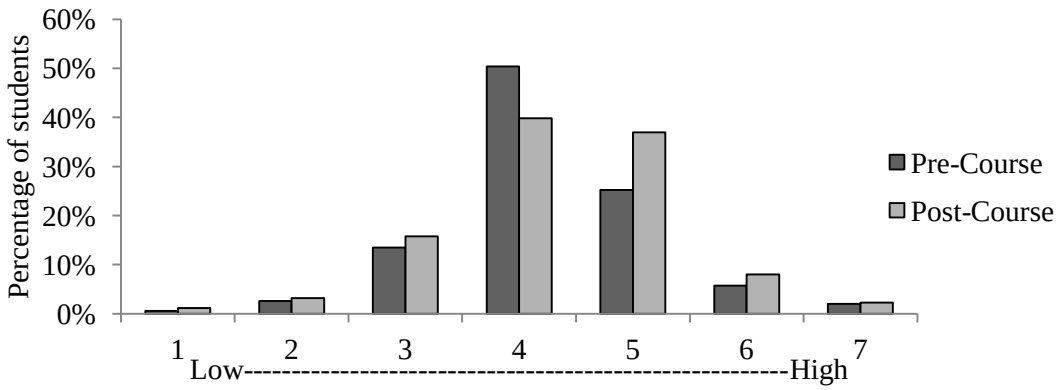

Figure 22. Environmental Conscientiousness reported by students before and after course

The final piece of evidence that develops an inferred measurement of the existence of a transformative education rests in the discovery of students' interests in interdisciplinarity, or in a broadening or reassessment of their initial, pre-course planned academic track. Therefore, we suggest that:

"Students generally consider adopting new majors or adding additional minors as a result of the course."

Discussion: A considerable proportion of students (n = 391) considered switching to another unidentified major (13.3%), while an additional 26.1% recorded considering adding a minor in sustainability. Moreover, 14.9% mentioned that they would have considered a switch/add, but that they cannot, for undisclosed reasons. In total, over half (54%) recorded that they considered altering their plan of study based on the information received in the course. We can tentatively accept the direction of this hypothesis.

One of the traditional roles of the introductory course is to help students find personally interesting areas of study to pursue. It is clear that the case study, with its

varied content, an emphasis on interconnectivity, and the importance of interdisciplinarity contributes to the development of interests in students. This development also helps to satisfy the conditions of the theoretical framework. However, the 45% who state that they did not consider switching majors or adding a minor may already have minors in sustainability. With so many business students in the class, many are pursuing sustainability minors, so this is not a wild assumption. Another possibility is that, because of the emphasis placed interdisciplinary teamwork those students can see that their major has avenues for working in sustainability.

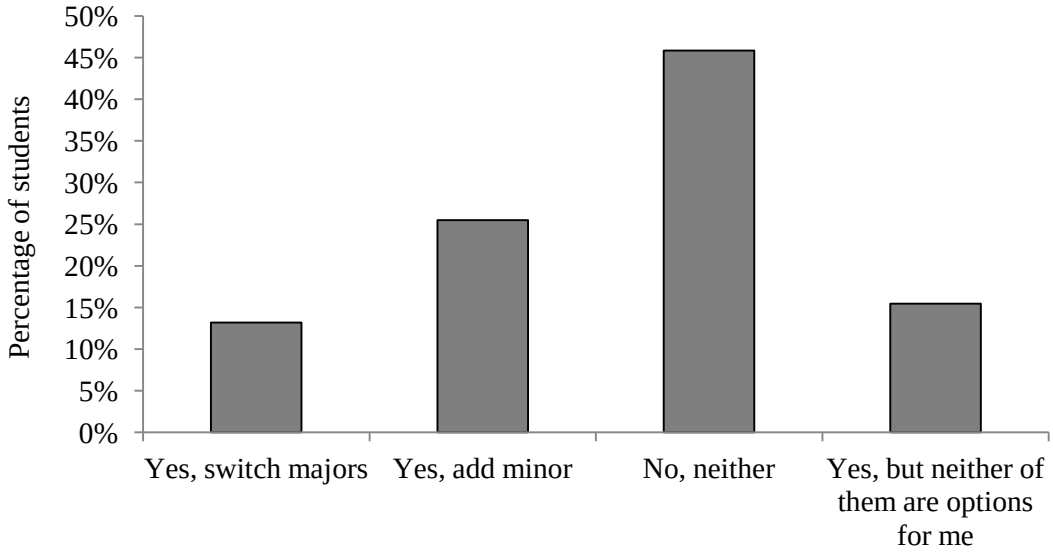

Figure 23. Consideration of Adopting New Majors/Minor

Summary

In this chapter, over a dozen hypotheses or propositions were subject to statistical tests or examined with descriptive statistics. Not surprisingly, some of the hypotheses are rejected, while others are maintained through the results. In either of these cases, important details emerge about the conditions under which ESD can be delivered. In

addition, evidence for the existence of transformative change in the case study is uncovered.

Because the many of the population distributions were not considered normal, non-parametric tests were also used; while a few parametric tests were also used, albeit in an exploratory fashion. The use of parametric tests on uneven distributions can be helpful in determining which direction the data is headed, even if not precisely, or with robust statistical power.

Some of the descriptive data was coded from open-ended questions from the exam, and from one question which came out of a homework assignment. While not considered conclusive, as significance is not established, these findings can also be helpful to determine the direction the data is headed. The descriptive statistics describing some of the data suggest areas for further exploration, and help to shape the context of the case study.

Overall, the data in this chapter helps to frame the context of the conclusions which will be found in the next chapter, and supports its recommendations.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

Introduction

This study is an exploration into the question, "Are we achieving our desired learning outcomes in education for sustainable development?" In this chapter, we will combine all of the investigated elements and arrive at a conclusion that suggests an answer for this important question. First, we will review the major and minor findings, and consider what they mean as insights into the three sub-questions. The literature review and conceptual framework will then be brought into the discussion and together, with the findings, we will shape a definitive but exploratory answer to the central research question.

In addition, we will put the thesis in the context of the scholarly record by discussing the general and specific contributions; detailing the advantages of the case study and survey; identifying specific limitations to the research, and reviewing the general limitations of the case study. Having thus explored the thesis' contribution to the literature, we can then suggest some informed recommendations. These recommendations will be in three areas: first, we will recommend areas of further research towards measuring learning outcomes and literacies in ESD. Next, we will make suggestions for effective classroom pedagogy and curriculum in the context of a holistic undergraduate education. Finally, we will put forward the specific ways that this particular course design can support university-wide efforts for education for sustainable development beyond the individual classroom.

Major findings

The results of the surveys held many findings that provide extensive reflection for introductory curriculum and pedagogy in education for sustainable development. Key among them is the fact that students come to the course with different levels of knowledge, interest and importance regarding specific topics in SD, and some of these differences are attributable to their academic level and major; however, they do not leave with different levels of knowledge, interest, or importance. The course therefore has a leveling effect, putting students on a level field for a future interdisciplinary discourse amongst themselves and the academic community regarding sustainability.

Students come to the course with a singular and imprecise conception of the definition of sustainability. They leave the course with a more multifarious and yet more precise definition of sustainability. This shows a maturation of the meaning of sustainability. Students leave the class with a significantly higher self-assessment of their perceived knowledge in topics in SD than they did when they came to the class. Furthermore, their comfort defining key vocabulary in sustainability related dialogues increases dramatically. Together, these three points show that the course not only increases the chance for shared context for dialogues in sustainability, but also increases the quality of that dialogue.

Students come to the course with expectations towards the efficacy of certain assignments and lectures regarding their usefulness for learning about sustainability. These expectations change, and we can attribute this to their more nuanced and substantive understanding of the underlying principles of sustainability. This change in expectations shows us ways towards bettering our curricula that intend to deliver ESD. A guest lecture component tends to implicitly provide an interdisciplinary context from where students can develop an appreciation for the complexity of sustainability issues.

By the middle of the course, students express values towards the consumption of goods and resources that largely comport with aspirations of ESD outcomes. Furthermore, they show an increase in self-perceived environmental conscientiousness because of the course. Together, these two considerations show a positive step in the direction towards a transformative education supportive of empathy and responsibility, and are evidence that the groundwork for further transformative education has been laid.

Students express a preference towards studying sustainability through the lens of current events as opposed to more abstract and less tangible history-based lessons. Many students perceive history topics as being interesting, but not as important for learning about sustainability. This shows us that there are more effective methods for approaching the goals of personal identification and relevance.

Sub-question One

"What are the expected learning outcomes for a freshmen-level introductory ESD course in urban sustainability?"

There are two basic domains of learning outcomes for and introduction to urban issues in sustainability. The first is content knowledge, which includes an awareness and understanding of the structures, systems, and processes of the urban environment, from democratic processes to the (non)linearity of material flow to nested scales and dependent and causal relationships. We can measure a student's current state of content knowledge through tests and grades, but ESD suggests that not only should the content knowledge be incorporated into the student's repertoire of competencies for a lifetime, but that the student should also be able to adjust to emerging uncertainties through the incorporation of new content.

The second domain of learning outcomes is non-content knowledge. This domain includes the behaviors and values affecting sustainability, and the beliefs that underlay them. A successful education in sustainable development requires that students' not only be able to self-reflect on values and behaviors, but incorporate self-reflection as a means to achieve outcomes that foster sustainable solutions to urban and other problems.

Before we approached the discussion of expected content knowledge learning outcomes, we first looked at one base condition of the students: what do they perceive themselves to know about topics in sustainability before the course begins, and does this have an effect on the outcomes of the course? One consideration of this basic literacy in SD of students was the effect that prior high-school course work in sustainability would have on that literacy. While the students with high school coursework did not record themselves as having more knowledge about the topics in sustainability, prior coursework did have a striking effect on self-reported confidence in defining terms in sustainability before the course began. The effect of the course, however, clearly shows much greater parity among the students for defining terms in sustainability; in fact, in some cases, the trends had reversed, and students with prior coursework were not reporting a higher comfort with defining the terms than other students. This, along with the traditional assessments of grades, and the dramatic and positive shift in the self-reported knowledge of topics, suggests that the course delivers an introductory education in sustainable development regarding acquiring the content knowledge necessary for continued studies in sustainability and literacy in SD.

Whether or not the students will retain the knowledge and incorporate it into future decisions, we cannot say. However, there is evidence that students tend to see themselves, not only as more environmentally conscientious, but that they also maintain

the position that rights of consumption are only relevant in the context of a healthy and sustainable planet. Together, this is evidence of the existence of an underlying belief that supports the long-term incorporation of the content knowledge. Further evidence of the presence of learning outcomes in the course for the non-content knowledge areas of ESD, (e.g. transformative outcomes), are found later in this summary.

Sub-Question Two

"What factors best facilitate meeting ESD outcomes?"

We explored the possibility that students felt that, after some exposure to the course, certain lecture topics and approaches in lecture delivery had been more helpful or beneficial for learning about sustainability. Students favored the group of three design-related lectures, over the group of science-based lectures, and they rated history-based lectures the least helpful in shaping their learning about sustainability. Furthermore, within each group, there were clear differences between the individual lectures that comprised the groups. For example, the students preferred the more recent current events type content of the "Changes to Cities" lecture to the "Ancient Civilizations" content. Not only did "Changes to Cities" rate higher on the survey, it elicited more questions from the students during the discussion portion of the course.

Other hypotheses examined the delivery format of the lectures (e.g. guest lecturers, online lectures). Unfortunately, the results of the survey may be biased from an unfortunate inability of the server to deliver the online content in a smooth, streamlined way. Particularly affected were the students who used Mac-type computers. However, data that were gathered from before the course began indicated that, while some students viewed online lectures as a satisfactory way to learn about sustainability,

and while there were no statistically significant differences in this matter based on major or academic level, online lectures were, nonetheless, the least favored option.

After the course, students reported that their valuation of the beneficence of lecture delivery types had changed. Interestingly, the students reported that in-class faculty lectures were slightly less important for learning about sustainability. Their report on guest lecturers remained high. This shift points to the notion that students perceive the benefit of interdisciplinary instruction as a means for learning about sustainability. This shift supports the idea that students understand the problems in sustainability to be issues best approached from multiple disciplines. This is a very important learning outcome. Supporting the idea that this learning outcome of interdisciplinarity was achieved is that the shift was universal: students did not perceive differences based on their major or their year in school.

The distinction that comes from differences in major or year is not superfluous: students did suggest that certain assignment types were more beneficent for learning about sustainability based on their majors and their year in school. For example, before the course, seniors anticipated that critical thinking would be more important for learning about sustainability. Similarly, Communication, Interdisciplinary Studies, and Law students reported their perception of interpersonal communication assignments as being more beneficial than Math, Engineering, 'Other' majors perceived it to be.

Unfortunately, due to changes in the syllabus, not every assignment type was used. Therefore, an examination of the beneficence of the same five assignment types queried in the *Before Course* survey would have been inappropriate to continue with in the *After Course* survey. Instead, only the two assignment types that were used were examined: self-reflection and data analysis. In this, self-reflection rated substantially higher than data analysis assignments for learning about sustainability. This result points

to the effective delivery of another outcome in ESD: that students understand the role of personal behavior and lifestyle choices as components of societal challenges in sustainability, and that these challenges transcend simple linear, rational answers.

Finally, students did report that the wide variety of source materials was helpful in learning about sustainability. They tended towards concise and engaging material with a high production value. TED Talks, for example, rated the highest by far. This data confirms that the course meets the complimentary component of the conceptual framework of Deep Learning that calls for a diverse pool of source materials.

Sub-Question Three

"How can we measure or assess these learning outcomes?"

Overall, it can be said that not only do students demonstrate knowledge of the content through tests, assignments and their final grades, but they also feel that they know much more about the aggregated topics in sustainability at the end of the course than they did at the beginning. Curiously, they do not report that they feel the aggregated topics are more interesting or important. However, this may be, in part, because the aggregated interest and importance of these topics was reported as quite high before the course, and remained so through to the end.

It is very difficult to get a direct measurement of the adoption of ESD outcomes of competencies, and literacies. In the first chapter we defined competencies as both knowledge (cognitive) and affective (emotive) capacities for particular actions, the "actionable aspects of literacies" while skills refer to the "methods and techniques by which those capacities are executed." We can infer that certain competencies are being developed in the case study. For example, there is evidence that students' conceptions of sustainability have become more "nuanced, specific, or meaningful" because of the

content and delivery of the course. Their definitions were also more focused, on average, and used fewer and more diverse sets of words to describe sustainability beyond the initial focus on the environment to include a more social and justice oriented definition.

In addition, it was clear that students largely rejected the notion that people have an absolute right to consume. Furthermore, when they did believe there was such a right, they also added the caveat that restraint was the proper response to acting on this right. The proportion of this attitude as a response to the course cannot be identified, as the question was extracted from an assignment, and not the initial survey, which leaves nothing to compare it to. However, with the additional evidence of a statistically significant self-reported increase in environmental conscientiousness, the idea that the course allows for an important early articulation of the responsibility inherent in personal action towards global sustainability is strongly supported.

Finally, we found that many students considered adopting new majors or adding an additional sustainability minor because of the course. Therefore, while the student interest and importance level was not found in the aggregated topics, there is strong indication that some personal relevance was found, and that the students' ideas of how best to use their education towards a more sustainable world were established. This also shows a strong case for the long-term incorporation of the lessons from the class. The case study consequently conforms to the requirements of the conceptual framework for long-term incorporation of learning and personal relevance. While direct measurements were not taken of non-content knowledge components of ESD, we can find evidence for it, and thus infer that such an education can be delivered. Alternative and more direct means of measuring non-content knowledge learning outcomes will be recommended further on in the chapter.

Minor Findings

Two important findings were uncovered that are interesting but not directly relative to whether the case study comports to the conceptual framework. The finding is that the course balances out the uneven literacies that students come to class with. There is even evidence that students are more appreciative of the role of other disciplines as contributive towards appropriate responses to challenging sustainability issues, or that the students see their disciplines as part of a holistic response to these issues.

When students first come to the classroom, they have varying attitudes about what they perceive themselves to be more knowledgeable about, and what topics they find more interesting. This is expected. Critically, though, there is evidence that they also see some topics as being more important. For example, Architecture and Design, and Urban Planning students might imagine design to be more important than, say, environmental justice for addressing sustainability issues. This, of course, is a problematic for a systems approach, and antithetical for an integrative, interdisciplinary response.

After the course, there is no evidence of such a disparity in individual topic knowledge, interest, or importance. If this is true, it shows that the course has an effect that could be interpreted as supporting an appreciation for interdisciplinary approaches to sustainability issues. The results of this inquiry can be found in appendix IV.

Limitations

Aside from the general limitations of case studies, this thesis naturally has a few others. The greatest might be that no questions on the survey asked directly about students' attitudes, values, and ethics of sustainability. This was done for one very important reason: a substantial focus on values before the course began may have

skewed the results to favor a value-based context for the entire class, while the goal of the thesis was to measure the effect of the course materials, lectures, and pedagogies for delivering ESD. Therefore, the only question that directly touched on values was through the question on environmental conscientiousness. This need not necessarily be the case, however, in this case study, the researcher chose to focus on the material, and err on the side of caution.

Furthermore, it may be that this case study was fairly heavily distributed towards upperclassmen for an introductory (lvl 100) course, as it only had 60% lower division students. If there is a course that has a greater percentage of underclassmen, I think the results will hold. With a greater number of upper classmen, it might change the results. However, we can assume that there are many upper division students present in the case study because the course, and sustainability itself, are relatively new: introductory courses should drift towards lower division enrollment in the long run.

Another limitation might be that race, ethnicity, religion, and gender were not included in the survey demographics. There may be substantive lessons from the influences that these distinctions might produce. However, in the creation of the survey instrument, many students voiced concern over the relevancy of these factors, and the thesis focused on the effect of the course, and not necessarily the effect of the students' backgrounds. We can assume that the distribution of students will be fairly standard in an introductory course, and there already exist substantial efforts towards studies in these areas.

Recommendations for Future Research

One possibility is that upper division students in particular disciplines will perceive themselves to know more in particular topics in urban sustainability. If the

appropriate conditions of random sampling and other prerequisites are met, future research might employ more advanced statistical analyses of these relationships. The effect of this particular course was one of that leveled the disparity in knowledge, interest, and importance between the before course and after course surveys, but more precise measurements may prove this evening out to be unique to this case study, and its results to be non-transferrable.

Another suggestion for future research would be to employ a much wider range of vocabulary terms, varying in conceptual complexity from the very simple (e.g. ecological footprint) to the very complex (e.g. panarchy). The sample of terms used in this study was not broad enough to measure a level of comfort across a range of complexity of terms. As ESD coursework in high school becomes more prevalent across the country, the comfort level and familiarity with terms will evolve. An understanding of student comfort with a range of terms might be informative in determining the effects of, and the nature of the topics that will emerge in ESD at the high school level.

Surveys of classroom performance might want to query whether the student uses a Mac product or pc, and what sort of devices the student uses. There are substantive differences in the effect their related software has on the accessibility of online content. In measuring the efficacy of online content, we might want to control for the accessibility issues that stem from different technology and platforms. In addition, especially for determining the efficacy of online content, the student's competencies in using technology might need to be controlled for.

The most important future research might be in determining the process of education for sustainable developing over the course of the entire undergraduate career. What should be taught when? How can we integrate all of the courses in ESD on a single campus to maximize the narrative progression between topics, pedagogies, and

complexity of though? The role of the introductory course has been established through this thesis. What should the next course look like, and what are its goals?

Recommendations for Instruction

Because there is strong evidence that the students in the case study showed a preference towards current events over historical events for learning about sustainability, there are lessons for curriculum development. One is that, when balancing the historical components of the course, it is better to provide fewer key historical examples and focus the lecture on the applicability and parallel nature of those events to the present situation. Not only is it more personally relevant for the student, it offers a chance for transfer (e.g. applying lessons from one topic to another distinct and separate topic). In other words, the focus should not be on historical events, *per se*, but the rather the focus should be on the relatedness of the issues surrounding those events to the issues at play today.

There were not too many distinctions between upper division and lower division students. Therefore, when they occur, we should look closely at them. Seniors anticipated critical thinking assignments as being more beneficial towards learning about sustainability before the course. The thesis only examined the change in assignments that focused on data analysis and personal reflection. Therefore, we cannot rule out that seniors may have kept their opinion had those assignments of that nature been completed. Because seniors have the most experience in actually attending classes and completing assignments, we should trust our senior level students and focus more on critical thinking for delivering ESD at the introductory level.

In addition, consider the level of embedded technology that the students are used to accessing for their communication. The students showed a preference in

electronic media that followed a linear progression favoring production value (e.g. picture quality, audio quality, direction, and other cinematic qualities). The higher quality the picture and audio, the higher the students ranked the electronic source material. If online content is to be used, consider using higher video quality TED Talks, FORA lectures, documentary movies, and other multimedia content with higher production values.

Finally, for many reasons, both practical and ethical, it is difficult and inadvisable to lecture on introspection. It is much more effective to allow the student the opportunity to explore these issues on his or her own. Homework assignments play a key role in this, as the instructions can be devised in such a way, much as they were in the case study, to facilitate the exploration of personal behavior and values for sustainability. At the introductory level, we can say that critical thinking and personal reflection should form the foundation of assignment design in ESD. Data analysis, fieldwork, and other foci for assignments might be best utilized after basic content knowledge, vocabulary, and personal relevance have been established through introductory coursework.

Conclusions

This case study delivers an initial component of an education for sustainable development. The students who leave the course sense that they have learned a significant amount of content knowledge. They have also developed a foundation of a language with which to discuss issues in sustainability. Furthermore, they have also taken some preliminary steps towards appreciating interdisciplinary thinking as a means for approaching sustainability-related issues. The course allows students to take steps towards incorporating processes of self-reflecting for examining their role in the

perpetuation of unsustainable behaviors and institutions. They have been exposed to, and appreciate, a variety of source materials for conceptualizing sustainable development. The assignments empowered students through a focus on "how to think" rather than "what to think."

Education for sustainable development is a process that cannot be expected to be finished in a single semester, or even perhaps even over the course of an undergraduate degree. Introductory courses have the responsibility to lay the groundwork for an increasingly more complex and integrated education. This can be done, and is being done at Arizona State University. However, the gains made in the introductory course should be applied shortly thereafter. Fieldwork rated extremely high among students as a means for learning about sustainability. Fieldwork is difficult to approach in large lecture-type classes. It might be that the next course to follow such a beginning should be in the form of introduction to fieldwork through an applied seminar.

This case study is a piece in the total investigation of a holistic university education. It should also be seen as a piece in the total education from K-12 through graduate school: courses such as "Sustainable Cities" are a bridge between ESD in secondary education and higher education. As ESD in secondary education becomes more pervasive and articulated in the secondary education curriculum, higher education will need to continue to employ surveys such as the one in this case study to determine the level of competency in ESD of its incoming students. A failure to commit to such a self-reflection will threaten the relevancy of university coursework if the curriculum does not appear to be a continuation of what was learned previously in high school. A loss of relevancy might appear to students that sustainability as subject has limited

capacity for articulation, and this threatens sustainability long-term as a viable approach for solving issues.

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APPENDIX I – ASSIGNMENTS

The Ecological Footprint Assignment

The Ecological Footprint assignment is mostly reflective, with some analytic qualities. Lectures preceding this assignment included: Sustainability Concepts; Ancient Cities*; History of Environmentalism*; Values in Sustainability*; and Changes to Cities*

Determining your individual ecological footprint will help you to identify some of the costs of daily activities and lifestyle choices. You should have read "What is an Ecological Footprint," and you have been introduced to this concept from the lectures. Use one or two citations from the readings somewhere in your paper.

Part one: Go to www.myfootprint.org and complete the Ecological Footprint quiz for your own ecological footprint, taking notes about the impact you have. Save the quiz results for your own footprint. Then change some of your answers to reflect different lifestyle choices.

Part two Write a synopsis report in 750 to 1000 words that answers the following questions:
1. What is an "Ecological Footprint"?
2. Very briefly, what were the results of your test and what did you find surprising?
3. What are the two most intense components to your ecological footprint and why?
4. What are two areas where you could easily reduce your ecological footprint?
5. What are two areas that would be impossible to decrease your footprint?
6. If everyone lived like you, how many earths would we need to sustain the current world population and what does that mean?
7. Does everyone on the planet have a right to consume as much as they want?

The Sustainability Indicators Assignment

The Sustainability Indicators assignment is mostly analytic, with some reflective qualities. Lectures preceding this assignment included: Biophilic Cities#; Measuring Sustainability; Sustainability Indicators; Risk, Vulnerability, Resiliency; Landscape Ecology#; Energy and Alternatives*; and Phoenix's Urban Ecology

Find a sustainability indicator program for a municipal government and answer the following questions.
Here is an example (do not use this example):
http://www.ci.minneapolis.mn.us/sustainability/indicators.asp
Write between 750 and 1000 words, using at least three different references.
1. What is a sustainability indicator and how is it different than a typical urban indicator?
2. Describe the sustainability indicator program you chose.
3. What are the indicators that they used?
4. How would you evaluate the effectiveness of the chosen indicators?
5. What changes could be made to improve the program?

*Guest Lecturer, #Online Lecture, @Online Video

The Phoenix on the Charts Assignment

An entirely analytic piece, Phoenix on the Carts is the third assignment.

Lectures preceding this assignment included: Urban Heat Island Effect#; Global Climate Change*; Sustainable Agriculture; Looking Forward (TED Talks); Sustainable Urbanism#; Urban Farming; Sustainable Design – LEED#; Water Resources*

SustainLane.com rates the status of sustainability programs, policies, and practices for the nation's 50 largest cities, including Tucson, Phoenix, and Mesa. It covers 15 categories that include metro congestion, air quality, tap water quality, city innovation, planning/land use, green economy, and energy/climate. Phoenix is on the list at 32 after dropping from 22 in 2006. This exercise asks you to identify those places where Phoenix would need to change in order to make it into the top ten, if that is even possible.

Take a look at the list of cities http://www.sustainlane.com/us-city-rankings/overall-rankings both by the overall ranking and by individual category.

Next click on Phoenix or use this link to read more about the strengths and weaknesses of this desert city. http://www.sustainlane.com/us-city-rankings/cities/phoenix

Answer these three questions by writing 750 to 1000 words describing what you think Phoenix could do to improve itself in those areas:

1) Decide which areas are where Phoenix could most easily improve and explain why.
2) Which areas would be most difficult to improve and why?
3) What are some results on the lives of the citizens of Phoenix?

The Envision the Sustainable City Assignment

A totally reflective piece, Envision the Sustainable City is the final assignment.

Read “Streets of Ectopia” in SUDR, page 379-384. Write 400-500 words on which ideas in the essay you feel are most realistic and which ones are not. Explain your opinions. Imagine what Phoenix will be like in 50 years. Write 400-500 words on what you imagine life in Phoenix to look like. Support your ideas with reasonable arguments.

Things to think about:

- What stands in the way of Ectopia becoming a reality?
- How do human values play a role in the evolution of cities?
- How do technology, politics and other factors play roles?

*Guest Lecturer, #Online Lecture, @Online Video

APPENDIX II – SURVEY INSTRUMENTS

Survey Instruments

Before Course Survey.

1. In a few sentences, describe what sustainability means to you.

2. Was the subject of sustainability ever the "main focus" of any high school class in your education? Y/N

3. Would you say that the subject of sustainability was a "substantial portion" of any high school class in your education? Y/N

4. If you are comfortable defining any of the following terms, check the box next to it.

- "Ecological footprint"
- "Food Desert"
- "Food Mile"
- "Ecosystem Assets"
- "Natural Capital"
- "Resilience"

5. How much a student already knows about a topic might influence how much more they will learn about it in this course. On a scale of 1 to 7, with 1 being "not knowledgeable at all", and 7 being "extremely knowledgeable", how would you rate your knowledge of the following topics? In other words, how much would you say you know about the topic of _____ right now?

1. personal values and lifestyle
2. ancient civilizations and their collapse
3. history of environmentalism
4. increasing global urbanization
5. energy: production, consumption and alternatives
6. global climate change
7. environmental justice
8. architectural and landscape design
9. water consumption
10. transportation

6. Learning might depend a great deal on how interesting you think a topic is. On a scale of 1 to 7, with 1 being "not interesting at all", and 7 being "extremely interesting", how would you rate the following topics? In other words, how interesting do you find the topic of _____ to be, right now?

- personal values and lifestyle
- ancient civilizations and their collapse
- history of environmentalism
- increasing global urbanization
- energy: production, consumption and alternatives
- global climate change
- environmental justice

- architectural and landscape design
- water consumption
- transportation

7. Do you think that some topics might be more important than others for learning about sustainability? On a scale of 1 to 7, with 1 being “not important at all”, and 7 being “extremely important”, how would you rate the following topics? In other words, how important do you think the topic of _____ is in learning about sustainability?

- personal values and lifestyle
- ancient civilizations and their collapse
- history of environmentalism
- increasing global urbanization
- energy: production, consumption and alternatives
- global climate change
- environmental justice
- architectural and landscape design
- water consumption
- transportation

8. Are you male or female? M/F

9. What is the general academic area of your major? If you have not chosen one yet, check "undecided".

1. Architecture/Design
2. Art
3. Biological Sciences/Health
4. Business
5. Communication/Media
6. Math/Computing
7. Education
8. Engineering/Technology
9. Environmental Sciences/Physical Sciences
10. Interdisciplinary Studies
11. Languages
12. Law
13. Social Sciences
14. Urban Planning
15. Sustainability
16. Other
17. Undecided

10. What year of studies are you currently in?

- Freshman
- Sophomore
- Junior
- Senior

11. How optimistic are you about the future? On a scale of 1 to 7, with 1 being “totally skeptical” and 7 being “totally optimistic”, how optimistic would you say you are about the future?

12. How important is sustainability? One a scale of 1 to 7, with 1 being “totally irrelevant” and 7 being “absolutely essential”, how important do you consider sustainability to be for society over the next 20 years?

13. To the best of your recollection, what grade were you in when you first heard the term “sustainability”?

- Pre-school
- Elementary
- Middle school
- High school
- College
- When enrolling for this class

14. On a scale of 1 to 7, with 1 being "not beneficial at all" and 7 being "extremely beneficial" how beneficial do you think that the following are in your understanding sustainability?

- Lectures
- Guest lecturers
- Online lectures
- Movies

15. On a scale of 1 to 7, with 1 being "not helpful at all" and 7 being "extremely helpful", how helpful do you think the following assignment types would be in developing your understanding of sustainability?

- critical thinking
- data analysis
- personal reflection
- field work
- interpersonal communication

16. On a scale of 1 to 7, how environmentally conscious do you consider yourself to be?

17. Very briefly, give two examples of where you think the City of Phoenix is unsustainable.

18. Briefly, name two things that cities can do right now to increase their sustainability?

Midterm Survey.

1. Three lectures were given related to history and sustainability. Which of these three would you say helped shape your present understanding of sustainability the most? Rank them 1 for the most influential, 2 for the next most influential, and 3 for the least influential.

Earliest cities – in class – Dr. Redman
Changes to cities – in class – Dr. Pijawka
History of environmentalism – online – Dr. Pijawka

2. Three lectures were given related to decision-making and sustainability.

Which of these three would you say helped shape your present understanding of sustainability the most? Rank them 1 for the most influential, 2 for the next most influential, and 3 for the least influential.

Sustainability Concepts – in class – Dr. Pijawka
Values of sustainability – online – Dr. Pijawka
Indicators – in class – Dr. Pijakwa

3. Three lectures were given related to design and sustainability.

Which of these three would you say helped shape your present understanding of sustainability the most? Rank them 1 for the most influential, 2 for the next most influential, and 3 for the least influential.

Biophilia – in class guest lecture – Dr. Beatley
Landscape ecology – in class guest lecturer – Dr. Cook
Urban ecology – in class – Dr. Redman

4. Three lectures were given relating science and sustainability.

Which of these three would you say helped shape your present understanding of sustainability the most? Rank them 1 for the most influential, 2 for the next most influential, and 3 for the least influential.

UHIE – online guest lecturer – Dr. Ruddell
UHIE – online video – Weather Channel
UHIE – in class guest lecturer – Dr. Brazel

5. Three lecture groups were given to help your understanding of sustainability.

Which of these three would you say helped shape your present understanding of sustainability the most? Rank them 1 for the most influential, 2 for the next most influential, and 3 for the least influential.

History
Design
Science

6. Which homework assignment most helped shape your current understanding of sustainability?

Ecological footprint – reflective
Indicators – analytical

After Course Survey.

1. Have you ever taken a course in sustainability before this class? Y/N

2. If you are comfortable defining any of the following terms, check the box next to it.

- "Ecological footprint"
- "Food Desert"
- "Food Mile"
- "Ecosystem Assets"
- "Natural Capital"
- "Resilience"

3. How much a student already knows about a topic might influence how much more they will learn about it in this course. On a scale of 1 to 7, with 1 being "not knowledgeable at all", and 7 being "extremely knowledgeable", how would you rate your knowledge of the following topics? In other words, how much would you say you know about the topic of _____ right now?

- personal values and lifestyle
- ancient civilizations and their collapse
- history of environmentalism
- increasing global urbanization
- energy: production, consumption and alternatives
- global climate change
- environmental justice
- architectural and landscape design
- water consumption
- transportation

4. Learning might depend a great deal on how interesting you think a topic is. On a scale of 1 to 7, with 1 being "not interesting at all", and 7 being "extremely interesting", how would you rate the following topics? In other words, how interesting do you find the topic of _____ to be, right now?

- personal values and lifestyle
- ancient civilizations and their collapse
- history of environmentalism
- increasing global urbanization
- energy: production, consumption and alternatives
- global climate change
- environmental justice
- architectural and landscape design
- water consumption
- transportation

5. Do you think that some topics might be more important than others for learning about sustainability? On a scale of 1 to 7, with 1 being “not important at all”, and 7 being “extremely important”, how would you rate the following topics? In other words, how important do you think the topic of _____ is in learning about sustainability?

- personal values and lifestyle
- ancient civilizations and their collapse
- history of environmentalism
- increasing global urbanization
- energy: production, consumption and alternatives
- global climate change
- environmental justice
- architectural and landscape design
- water consumption
- transportation

6. How optimistic are you about the future? On a scale of 1 to 7, with 1 being “totally skeptical” and 7 being “totally optimistic”, how optimistic would you say you are about the future?

7. How important is sustainability? One a scale of 1 to 7, with 1 being “totally irrelevant” and 7 being “absolutely essential”, how important do you consider sustainability to be for society over the next 20 years?

8. On a scale of 1 to 7, with 1 being "not beneficial at all" and 7 being "extremely beneficial" how beneficial do you think that the following are in your understanding sustainability? In-class

- Lectures
- Guest lecturers
- Online lectures
- Movies

9. On a scale of 1 to 7, with 1 being "not helpful at all" and 7 being "extremely helpful", how helpful do you think the following assignment types would be in developing your understanding of sustainability?

- data analysis
- personal reflection

10. In this course we offered a variety of source materials for you to get information from, including textbooks, peer-reviewed articles, TED Talks, YouTube videos, a newscast, online encyclopedia entry and a cable television show with a celebrity host (Hulu.com). We'd like to know which format for source materials you found to be most effective. Please rank these source materials. Give your favorite source a 7, second favorite a 6 and so on. Your least favorite should be a 1.

- SUDR Textbook
- Journal articles
- 18 minute TED Talks
- YouTube videos
- 5 minute newscasts
- online encyclopedia
- 25 minute cable show (Hulu.com)

11. On average, did you find the wide-variety of source materials to interfere with your learning experience or did you think the variety ultimately helped you to understand sustainability more than if there was only say, one textbook.

- the variety helped a great deal
- the variety helped a little
- Neither helped, nor interfered
- the variety interfered a little
- the variety interfered a great deal

12. On a scale of 1 to 7, how environmentally conscious do you consider yourself to be?

13. The assignments had only a minimal amount of instructions, and were largely left open for interpretation. Did you find this a net positive or a net negative? In other words, did you find it either unsettling or confusing, or did you find it somewhat refreshing or liberating?

- Definitely a net positive
- Mostly a net positive
- Neither
- Mostly a net negative
- Definitely a net negative

14. We'd like to know how you think understanding of issues in sustainability should be tested. Do you think that the exams should be in essay form, multiple choice or a mixture?

- Essay
- Multiple Choice
- Mixture of Both

- Other

15. We'd like to know if the extra credit movies were helpful for developing your understanding of sustainability issues. Please rate each extra credit movie on a scale of 1 to 7. A score of 1 means it wasn't helpful at all, and a score of 7 means it was exceptionally helpful. If you did not attend the movie, mark it zero.

- Collapse (Jared Diamond)
- The Unforeseen (Texas water rights)
- The End of Suburbia (Howard Kunstler)
- Dirt (soil management)
- What a Waste (German Ecovillage)

16. Did this class at any time give inspire you to either switch your major to something else, or to add a sustainability minor?

- Yes, switch majors
- Yes, add minor
- No, neither
- Yes, but neither of them are options for me

17. In a few sentences, describe what sustainability means to you.

18. The sustainability of our cities has many facets: it would be impossible to cover them all in one semester. Because this is a first year course, we try to expose the student to as many different issues as possible. This is so that students can find their interests sooner. In general, did you find this strategy problematic, or do you think it has merit? Considering all of this, how do you think this course should be treated? Choose one of the following:

- Go nuts: include more topics (14 or more) and just skim the surface (more than one topic per week)
- Keep it just like it is: many topics (10-12) and shallow depth (one week per topic)
- Tighten it up a bit: fewer topics (@8) and more depth (@two weeks per topic)
- Tighten it up a lot: far fewer topics (@5-6) and much more depth (@three weeks per topic)
- Focus on only a few topics (@3-4) as deep as a first year class can expect (@four weeks per topic)

APPENDIX III – SURVEY VALIDATION

Survey Validation

In this appendix we verify the survey instrument domain scales as reliable with the use of the Cronbach's alpha statistic. Factor analysis was not employed because the ration of case numbers (respondents) versus survey item number is low, and the sample size is also comparatively low (Pallant 2010). Then we execute a number of statistical tests to accept or reject our hypotheses. Some hypotheses are instead best described using descriptive statistics, as the data is not able to be studied by statistical analysis. These descriptives show differences that might be interesting for further study with more rigorous means. The *Knowledge Before* Scale is the only scale that approximates normal distribution. For this reason, most tests are non-parametric. However, some parametric tests are used. First, in some cases, there are no nonparametric tests to assist in the approval or rejection of particular hypotheses. Also, some of the assumptions of the parametric tests can be safely ignored, as this is an exploratory study, and not intended to be representative.

Survey Reliability

The Cronbach's alpha statistic is used to analyze the reliability of the two survey instruments (e.g. *Before Course Survey* and *After Course Survey*) on each of three scales: *knowledge*, *interest*, and *importance*. Cronbach's alpha values are given, as are Corrected Item-Total Correlation, and Squared Item Correlations. Finally, we show scale mean, variance, and alpha "if item deleted." The alpha coefficients for the six surveys show either a 'high' or 'excellent' internal consistency. In order to maintain a level of readability, we present only the first item correlation table; the other five item-total charts are in the appendix. The question prompts from the first survey are listed here; the *after course* survey questions were repeated verbatim, so they are not repeated.

Knowledge of Topics Before Course. The Cronbach's alpha coefficient reported a statistic of .881 for the Knowledge Before scale. All items show a decrease in alpha if deleted, except for Personal Values, for which the change was negligible at .008. This shows a high level of internal consistency. The individual topics rated by the students were the same in all six scales:

- personal values and lifestyle
- ancient civilizations and their collapse
- history of environmentalism
- increasing global urbanization
- energy: production, consumption and alternatives
- global climate change
- environmental justice
- architectural and landscape design
- water consumption
- transportation

Table 20 relates to the *Before Course Survey* question:

"How much a student already knows about a topic might influence how much more they will learn about it in this course. On a scale of 1 to 7, with 1 being "not knowledgeable at all", and 7 being "extremely knowledgeable", how would you rate your knowledge of the following topics? In other words, how much would you say you know about the topic of _____ right now?"

Table 20

Item-Total Statistics - Knowledge of Topics Before Course

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Knowledge Before Personal Values	32.03	85.852	0.351	0.157	0.888
Knowledge Before Ancient Civ	33.65	82.35	0.499	0.358	0.878
Knowledge Before Hist Enviro	34.32	79.889	0.676	0.589	0.866
Knowledge Before Increas Urbaniz	33.39	78.083	0.68	0.52	0.865
Knowledge Before Energy	32.77	77.842	0.694	0.591	0.864
Knowledge Before Climate Change	32.62	79.89	0.629	0.537	0.869
Knowledge Before E J	34.02	78.494	0.643	0.523	0.867
Knowledge Before Arch Design	33.71	78.219	0.553	0.356	0.875
Knowledge Before Water	33.17	76.993	0.705	0.591	0.863
Knowledge Before Transport	32.7	76.849	0.695	0.575	0.863

Survey Instrument Reliability – Interest in Topics Before Course. The Cronbach's alpha coefficient reported a statistic of .834 for the Interest Before scale. All items shows a decrease in alpha if deleted, except for Personal Values and Architectural Design, for which the change was negligible at .002 and .001, respectively. This shows a high level of internal consistency. However, the *Knowledge* and *Interest* questions could have been better worded. For example, using a bi-directional prompt such as "may or may not," could illicit different responses than the mono-directional prompt of "might"

due to a phenomenon known as 'acquiescence bias' (Groves, et al. 2009). The *Interest Before Course* survey question read:

"Learning might depend a great deal on how interesting you think a topic is. On a scale of 1 to 7, with 1 being "not interesting at all", and 7 being "extremely interesting", how would you rate the following topics? In other words, how interesting do you find the topic of _____ to be, right now?"

Survey Instrument Reliability – Importance of Topics Before Course. The Cronbach's alpha coefficient reported a statistic of .855 for the Importance Before scale. None of the individual items shows a decrease in alpha if deleted. This shows a high level of internal consistency. Similar to the first two scales, the *Importance* scale question could have been worded better (e.g. "… might or might not be …") for an increased level of precision. The *Importance Before Course* survey question read:

"Do you think that some topics might be more important than others for learning about sustainability? On a scale of 1 to 7, with 1 being "not important at all", and 7 being "extremely important", how would you rate the following topics? In other words, how important do you think the topic of _____ is in learning about sustainability?"

Table 21

Reliability Statistics – Survey Scales

Index	Cronbach's alpha	Cronbach's alpha based on standardized items
Total Knowledge Before	.881	.883
Total Interest Before	.834	.839
Total Importance Before	.855	.868
Total Knowledge After	.905	.907
Total Interest After	.874	.880
Total Importance After	.908	.916

APPENDIX IV – EXPLORATION TWO: ACADEMIC MAJORS AND INITIAL KNOWLEDGE, INTEREST, AND IMPORTANCE

One area of exploration that was interesting was the discovery that students can tend to favor certain topics in sustainability regarding knowledge, interest, and importance according to their major.

Table 22

Significant Difference in Topic by Major

	PV	AC	HE	IU	E	CC	EJ	AD	W	T
Chi-Square	15.18	12.82	18.06	21.84	19.59	15.98	25.28	48.49	17.61	23.98
df	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Asymp. Sig.	0.37	0.54	0.20	0.08	0.14	0.31	0.03	0.00	0.23	0.05

A Kruskal-Wallis Test was conducted to explore statistically significant differences in students' knowledge, interest, and perceived importance of individual sustainability topics in the *Total Before* and *Total After* scales in all three domains according to their majors. Significant differences were found in Environmental Justice (Arch/Design, n = 37, Art, n = 3, Biological Sciences/Health, n = 7, Business, n = 95, Communications, n = 12, Math/Computing, n = 3, Engineering/Technology, n = 24, Environmental Sciences/Physical Sciences, n = 13, Interdisciplinary Studies, n = 5, Law = 4, Social Sciences, n = 11, Urban Planning, n = 36, Sustainability, n = 70, Other, n = 12, Undecided, n = 17), χ^2 (3, n = 349) = 25.28, p = .032; Architecture and Design, χ^2 (3, n = 349) = 48.49 p = .000; and Transportation, χ^2 (3, n = 349) = 23.98, p = .046.

A one-way between groups analysis of variance was used to explore the individual differences. There were significant differences, therefore, we can safely accept the null hypothesis. There was no significant difference in seven of the individual topics, but three topics did contain variation based on major, including Architecture and Design, in all three scales of knowledge, interest, and importance.

Table 23

Significant Difference in Architecture and Design

		Sum of Squares	df	Mean Square	F	Sig.
Knowledge Before Arch Design	Between Groups	134.34	14	9.595	4.066	.000
	Within Groups	788.23	334	2.36		
	Total	922.57	348			
Interest Before Arch Design	Between Groups	136.91	14	9.779	4.283	.000
	Within Groups	762.62	334	2.283		
	Total	899.53	348			
Importance Before Arch Design	Between Groups	51.66	14	3.69	2.133	.010
	Within Groups	577.78	334	1.73		
	Total	629.44	348			

Discussion: A Tukey HSD test was also conducted to define which pairs of majors differed significantly. Architecture and Design and Urban Planning students recorded significantly higher on the index "*knowledge of"* for the topic of Architecture and Design: significantly higher than Business, Social Sciences, and Sustainability students. Architecture students also recorded themselves as being significantly more *interested in* Architecture and Design than Business, Communication, Sustainability, Engineering and Other or Undecided students.

Urban Planning students were significantly more knowledgeable about the topic of Environmental Justice than were Social Science students; Sustainability was more interested in Environmental Justice than were Business students. Business students rated themselves as more knowledgeable about Transportation issues in sustainability than Social Science students; Urban Planners were more interested in Transportation than were Undecided students.

Importantly, there were no significant differences among any academic majors in the After Course survey. Again, the course is shown to have an equalizing effect on the students.

This test is exploratory only, and the results are to be used only as points of interest for further research, not explanatory, even for the case study itself.

Table 24

Differences in Architecture Knowledge Before – by Major

(I) Major (Favoring)	(J) Major	Mean Difference	Significance
Architecture/Design	Business	1.371	.001
	Social Sciences	2.479	.000
	Sustainability	1.383	.001
Art	Social Sciences	3.515	.037
Urban Planning	Business	1.240	.004
	Social Sciences	2.348	.001
	Sustainability	1.252	.007

Table 25

Differences in Architecture Interest Before – Architecture and Design

(I) Major (Favoring)	(J) Major	Mean Difference	Significance
Architecture/Design	Business	1.728	.000
	Communication/Media	2.115	.003
	Engineering	1.990	.000
	Sustainability	1.608	.000
	Other	1.865	.019
	Undecided	1.924	.001

Table 26

Differences in Environmental Justice Knowledge Before – Urban Planning

(I) Major	(J) Major	Mean Difference	Significance
Urban Planning	Social Sciences	1.801	.018

Table 27

Differences in Environmental Justice Interest Before – Sustainability

(I) Major	(J) Major	Mean Difference	Significance
Sustainability	Business	.864	.048

Table 28

Differences in Transportation Knowledge Before – Business

(I) Major	(J) Major	Mean Difference	Significance
Business	Social Sciences	1.634	.030

Table 29

Differences in Transportation Interest Before – Urban Planning

(I) Major	(J) Major	Mean Difference	Significance
Urban Planning	Undecided	1.381	.036

Table 30

Course Composition by Academic Major