Development, Implementation, and Evaluation of Sustainability Education through the Integration of Behavioral Science into Pedagogy and Practice

by

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ABSTRACT

For some time it has been recognized amongst researchers that individual and collective change should be the goal in educating for sustainability, unfortunately education has generally been ineffective in developing pro-environmental behaviors among students. Still, many scholars and practitioners are counting on education to lead us towards sustainability but suggest that in order to do so we must transition away from current information-intensive education methods. In order to develop and test novel sustainability education techniques, this research integrates pedagogical methods with psychological knowledge to target well-established sustainable behaviors. Through integrating education, behavior change, and sustainability research, I aim to answer: How can we motivate sustainable behavioral change through education programs? More specifically: How do diverse knowledge domains (declarative, procedural, effectiveness, and social) influence sustainable behaviors, both in general as well as before and after a sustainability education program? And: What are barriers hindering education approaches to changing behaviors?

In answering these questions, this research involved three distinct stages: (1) Developing a theoretical framework for educating for sustainability and transformative change; (2) Implementing a food and waste focused sustainability educational program with K-12 students and teachers while intensively assessing participants' change over the course of one year; (3) Developing and implementing an extensive survey that examines the quantitative relationships between diverse domains of knowledge and behavior among a large sample of K-12 educators.

The results from the education program demonstrated that significant changes in knowledge and behaviors were achieved but social knowledge in terms of food was more resistant to change as compared to that of waste. The survey results demonstrated that K-12 educators have high levels of declarative (factual or technical) knowledge regarding anthropocentric impacts on the environment; however, declarative knowledge does not predict

their participation in sustainable behaviors. Rather, procedural and social knowledge significantly influence participation in sustainable food behaviors, where as procedural, effectiveness, and social knowledge impact participation in sustainable waste behaviors. Overall, the findings from this research imply that in order to effectively educate for sustainability, we must move away from nature-centric approaches that focus on declarative knowledge and embrace different domains of knowledge (procedural, effectiveness, and social) that emphasis the social implications of change.

DEDICATION

I could not have completed this research without the endless love and support of my husband, Aaron Redman. In those moments that I did not believe in myself, he believed enough in me for the both of us. It was not just his confidence in me but also his passion and dedication to sustainability that provided me with inspiration in seemingly dark moments. To my life partner in all things, this manuscript is dedicated to you—Aaron Redman.

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I would also like to thank my committee members, Dr. Hallie Eakin and Dr. Katherine Spielmann, for engaging so thoroughly in my dissertation. The suggestions they provided for every chapter truly added to the rigor and intellectual merit of the work produced here. I am so grateful to have committee members that I respect so fully and truly admire. The dedication of each of these women to sustainability is inspiring and it has been an honor to learn from them.

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TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

APPENDIX Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

Chapter 1

INTRODUCTION

Mounting evidence indicates that actions promoted and propagated throughout industrialized society could destroy the health and well-being of our planet (Rockström, Steffen, & Noone, 2009). The current rate of species extinction is over a thousand times greater than the natural rate of extinction (Kates & Parris, 2003). The imbalance of wealth and power is increasing, leading to decade long conflicts and forced migrations. Water consumption has increased six-fold over the last century, yet over one billion people still lack access to water for their own basic needs (Larson, Gustafson, & Hirt, 2009). Increasing consumption paralleled with growing poverty, decreasing resources, and seemingly unsolvable conflicts (Vlek & Steg, 2007) are the kinds of "wicked problems" that future generations will inherit (Reed & Kasprzyk, 2009). These "wicked problems" lack definitive solutions (the "optimal" solution is different for everyone) and the range of consequences is uncertain and often irreversible. The transition to sustainability will require creativity, engaged citizenship, anticipatory governance, a greater capacity for empathy, compassion, and solidarity, as well as intellectual leadership based on a clear understanding of where we stand relative to the larger system (Orr, 2002; de Hann, 2006; Segalas, 2010; Barben, et al, 2008); in short, it will require transformative change.

Education has long been seen as a central to fostering a transition toward sustainability. As far back as at the 1972 Stockholm Conference on the Human Environment, education was highlighted as essential for making progress toward sustainability (Qablan, Al-Ruz, Khasawneh, & Al-Omari, 2008). Yet, while many scholars and practitioners rely on education to lead us towards sustainability and foster transformative change (Rowe, 2007; Sterling, 2001; UNESCO 1997), research indicates that the current education system may be doing the opposite. In particular, schools tend to teach competition through didactic teaching methods focused on individual products and high-stakes testing, as opposed to focusing on collective solutions for the

social and environmental problems we face (Sterling, 2001). These traditional methods of lecture and assessment are apt to over-simplify complex issues and trade-offs into right or wrong answers, while emphasizing declarative (technical, ecological) knowledge and neglecting other ways of knowing.

In this dissertation, I take a novel approach to sustainability education, incorporating insights from behavior change research in order to foster sustainable action. I focus on the following questions: How can we motivate established sustainability-related behaviors through education programs? More specifically: How do diverse knowledge domains (declarative, procedural, effectiveness, and social) influence sustainable behaviors, both in general (extensive survey; see Chapter 4) as well as before and after a sustainability education program (intensive case study; see Chapter 3)? What are barriers hindering education approaches to changing behaviors (interviews with teachers, Chapter 5)? In answering these questions, this dissertation takes a three-paper approach in which each journal article focuses on a particular aspect of this research. Chapter 2 (Frisk & Larson, 2011) lays out the theoretical framework and interdisciplinary approach that will be utilized to create the education program and subsequent case study (Chapter 3, Redman, 2013), and will be used to frame the development and analysis of an extensive survey (Chapter 4, Redman & Redman, 2013). The dissertation concludes with brief discussion on key barriers and recommendations to educating for sustainability in traditional K-12 classrooms based on collaboration and interviews with K-12 teachers (Chapter 5).

This research began by first integrating three critical yet mostly disparate bodies of research— *educational pedagogy, behavioral change, and sustainability science*— through the development of competencies and practices that promote sustainable change (Frisk & Larson, 2011). Chapter 2 (Frisk & Larson, 2011), focuses on prominent behavioral theories and related studies in order to inform the relationship between education and action while considering four different domains of knowledge: declarative (factual/technical socio-ecological information),

procedural (how-to information), effectiveness (understanding of impacts/efficacy), and social (understanding of normative trends and social expectations) (Frisk & Larson, 2011; Kaiser & Fuhrer, 2003). The incorporation of behavioral theories— such as Stern's Value-Belief-Norms (VBN) Theory of Environmentalism (2000), Hines' Model of Responsible Environmental Behavior (1986), and Ajzen and Fishbein's Theories of Reasoned Action (TRA) (1975) and Planned Behavior (TPB) (1980)—into educational pedagogy has yet to be done, even in the closely related field of environmental education. This interdisciplinary, integrated approach is critical to furthering our theoretical understanding of how to effectively educate for sustainability and transformative change.

The second phase of this research is the application of the theoretical approach to an education program (Chapter 3, Redman, 2013). The education program provided an opportunity to actualize the strategies developed in Chapter 2 and to evaluate the success of the curriculum and practices based on student and teacher feedback. The two-week long program was held during June and July 2011 in collaboration with ASU's School of Sustainability, STEM College for Kids, and the NSF Graduate STEM Fellows in K-12 Education Program (GK-12) and was financially supported by the Neely Foundation. The participants were lower-income minority youth and K-12 teachers seeking to learn more about sustainability education. The program targeted behaviors associated with reducing the students' ecological footprints within the urban context, specifically those related to waste reduction and food choices. In order to assess both the short- and long-term impact of the program, pre- and post-program surveys were conducted and a year-long case study with select students was implemented. The case study examined the broader impact of the program on family and friends as well as the long-term impact on the participants themselves.

In order to generate a broader understanding regarding the influence that knowledge domains have upon sustainable behaviors, I also conducted an extensive survey of K-12 educators

(Chapter 4, Redman & Redman, 2013). The web-based survey examined educators' knowledge and associated food and waste behaviors. The analysis not only looked at internal reliability of using the knowledge domains as distinctive constructs; it also examined the relationship between the knowledge domains and different types of behaviors. Research on the four knowledge domains and their influence on behaviors is lacking (Kaiser & Fuhrer, 2003), therefore this survey significantly enhances the conceptualization of multiple constructs of knowledge. Also, understanding which knowledge domains have a greater influence upon sustainable behaviors is essential to tailoring an effective education program and understanding where the gaps in knowledge and behavior lie.

Defining the Problem

The field of sustainability emerged due to the complex ("wicked") problems that society is facing. Rather than focusing on a single disciplinary topic, sustainability science aims to grapple with the urgent, cross-disciplinary problems that face society. As such, research in the field of sustainability science is generally focused on a problem or suites of problems. Due to the multidisciplinary nature of this research, I define the research problems addressed herein based on the three fields of literature I draw upon: sustainability, behavior change, and education pedagogy.

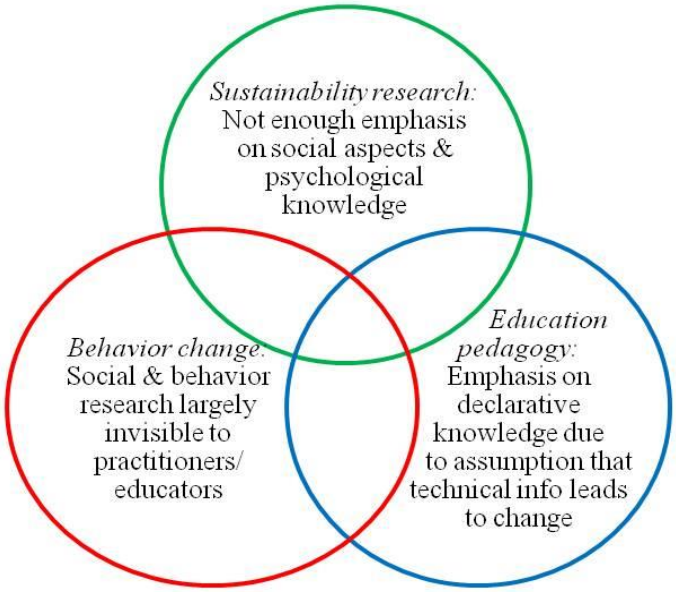

Figure 1. Defining the problem in terms of sustainability, education, & behavior change

The problem in terms of sustainability research.

Changing from patterns of over-consumption to those of conservation requires technological, political, and consumer-driven change. While sustainability research should focus on a wide range of problem-solving approaches, including technological innovation and diverse approaches to governance, this research focuses specifically on sustainable consumption and disposal. Individual and societal change in terms of patterns of consumption and disposal is essential for progressing towards sustainability (McKenzie-Mohr, 2000). Individual change is a social process, as consumers are often "locked-in" by social norms and structures that support environment-burdening patterns of consumption. As a result, psychological research is pivotal to achieving sustainability (Vlek & Steg, 2007).

Unfortunately, sustainability research and education practices all too often focus only on cognitive understandings regarding ecological problems, while neglecting action, change, and psychological knowledge (McKenzie-Mohr, 2000). Although 'society' is considered one of the three pillars of sustainability (society, economy, environment), my research postulates that societal choices either facilitate or impede environmental and economic sustainability—making

the social dimension central to all three pillars. While my research doesn't capture all the facets of the social dimension of sustainability, it does explore localized, social pressures and norms as a key impediment or motivator for change. Therefore, this dissertation squarely focuses on individual and social change as the key to overcoming many of the sustainability challenges we are facing.

In particular, my research is premised by the assertion that patterns of consumption and disposal must change in order for sustainability to be achieved. This approach implies, for example, that rather than looking at deforestation as an environmental issue, we focus on deforestation as a product of paper consumption and meat consumption (in the case that deforestation occurs to make room for agriculture related to the meat industry). Then, I further look at the drivers of meat consumption, for instance, and suggest tangible, individualized solutions for change. Through reducing the urban ecological footprint by changing people's consumption and disposal behaviors, a cascading effect that radiates throughout the environment and economy would occur. Sustainability is a going to be achieved or not based on human actions and social patterns, therefore understanding social drivers and barriers to change is fundamental to the challenges of sustainability.

The problem in terms of behavior change.

For decades, environmental degradation, human well-being, and environmental behavior have been the topic of social and behavioral research (Vlek & Steg, 2007). This research, however, has yet to be integrated into the application of education philosophy. While journals are full of articles on promoting pro-environmental behavior, this literature is largely invisible to those who could most benefit from it (McKenzie-Mohr, 2000). McKenzie-Mohr, a prominent researcher who focuses on behavior change, has come to believe that most educators and program planners are unaware of psychological literature and its relevance to developing and implementing programs focused on promoting pro-environmental behaviors.

The problem in terms of behavior research, is clearly articulated by McKenzie-Mohr (2000, pp. 544), "until we reach out to the individuals who design and deliver environmental programs, our efforts will remain invisible to those who can most benefit from them." For this reason, my research has been developed, implemented, and evaluated with students and educators. I pay particular attention to integrating the perspectives of key stakeholders (K-12 teachers and students) into the research process and outcomes. Additionally, I am disseminating my findings at conferences that are attended by K-12 teachers (e.g., The National Green Schools Conference), publishing my articles in open-source formats so that K-12 teachers will have access to them, and collaborating with education professionals in order to facilitate workshops and professional training for K-12 teachers.

The problem in terms of education pedagogy

One of the primary goals of environmental education is increasing participation in pro-environmental behaviors (Hovardas & Korfiatis, 2012). While many environmental education programs have been shown to increase knowledge and even increase the intention to behave in a pro-environmental manner (Hovardas & Korfiatis, 2012), education has largely failed to foster the transformative change necessary to progress towards sustainability (Huckle & Sterling, 1996; Sterling, 2004). Particularly, environmental education focused on, "apolitical, naturalist and scientific work" (Tilbury, 1995, p. 195) has neglected the normative components of sustainability that enhance subjective forms of knowledge (i.e., effectiveness and social knowledge). This research aims to move away from the information-intensive, value-free idea of science education through the development and implementation of an education program that integrates subjective knowledge in order to foster behavior change. In addition to engaging in normative topics, this research aims to build capacity for change by moving beyond ecological (declarative) knowledge and didactic methods in order to encourage hands-on, experiential learning based on multiple ways of knowing.

Educating for sustainability also requires changing the very perception of sustainability among educators. While many teachers feel it is important to include aspects of sustainability in their lessons, recent studies have shown that teachers tend to lack deep knowledge of key sustainability concepts. One such study, conducted in Australia, found that teachers' knowledge regarding environmental issues was minimal and insight into the social, cultural, and economic complexities of sustainability was quite superficial (Stir, 2006). The researchers also found that the teachers did not seem to go beyond knowledge and awareness when considering aspects of sustainability. Over 90% of teachers concentrated on traditional information and knowledge regarding environmental issues; few teachers included action as a component (Stir, 2006).

This dissertation research highlights the need to work with the teachers who are actually in charge of the classrooms and to enhance continuing education opportunities. Teachers must have the tools to educate for a sustainable future in order to achieve transformational action; hence research conducted on sustainability competencies within higher education must also be translated and utilized with teachers within the K-12 sectors.

Justification for Food and Waste Focus

Many researchers suggest that changes in consumption and disposal have compounding effects that radiate throughout the globe (Heller & Keoleian, 2003; Seyfang, 2006). Heller and Keoleian's (2003) research on the life-cycle of the US food system suggests that consumption patterns can influence not only the production of food but also food policy. When looking at the life-cycle of food, one cannot ignore the end of life management (i.e., food disposal); therefore, food and waste practices are inherently linked. Additionally, a number of decisions that impact waste strategies, such as reducing waste through using reusable grocery bags, happen at the point of purchase or the consumption phase of the food system life cycle. Other researchers have also suggested a positive correlation between food and waste behaviors, such as recycling and purchasing organic (Thøgersen, 2004). This link between food and waste behaviors is beneficial

when creating an education approach that aims to overcome barriers and motivate change because presumably, if the behaviors are connected they share some similar drivers to change.

Not only is the interconnectedness of food and waste behaviors conducive for the focus of an education program but the do-ability of the targeted behaviors is also relevant for a program focused on empowering youth to create change. Other researchers have found that adolescents are making food purchasing decisions for themselves and their households (Bissonnette & Contento, 2001); thus youths tend to have relative agency with regard to food behaviors. Adolescents also wield great purchasing power, spending an estimated $4 billion per year on food and snacks for themselves plus $19 billion from their families to spend for family food shopping (Bissonnette & Contento, 2001). Additionally, the teenage years are a critical life stage in terms of forming life-long dietary habits.

National data indicates that adolescents are developing unhealthy habits, such as infrequent consumption of fruits and vegetables (Robinson-O'Brien, Story, & Heim, 2009), which has, in part, led to increased rates of obesity (Gortmaker Sl & et al., 1999). In order to promote more sustainable food choices (e.g., whole foods over processed, reduced red meat consumption, less fast food) amongst adolescents, the education program conducted as part of this research provided students with a range of options from which to select strategies that best fit their lifestyle. Research on behavioral choice theory suggests that providing students' options increases their sense of control and ultimately the success of the intervention (Gortmaker et al., 1999; Vuchinich & Tucker, 1998)

In this project, students were provided a number of choices to improve the sustainability of their waste practices, such as recycling, composting, reusing, and reducing. K-12 schools have a long history of working with youth in order to promote sustainable waste decisions such as recycling (Boerschig & De Young, 1993). Researchers have found that not only do students have individual agency over their waste decisions but they often influence their families' waste

practices as well (Boerschig & De Young, 1993). This long history of youth as leaders for their school and household waste practices makes the topic of sustainable waste well suited for youth programs. The agency that youth have to engage in sustainable food and waste practices as well as the importance of building habits during this pivotal life stage, makes the topical areas particularly salient for the target population.

Progressing Towards a Solution

Developing strategies to effectively educate for sustainability may take decades and contributions from hundreds of researchers, practitioners, politicians, students, and advocates. This research aims to further the understandings of the barriers and motivators that drive or impede behavior change while suggesting practical strategies for fostering transformative sustainable change in the classroom or other educational settings. Through focusing on the social complexities of sustainability and centering this research on the human dimensions of sustainability, this research hopes to address some of the gaps that occur in sustainability science when theory on behavior change is ignored.

Through collaboration with K-12 teachers and students, I hope to inspire practitioners to engage with behavior change research as well as to learn from these stakeholders how to best integrate these novel approaches into traditional environments. With the implementation of curricula focused on diverse domains of knowledge and student-centered practices, I demonstrate the benefits of moving away from didactic, information-intensive education methods.

The intellectual merit of this research largely rests in the successful merging of behavioral science, sustainability competencies, and educational pedagogy to develop effective teaching methods and approaches that motivate change. Many scholars have already studied and written about the connection between sustainability and education (Sipos, et al., 2007; Orr, 2002; Sterling, 2001), but they often overlook behavioral sciences. So addressing this gap will help further our understanding of how to effectively educate for sustainability.

The broader impact of this research begins with the direct impact on the student and teacher participants. The students and teachers who participated in this research have become change agents that proudly and confidently promote sustainability. Additionally, the K-12 teachers who utilized the sustainability curricula and practices had a confounding impact on their students and school environment. The broader impacts, however, do not end with the stakeholders that directly participated in the research, or even with improving sustainability education. The change created in the knowledge and behaviors of the participants demonstrates the usefulness of this kind of interdisciplinary approach focused on behavior change, which can be adapted in other programs focused on health, substance abuse, or environmental education.

Chapter 2

EDUCATING FOR SUSTAINABILITY: COMPETENCIES & PRACTICES FOR TRANSFORMATIVE ACTION

As the urgency to address environmental, social, and economic challenges increases worldwide, education continues to be seen as a central part of the solutions for sustainability (Sterling, 2001, UNESCO, 1997). In 1997, UNESCO issued a report declaring: "education is the most effective means that society possesses for confronting the challenges of the future. Indeed, education will shape the world of tomorrow" (UNESCO, 1997, p. 17). The UNESCO report goes on to argue that education should play a pivotal role in bringing about the deep change required to move towards sustainability (UNESCO, 1997). With a focus on educating for sustainability and transformative action, this paper aims to establish effective educational practices needed to achieve key competencies and the behavioral changes required to attain a sustainable future.

While many scholars and practitioners are relying on education to lead us towards sustainability (Rowe, 2007; Sterling, 2001; UNESCO 1997), our current education system may be doing the opposite. In particular, schools tend to teach competition through didactic teaching methods focused on individual products and high-stakes testing, as opposed to focusing on collective solutions for the challenging social and environmental problems we face (Sterling, 2001). These traditional methods of lecture and assessment tend to over-simplify complex issues and trade-offs into right or wrong answers, while emphasizing individual achievement over group collaboration. In dealing with challenges of the 21st century, we cannot perpetuate the thinking and educational practices of the past (Nolet, 2009; Sterling, 2001). Instead, we must envision a new education system capable of addressing modern environmental and societal challenges in all their complexity. As Orr (1991) notes, it is only education of a "certain kind" that will save us, progress us, or advance us towards sustainability.

The dominant philosophical approach of many environmental education programs can be summarized in a statement by ecologist Babia Dioum Senegalese: "In the end, we will conserve only what we love. We only love what we understand. We only understand what we are taught" (Purrenhage, 2010; Donahue, 2008, K-12 and Community Programs section). Or, in the words of Jane Goodall: "Only if we understand can we care. Only if we care will we help. Only if we help shall we be saved" (Rimington, 2010, Excerpt from Speech section). Implicit in these inspirational quotes is the notion that knowledge leads to behavior change and environmentally favorable action, which is in fact the ultimate goal of most environmental education programs (Simmons, 1991). In spite of this worthy goal, substantial research illustrates how programs have failed to achieve transformative change (Ramsey, 1993).

Standard knowledge-based educational approaches to behavior change have a disappointing track record (Finger, 2010; Nolet, 2009; Stern, 2000). The failure of environmental education to broadly change individual behaviors and collective action is primarily due to unsubstantiated assumptions about the relationship between knowledge and behavior (Finger, 2010; Simmons & Volk, 2002; McKenzie-Mohr, 2000; Ramsey, 1993). The quotes from Senegalese and Goodall imply that understanding an issue or problem is a causal factor for concern, and ultimately, behavior change. As Dr. Harold Hungerford, a well-respected environmental educator, stated: "[Environmental educators] still believe—so very strongly—in the knowledge>attitude>behavior model of learning when, at the same time, we know how desperately inadequate this is when it comes to changing the citizenship behaviors of large numbers of learners over long periods of time" (Simmons & Volk, 2002, p. 7).

Although the literature unequivocally points to a lack of success in information-based approaches to behavioral change (Finger, 2010; Leiserowitz, et al., 2005; Barr, 2002; Trumbo & O'Keefe, 2001; McKenzie-Mohr, 2000; Stern, 2000), educators still cling to the outdated mantra that more knowledge will spur transformative action (Simmons & Volk, 2002; Sterling, 2001;

Senge, 2000). The failure to incorporate behavioral sciences into educational philosophies and practice has resulted in a fundamental inability to promote transformative action, despite the fact that behavior change is often a stated goal of educational programs. Through the integration of knowledge domains that speak to ecological knowledge as well as social norms, beliefs about behaviors, and how-to information about specific problems and actions, we aim to develop an educational approach that resonates with behavioral science and core competencies for sustainability.

To further educational efforts for transformative action, we integrate three critical yet mostly disparate bodies of literature—behavioral research, sustainability competencies, and education pedagogy (Figure 2). First, we review the role of varying types of knowledge, information, and education in changing behaviors, in addition to broader theoretical and empirical insights about what motivates and constrains environmental actions. Next, we integrate the educational and sustainability literature to illustrate how four competencies central to sustainability education can most effectively be achieved via particular teaching approaches, specifically focusing on transformative actions in the context of systems thinking, a future orientation, and collaborative decision making. We end by reflecting on critical challenges and opportunities for educational initiatives aimed at changing behaviors for sustainability. Our focus is on K-12 education since socially pervasive behaviors are highly resistant to change as they become engrained in adulthood (Leiserowitz, et al., 2005). However, these principles and practices are adaptable to many different age groups and social settings for learning.

Figure 2. Integrating disparate fields for an interdisciplinary approach to sustainability education

Education and Behavioral Change Research

The centrality of behavioral sciences for achieving the goal of transformative action is often overlooked in educational philosophies and practice. Various theories and studies explain and examine human behavior and how best to motivate pro-environmental actions, yet this research has not been well integrated into educational practices. Although hundreds of studies have been done, no single theory fully captures why people act the way they do, largely because of the complexity of multifaceted human behaviors in diverse contexts (Kollmuss & Agyeman, 2002). Varying classes of pro-environmental behaviors—encompassing consumptive and political actions in both private and public spheres—ultimately have different motivators and barriers (Stern, 2000). Rather than offering an exhaustive review of the literature, we discuss prominent behavioral theories and related studies in order to inform the relationship between education and action while considering four different domains of knowledge: declarative, procedural, effectiveness, and social knowledge (Kaiser & Fuhrer 2003). While insufficient individually in explaining the motivations behind people's actions, these knowledge domains collectively provide an overarching framework for synthesizing various schools of thought in the behavioral sciences, especially in linking predictors of behavior to effective educational approaches for sustainability (Table 1).

Ecological or declarative knowledge typically addresses how environmental systems operate in technical, mechanical or biophysical terms, as with information about the ecological structure and functioning of ecosystems (Kaiser & Fuhrer, 2003). Although the least effective in promoting pro-environmental behaviors, declarative knowledge has been the central focus of most educational programs (Simmons & Volk, 2002; Pooley & O'Connor, 2000). Declarative knowledge is emphasized in the Information-Deficit Model (IDM) developed by behavioral scientists in the early 1970s (Kollmuss & Agyeman, 2002). In a straightforward, linear fashion, this model claims that environmental knowledge leads to awareness and concern, and ultimately, to pro-environmental behaviors. Psychologists and others have refuted this simplistic assumption, noting that changing behavior is very difficult and information is simply not enough to spur change (Kollmus & Agyeman, 2002). While declarative knowledge often does not appear to directly motivate behaviors, the lack of such knowledge may form a barrier to changing behaviors (Monroe, 2003). For example, declarative knowledge about drought conditions or where water comes from is not likely to motivate water conservation behaviors. However, a lack of specific declarative knowledge—such as the water needs of one's plants—may lead people to over-irrigate low water-use species, as this information embodies procedural information about how much plants should be watered.

The second domain is procedural knowledge, which refers to basic how-to information such as how to sort garbage into recyclables and non-recyclables for proper disposal (Kaiser & Fuhrer, 2003; Monroe, 2003). Certain forms of procedural knowledge have been found to be more effective in promoting behavioral change; for instance, information about how to participate in decision-making processes is a strong predictor of political engagement (Kaiser & Fuhrer, 2003). Procedural information provides answers to questions such as 'where do I vote?' or 'how do I register?,' but not value-laden questions such as 'what is the significance of my vote?' Procedural knowledge correlates closely with broader situational and structural factors that

facilitate or constrain action, since people's awareness of infrastructure or incentives that support or limit behaviors is crucial for taking advantage of opportunities or overcoming obstacles to action. This type of knowledge is especially crucial for developing an understanding of the strategies that can be taken under a set of circumstances, but it tends to be most effective when coupled with effectiveness and social knowledge.

Effectiveness, or impact, knowledge addresses understanding of the outcomes of different behaviors, essentially answering the question 'is the behavioral sacrifice worthwhile?' (Kaiser & Fuhrer, 2003; Monroe, 2003). Stern's (2000) Value-Belief-Norm (VBN) model of pro-ecological behavior highlights two key determinants pertinent to effectiveness knowledge; the first is the perceived consequences of behaviors, and the second is beliefs about who is responsible for environmental outcomes. The latter correlates to a person's "locus of control," which represents the confidence individuals have in their ability to bring about impactful change through their personal actions (Kollmuss & Agyeman, 2002; Monroe, 2003, Hines et al., 1986). Effectiveness knowledge influences behaviors through people's perceptions about how their behaviors impact the environment. As such, they are closely correlated to subjective values, beliefs, attitudes, and norms (Kaiser & Fuhrer, 2003; Monroe, 2003). For example, if an individual believes that recycling is not a cost-effective or sustainable means of waste management, their negative attitudes may deter them from recycling. While educating people about how their actions impact the environment or society is worthwhile, practitioners must recognize that people often selectively acquire and process information to match their values, beliefs, or behaviors (Kollmuss & Agyeman 2002), thereby presenting potential barriers to behavior change. In particular, Cognitive Dissonance Theory (Festinger, 1957) explains that individuals rationalize inconsistencies in information in order to match their preexisting views or actions; therefore, people may not act upon new information if it diverges from or conflicts with preexisting knowledge, attitudes, or behaviors. Thus, people's understanding of the impacts of their behaviors

is crucial to consider, including factual knowledge as well as subjective beliefs about control, efficacy, and ultimately, the outcomes of particular actions.

Fourth, and finally, social knowledge encompasses information regarding the motives and intentions of other people (Kollmuss & Agyeman, 2002). Social knowledge embodies what is typically described as social norms by behavioral scientists (Trumbo & O'Keefe, 2001; Stern, 2000). Kaiser and Fuhrer (2003) use social knowledge to explain two types of norms; conventional norms refer to customs, traditions, and expectations associated with the need for social approval, while moral norms refer to the value or importance a person places on equity, human welfare, environmental impacts or other behavioral outcomes. Schultz et al. (2007) further distinguish between different types of norms; descriptive norms refer to perceptions of what is commonly done, whereas injunctive norms refer to what is approved or disapproved by others. Community-Based Social Marketing (CBSM) stresses the power of injunctive norms by applauding desirable behaviors and establishing positive views of people's ability to create change (McKenzie-Mohr, 2000). Such approaches represent the combined use of social and effectiveness knowledge, respectively, emphasizing the behavioral outcomes valued by society. Changing the perception of what society approves of or views as desirable has been the subject of much research and marketing campaigns ranging from anti-smoking to recycling. The importance of social norms as a predictor of behavior is especially critical in a normative field such as sustainability, where societal values are central in guiding what we ought to sustain and how.

Many theories underscore the importance of social knowledge while highlighting the role of knowledge domains in changing behaviors, in addition to going beyond the technical approach emphasized in the failed Information Deficit Model (IDM) (see Table 1). For example, the Theories of Reasoned Action (TRA) (Fishbein and Ajzen 1975) and Planned Behavior (TPB) (Ajzen, 1985) both stress beliefs concerning behavioral consequences (effectiveness knowledge)

as well as normative expectations of others (social knowledge), which are also emphasized by Stern's VBN Theory (2000). In recognizing a variety of predictors for behaviors in different settings, Community-Based Social Marketing (CBSM) fosters sustainable behaviors by employing a contextually rich, place-based approach to identifying and remedying specific barriers to desired actions (McKenzie-Mohr, 2000). Linking the predictors of behavior to diverse knowledge domains (Table 1) drives home the importance of incorporating an array of information into educational efforts, above and beyond the traditional reliance on declarative knowledge.

Table 1

Theoretical predictors of behavior in relation to knowledge domains

Knowledge Domains	**Predictor of Behavior (source theory*)**
Declarative: Understanding of how environmental systems function	Technical information (IDM) Awareness of environmental problems (IDM) Mechanical understanding of issues (IDM)
Procedural: Awareness of how to undertake particular actions	Process-oriented 'how to' information (IDM, MREB) Structural influences & limits (VBN, CBSM) Situational constraints & opportunities (VBN, CBSM)
Effectiveness: Views of the outcomes of different behaviors	Personal efficacy & locus of control (VBN, MREB, TRA, CBSM) Perceived consequences of actions (VNB) Attitudinal evaluations of outcome (TRA, TPB)
Social: Awareness of motives and intentions of other people or society	Ascribed responsibilities to self & others (MREB) Beliefs about social norms & expectations (TRA, TPB) Perceptions & pressures conveying what is dis/approved (CBSM)

*Information Deficit Model=IDM (Kollmuss & Agyeman, 2002), Value-Beliefs-Norms=VBN (Stern, 2000), Theory of Reasoned Action=TRA, Theory of Planned Behavior=TPB (Ajzen, 1985), Community-Based Social Marketing=CBSM (McKenzie-Mohr, 2000), Model of Responsible Environmental Behavior=MREB (Hines et al. 1986)

Insights from behavior change research can be integrated into educational practices in many ways. As Monroe (2003) explains in her review of behavioral research a successful educational program to promote the purchase of locally grown food would emphasize

testimonials from people who buy and enjoy it (social knowledge), recipes and information about how to acquire it (procedural knowledge), and details on its easy availability, freshness, taste, and other positive impacts (effectiveness knowledge). The focus of such a program would not simply be based on knowledge about food miles, greenhouse gases, or other ecological aspects of food production (declarative knowledge), but instead would addresses barriers, intentions, beliefs, and social norms across knowledge domains. In short, sustainability education intended to spur action should take a systemic, multi-pronged approach to changing behaviors by incorporating multiple knowledge domains—including value-based judgments and beliefs—to motivate sustainable actions.

Sustainability Competencies and Reinforcing Educational Approaches

Sustainability does not refer to some static paradise, but rather, implies a capacity for human beings to continuously adapt to environmental and societal conditions (Scott, 2002). In other words, successful sustainability strategies are flexible, resilient, and responsive (Crow 2007). Similarly, the principles and practices developed for sustainability education should have a flexible, adaptable character to ensure their relevance in a variety of different settings. Building healthy, responsive educational systems requires that schools continuously learn and adapt, rather than press on with the out-dated education practices. Rather than simply meeting set standards and "checking off" that sustainability has been taught, the challenge lies in developing methods and actions through which students are effectively acquiring key competencies in support of sustainable actions (Sterling, 2001).

Competence-oriented education stresses student outputs, whereas traditional, didactic approaches in K-12 and higher education have centered on teacher inputs. The input approach is often related to standards for whether the teacher has covered the material pertaining to conceptual strands such as " The History and Nature of Science" (AZ Department of Education, 2005). In contrast, the output-oriented approach focuses on students gaining the "concepts and

abilities for social action" (de Haan, 2006: 22). Taking an output-oriented approach herein, our sustainability "competencies" embody the concepts and skills that will enable students to understand and resolve complex sustainability problems by equipping them with the ability to become change agents (Wiek et al., 2011). In discussing educational approaches that reinforce the competencies, we emphasize pedagogy in terms of the teaching and learning methodologies and strategies that support the attainment of sustainability competencies (Segalas, et al., 2010; Sipos, et al., 2008).

A variety of projects have recently tried to reform schools so that they educate for sustainability. *The Washington Sustainable Design Project* was created to integrate sustainability throughout the state's K-12 schools, with the following key competencies: systems thinking, active engagement, cooperative group learning, and connection with communities and stakeholder perspectives (Wheeler, et al., 2008). A German sustainability program similarly highlights foresighted thinking, an interdisciplinary approach, and action-orientation as its core competencies (de Haan, 2006). Many of these same sustainability competencies are reiterated elsewhere in the literature (UNESCO, n.d.; Church & Skelton, 2010; Sipos, et al., 2008; de Hann, 2006; Gruenewald, 2004). Yet little dialogue has developed on how best to convey these competencies so that students actually acquire them (Wiek, et al., 2011).

Drawing on previous work, we focus on four key sustainability competencies: (1) systems thinking and an understanding of interconnectedness (Garrett & Roberson, 2008), (2) long-term, foresighted reasoning and strategizing (Pepper & Wildy, 2008; MacKay & McKiernan, 2004), (3) stakeholder engagement and group collaboration (Segalas, 2010), and (4) action-orientation and change-agent skills (Wiek, et al., 2011; Sipos et al., 2008; Rowe, 2007; de Haan 2006) (Table 2). In order to transform the way people "learn, reason, innovate, communicate, plan, predict, and organize" (Crow, 2007, p. 1), success in acquiring sustainability competencies extends beyond memorization and requires that knowledge about both behavioral

change and pedagogy be incorporated into educational approaches. Hence, in the sections that follow, we first explain each competency and it's centrality to sustainability, while illustrating how the four knowledge domains apply, and finally, demonstrating the most effective educational approaches to support the development of knowledge and skills for transformative action.

1. Systems thinking and an understanding of interconnectedness.

A systems perspective acknowledges that the world is increasingly connected and decisions made in one area affect others in a complex array of local to global, human-environment interactions and impacts. Progressing toward sustainability entails grappling with these dynamics in the face of multiple, potentially conflicting objectives, such as improving societal welfare, providing economic opportunities and restoring or protecting life-supporting ecosystems (Sherman, 2008; Agyeman & Angus, 2003; Orr, 2002). Achieving an array of ecological, social, and economic goals can be extremely difficult and often requires choosing one benefit or cost over another (Pepper & Wildy, 2008). In the current K-12 educational model, little acknowledgement is given to these complex human-environment interactions and associated trade-offs due to the fragmentation of real systems by disciplinary subjects and the simplification of issues into multiple choice, true/false, and similar questions on standardized tests (Gruenewald, 2004). This fragmentation has led to a decoupling of nature and society in K-12 education, while the concepts and skills needed for 'systems thinking' are neglected (Nolet, 2009; Sterling, 2001). In order to bring about behavioral change among students and society, people must learn to analyze the consequences of their actions, both intended and unintended, while recognizing the tradeoffs now and into the future.

For systems learning and thinking to result in transformative change, all four knowledge domains are relevant for educational curricula. Effectiveness knowledge for systems thinking incorporates the impact of the individual into the broader picture, meaning that students need to consider the individual and collective effects of their own and others' actions over time. Since

many environmental behaviors often only have a significant impact in the aggregate, cumulative action is often necessary before substantive, positive impacts occur (Stern, 2000). Although understanding the larger system is important, it may actually create a barrier to change as individuals realize that their actions alone will not lead to substantive outcomes (Agyeman & Angus, 2003). Thus, effectiveness knowledge must clearly relay that change is made through individuals acting as a part of the collective, while building the social knowledge needed to advance sustainability—that is, by establishing the ethics and expectations for individual action. By instituting social norms that promote sustainable actions, barriers to personal change (due to limited effectiveness knowledge) can be addressed. Moreover, procedural knowledge can equip students with the skills that allow them to act within the system, while declarative knowledge highlights the processes and impacts, trade-offs and complexities essential to making decisions for a sustainable future.

Using food choices as an example, an educational program embodying all forms of knowledge might convey: (1) life cycle analysis, or the human-ecosystem processes by which products are produced, consumed, and decomposed (declarative knowledge); (2) how to read labels and understand the meaning of different certifications, such as organic and fair trade (procedural knowledge); (3) the broader impacts of switching to a more sustainable diet, for instance, how fair trade affects the livelihoods of farmers or how organic farming minimizes pollution while maintaining soil fertility (effectiveness); and, (4) the social desirability of individual decisions and underlying reasons for cultural norms, such as high-meat diets in the U.S. (social knowledge). Developing educational approaches that incorporate the four knowledge domains in this manner will help build students' competence in systems thinking while fostering behavioral change pertinent for sustainability.

Through the use of real-world explorations of sustainability problems, subject matter can be conveyed in a more connected, interdisciplinary manner that acknowledges complex system

interactions (Brundiers et al., 2010; Segalas, 2010; Steiner & Posch, 2006). Real-world explorations present authentic investigations of intersecting components while avoiding the over-simplifications found in hypothetical scenarios (Barab & Luehmann, 2002). On-the-ground cases should be place-based while revealing multiple and potentially conflicting goals, tradeoffs and uncertainties, and the array of related values and beliefs (Steiner & Posch, 2006; Barab & Luehmann, 2002). Place-based learning allows students to engage in their own communities while investigating real-world problems with diverse stakeholders. Problem-based learning is inherently a part of real-world explorations as students explore the problems and possible solutions to critical issues such as consumption patterns, vicious cycles of poverty, and their inter-linkages (Dale & Newman, 2005). Through such approaches, educational activities can be "enjoyable, hands-on and relevant to life outside school while addressing the problems of our world" (UNESCO, "Education for Sustainable Development," n.d.).

For instance, students could explore their local food system by tracking what they eat, where their food comes from, and how it is produced; this might require talking with cafeteria staff at their school, managers at their local grocer, and their parents, thereby also enhancing their interpersonal communications. While exploring the relationships between food miles, prices, and agricultural practices, complementary learning modules could also engage students in issues of water quality and nutrients (i.e., eutrophication), health and nutrition, labor practices, access, and equity. Throughout the exploration into their local food system, students should be reflecting upon how they can progress to more sustainable food behaviors. Rowe (2007) notes that assignments focusing on actual sustainability issues engage students and help institutions turn towards more sustainable behaviors and norms. In systems thinking approaches to institutions, it is important to note that systems are dynamic so adaptability and change is central to achieving a resilient, sustainable system. Educating for systems thinking competencies entails discovering

the interconnections between people, institutions, nature and wildlife, while also generating empathy for the implications of today's decisions on future generations.

2. Long-term, foresighted thinking

The Bruntland Report defined sustainability as meeting the "needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). A commitment to future-oriented living is fundamental to sustainability (Sherman, 2008). As Wiek and colleagues (2011, p. 11) note, "the concept of sustainability calls for long-term future orientation and envisioning," including "the anticipation and prevention of harmful unintended consequences, and the imperative of intergenerational equity." Foresighted thinking involves asking questions about long-term trends and possible future scenarios, while also employing anticipatory approaches to understand, mitigate, or adaptively prepare for future changes in system dynamics (Wiek, et al., 2011; Gibson, 2006). It also involves placing value on the future, taking responsibility and ownership of our impacts on generations to come, and promoting concepts of intergenerational equity. Gibson (2006) explains that intergenerational equity requires society to act in a way that preserves or enhances opportunities for future generations to live sustainably. As such, society should reduce over-exploitation of resources and pressures on ecological systems so that natural resources and ecosystems are available for use and enjoyment into the future.

When applying foresighted thinking to a specific content area, in this example renewable and non-renewable resources, students could learn about: (1) the earth processes involved in the creation, extraction and regeneration of resources—such as fossil fuels—over time (declarative); (2) how to make sustainable purchases based on the renewability of the products they use, for example, by choosing reusable bags made from natural cotton fibers, rather than petroleum-based, plastic bags (procedural); (3) the impacts of different types and rates of consumption on the availability of resources into the future, which could encompass concepts such as 'peak oil'

and geologic time as well as activities such as graphing and calculating individual and collective rates of resource use over time (effectiveness); and, (4) patterns of resource use and availability now and into the future, with emphasis on intragenerational fairness (e.g., oil consumption patterns in developed compared to developing countries) and intergenerational equity (e.g., fossil fuel availability today versus the future) (social). These knowledge domains can be readily integrated into K-12 classrooms, for instance, by having students graph rates of consumption in math class and explore biophysical processes in earth science classes.

To incorporate foresighted thinking into the classroom, visioning exercises are a primary approach. Creating a vision for the future generally follows four basic steps of investigation: (1) where are we now (current state), (2) where are we going (based on past, present, and future trends), (3) where do we want to be (vision statement), and (4) how do we get there (action plan) (Project Learning Tree, 2006). MacKay and McKiernan (2004) emphasize that attitudes and values shape the vision individuals have of the future, creating a "foresight bias." Constructing a sound vision of the future therefore requires awareness of the causes and consequences of past events. Through visioning activities, students reflect on and discuss the social knowledge—including values and norms—surrounding their vision statements and action plans while also discussing their individual role in achieving that future. Visioning exercises exist in many forms—visual (photography, art, media), verbal (narratives, presentations, word associations), and written (statements, reports, poems) (Wiek & Selin, 2010), thereby allowing flexibility to incorporate relevant activities into a range of classes from writing and art to social studies and earth sciences.

Backcasting and forecasting are additional techniques for creating a future vision (Segalas, et al. 2010; MacKay & McKiernan, 2004). Forecasting is the most common technique used to model and depict various scenarios of the future (MacKay & McKiernan, 2004). Forecasting is simply the application of past data points projected into the future under certain

conditions. Backcasting, on the other hand, involves working backward from future goals to the present after evaluating how the future could be managed and constructed to achieve possible scenarios for attaining the desired goals (Segalas, et al., 2010). Used in conjunction with visioning exercises, backcasting can inform the plans for action to get from the current state to the envisioned state. Collaborating with others during these visioning exercises is useful for promoting respect for multiple perspectives as well as for overcoming 'foresight bias' by building several scenarios of the future (MacKay & McKiernan, 2004). Each of these visioning techniques stresses the importance of individual and collective change through stories and plans for how the future should or could evolve for sustainability.

3. Stakeholder engagement and group collaboration

Overcoming barriers to sustainability requires collaboration across many scientific fields while also considering and diverse values and normative perspectives about how things ought to be (de Haan, 2006). Because sustainability problems are complex, there is no single 'right' solution. Fostering collaboration not only has the potential to mitigate or solve 'wicked' problems; it is also a matter of equitably incorporating multiple views on how to address those problems (Steiner & Posch, 2006). The interdisciplinary nature of the field of sustainability reiterates the need for inclusiveness of multiple scientific perspectives (Wiek, et al., 2011; Segalas, et al., 2010; Sipos et al., 2008; Steiner & Posch, 2006), yet science alone is not enough. The perspectives and experiences of varying stakeholders are also critical for providing local knowledge and information about the values and concerns that inform societal actions. Ultimately, stakeholder engagement and participatory decision making better fulfill public interests compared to the decisions based on the lobbying of select, powerful interests (Agyeman & Angus, 2003). Equipping students with the skills and resources to engage in collaborative decision making is essential for realizing democratic processes that reflect diverse stakeholder interests.

The four knowledge domains can be utilized to address the importance of collaboration, for example, by teaching students about: (1) multidisciplinary information and perspectives on a particular issue, such as engineering, ethical, and policy issues in nano-technology (declarative) (Barben, et al., 2008), (2) how to effectively communicate, negotiate, and resolve conflicts in support of collaborating and participating in group activities (procedural), (3) illustrating how and why sustainability projects have succeeded due to active and engaged citizen involvement, as with the Dudley Street Neighborhood Initiative in which resident-driven plans to revitalize their Boston community were developed and implemented through collaboration with local businesses and organizations (effectiveness) (Agyeman & Angus, 2003), and (4) fostering respect and tolerance of multiple ways of knowing through joint problem solving and mutual learning (social) (Steiner & Posch, 2006). In order to move away from the individualistic, competitive atmosphere, group projects can help build effective communication, team-building, and conflict-resolution skills, along with techniques for managing collaborative projects (Steiner & Posch, 2006).

Segalas et al. (2010) argue that collaboration will result in better products and processes for student learning. In a study done to compare different pedagogical approaches, they found that more community-focused, group-oriented activities resulted in higher cognitive learning and more dynamic interactions than individual approaches. Although classrooms are typically set up for individual work and most assessments are exclusively individualistic, well-established techniques exist for promoting group collaboration and stakeholder engagement. Group collaboration can involve classroom activities, such as group projects, presentations, and role-playing activities, as well as out-of-classroom techniques such as community-service learning. Role-playing—which combines real-world situations and group work—enables students to go beyond just listening to others' perspectives and into the realm of lobbying for others' interests, especially as they take on stakeholder roles and promote the perspectives of particular individuals

or interest groups (Segalas, et al., 2010). A "citizen's jury" is one form of role playing in which students compile research, question "experts," and make informed recommendations based on discussion and deliberation (Agyeman & Angus, 2003, p. 353-354) Community-service learning is also an excellent way to promote group collaboration because it requires students, teachers, community members, and organizations to work together towards a common goal that is mutually beneficial.

Overall, community-oriented approaches enhance learning and facilitate understanding of multiple perspectives (Segalas, et al., 2010), while also offering a potent way to empower students to take action locally (Sterling, 2001). Not only do students learn how to participate in civic activities and group decision-making processes—making it more likely that they will engage again—but they also develop a stronger sense of responsibility within their community (Agyeman & Angus, 2003). In linking group activities to multiple disciplines and systems thinking, students can more effectively engage in problem-solving and decision-making processes that incorporate social, economic, and environmental sciences and a range of other perspectives on complex problems.

4. Action-orientation and change-agent skills

At its core, sustainability is a call for a change from our current trajectory, or in other words, a call to action (Barr, 2003). Sustainability cannot be achieved by simply relying on state intervention, legislation, or new technologies; it requires that people actively participate in decision making, problem solving, and sustainable change. Engaging students in active, applied learning will not only increase their understanding of the content but will also instill in them the importance of action and engagement throughout their lives. Sipos et al. (2008) explain that action learning is a form of experiential learning in which students are asked to question their assumptions and apply new knowledge and skills to diverse situations. Action learning, combined with systems thinking, stakeholder engagement, and foresighted thinking, can facilitate

students' development as sustainability change agents. Promoting change agency isn't simply about taking action but also about understanding the implications of our actions, which requires emotional intelligence, interpersonal skills, and understanding of normative aspects of problems and potential solutions (Wiek, et al., 2011; Segalas, et al., 2010; Sipos, et al., 2008).

While fostering change-agent skills through active education in a specific content area, such as sustainable waste strategies, students could learn about: (1) cases in which change-agents have transformed waste strategies in their communities, for example, looking at Nova Scotia's CBSM campaign to promote backyard composting (declarative) (McKenzie-Mohr, 2000), (2) how to sort recycling and compostable materials (procedural), (3) the amount of waste diverted from landfills due to personal and collective actions in the classroom and local community (effectiveness), (4) overcoming the social stigma associated with sustainable waste strategies (e.g., composting is unpleasant) while also exploring the inequitable distribution of hazardous waste (e.g., e-waste) globally (social). The change-agency approach to education bridges social and ecological systems by exploring students' roles within society and the environment, thereby engaging concepts in the political, economic and civic realms as well as those pertaining to earth processes and the biophysical environment.

Numerous educational case studies illustrate that experiential activities lead to transformative learning (Sipos, et al., 2008; Barab and Luehmann, 2003). Segalas, et al. (2010) found active learning to be effective in teaching competencies such as systems thinking and collaborative communication skills, both of which are vital skills for sustainability change agents. Experiential lessons present an approach to active learning wherein students apply their ideas to new experiences. For example, students could apply learned knowledge about composting and seasonal foods to the task of creating and maintaining a garden (Tidball & Krasny, 2010). Unlike traditional methods, in which the hope is that conceptual knowledge will eventually lead to application, experiential lessons provide an opportunity for students to directly apply their

knowledge. In addition to promoting active engagement, experiential activities also increase long-term retention. In fact, students retain an estimated 80% of knowledge, skills, and values from active participation, in contrast to only 10% to 20% of what they hear or read (Cortese, 2003). Behavioral scholars explain that direct experiences have a stronger influence on people's behavior than indirect experiences (Kollmuss & Agyeman, 2002). Hence, experiential learning has a stronger influence on behaviors than traditional lectures emphasizing declarative knowledge. Beyond providing direct experiences, experiential education also builds students' confidence that their behaviors do in fact bring about change.

Project-based learning (PBL) is a commonly used experiential approach that prepares students for assessments while empowering them to be actively engaged in problem solving, hands-on inquiry, and collaborative learning. PBL typically involves three components: 1) a driving question that organizes a long-term, authentic investigation; 2) the production of tangible, meaningful products; and, 3) collaboration with peers, teachers, and/or members of society (Barab & Luehmann, 2003). Through project-based learning, students actively find, define, and solve problems via collaborative teamwork and active engagement. Another form of experiential education is community-based service learning. Community service is not only action-oriented and place-based but also interdisciplinary, for example teachers and students may work with horticulturists in gardens or contractors in Habitat for Humanity, or biologists in riparian projects. Engaging in community service allows students to observe their teachers, peers, and other community members demonstrating civic responsibility, which in turn fosters a sense of civic engagement as a societal norm. In order to further enhance sustainable actions as the norm, students can make public commitments or pledges in which they promise to change while also asking their neighbors and peers to make a commitment (McKenzie-Mohr, 2000). These commitments can incorporate public-speaking activities as well as artistic displays, or persuasive writing activities.

Place-based projects are also essential in creating an atmosphere in which students feel they have the personal capacity to take action. Projects are most successful when implemented where people feel empowered to act, starting at the local level (Wheeler, et al., 2008). Sterling notes that through local initiatives, "young people can gain confidence and a belief that they can make a difference, and their efforts can stimulate action by parents and the broader community" (2001, p. 68). According to the *Sustainable Design Project* (Wheeler, et al., 2008), effective learning most often occurs when in it is relevant to students' lives, where they live, learn, and play. Developing place-based projects in which the students get to see the impact of their actions is important in building their confidence to act and in developing the skills to engage in decisions about the future.

Table 2

Summary of key competencies and approaches for sustainability education

Sustainability Competencies:	**Educational Pedagogy**
1. Systems thinking and an understanding of interconnectedness	*Concepts:* Interconnections among the environment, economy, and society, including impacts, trade-offs, feedbacks, and unintended consequences of individual and collective actions *Methods:* Real-world case studies with place-based lessons and activities Interdisciplinary approaches to problem-based learning *Avoid 'assembly-line' fragmentation of subjects and oversimplification of issues as simply right/wrong or true/false*
2. Long-term, foresighted thinking	*Concepts:* Future orientation in terms of achieving inter-generational equity, in minimizing the long-term impacts of human actions, realizing societal visions of the future and developing transition strategies and evaluative techniques *Methods:* Visioning exercises Forecasting & backcasting activities *Avoid 'one-size fits all' solutions in visioning activities*
3. Stakeholder engagement and group collaboration	*Concepts:* Democratic decision making, including intra-generational equity in participation and consideration of plural perspectives and transdisciplinary collaborations *Methods:* Community-based service learning Role-playing activities such as mock citizen jury or conflict resolution Group projects and collaborative activities *Avoid evaluating students solely based on individual activities and outcomes*
4. Action-orientation and change-agent skills	*Concepts:* Transformational consumer actions, along with civic and community engagement *Methods:* Experiential lessons including project-based learning, community service-learning, and place-based activities Commitment pledges *Avoid informational learning solely based on declarative knowledge*

Challenges and Opportunities in Educating for Sustainability

Evolving into a sustainable society is a complex challenge which requires new ways of educating for behavior change. Yet, there are barriers to incorporating novel, effective approaches to sustainability education into the current K-12 school system. In particular, short class periods restrict activities (such as community service learning) to weekends or after-school programs, while lengthy lists of standards require teachers to cover traditional subject material rapidly, leaving little time for inquiry and debate (Barab & Luehmann, 2003). Although these factors present constraints to implementing some of the recommended approaches into the current educational system, they are not insurmountable. Many programs are already integrating place-based and project-based learning throughout the curriculum, while embedding interpersonal skills and systems thinking into traditional disciplines including math and science (Garrett & Roberson, 2008; Wheeler, et al., 2008). Collaborative projects and problem-based activities have actually been proven to improve test scores—an important part of the current system—while also contributing to the attainment of sustainability competencies (Garrett & Roberson, 2008; Barron, et. al, 1998). The transition to educating for sustainability may be slow and even piecemeal but it should be pursued immediately and continuously. Educators can begin imbedding sustainability competencies and associated pedagogy slowly, while progressing and adapting towards a new way of educating in light of changing situations and opportunities.

Education has for decades sought value-free knowledge, and thus, the idea of incorporating theories of values, beliefs and norms into education may seem out of place to some educators, students, and even parents (Sipos, et al., 2008). However, the traditional practice of detaching the course content from values and morals does not translate into the absence of values. Sipos and colleagues note, "all curricula are in fact value-laden" (p. 70). In looking towards a sustainable future, we must encourage the imparting of sustainability values and norms through emphasizing cooperative and collaborative efforts as well as promoting sustainable practices such

as recycling and energy conservation. Values and normative aspects of sustainability are embedded within each of the key competencies—systems thinking suggests that we see ourselves as a part of the environment, rather than removed from or ruling over nature; foresighted thinking emphasizes intergenerational equity, hence placing a value on the needs future generations; stakeholder engagement and group collaboration promote respectful inclusion and representation of diverse perspectives; and, finally, action-orientation and change agency highlight the need to evaluate our assumptions, reflect upon our actions, and modify our choices in light of situational and structural circumstances.

Developing curriculum and programs in universities, where they tend to be prevalent (Wiek, et al., 2011; Segalas, et al., 2010; Rowe, 2007), is a great start to sustainability education, but focus on young adults is simply not sufficient to build habits and create change that will persist throughout an individual's lifetime (Shultz, et al., 2007). Working with K-12 schools allows us to not only work with youth but to work where youth spend the majority of their waking hours. Additionally, special attention to youth is essential because socially pervasive behaviors are highly resistant to change once they have formed and engrained in adulthood (Leisowitz, et al., 2005). Corroborating studies have found that habits developed during childhood or adolescence—ranging from dietary and health choices to substance abuse and more—are strong indicators of adult behaviors (Harris, et al., 2005; West & O'Neal, 2004). An investigation into recycling behaviors also found that young students who recycle at school are more likely to develop ecologically-minded waste strategies as adults (Monroe, 2003). By targeting youth and developing pro-environmental behaviors at a young age, such behaviors will become habits and the established norms of a more sustainable society (Shultz, et al., 2007; Werder, 2006; Monroe, 2003; Stern, 2000).

Conclusion

"Achieving sustainability will depend ultimately on changes in behavior and lifestyles, changes which will need to be motivated by a shift in values and rooted in the cultural and moral precepts upon which behavior is predicated" (UNESCO, 1997, p. 34). Changing individual behaviors and motivating collective action is essential to achieving a sustainable future and is therefore a central motivation of sustainability education. Professor William Scott (2002, p. 11) argues that in this way sustainability and education "are necessary bedfellows." We argue that bedding sustainability and education, while a start, may not be sufficient if the current focus on ecological, or declarative, knowledge continues. In order to truly achieve the transformative change that sustainability calls for, behavioral change motivators and constraints must not just guide the educational approaches; they must be deeply incorporated into school programs and curriculum. Schools and teachers are impacting the way in which students interact with society and the environment now and into the future, and this is an opportunity that must be seized and utilized in order to effectively promote sustainable behavior change.

In targeting behavior change through the knowledge domains, we go beyond information retention as a goal of educating for sustainability (see Figure 3). Declarative knowledge can be used to create an understanding of socio-ecological interactions and interconnectedness while also reducing misconceptions and misinformation. Procedural knowledge can explain how to undertake particular actions (e.g., sorting recyclables) while also focusing on local action strategies, such as how to use local public transportation systems. Effectiveness knowledge can illustrate to students the link between their personal decisions and the consequences (both positive and negative) of their actions. Social knowledge can address barriers to change due to social stigmas or cultural norms and through propositioning sustainability actions as positive and desirable. As a whole, a robust approach incorporating diverse knowledge domains as well as other factors is essential to educating for sustainable behavior change.

We acknowledge that many other factors, beyond knowledge, influence behaviors and habits, such as structural and situational constraints. Educating for sustainability is one intervention point for promoting behavioral change but when it comes to overcoming many of these structural constraints, incentives and regulations will also be necessary. Working with schools and promoting sustainability through education is pivotal in creating change but it is not the only arena in which transformation needs to occur. We hope our conceptual approach (Figure 3) and recommendations will help this process, but these alone are not enough. Continual application, evaluation, and adaptation are essential to assuring the long-term vision of a sustainable society is achieved.

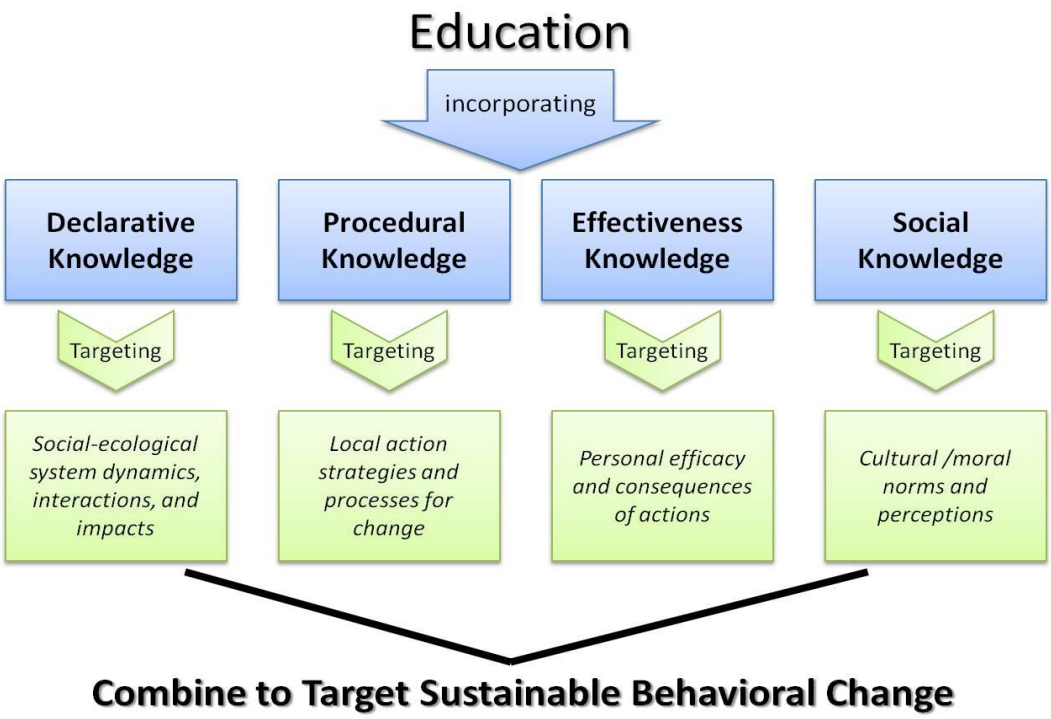

Figure 3. Targeting behavioral change through knowledge domains

Chapter 3

ADVANCING EDUCATIONAL PEDAGOGY FOR SUSTAINABILITY: DEVELOPING AND IMPLEMENTING PROGRAMS TO TRANSFORM BEHAVIORS

Many scholars and practitioners are counting on education to lead us towards sustainability. Unfortunately research indicates that our current education system may be doing the opposite (Rowe, 2007; Sterling, 2001; Orr 1991). Traditional methods of lecture and assessment over-simplify complex issues and trade-offs into right or wrong answers, while emphasizing individual achievement at the cost of positive societal outcomes. All too often, students are asked to absorb pre-packaged information presented by their teachers, even though research indicates that didactic, teacher-centered education results in reduced cognitive and behavioral outcomes (Duerden & Witt, 2010; Segalas, et al., 2010). Educating for sustainability requires that students develop the skills to be change agents and grapple with real-world challenges through explorations that engage multiple ways of knowing and move beyond facts as the central form of knowledge.

In order to build competence in sustainability and promote sustainable change, this research integrates three critical yet mostly disparate bodies of research− *educational pedagogy, behavior change, and sustainability competencies*. In order to test the impact of the behavior change techniques, sustainability practices, and curricula in fostering long-term sustainable change, I developed and implemented a two-week long education program for Phoenix-area middle and high school students called *Progressing towards Sustainability*[1]. This program focused on fostering transformative action through targeting diverse domains of knowledge (declarative, procedural, effectiveness, and social) in regards to food and waste behaviors. I collected extensive data throughout the 2-week program, and continued to collect data regarding

[1] This summer program was supported by the Neely Charitable Foundation Food and Agriculture Sustainability Research Grant program managed by the School of Sustainability, ASU's School of Sustainability, STEM College for Kids (run through the Mary Lou Fulton Teachers College), and the NSF Graduate STEM Fellows in K-12 Education Program (GK-12).

students' knowledge and actions throughout the course of one year (June 2011- June 2012). Through the assistance of grants, the summer program was free of charge for the students and was advertised to groups focused on mentoring low-income, minorities, and potential first-generation college students. In addition to the grants for the summer program, the year-long case study was funded by a CAP LTER grant[2] which enabled me to provide stipends and supplies for the students who conducted interviews with their household members and peers as part of my research throughout the year.

During the 2-week education program and year-long case study, I focused on addressing: 1) How and to what degree does enhancing declarative, procedural, effectiveness, and social knowledge influence sustainable behavior change? And 2) How and to what degree is that behavior change sustained overtime and what were the barriers and constraints to implementing and maintaining the change? Few environmental education programs evaluate both knowledge and behaviors; therefore, the relationship between potential antecedents (knowledge in each domain) and of actual performance (behaviors) is still poorly understood, especially in relation to the motivations and barriers to sustained change (Duerden & Witt, 2010).

The education program focused on promoting a suite of actions specifically regarding food and waste decisions that could reduce students' overall environmental impact. A number of studies have established the importance of environmentally responsible consumption to sustainability, especially in regards to individual dietary habits (Gossard & York, 2003; Heller & Keoleian, 2003) and waste behaviors (Barr & Gilg, 2005; Granzin & Olsen, 1991). Hence, this study proceeds on the assumption that individual food and waste choices are critical components in progressing towards sustainability. The summer program focused on widely accepted sustainable waste practices, including waste reduction, reuse, and recovery (recycling and composting) (Barr & Gilg, 2005) and food practices, including purchasing and consuming food

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that is organic and locally grown, fresh (rather than packaged/processed), animal friendly, and largely plant-based (i.e. reduced meat consumption) (Bissonnette & Contento, 2001; Gossard & York, 2003; Tanner & Cast, 2003; Vermeir & Verbeke, 2004).

Middle school and high school students generally have some control over their food (Bisonnette & Contento, 2001) and waste behaviors (Cherif, 1995) but their specific home and school context, in large part, determines which strategies for behavior change will be most successful. Students selected specific strategies for changing their own food and waste behaviors while considering any personal constraints or barriers to change. Providing choice allows students to focus on behaviors that resonate with them and has been shown to increase learning outcomes and youths' confidence (Patall, Cooper, & Robinson, 2008). Similarly, self-determination theory posits the need for choice so that students select behaviors they perceive as do-able and relevant to their specific environment (Cordova & Lepper, 1996; Patall, Cooper, & Robinson, 2008). Other researchers have found that by successfully implementing one or two sustainable food or waste strategies of their choosing, students are more likely to adopt other, similar strategies in the future, thus increasing the ultimate impact of the education program (Thøgersen, 2004).

Conceptual Approach

In the following section, I briefly review key concepts that underlie my approach to educating for sustainability. I begin by focusing on four domains of knowledge that integrate technical (declarative & procedural) and subjective (effectiveness & social) knowledge in a systematic way that targets barriers to behavior change while providing the skills and confidence to take action (Frisk & Larson, 2011; Kaiser & Fuhrer, 2003). Next, in order to inform the curriculum, I discuss four sustainability competencies that emphasize the complexities of action and change within interconnected social and ecological systems (Cortese, 2003; Wiek, Withycombe, & Redman, 2011). I conclude by addressing education pedagogy in order to

highlight the importance of how we teach, not just what we teach. Throughout, I provide examples of how knowledge domains, competencies, and pedagogy can be applied to educating on food and waste sustainability.

Approach to knowledge domains

This research focuses on prominent behavioral theories and related studies in order to inform the relationship between education and action while considering four different domains of knowledge: declarative, procedural, effectiveness, and social knowledge (Kaiser & Fuhrer 2003). Declarative knowledge refers to traditional social/ecological information, procedural is defined as 'how-to' knowledge, effectiveness knowledge encompasses one's capacity to participate in various behaviors, and social knowledge consists of understanding what is commonly done and judgments of the behavior in a given social or cultural environment (Frisk & Larson, 2011). While the knowledge domains are insufficient individually to explain the motivations behind people's actions, they collectively provide an overarching framework for synthesizing various schools of thought in the behavioral sciences.

Declarative (ecological) knowledge consists of information about how ecosystems function and how people interact with and impact the environment through their actions and decisions. The linear Information Deficit Model (IDM) model emphasizes declarative knowledge, claiming that more environmental knowledge leads to awareness and concern for the environment, and ultimately, to pro-environmental behaviors (Kollmuss & Agyeman, 2002). Psychologists and others have refuted this simplistic assumption, noting that changing behavior is very difficult and information on its own is insufficient to drive change, though the lack of declarative knowledge can form a barrier to changing behaviors (Kollmuss & Agyeman, 2002; Monroe, 2003; Trumbo & O'Keefe, 2001; McKenzie-Mohr & Smith, 1999). Although it is least effective in promoting pro-environmental behaviors, declarative knowledge has been the central focus of most educational programs (Pooley & O'Connor, 2000; Simmons & Volk, 2002). In

terms of food, declarative knowledge includes information such as the amount of water it takes to produce a beef patty or the requirements for achieving organic certification.

Procedural knowledge encompasses 'how-to' information that builds an individual's capacity for action and correlates closely with situational and structural factors that may facilitate or constrain individual action (Kaiser & Fuhrer, 2003; Monroe, 2003). Information about how to participate in decision-making processes as well as knowledge about incentives and restrictions are critical to enhancing procedural knowledge and reducing the barriers to action. For recycling, procedural knowledge would include understanding the how-to's of the local recycling system; some places have curb-side pick-up while others may not and some places may recycle only #1 plastic where as others recycle #1-7.

Third, effectiveness (impact) knowledge is the domain encompassing the individuals' understanding of whether a certain behavior is worthwhile and desirable (Kaiser & Fuhrer, 2003; Monroe, 2003). Stern's (2000) Value-Belief-Norm (VBN) model of pro-ecological behavior highlights two key determinants relating to effectiveness knowledge: the first is the perceived consequences of behaviors, and the second is beliefs about who is responsible for environmental outcomes. These factors relate to a person's "locus of control," which represents the confidence individuals have in their ability to bring about impactful change through their personal actions (Hines, Hungerford, & Tomera, 1986; Kollmuss & Agyeman, 2002; Monroe, 2003). In terms of waste behaviors, such as composting, greater effectiveness knowledge would [in theory] reinforce the students' confidence about their ability to implement and maintain a composting system while also highlighting that composting is impactful, and worthwhile.

The final domain, social knowledge, includes an individual's information regarding the motives and intentions of other people as well as perceptions about expectations in terms of perceived desirability of particular actions or decisions (Kollmuss & Agyeman, 2002), which are often described as norms (Trumbo & O'Keefe, 2001; Stern, 2000). Cialdini (2007) breaks norms

into two different categories; descriptive norms refer to perceptions of what is commonly done and injunctive norms refer to what is approved of or disapproved of by others. The influence social knowledge has upon behaviors is in part dependent upon the individual's need for social approval and awareness of norms. The importance of social norms as a predictor of behavior is especially critical in a normative field such as sustainability, where societal values are central in guiding what we ought to sustain and how. In order to foster positive social norms regarding sustainable food behaviors, for instance, students could share publicly one sustainable food choice they made recently and be applauded by their peers and teachers for said behavior.

Approach to sustainability competences

Competencies refer to concepts and skills that enable students to understand and resolve complex sustainability problems and tasks (Frisk & Larson, 2011). After reviewing the literature on sustainability competencies (Church & Skelton, 2010; Cortese, 2003; de Haan, 2006; Nolet, 2009; Sipos, Battisti, & Grimm, 2008; Wiek, et al., 2011), I focus on four competencies: (1) systems thinking and an understanding of interconnectedness, (2) long-term, foresighted reasoning and strategizing, (3) stakeholder engagement and group collaboration, and (4) action-orientation and change-agent skills. These competencies were selected for their dominance in the literature and relevance to fostering transformative action and empowering students to be change agents in this transition to sustainability. In the sections that follow, I briefly describe each competency as it relates to broad concepts of sustainability as well as classroom specific approaches.

Systems thinking skills

The world is increasingly interconnected and decisions made in one region affect others in a complex array of local to global, human-environment interactions and impacts. Systems thinking skills are therefore essential for being aware of cascading effects, reducing unintended consequences, and assessing trade-offs. In applying systems thinking in the context of education

for sustainable change, it is important not to just talk about interconnected global systems but also to delve into system linkages at the household, classroom, and school scale, these being systems that students impact and interact with regularly. Understanding patterns and interactions enables us to change system processes and components more effectively (Senge, 2006). For instance, students can select one food product from their household and talk with their parents about what influenced their purchasing decision, then research where that food product originated, the nutritional value of the ingredients and how the life cycle of the product connects to the broader system dynamics.

Foresighted thinking & strategizing

Foresighted thinking entails an understanding that the actions we take today have consequences long into the future. Related ideas include long-term and future thinking, anticipatory competence, and intergenerational equity (de Haan, 2006; Gibson, 2006; MacKay & McKiernan, 2004; Wiek, et al., 2011). Foresighted thinking and strategizing inherently places a value on the future and promotes acting in a way that does not impede long-term sustainability or negatively impact future generations (Brundtland Commission, 1987). By engaging in group activities that ask students to share what they want for their future, individuals can explore their visions for a sustainable future in relation to the perspectives of others and to strategize about the decisions and actions that will lead to various future states. The commonly advocated approach to visioning includes four key steps: (1) describing the current state (2) understanding the possible scenarios of the future (based on past, present, and future trends), (3) envisioning an ideal future state (vision statement), and (4) developing strategies for getting from the current state to the envisioned state (action plan) (Project Learning Tree, 2006).

Stakeholder engagement and group collaboration

Sustainability requires collaboration in order to take into account diverse values and normative perspectives about how things ought to be (de Haan, 2006). Building competence in

stakeholder engagement includes equipping students with the skills and resources to partake in collaborative decision making, mediate conflict among opposing perspectives, and negotiate diverse stakeholder interests while acknowledging different visions of the present, past and future. In order to promote open discussion that allows for diverse perspectives to be heard and acted upon, the classroom atmosphere should facilitate collaboration and community engagement while fostering interpersonal skills. When targeting long-term change in food and waste decisions, it is especially critical to engage members of students' households as key stakeholders involved in the decision making process. This can be done through assigning students to interview their parents or even just cook a meal with their parents and report on the cultural or familial significance of that meal.

Action orientation and change-agency

At its core, sustainability is a call for change from our current trajectory, in other words it is a call to action (Barr, 2003). Individual and collective action will be especially crucial in accomplishing the transformative change necessary to shift society away from patterns of over-consumption and inequity (de Haan, 2006). Equipping students with the skills and confidence to take action and become active participants in shaping their future is of prime importance to educating for sustainability. Nolet (2009) laments that action and transformative change are all too often left out of the education agenda, hence stalling reform while promoting the status quo. Progressing towards sustainability requires educating teachers and students for sustainability, not just about sustainability and in doing so they must move beyond information-based approaches and include action as a core competency (Nolet, 2009). Action-oriented education includes, for instance, students composting, recycling, and using of paper made from post-consumer as part of their everyday classroom operations.

Approach to education pedagogy

In a study on the effect of pedagogical approaches in sustainability courses, researchers found that multi-methodological, experiential, active learning approaches improved students' system thinking skills and cognitive understanding of sustainability (Segalàs, Ferrer-Balas, & Mulder, 2010). Even programs focused solely on cognitive outcomes can achieve higher order learning through novel education approaches that engage diverse domains of knowledge (Sipos, Battisti, & Grimm, 2008). Due to their significance to cognitive understandings and skill-building for sustainability, I focus on three interconnected pedagogical methods: real-world learning, critical problem-solving, and experiential learning (Brundiers & Wiek, 2011; Hmelo-Silver, 2004; Segalàs, et al., 2010). Although I utilized a variety of other, more standard education approaches (such as collaborative learning), these three approaches to education are both distinctive and particularly critical when educating for sustainability.

Real-world learning

Real-world explorations incorporate authentic investigations with complex goals and provides opportunities for problem-solving while involving students' beliefs and values (Barab & Luehmann, 2003; Brundiers, Wiek, & Redman, 2010; Frisk & Larson, 2011; Segalàs, et al., 2010; Steiner & Posch, 2006). Debra Rowe writes, "by providing assignments that focus on solving real sustainability issues, educators can engage students and help institutions turn towards more sustainable behavioral and policy norms" (2007, pp. 324). Through real-world learning experiences students apply their classroom learning to study a sustainability issue and engage with people in the community (Brundiers et al., 2010). Real-world learning also enables students to apply theory to practice and builds interpersonal skills for engagement with stakeholders, both of which are critical for sustainability. Real-world learning modules are often place-based so that the curriculum engages in the context of the participants' own lives. Sterling notes that through place-based activities, "young people can gain confidence and a belief that they can make a

difference, and their efforts can stimulate action by parents and the broader community" (2001, p. 68). By situating real-world learning modules in the local context, students will develop the knowledge and skills to be change agents in their own lives, homes, and schools

Four methods provide real-world learning experiences to students: (1) bringing the real-world into classrooms (e.g. guest speakers), (2) visiting the real-world (e.g. field-trips), (3) simulating the real-world (e.g. role playing activities), and (4) engaging with the real-world (e.g. interviews with household members) (Brundiers, et al., 2010). When focusing on food systems, students can simulate the real-world by taking on the role of farmers, school principles, parents, students, and teachers in a debate involving improving school lunches. Through role-playing, the students advocate for the perspective of their interest group while working with the other groups to create a compromise amongst each stakeholder involved in the debate. Successful role-playing activities should be coupled with at least one other real-world experience; for instance, bringing in guest speaker to discuss school lunches with the students, or by having the students interview a person who represents one of the interest groups involved in the activity.

Critical problem-solving

The field of sustainability has emerged largely due to existing and anticipated complex problems, such as climate change, desertification, and environmental injustice (Wiek, et al., 2010). In order to better understand and hopefully solve these 'wicked' problems, sustainability scholars have focused on teaching approaches that are problem-driven and solution-oriented. Problem-based learning centers on a complex problem that does not have a single correct solution (Hmelo-Silver, 2004). The critical thinking and problem-solving process should be student-led, experiential, and collaborative in order to emphasize that there is more than one correct point of view when exploring problems. Although there should be debate about the solution(s), focusing on problems without discussing actionable solutions and strategies can leave students feeling disinterested (Scott, 2010). Rather than overwhelming students with a barrage of large-scale

environmental catastrophes, students should focus on simple problems and solutions that promote individual agency and reduce the likelihood of distressing or distancing due to negative feelings (Kollmuss & Agyeman, 2002).

Good problem framing should be tangible, resonating with the students' lives, and the solution to the problem should be actionable. In Hmelo-Silver's research on problem-based learning (2004), she found that distant goals that seem insurmountable to the student can be disempowering. Research indicates that the problem chosen for the classroom should be focused around issues of a scale and complexity that will enable and empower the students to act (Hmelo-Silver 2004; Sterling, 2001). In my case study, I focused on problems associated with consumption and disposal of food and waste because there are multiple intervention points at the individual, household, and classroom scales at which students interact. Although many of the problems we explored, such as the accumulation of plastic debris in the environment (Thompson et al., 2004), have simple and achievable solutions, like using a reusable bag, bottle, and mug instead of the disposable alternatives, these issues are indicative of larger sustainability challenges. UNESCO chair, Dr. Arjen Wals notes, "The story of plastic in a sense captures the urgency, systemic nature, magnitude, uncertainty, ambiguity, complexity as well as the moral and ethical underpinnings of the sustainability challenge" (2010, p. 6). Connecting an individual scale solution, such as choosing reusable products over disposables, to larger systemic challenges allows students to feel empowered, while acknowledging the broader system and environment with which this problem was created and propagated.

Experiential (active) learning

Engaging students in active, applied learning not only increases their understanding of the content but also emphasizes the importance of action and engagement in their lives. Experiential learning provides direct experiences and contextualizes learning by applying knowledge to action. Sustainability scholars have pointed to experiential learning as a way to

empower, engage, and motivate students while also breaking down the typical compartmentalization between action and education (Cortese, 2003; Sipos, et al., 2008). Additionally, direct experience is far more persuasive in developing pro-environmental behaviors as compared to indirect experiences (Duerden & Witt, 2010; Kollmuss & Agyeman, 2002). Developing sustainable operations within the classroom creates a context for conversations about sustainability, provides direct opportunities to engage in sustainable practices, and empowers students by equipping them with the skills to take action (Higgs & McMillan, 2006).

In providing direct experiences for students to practice sustainable behaviors in the classroom, teachers are able to also model sustainable behaviors. Researchers have found that inconsistency between the concepts being taught and the unsustainable behaviors that are demonstrated by instructors decreases both the likelihood of educational effectiveness and of transformative change (Huggs & McMillan, 2006). In addition to developing consistent intended messages about sustainability, building sustainability actions into the classroom is also essential for effectively integrating behavior change tools and knowledge domains. For instance, without actually having a composting bin in the classroom (or school) it is difficult to go beyond declarative knowledge in a unit about organic waste as many of the other domains require hands-on interactions. Building procedural knowledge about composting could include sorting the waste correctly into the various bins; effectiveness knowledge could be enhanced by measuring the amount of waste diverted from the landfill through composting; and social knowledge could be addressed through rewarding students for composting. Sustainability education researchers, Higgs and McMillan (2006, pp. 44), wrote, "carrying out sustainable behaviors is a necessary precondition to effective sustainability modeling," and modeling can strongly impact students' knowledge, skills, values, and actions.

Methods

Logic models create clear connections between planned work and intended results and therefore provide a clear organization for my methods (Kellogg Foundation, 1998). As seen in the logic model (Figure 4), the sustainability competencies informed my approach to pedagogy while each activity targeted various domains of knowledge. The following section begins with a brief overview of education methods (Part I), then moves into the data collection and analytical approach used throughout the year (Part II). The education methods are organized by the program theme, sustainability competencies, and the data collection methods are organized by data type, quantitative then qualitative. Both the education and data collection methods focus on targeting and assessing the acquisition of knowledge domains and sustained behavior change.

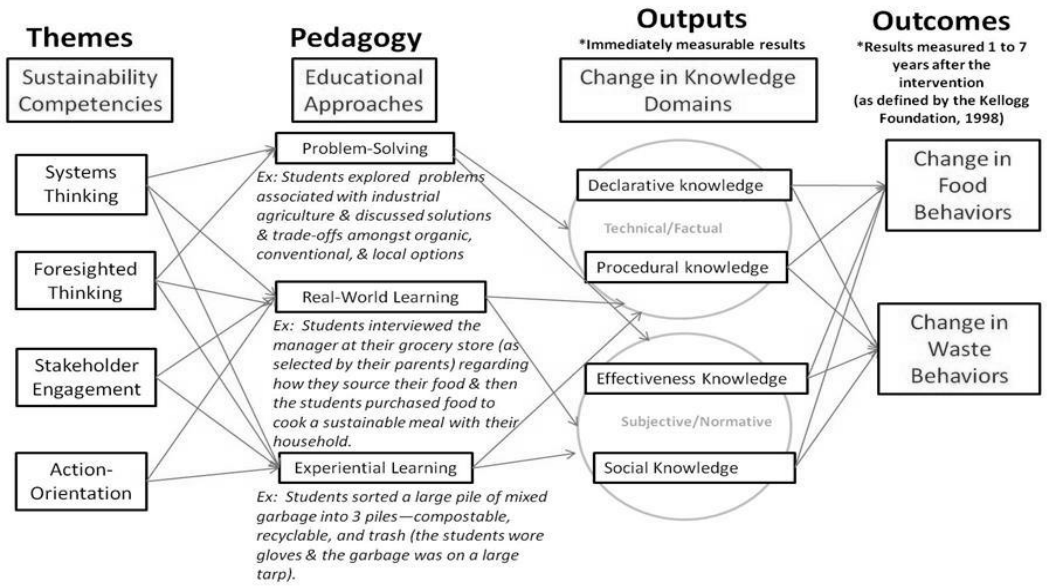

Figure 4. Approach for targeting behavior change outcomes

Part I: Sustainability education methods

The summer program was held during June 2011 at the School of Sustainability on the Arizona State University campus. There were 3 middle school students, 3 high school students, and 3 K-12 teachers in attendance throughout the two weeks. All six students described themselves as Hispanic or Latino and the highest level of education achieved by their

parents/guardians was high school. With grant funding[1], I was able to target low-income youth and provide free tuition as well as sustainable lunches each day, light rail passes to and from the campus, and materials necessary for undertaking sustainable behaviors at home and school (e.g., reusable bags, composting & recycling bins, gift cards for purchasing sustainable food).

This section is organized by the competencies since they provided the structure for what should be taught and how during the summer program (Figure 4). In providing a few specific examples and strategies from my education program, I highlight how the key sustainability competencies informed my approach to educating about sustainable food and waste strategies. Each competency was integrated into my education methodology during both the food-focused week (week one) and the waste-focused week (week two).

Educating for systems thinking

During the food-focused week, students explored their local food system by tracking what they ate, where their food comes from, and how it is produced. Foundational to this portion was the students 'interviewing' their household members as well as a manager at their local grocer, thereby also improving their interpersonal competency. The students began by examining their personal food choices (tracking their daily eating habits and household purchasing patterns) and then traced the connected system outwards (visiting and exploring the local grocery store), ultimately arriving at the broader implications (researching and engaging in life cycle analysis activities) of their individual food decisions on collective social and environmental change. By engaging students first in their personal motivations and decisions, I was able to frame the discussions and activities around their choices and preferences as well as values and norms, rather than beginning the education program with unfamiliar values and seemingly, insurmountable challenges associated with our complex, global food system.

While exploring the relationships between food miles, prices, and agricultural practices, complementary learning modules engaged students in issues of water quality, health and

nutrition, labor practices, and equity. In one such activity, students were asked to engage in higher order learning by evaluating local, organic, and conventional food products based on economic, social, and environmental criteria. For this activity, actual products (i.e., different types of salsas) were used rather than creating hypothetical products/brands because it better prepares students for assessing the sustainability of their own food choices in the 'real-world.' The students discussed the (un)sustainable aspects of each product and worked together to design an ideal product that meets or exceeds the social, economic, and environmental sustainability criteria discussed in the lesson.

The goal of this activity was not simply identifying the 'right' product to purchase but rather fostering an understanding of how our food decisions are connected to social equity, access to economic opportunities, and environmental health locally and globally. The students mutually came to the conclusion that there are trade-offs associated with each product and that elements of uncertainty associated with the life cycle of products make the evaluation process more complex. Throughout the exploration of their local food system, students were also asked to reflect upon how they as individuals could progress to more sustainable food behaviors and to commit to trying various strategies during the course of the program and afterwards.

Educating for foresighted thinking

During my education program visioning exercises were used to engage students in foresighted thinking. Through the visioning activity, students reflected on and discussed social knowledge—including values and norms—surrounding their vision statements and action plans while also acknowledging their individual role in achieving that future. On the vision boards students crafted vision statements, wrote stories about the future they would like to see, drew and cut out pictures from magazines that represented that vision, and created personal action strategies that would contribute to achieving their vision. One group envisioned a future in which people have greater connections to their food and deeper relationships with the cultivation

process. Their vision board included things such as school, community, and home gardening. In creating their personal action strategies, the students discussed the deliberate decisions and changes that would have to be made as well as the strategies and stages for implementation required to achieve their desired outcomes.

Visioning exercises are in part about understanding the relationship between present actions and future consequences. Throughout the program, the students developed action plans and strategies for change so we used their previous selected actions as the entry point for the visioning exercise. The students were asked to connect their strategies and actions (e.g., eat less meat) to their broader long-term visions (e.g., cows return to grass ranging and are an integral part of improving soil quality and farm sustainability). We discussed several future scenarios along the continuum between an ideal food system and an unhealthy, unsustainable system. By building out several scenarios of the future, the students began to understand that the vision they were creating contained many components, beyond eating meat, including an array of actions, strategies, and decisions that led to a desirable or undesirable future. The final vision statement should tell a story of what the future should or could evolve to, while the strategies and action plans elaborate the specific individual and collective changes which would be needed in order to lead to achieving that vision. The students in the summer program created two vision boards; one group focused on the consumption and production of local, fresh, and organic food through the expansion of community gardens, farm to school programs, and farmers markets, while the other group focused on reforming the meat industry through reduced meat consumption, decreased confined animal factory operations, and an increase in pasture raised animals that have a natural, hormone free diet.

Stakeholder engagement

My education program utilized collaborative learning techniques, group work, and stakeholder interviews in an effort to improve interpersonal skills and promote collaboration.

During the summer program students were asked to go to their local grocery store with their parents to interview a manager about the selection (or lack of selection) of organic and sustainably sourced foods. Then they were asked to purchase sustainable foods (gift cards were provided), prepare a meal with their household members using that food, and interview their parents/guardians about how and why they currently make the food purchasing decisions they do. The students were asked to develop strategies with their household members based on what they learned during the program and what their household members' value when making food purchasing decisions. As part of their action plans, they were also asked to develop a strategy for sharing their experience throughout this food exploration with a peer. Including key stakeholders in the students' action plans—that is, their household members, grocery store managers, and peers—not only fosters interpersonal skills but also, it was hoped, increases the likelihood of success after the program due to external support for the actions.

In addition to the outside of the classroom experiences, students had the opportunity to engage with stakeholders throughout our regular programming. We visited restaurants (e.g., Engrained—an ASU campus restaurant focused on locally grown and harvested food prepared to order), sampled food items from various local sources (e.g., farmers markets and community gardens), and talked with ASU's food service provider as well as the director of the Phoenix Pubic Market and Community Food Connections (a local non-profit focused on improving access to healthy food in underserved areas through expanding outlets for and production of local food). Engaging with local companies, non-profits, and change agents within the food industry provides students with multiple perspectives on food sourcing and purchasing while also being place-based and experiential. At the end of the week, we reflected upon the trade-offs involved in food purchasing decisions and the importance of including a broad array of individuals in developing strategies for a sustainable food future.

Educating for change-agency

In the summer program, action orientation was a dominant theme and was imbedded into my approach to teaching all of the sustainability competencies and knowledge domains. To address waste strategies through an action-oriented activity, everyone brought in garbage from their homes which we displayed on a large tarp, and then the students sorted the garbage into compostable, recyclable, and landfilled trash piles. Once the piles were created, we asked them to look at the pile destined for the landfill and reflect on what they could do to reduce that pile through reuse and reduce strategies. We looked at the recyclable pile and identified which items were already made from post-consumer content and which of the recyclable products would mostly likely be up-cycled versus down-cycled. In exploring the compostable pile, the students reflected that the remains of healthy, nutritious things (fruit and vegetable scraps mainly) made up the majority of compostable items so there is clearly a link between eating healthy foods and composting waste. Rather than just talking about these issues in a hypothetical sense, the students collected their trash over the course of the program and physically sorted it while noting how they could change some of their currently unsustainable waste strategies.

As seen in Table 3 (below), the education activities included eating, cooking, grocery shopping, sorting, building, and many other action-oriented lessons. Students individualized their action strategies and developed a personalized plan for achieving their goals, hence providing autonomy while simultaneously promoting action. Many of the action strategies were developed in conjunction with the students' household members. For instance, the students' guardians were sent home forms asking them which waste strategies they would be interested in doing: recycling, worm composting, or outdoor composting. They were asked to select one, more than one, or none and then check what materials they would allow their children to take home in order to implement the strategies. Providing students with a supportive environment for taking action is central to maintaining the change in the long-term and reducing the barriers to implementation.

Table 3.

Action strategies and associated activities that target various knowledge domains

Food Related Strategies & Activities (Week 1)		
Action Strategies	Education Activities	Knowledge Domain & Justification
-Reduce meat consumption -Substitute chicken for beef >1/week - Commit to meat-free week each month -Eat a vegetarian meal >1/week (e.g., meatless Monday)	-Ate vegetarian lunches every day & shared recipes with students -Students prepared vegetarian meal with families & shared their meal plans & feelings with the group -Students brought in their favorite vegetarian snack to share with the class	Procedural & Social: Students observe their teachers & peers eating sustainable lunches while also developing their skills to cook at home. These activities also provide direct, real-world experiences.
-Choose local &organic products when possible -Purchase food from growers by shopping at farmer's markets	-Ate at restaurant focused on local, sustainable food production & spoke with chef and sustainability manager about the restaurants commitment to sustainability -Students created life cycle diagrams of organic, local, & conventional products & evaluated them based on sustainability criteria -Students spoke with the director of the largest farmers market in the city & ate lunch provided by the farmers market	Declarative, Effectiveness, & Social: Students learned about the classifications for food production & sourcing and experienced sustainable food in an accessible and deliciously prepared way. They spoke with food professionals about the positive aspects of using sustainable food in restaurants & purchasing at local farmers markets.
-Avoid highly processed foods -Choose fresh foods when possible	-Students brought in cereals & other breakfast items they typically eat & we analyzed the nutrition labels -Students kept food journals & shared their choices with the class	Declarative, Procedural & Effectiveness: Students learned how to read nutrition labels & through tracking their food they were able to reflect upon how & what they could change.
Waste Related Strategies & Activities (Week 2)		
Action Strategies	Education Activities	Knowledge Domain & Justification
-Use re-usable bags instead of disposable plastic -Choose products with less or no packaging	-Students used their reusable bags at their grocery store & reflected on the experience in journals & in class -Students selected products with little or no packaging at the grocery store & kept food/packaging waste for the sorting activity described below	Procedural & Effectiveness: The students learned how to reduce their waste through real-world, hands-on experience, which also increased their confidence to implement these strategies the future.
-Use a re-usable mug or water bottle instead of a disposable product	-Students received stars next to their names each day they remembered their reusable water bottle & were given prizes at for the most stars	Effectiveness & Social: Providing positive incentives and feedback can help foster positive attitudes about the behavior
-Recycle and sort your recyclables appropriately	-Students made signs for their new household recycling bins (for those who selected this strategy)	Procedural: The sign reminds students at the point of action to recycle & what they can recycle.
-Compost your organic materials	-Students sorted garbage into compostable, recyclable, and trash (landfill) -Students built composting bins (if that was one of their selected strategies)	Procedural, Effectiveness & Social: Students demonstrated they knew how to set-up & maintain a composting system. Students were able to promote composting as the norm in their homes.

Part II: Assessment methods

To examine knowledge among the students, as well as the changes during and after the education program, I utilized a variety of approaches: pre- and post-surveys, observations (videos of every session and copies of students' journals and assignments), and interviews (see Figure 5). This mixed-method approach provided both qualitative and quantitative data that together create a more holistic picture of the impact of the intervention on student knowledge and behaviors. In addition to the data collected during the summer program, I continued to work with three of the six summer program participants through a CAP LTER grant[2]. With the support of this grant, I was able to collect data on these three students' barriers, motivations, and social constraints to sustainable behavior change over the course of a year. In order to understand the students' change in relation to their context, each student interviewed five or six family members and/or friends, for a total of sixteen interviews amongst the three students. Although there are obvious limitations to working with only three students for the year-long research, collecting detailed data on each student enabled me to explore the underpinnings of sustainable change in the context of their lives and specific circumstances. By treating each student as an individual case for understanding the relationship between the education program, knowledge domains, and sustained behavior change, I aim to not just posit that change occurred but also to explain in what context and circumstances sustained behavior change was achieved.

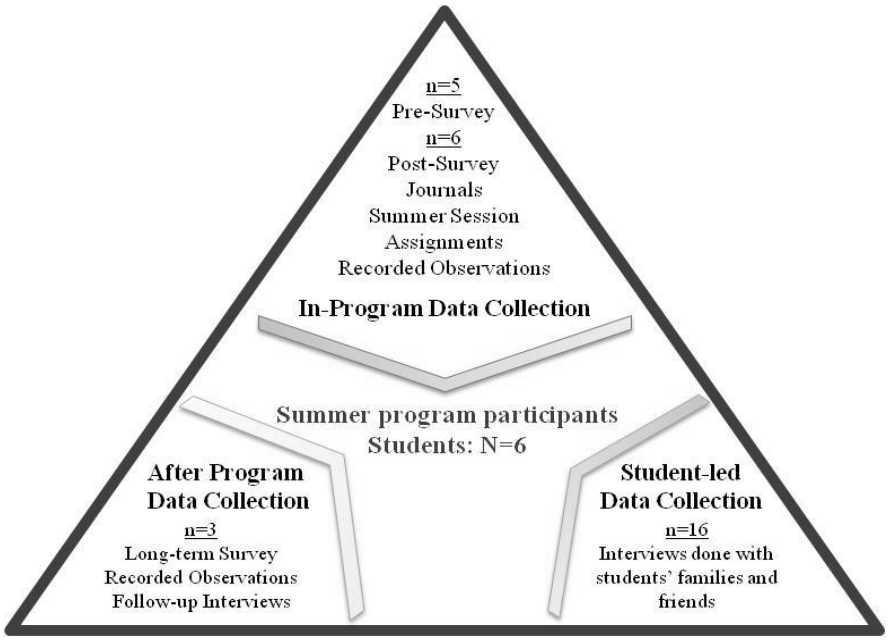

Figure 5. Triangulated data collection

The pre- and post-program surveys

The pre-program survey consisted of 106 questions, 19 of which were open-ended. The close-ended questions utilized a 5-point Likert Scale to assess knowledge in each of the four domains and to measure the frequency of food and waste behaviors (see Appendix A for more information). The post-survey differed from the pre-survey in that it did not ask for demographic information (as these responses would not change over the course of two-weeks), the open-ended questions were adjusted to enable the participants to reflect upon what they enjoyed most/least about the program and the close-ended questions regarding behavior were changed from what they did over the past year (pre-survey) to what they plan to do during the upcoming year (post-survey).

The first step to analyzing the results of the survey was to standardize[3] the responses so that 5 always indicated the most sustainable response. Once the data were standardized, it was

[3] Standardization was accomplished by taking those questions where a response of 1 was considered most sustainable and reverse coding it so that 1 became 5. The responses to the surveys were therefore

necessary to reorganize and group the data first by knowledge domain/behavior and then by food and waste. Two different approaches were taken for analyzing the results. First the whole groups' responses to each question were taken together and averaged for each domain and associated behaviors comparing responses in the pre- and post-surveys (Figure 6). This approach results in five pre-program averages and five post-program averages for both food and waste and allows for a comparison amongst the domains of knowledge (i.e., which domains changed the most/least due to the program). The other approach was to create an overall knowledge and behavior score for each student, pre- and post-program. This was done by averaging their responses for each knowledge and behavior domain, and then averaging those results together (this weighs each knowledge domain equally regardless of the number of questions). This method does not separate out the domains but rather gives one knowledge score for food and for waste and then compares that against the associated behavior scores. This enables a comparison of the participants' knowledge and behavior pre- and post-, visualizing the changes to knowledge and to behavior for each participant (Figure 7).

Mixed methods for participant observations

A variety of studies have suggested that utilizing the educator to observe student behaviors is an effective approach (Hay, Nelson, & Hay, 1977; Hay, Nelson, & Hay, 1980). During the summer program, I was the educator and due to the difficulty of recording observations while being the instructor, I employed a variety of different methods to ensure that critical information was not missed, including video recording, copying student journals, and taking field notes[4]. Also, given that behavior is such a central part of my research, I put up a poster in the room to record when

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standardized so that the score of '5' on the graphs always represents the highest level of sustainability knowledge or behavior.

[4] In order to directly record the students' behavior, I had a video recorder set up in the back of the classroom. I took notes regarding interesting comments and behaviors (field observations) as well as writing reflections at the end of each day. The students were asked to journal at home and take notes throughout the program in their own notebooks, and I copied their notebooks, with their permission, at the end of the program. I made copies of many of the student worksheets, such as their commitment pledges and action plans.

students were ‘caught behaving sustainably’ and stickers were placed next to student’s names when they brought their reusable bottles/bags/utensils to class and, recycled, composted, or otherwise publicly acted sustainably. The poster allowed me to build-in recording behaviors as part of the curriculum while positively reinforcing sustainable behaviors.

Many educational programs only collect data during and immediately following the intervention. Although that may effectively capture short-term results, in sustainability we are interested in fostering long-term change. Therefore, I contacted all of the participants and their parents six months after the program and asked if they could meet for a follow-up interview. Despite multiple contacts with each participant, I was only able to get fifty percent of the students (3 students) to participate in interviews as part of a semester long follow-up research program.

The three students who participated in the follow-up research were given stipends to compensate for their time and in return were asked to interview the six most influential people in their lives and develop and implement a sustainability campaign or project of their choosing in their school. The three high school students, myself, and an undergraduate sustainability student worked together to develop interview protocol to be used with selected family and friends. The final interview protocol consisted of 25 questions; 12 regarding waste behaviors (recycling, composting, and reuse) and 13 about food behaviors (purchasing and consumption of meat and organic, local, and processed foods). We met once a week during spring 2012 to discuss the interviews and the students’ efforts to implement and maintain sustainable strategies at home and at school. During these weekly meetings I continued to collect data by taking notes, having an undergraduate sustainability student record the high school students’ comments and actions, and by copying the students’ journals and interviews. This data provides key insights on the barriers and constraints to change and has allowed for a more detailed analysis of the program’s effectiveness.

Due to the intensive nature of the qualitative data collected on the three students who participated in the year-long follow-up, I focus my qualitative analysis on only those three participants. Following a case study approach, I document each student's knowledge and behaviors as well as their broader social situation in order to fully develop a holistic picture of the motivations, barriers, and environment surrounding and affecting un/sustainable choices.

Results

The following section will begin by detailing the results that were collected through the two-week summer program and then move into the results found over the course of the year-long follow-up, first detailing the quantitative results then the qualitative results. The anonymity of all participants in this study has been protected. As I describe each student's cultural and peer environment, journal contributions, interview, and survey results, I use a pseudonyms for each participant.

Student survey results from summer program

Overall the students' sustainability knowledge (as measured by the survey) increased in all four knowledge domains in terms of both food and waste over the course of the program. On average, the students' pre-program knowledge regarding waste was greater than that of food in three of the four domain areas, with the exception being social knowledge (Figure 6). Although the average post-program scores for waste knowledge were high, the change between pre- and post- knowledge regarding food was greater, in part because students entered the program with less food knowledge. The highest average post-program knowledge score across all four domains for both food and waste was that of *food* declarative knowledge. In spite of the greater shift in food knowledge amongst three of the four domains, *waste* behaviors changed more than *food* behaviors. This may be due to the rigidity of social knowledge regarding food, with the post-program averages barely increasing from pre-program social knowledge averages. The change in social knowledge regarding waste choices was greater than for food, but still less than the shift in

the other three domains of knowledge for waste. These survey results show that the outcome of behavior change in terms of *waste* was more successfully achieved than that of *food*, while the qualitative data suggests reasons for the resistance to change in terms of food behaviors.

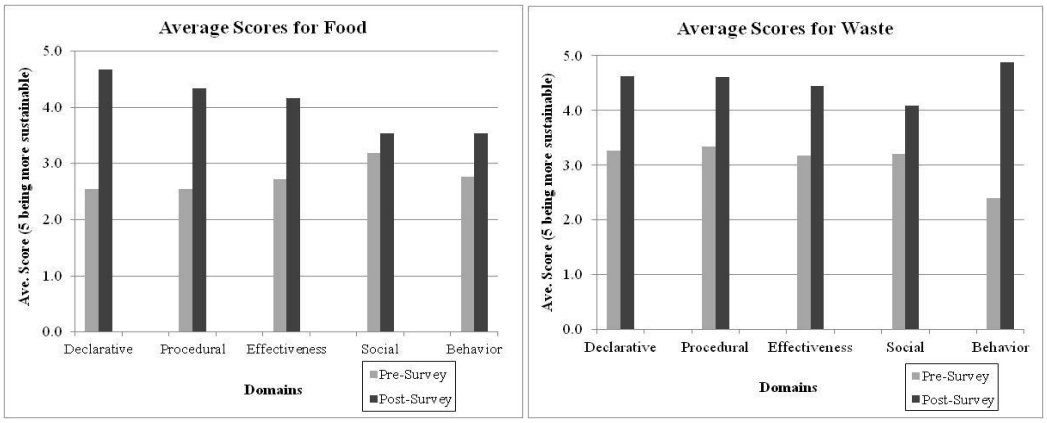

Figure 6. Average food and waste scores for each domain and associated behaviors

From Figure 7, one can see that the students were grouped in the pre-survey and that the responses on average changed similarly for each student so that they ended up grouped after the summer program as well. One of the 6 students did not take the pre-program survey because the coordinators of the STEM education program brought him to the wrong program on the first day, so his data is not included in the graph below. The behavior scores for the pre-program survey represent the behaviors they reported engaging in previous to entering the program and the behavior scores in the post-program survey represent the sustainable behaviors they intended to engage in after the program. For each student their score in the knowledge domains increased to an average of between 4 and 5 for both food and waste. In spite of the knowledge scores being comparable (as seen on the x-axis on Figure 7) the change in behaviors was very different for food and waste. The students scored virtually as high as possible for the waste behaviors they planned to take up after the summer program, whereas their intended food behaviors averaged only slightly more sustainable than from before the program.

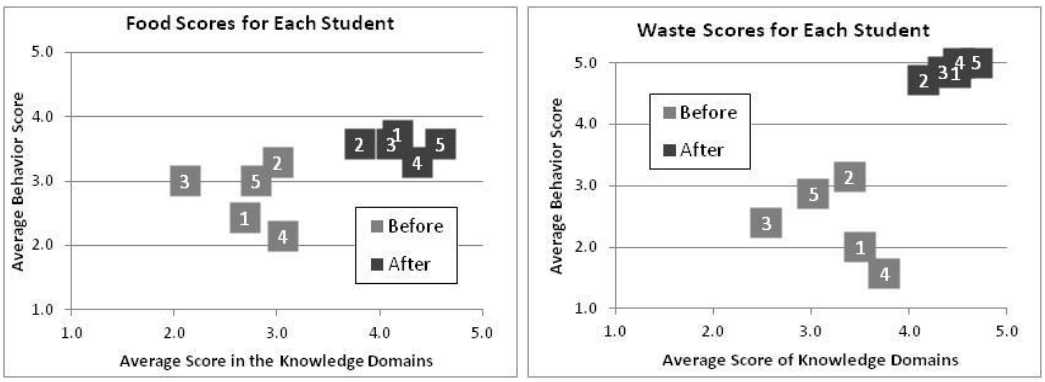

Figure 7. Food and waste scores before and after the program for each student

Year-long case study survey results

In order to better represent the long-term behavior change that occurred, I focus on a couple of specific food and waste behaviors amongst the three students who I studied over the course of a year. In Table 4, the survey results compare the pre-program survey, post-program survey, and the long-term follow-up survey[5] for reuse (reusing bottles/bags/napkins) behaviors, meat consumption, and organic food purchasing. These results demonstrated that long-term change did occur but behaviors did not change as much as expressed intentions (in the pre-survey) indicated they would. The long-term survey also shows that the sustainable waste behaviors are done more frequently, many done on a daily basis or every time the opportunity arises, as compared to the sustainable food behaviors that are done on a weekly to monthly basis for all three students.

[5] The question format varied only in the time frame that the questions were referring to. For the pre-survey, students were asked about their behaviors over the past year; in the post-survey they were asked about what they plan to do over the next year (intentions); and in the long-term follow-up survey, students were asked about what they actually did over the past seven months.

Table 4.

Examples of changes in participant reported behaviors

Survey Questions	Survey Response Period	**Survey Question Format:** (Daily to Yearly, 5-point scale) *Pre-survey*: Over the last year how often did you…. *Post-survey*: Over the next year, how often do you plan to….. *Long-term survey*: Over the past 7 months how often did you……		
		Student 1 (John)	**Student 2 (Jane)**	**Student 3 (Jill)**
Use reusable, washable napkins instead of paper ones?	Pre:	Weekly	Never	Never
	Post:	Daily	Weekly	Daily
	Long-term:	Daily	Monthly	Monthly
Use cloth or other reusable bags at stores (instead of plastic/paper bags given at checkout)	Pre:	Weekly	Never	Never
	Post:	Daily	Daily	Daily
	Long-term:	Weekly *(every time we go to a store)*	Daily	Monthly
Reuse my water bottle	Pre:	Monthly	Weekly	Never
	Post:	Daily	Daily	Daily
	Long-term:	Weekly	Daily	Daily
Eat meals with no meat (chicken, beef, pork, etc.) at all.	Pre:	Monthly	Monthly	Never
	Post:	Monthly	Daily	Monthly
	Long-term:	Weekly	Monthly	Monthly
Buy organic foods over non-organic ones.	Pre:	Monthly	Yearly	Never
	Post:	Weekly	Monthly	Weekly
	Long-term:	Monthly	Monthly	Weekly

Qualitative results for year-long case study

For the three students, who were involved in this project over a year, I have detailed qualitative data regarding their families' and friends' behaviors, values, and attitudes as well as their own knowledge and behaviors. In the section that follows, I will explain how and why the students changed (or didn't) given particular motivations and constraints associated with the various behaviors.

Student 1: John

John is a high school student at one of the large public schools where he is in an advanced track because of his academic aptitude. He does not live with his father and his mother has passed away so he has taken on many of the tasks that adults often perform in a household, such as purchasing food and taking out garbage. John shares his house with his older brother, sister-in law, niece, and younger brother. Although his independence affords him greater agency, it also presents unique barriers associated with being a high school student and running a household simultaneously. John participates in a mentor program and his mentor is a professor in the School of Sustainability. John's mentor composts, recycles, and partakes in many reuse behaviors but he is less engaged in sustainable food behaviors. John's mentor, brothers, and friends all commented that they eat meat every day and don't regularly purchase local or organic food because of convenience or cost. Of the six people who John interviewed, three of them currently live in his household and those three are the ones whose behavior shifted most due to John's participation in the program (see Figure 5).

John's waste behavior changed significantly in the long-term due to the summer program. Before the summer program, John's household did not recycle. On John's pre-program survey, he wrote that his neighborhood did not have curbside recycling; this demonstrated a lack of procedural knowledge because his neighborhood did have curbside recycling. I looked up his neighborhood on the City of Phoenix website and we discussed his neighborhood's recycling program. Some of his family members do not have residency paperwork and they were concerned about calling the city to ask for a bin. In order to overcome this barrier, I called the city and asked to have a recycling bin delivered to their house (before for program was over the bin had arrived). In addition to the curbside bin, John was given a recycling bin for inside their house and he created signs for the bins so that his household members would know how to appropriately sort recyclables, again demonstrating enhanced procedural knowledge. In the post-

program and long-term surveys, John noted that his neighborhood does have curbside recycling and that he has been recycling at home on a daily basis.

Eight months later, John noted that "recycling has been the easiest sustainability action to maintain since the summer program because the recycling bin at home makes it more convenient." In addition to recycling, John's household also began composting and was still composting regularly, one year after the program. The education program has changed not only John's behavior but also that of his other household members (see Figure 5). As a leader in the household, John has taught the other members of his household how to recycle and compost. Additionally, he implemented a recycling project in his school in which he placed 11 new recycling bins (purchased with the CAP LTER grant) throughout his school with signs explaining what can/not be recycled. His confidence to create positive change as well as his capacity to implement change over the long-term demonstrates enhanced effectiveness knowledge in regards to sustainable waste behaviors.

John's favorite activities during the summer program and spring meetings were all related to food sustainability. He noted that his favorite homework assignment during the summer program was buying sustainable food at a store and his favorite in-class activity was eating at a sustainable restaurant (the students were served food every day so this was not simply because he was given lunch). A year after the program, he commented on the restaurant's local and organic food selection, and highlighted a tour of the campus garden as one of the most fascinating parts of the program. Even though he was able to recall information (declarative & procedural knowledge) about pesticides and synthetic fertilizers used in non-organic agriculture and facts about water-use and beef, as well as the economic benefits of local food, he did not feel confident in his ability to initiate significant food changes in his household (effectiveness knowledge) and the norm in his household is to choose food by cost (social knowledge). Although any measurable change in food decisions is difficult to fully decipher, John reflected that he chooses

vegetables over chips when he has the option and since the program has visited a local farmers market a number of times with his brother's girlfriend and his mentor. Food behaviors may be more resistant to change than waste behaviors but the summer program spurred small changes that could lead to more transformative change in John's future.

John's transformation goes beyond recycling, composting, and eating vegetables. Through this program he was empowered to create change in his home and school, becoming a leader for sustainability. However, John's greatest transformation is in his hopes for the future. During the program we had many professionals in sustainability speak to the students about their careers and the passion they have for what they do. This seemed to resonate strongly with John because he is now planning on pursuing a career in sustainability, specifically sustainable design and architecture. Before the program, he noted that he did not even know what sustainability was, now he wants to pursue it in college and thereafter.

Student 2: Jane

Jane is a sophomore at a private high school. Jane and her sister both participated in the summer program and follow-up research. Jane's household consists of her mother, sister, brother, grandmother and grandfather. Jane's mother works full-time and supports her daughters in all their athletic and academic opportunities. Jane plays sports year-round and is active in many school clubs, making time a big barrier for many activities such as spending a Sunday at the local farmers market or even cooking dinner at home.

Jane's favorite activities during the summer program were separating the trash into recycling, compostable, and landfilled and for homework she enjoyed tracking her trash. Her favorite products she received during the summer program were the reusable water bottle and compost bins. One year after the program she noted that recycling was the easiest sustainability action to maintain and that having a bin inside for sorting trash in the kitchen was very convenient. Prior to the summer program, her family had to walk outside to the curbside bin to

throw away any recyclable item but through the Neely Grant[6] their household was given an indoor recycling bin so they only had to take the recycling out once a week. The indoor bin enabled Jane to overcome the perceived inconvenience of recycling. Jane commented that she feels she has influenced her mom to behave more sustainability because now "my mother is always throwing things in the recycle bin instead of the trash." The only member of her household who Jane formally interviewed was her grandmother and the interview indicates that she changed her grandmother's waste behaviors significantly. Jane's grandmother is thrifty and likes the idea of using less, hence he has been a big supporter of Jane's efforts to reuse products and reduce consumption.

As a result of the summer program, Jane experimented with being a vegetarian for the remainder of the summer (2 ½ months). As noted previously, when teachers model sustainable behaviors, students often attempt to mimic that behavior. I am a vegetarian and after Jane observed me eat vegetarian food every day during the two week program, she wanted to experiment with this diet herself. I provided her with over a dozen vegetarian recipes and she successfully ate vegetarian for 2 ½ months. When school started, she noted that she started to feel light-headed and sick so she went back to integrating meat into her diet. In order to make such an extreme shift in diet, she probably needed greater procedural knowledge in regards to cooking and eating vegetarian, especially in the school environment where there are limited options. One of the key nutrition elements for vegetarians is being aware of different forms of protein. In Jane's interviews it was clear that her friends and family had no idea that non-meat items could contain protein, again demonstrating a lack of procedural knowledge. Meat-less meal preparation was a small part of the program because I was focusing on meat-less Mondays and other small, incremental changes, rather than the radical shift that Jane attempted. Although the change ultimately didn't last, she was proud of trying and I did not want to discourage her

[6] The Neely Charitable Foundation Food and Agriculture Sustainability Research Grant program is managed by the School of Sustainability

attempt. However, this case does demonstrate the value of gradual change over time. One year after the program, Jane reflected that she would still enjoy eating more vegetarian meals and she feels her approach to food has been transformed.

In reflecting on her overall transformation during the last year, Jane remarked, "I have learned to value my waste, food consumption, and myself as a sustainability promoter." Through this program, Jane developed a way to speak to her classmates about sustainability in a way that readily resonates with them. She attends a Catholic high school and used values presented by their religion to integrate concepts of social justice and environmental conservation (protecting the creatures that God created). This religious approach is very different from those taken by the other students and demonstrates the autonomy each student had to view sustainability through the lens of their own values. By framing sustainability in a personally relevant way, Jane gained confidence. She said that, "the most important quality I received from this program was courage" and she used that courage to be a sustainability leader at school and home.

Student 3: Jill

Jane's younger sister, Jill, also participated in the summer program and extensive follow-up. Jill attends the same private Catholic school as her sister and is equally as busy with sports and clubs. Jill interviewed her mother, grandfather, and three friends from school.

After the summer program was over, Jill continued, for 5 weeks, to track how many disposable plastic water bottles she used. Over that time period, she purchased 4 disposable water bottles. Prior to the summer program she used reusable water bottles during sports practice/games (her entire team had decorated reusable bottles with their jersey numbers on them) but purchased disposable water bottles every day at lunch. Since the summer program, Jill has become very interested in promoting the use of reusable water bottles at her school. She spoke to her principle about selling reusable water bottles with their school logo and promoting their use over the disposable bottles. Although this project was a great idea, it was logistically very

difficult because the school makes money from selling the disposable water bottles. Despite the set-back in creating change at the school-wide level, Jill felt positive about the impact she had on her friends' and family's waste behaviors, noting that more of her friends use reusable water bottles now and her household composts, recycles, and uses reusable napkins (see Figure 7).

Jill's favorite lesson during the program was evaluating local, organic, and conventional salsa brands based on sustainability criteria. Through this activity, as well as others, Jill gained procedural knowledge regarding how to identify local, organic, and conventional foods, as well at the significance of these labels. However, Jill commented that it was difficult to explain the criteria and labeling to her family. During Jill's interviews a couple of her respondents said they ate local and organic but the later questions regarding what that meant were not answered in a way that supports their claim. For instance, her grandfather said that yes, he eats organic but when asked to distinguish between organic food and processed food, he could not. Jill's mother also had some difficulty distinguishing between locally produced food and food from multi-national corporations. Jill's mom said that she buys local and when asked where, she said at her grocery store (a large chain), noting that local food is everywhere in the store so it is easy to purchase. However, her grocery store does not stock local food, so it is likely that she was not sufficiently familiar with the food system. The interviews Jill conducted highlight that even though her household members intended to purchase sustainable food, their lack of procedural knowledge was clearly a barrier in doing so.

In contrast to Jane's personal transformation and John's professional sustainability aspirations, Jill's change seems less profound. The difficulty in evaluating Jill's transformation is that Jane is the leader of the two sisters so many of Jill's behavioral changes could be attributed to Jane's leadership. Yet, Jill went from not knowing what sustainability meant to trying to implement a school-wide sustainability campaign. Jill also started to speak to more of her friends about sustainability and was very excited when two of them were interested and engaged in the

topic. She also said that she has started to pack a lunch for school so that she can eat a meatless lunch a couple of days a week. Although it is difficult to tease apart the causal reasons for the change, Jill's knowledge, values, and behaviors did change over the course of the year.

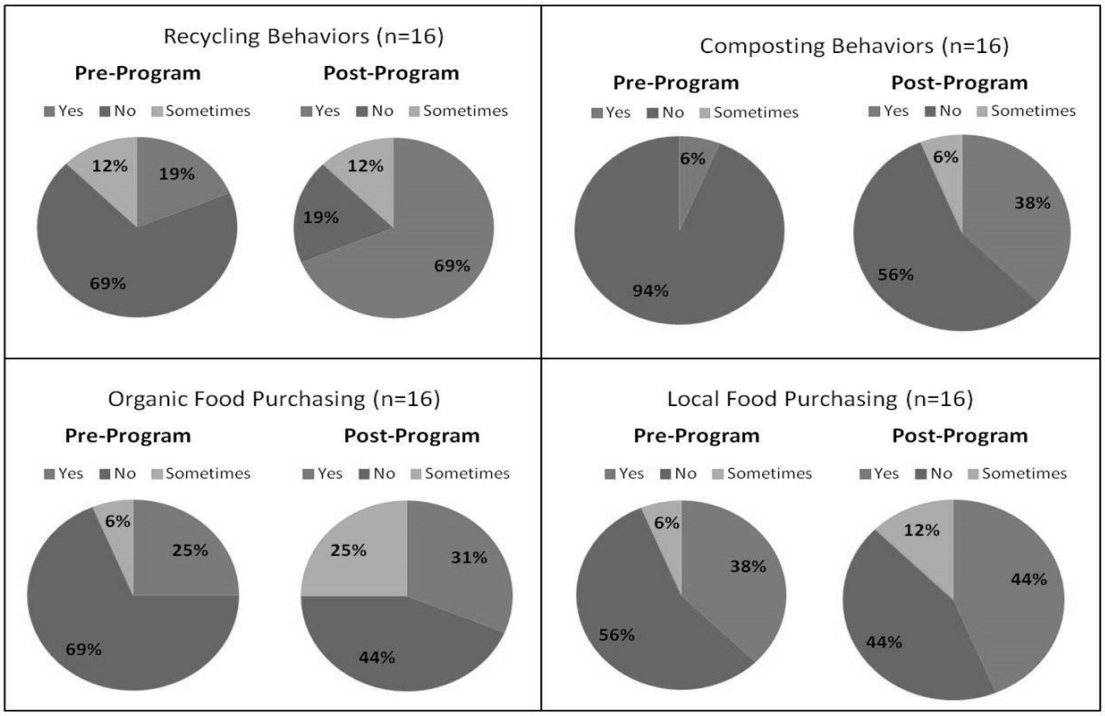

Figure 8. Behavior change in students' friends and family

The graphs in Figure 8 represent the change that occurred amongst John's six interviewees (3 of which were household members), Jane's five interviewees (3 friends, 1 friends' parent, & her grandmother), and Jill's five interviewees (her mother, grandfather, and 3 friends). As seen in Figure 8, the majority of the family and friends interviewed began to recycle after the intervention, even though only 19% recycled prior to the program. Although the interviewees had heard of recycling and many sometimes participated in recycling, only one of the interviewees knew what composting was prior to the program and yet an astonishing 38% of those interviewed composted after the program. Although the changes in food behaviors were less drastic, change did occur, with 56% of interviewees remarking that they do or sometimes do purchase organic foods, which is up from 31% prior to the program. By supporting the students

through this interview process, they were able to further develop their interpersonal competency and create an approach for speaking with their friends about sustainability while also building their confidence as agents of change in their homes and schools.

Discussion

The results from the summer program and year-long case study demonstrate that not only do different types of knowledge impact behavior to varying degrees but also that food and waste behaviors have different sets of barriers and constraints that impact whether the intended behavior changes are implemented and maintained over time. Herein, I will discuss the results as they relate to the research questions; 1) How and to what degree does enhancing declarative, procedural, effectiveness, and social knowledge influence sustainable behavior change? And 2) How and to what degree is that change sustained overtime and what were the barriers and constraints to implementing and maintaining the change?

Relationship between knowledge and behaviors

Although the convergence of all four knowledge domains appears to lead to sustained behavior change, each knowledge domain influences behavior change differently. Throughout this section I will discuss each knowledge domain as it relates to my findings, while also proposing justifications based on other research.

While the relationship between declarative knowledge and behavior change appears to be weak, certain types of declarative knowledge appealed to students' emotions. Although upon leaving the summer program, the highest level of knowledge, as measured by the survey, was attained in regards to food declarative knowledge, but the food behaviors themselves were rather resistant to change. John in particular retained much of the food declarative knowledge months after the summer program, especially in regards to the ecological footprint of meat consumption, yet he was the least interested amongst the group in adopting a lower meat diet. This could be because the declarative knowledge presented during the summer program fostered a greater

emotional response amongst the female participants since other researchers have found that women react more emotionally to environmental problems, which coupled with an internal locus of control (or enhanced effectiveness knowledge) will likely to lead to acting pro-environmentally (Kollmus & Agyeman, 2002). Jane, for instance, felt a sense of sadness about how animals are treated in confined animal factory operations and was angered that living creatures could be treated so inhumanely, so she did not want to use her purchasing power to support system that she didn't approve of. Although this type of emotional response to declarative information can be useful, this declarative knowledge alone is not sufficient in fostering change but rather one part of the broader knowledge that is needed. There are also concerns about creating a sense of guilt and helplessness in students that leads to emotionally distancing or resignation when students are constantly exposed to sad or painful information (Kollmus & Agyeman, 2002). Therefore, tangible solutions and positive actions should be coupled with declarative knowledge on environmental degradation and social injustice. In particular, coupling procedural knowledge regarding actionable solutions to sustainability challenges can aid in alleviating students' sense of helplessness.

Although procedural knowledge is essential in equipping students with the skills to take decisive action, there seems to be a gap between perceived procedural knowledge and actual procedural knowledge. While this gap is not apparent in the student participants themselves, it is clear that the students' family and friends lack procedural knowledge in spite of their confidence that they are fully informed. In particular, the family members of Jane and Jill commented that they knew what organic food is and even purchased organic food on occasion yet upon further questioning they were under the misconception that organic food was simply whole, unprocessed food rather than food produced without the use synthetic pesticides and fertilizers or growth hormones. There is great promise for programs that focus on procedural knowledge not only because there is a deficit in that type of knowledge but also because students seem to enjoy the

hands-on activities focused on procedural knowledge. Activities focused on procedural knowledge, such as sorting trash into landfill, recycle, and compost piles, are not only hands-on and provide direct experience but they were amongst the students' favorite activities. Developing classroom operations that enhance procedural knowledge, for instance classroom composting and recycling, enables students to participate in alternative waste strategies while building sustainable habits.

The results regarding effectiveness knowledge demonstrate the importance of targeting all four domains. The students reflected that they had the ability to change their behaviors because they were equipped with the skills to do so through activities focused on enhancing procedural knowledge. In addition to coupling procedural knowledge with effectiveness knowledge, students also need to be informed about how their actions connect to the broader system in order to assess the consequences of changing a certain behavior (e.g., declarative knowledge regarding systems interactions). Effectiveness knowledge was also largely tied to social knowledge in that students perceive a behavior as desirable and worth the sacrifice if it is generally accepted in their social environment. In the classroom, we made an effort to positively reinforce behaviors like using a reusable water bottle; therefore it was no surprise that the students responded that using a reusable water bottle was both convenient and desirable. While the program did enhance their effectiveness knowledge, as shown by their sense of responsibility to create change in their school and homes, their confidence to act seems to be tied to enhanced knowledge in other domains.

My research indicates that of the four knowledge domains, social knowledge is the most resistant to change. Additionally, the less social knowledge changes during an education program would appear to predict less change in the corresponding behaviors afterward. The students' post-program survey showed enhanced declarative, procedural, and effectiveness food knowledge. Yet, the rigidity in social knowledge seems to have resulted in only small relative

changes in food behaviors as compared to the substantial and maintained behavior change in terms of sustainable waste strategies. The data also suggests that social norms surrounding food are far more engrained than those surrounding waste. These results are in line with established research on Cultural Cognition Theory (CCT). CCT posits that individuals tend to form perceptions of societal risks that cohere with values characteristic of groups with which they identify and the knowledge they gain is interpreted through their cultural philosophies (Kahan et al., 2012). During the case study, the high school students reflected on their interviews noting that their family and friends were resistant to changing their food behaviors, making a change in their own behavior more difficult given their social context. Furthermore, a recent survey of students in Sweden found that social knowledge was a barrier to pro-environmental behavior change given the cultural environment of materialism and consumption (Kim, 2012).

In order to effectively promote sustainability as the social norm, there must be change agents leading the way and charting alternatives to the unsustainable status quo. Successful diffusion of sustainability behaviors requires that social knowledge becomes a tool for change rather than a barrier. Work by Rogers (2003) suggests that once 16% of a given community adopts a desired behavior, also known as "the tipping point" (Gladwell, 2000), diffusion of that behavior is more likely to occur; especially when the opinion leaders have already adopted said behavior. In creating programs that promote sustainability as desirable, it may be advantageous to target the peer or community leaders as the early adopters of the sustainable behaviors in order focus on achieving the necessary tipping point for the change to become self-sustaining. By getting the leaders to model sustainable behaviors and positively reinforce those behaviors in others, there is great potential is utilizing social knowledge as a motivation tool rather than a barrier.

Barriers and constraints to change

While this research focuses equally on food and waste behaviors, the barriers and constraints associated with food behavior change are very different than those associated with waste behavior change. In the following section I am going to describe specific barriers associated with local and organic purchasing and reduced meat consumption versus those associated with composting and recycling. These behaviors are indicative of the depth with which food behaviors are embedded in complex social structures and in comparison, the relative ease with which waste behaviors were changed and maintained.

Food systems are incredibly complex and tied to an array of political, cultural, and social structures and ideals. In addition to being complex, the food system from seed to table has undergone tremendous change over the last forty years, including changes in the size of farms, the average age of farmers and growth in biotechnology as well as organic industries (Heller & Keoleina, 2002). The substantial changes in the production, processing, and consumption of food products over the last couple of decades makes discussing food choices across generations far more difficult. For instance, Jill and Jane live with their grandfather, whom lived on a small farm when he was young. Upon discussing problems associated with conventional agriculture, particularly in terms of how pesticides impact workers and consumers health, their grandfather responded that he lived on a conventional farm from the 1930s until the 1960s and has eaten conventional food products his entire life and is doing just fine. However, the conventional food system of the 1930s is incredibly different than the industrialized system we have today. Jill and Jane's Grandfather experienced pre-Green revolution agriculture, in which the primary source nutrients were manure rather than synthetic fertilizer, and farms were more often run by families rather than corporations and the top 5 seed companies didn't control 75% of the vegetable seeds sold in the world (Heller & Keoleina, 2002). The changing food system presents a barrier to

sustainable food purchasing because the term organic is 'new' and 'radical' to many older generations who still hold tightly to their perceptions of the conventional family farm.

The barriers to sustainable food purchasing varied in John's household from those in Jill and Jane's. A number of John's interviewees, such as his mentor and his brother's girlfriend, were interested in purchasing more organic food in the future but were highly resistant to the idea of reduced meat consumption. John noted that while he likes rice and beans, any real dinner includes meat, typically in the form of hotdogs or beef. Part of this perception may come from the social norm that men need to eat more meat than women (Gossard & York, 2003). Not only is John a male but he is also in a male dominated household (his mother passed away and he has only male siblings). A recent survey found that in fact, men do consume more meat than women and they also consume more beef than women (Gossard & York, 2003). In addition to the masculinity factor associated with meat consumption, John's social structure falls into many other categories that are indicative of greater meat and beef consumption.

The Gossard and York study (2003) found that Hispanics eat more meat than non-Hispanics (John is Hispanic), people who have laborer occupations eat more meat than professionals or people in the service industry (John's family members are landscapers), and people with more education eat less meat and total beef (the highest level of education completed by his father and eldest brother is middle school). John's social structure represents a barrier to reducing his meat consumption and his resistance to change exemplifies how deeply entrenched dietary habits are within complex, social forces. When working with a target population that has a predilection to higher meat and beef consumption, the depth of transformation that is needed to successfully change their dietary habits may be greater than can be achieved in the course of a two-week or even one year program.

The barriers to changing the students' waste behaviors were less entrenched than those associated with their food behaviors. Often odor is cited as a barrier to composting and one that

both Jill and Jane noted in their pre-program survey. However, by having a bin in our classroom their perception about odor was changed with both girls eagerly reassuring their family members that composting isn't smelly. The openness to changing their opinions about composting is indicative of the ease with which waste behaviors were changed as compared to food behaviors. While Jill and Jane's grandfather pushed back against the idea of purchasing organic or local food products, he was eager for the girls to engage in waste reduction strategies. He was so interested in composting that he brought home food waste from the restaurant he works at part-time. Jill and Jane's grandfather enjoys gardening was excited to get 'free' fertilizer through composting. Their grandmother also noted that she liked the idea of 'wasting less' by reusing things that would otherwise be sent to the landfill. Other researchers have found that people that value frugality (i.e. wasting less) are more likely to participate in waste reduction and recovery strategies (DeYoung, 1986). The American ideals associated with frugality and by extension sustainable waste practices resonated with Jill and Jane's grandparents and resulted in a supportive social context for these changes. John's household also found composting to be a beneficial habit given that they could use their finished soil in their landscaping jobs. Unlike Jill and Jane's household, John's household chose not to compost their food waste but to focus on composting their landscaping waste.

A number of researchers have found that one of the biggest barriers to recycling is convenience (Barr & Gilg, 2005; McCarty & Shrum, 2001). My research indicates that it is not just the convenience of having curbside recycling program but also having an indoor recycling bin that is placed next to each trash can that will lead to higher rates of recycling. The students in my summer program all lived in neighborhoods with curbside recycling (even if they were unaware of this fact), yet they all remarked that their households rarely recycled. When we discussed why, a number of the students noted that it is so hot outside and they didn't want to walk out to the bin each time they had a soda or used a piece of paper. In order to overcome this

barrier, each student was provided with an indoor recycling bin (purchased at Office Max with Neely Grant funds) so they only had to take the recycling out once a week rather than every single time they used a recyclable product. Supplying households with indoor bins or ideas about making their own seems like a simple solution that reduces barriers recycling associated with convenience, yet it is not a part of our current recycling program.

In addition to social constructs associated with frugality or masculinity, other researchers have found that the ambiguity associated with the 'right' choice may lead to reduced participation in pro-environmental behaviors (Monroe, 2003). The goal of the waste behaviors targeted in this program was simple; reduce the amount of waste sent to the landfill. While that simple goal leads to many cascading effects, such as reduced greenhouse gas emissions, the goal is clear and the suggested actions have direct consequences (e.g., using reusable bags at grocery stores results in a reduction of plastic disposable bag consumption). On the other hand, there is a myriad of intended outcomes associated with sustainable food purchasing and consumption, such as improved water quality, improved soil quality, healthier working conditions, reduced obesity, reduced resource consumption, enhanced biodiversity, enhanced sense of community and increased access to healthy food products. Given the wide range and scope of goals, it is difficult for an individual to choose which food item is the 'right' choice especially given the trade-offs associated with each product. For instance, purchasing organic products is associated with improving water quality due to reduced use of harmful pesticides, while purchasing a local product at a farmers market may lead to an enhanced sense of community; who can say which of these two options is the 'right' choice? Although researchers are studying the life cycle of food products (Heller & Keoleian, 2003) and examining the environmental impact of meat-heavy diets (Gossard & York, 2003; Pimental & Pimental, 2003), much of this information has yet to reach the general consumer. In contrast, recycling programs are ubiquitous throughout schools (Cherif, 1995) and communities (Gamba & Osdamp, 1994) and reusable bag programs exist at places like

Target, CVS (Horovitz, 2009) and Walmart (Walmart Stores Inc., 2012). The uncertainty associated with choosing sustainable food products, the opaqueness of the food industry and the complexity of the social structures influencing dietary habits (such as culture) combine to make food behaviors more resistant to change than waste behaviors.

Conclusion

This research focused on developing an education program that targeted specific behaviors through a structured approach to curriculum, which incorporated sustainability competencies and behavioral theory to target long-term uptake of sustainable behaviors by the student participants and their network. While there were only a small number of participants with whom to assess this approach to curriculum development and practice, evaluations of the outputs and outcomes suggest a strong potential to the approach elaborated here. In terms of outputs, the program was successful, with all participants showing dramatic improvement in the targeted knowledge domains for food and waste. In evaluating long-term change through the course of a year, there were clear and substantial changes among participants which appear to be durable and may lay the foundation for continued change by the participants into the future.

The data collected through the students' interviews with 5-6 influential people in their lives demonstrates that behavior change is easier to maintain if the students' social context changes in order to accommodate that new behavior. The households of all three students involved in the one-year case study, adopted sustainable waste behaviors, including composting and recycling. When the students reflected on which behaviors were easiest to maintain, they all explained that the easiest behaviors to maintain were the ones their household members were participating in. In the case of Jane, she attempted a dramatic change in her food behaviors, going vegetarian, but because her school and household did not support that practice, it was impossible for her to maintain. This demonstrates the two-way flow of behavior change; students can change the behaviors of their friends and household members, in turn making those behaviors

easier to maintain in the long-term (as seen in waste behaviors) or household members and peers can be resistant to change, making behavior change more difficult for the student to maintain (as seen in food behaviors).

Another interesting finding is that the students' favorite lessons do not necessarily correlate with their most significant behavior changes. Both Jill and John commented that their favorite lessons during the two-week program were associated with the food unit. Yet both only negligibly changed their food behaviors. This finding highlights the need to move beyond just curriculum add-ons when educating for sustainability because curriculum alone is insufficient in motivating change. Sustainable behaviors need to be incorporated into the classroom, incentivized and modeled by the teachers, not just discussed in fun, hands-on activities. This is not to belittle the importance of developing engaging sustainability lessons, but rather to emphasize that the lessons, themselves, are one of the handful of methods for targeting change in the classroom.

This research highlights the importance of social context in maintaining behavior change. Schools can lead the way towards sustainability by providing a supportive atmosphere for sustainable behaviors. All too often, educators leave it up to the parents/guardians of the students to take action and model sustainable behaviors, yet youth typically spend more awake hours at school than at home so the classroom activities play a vital role in building sustainable habits and change. UNESCO declared, "education is the most effective means that society possesses for confronting the challenges of the future" (UNESCO, 1997) but the challenges of the future cannot be met without a broad shift to more sustainable behaviors. Sustainable behaviors and actions must be incorporated into our educational strategy and our education strategy has to go beyond technical, information-based knowledge. If schools create a culture in which unsustainable lifestyles are propagated as the norm, then even if the students have pro-environmental attitudes

and abundant knowledge, pro-environmental behavior is unlikely to occur (Kollmuss & Agyeman, 2002).

While I have been critical of information-focused approaches to educating for sustainability, it is certainly important to equip students with the ability to gather data and marshal arguments in favor of a more sustainable lifestyle. Unlike many research articles focused on behavior change, the ultimate goal of this research was not just to promote sustainable behaviors but also to enhance competence in sustainability. Successful sustainability change agents should not only demonstrate sustainable behaviors but they should also be capable of communicating the importance of environmentally responsible consumption in terms of sustainability. By enhancing their knowledge and skills, the students that participated in the year-long case study have taken on the roles of opinion leaders in regards to sustainability knowledge, become early adopters of sustainable behaviors, and change agents in their households and schools.

Starting with a small sample enabled me to delve into the lives of these students for a full year, something that is not commonly done as part of the evaluation of education programs. The next step is to scale up and test the behavior-based education approach with a statistically significant sample size and then expand the suite of behaviors targeted to include transportation, water-saving strategies, energy conservation, and civic engagement. In addition to testing this integrated approach with more students, it is critical test the strategies and methods discussed here with K-12 teachers and refine the approach so it is palatable in shorter teacher training seminars.

Chapter 4

EXPLORING THE INFLUENCE OF MULTIPLE DOMAINS OF KNOWLEDGE ON SUSTAINABLE FOOD AND WASTE BEHAVIORS

Introduction

Sustainability advocates widely recognize that behavior change is necessary in order to achieve a sustainability transition that will meet human needs, reduce social inequities and maintain the natural resources necessary to support human life on Earth (Leiserowitz, Kates, & Parris, 2005). Education is central to this transition and many researchers have turned to education as the means to equip society with the knowledge, skills, and behaviors necessary to cope with our sustainability challenges (Cortese, 2003; D. Orr, 1991; Rowe, 2007; Nolet & Wheeler, 2010). While the ultimate aim of education is shaping human behavior (Hungerford & Volk, 1990), most programs proceed on the faulty assumption that information will automatically lead to change (Information Deficit Theory). Hence, education is generally failing to foster the necessary transformative change due to a narrow focus on information-based approaches (relying on declarative, technical knowledge about how the world works).

Researchers and practitioners have generally confined the term 'knowledge' to solely mean 'factual knowledge' (Grob, 1995). Yet there is growing awareness that knowledge encompasses more than information and fact retention; rather there are different types of knowledge, including: declarative (factual/technical socio-ecological information), procedural (how-to information), effectiveness (understanding of impacts/efficacy), and social (understanding of normative trends and social expectations) (Frisk & Larson, 2011; Kaiser & Fuhrer, 2003). Studies rarely address more than two of these knowledge domains, typically declarative and procedural, while education programs generally focus solely on declarative knowledge. To date, the interaction of all four knowledge domains on sustainable behaviors has yet to be broadly assessed (Kaiser & Fuhrer, 2003). Hence, this article focuses on research that

has assessed the relationship between knowledge in all four domains with sustainable food and waste behaviors.

Kaiser and Fuhrer (2003) hypothesize that sustained behavior change is most likely to occur when four domains of knowledge (declarative, procedural, effectiveness, and social) converge towards a common ecological goal. By looking at each knowledge domain as distinctive constructs, we are examining whether knowledge in the four domains predicts behavior and the extent to which particular domains affect specific types of food and waste choices. In doing this, we pose two research questions: 1.) To what degree does knowledge in each of the four domains predict pro-environmental behaviors? And 2.) Do the knowledge domains influence pro-environmental food and waste behavior in the same manner?

Numerous surveys have found that while individuals tend to generally have pro-environmental attitudes, and knowledge (as a distal factor or precondition for pro-environmental attitude) these attitudes and knowledge do not translate into those individuals regularly engaging in pro-environmental behaviors (Kaiser & Fuhrer, 2003; Leiserowitz, et al., 2005; McCarty & Shrum, 2001). One of the reasons for the apparent disconnect between attitudes, knowledge and behaviors in most surveys lies in the fact that while general attitude and knowledge questions are asked (e.g., do you care about the environment), behavior questions are very specific (e.g. do you recycle). In order to align the knowledge questions closely with the focal behaviors, this survey focuses on a few widely accepted food and waste actions and frames every knowledge question around those actions.

The target population for the survey was future and current K-12 educators. There is growing consensus among researchers and educators that educating for sustainability in K-12 classrooms is essential for building capacity for transformative change (Nolet, 2009; Simmons & Volk, 2002; Sterling, 2001). Yet, few educators incorporate action and change as a component of their teaching or classroom practices (J. Moore, 2005; Stir, 2006). One barrier to integrating

sustainability practices into the classroom is a lack of deep knowledge among teachers regarding sustainable behavior (Nolet, 2009). While research indicates that educators have adequate surface knowledge regarding socio-ecological interactions, they tend to neglect practical skills and action as part of sustainability education (Nolet, 2009; Stir, 2006). In order to address the barriers to action and uncover the major gaps in knowledge, we are assessing sustainability-related knowledge and behaviors amongst K-12 teachers. Through this extensive survey of future and current K-12 teachers across the United States, we address where knowledge (and what types) is most lacking and how the presence or absence of different types of knowledge impacts sustainable behaviors. The results of this research can inform approaches to teacher education in order to target gaps in knowledge and behaviors with the ultimate goal of imparting knowledge in the four domains and modeling sustainable behaviors to students.

Justifying food behaviors

A number of researchers have established that consumer behavior and dietary habits have a significant impact on agricultural production, distribution and the nature of our food options (Heller & Keoleian, 2003). The benefits of changing food consumption and purchasing behavior radiate throughout the food life cycle, multiplying the impacts of consumers adopting more sustainable behaviors. We narrowed our focus to a few specific behaviors that were selected because of their action-ability at an individual scale and prevalence in the food sustainability literature. Our survey focused on the following sustainable food behaviors: 1.) reduced meat consumption, 2.) purchasing of organic foods, 3.) purchasing of local products from farmer's markets, 4.) consumption of whole foods rather than processed ones.

The industrial meat industry is one of the leading causes of environmental destruction (Gossard & York, 2003). A number of researchers have suggested that one of the most effective environmental choices that a consumer can make is to eat less meat (Carlsson-Kanyama, Ekström, & Shanahan, 2003; Gossard & York, 2003; Heller & Keoleian, 2003). Meat production

is extremely resource inefficient, requiring more land, water, and energy than a plant-based diet (Gossard & York, 2003; Pimentel & Pimentel, 2003; Reijnders & Soret, 2003). Not only does a meat-heavy diet require more resources but meat-eaters have a far larger carbon footprint than their plant-eating counterparts (Matthews, 2006; Weber & Matthews, 2008). Meat also has a large social and economic cost. Pimental and Pimental estimate that the amount of grains fed to US livestock is sufficient to feed 840 million people who follow a plant-based diet and if those grains were exported it would boost the U.S. trade balance by $80 billion a year (2003). Reducing the amount of meat one consumes is also linked to improved health (Kalof, Dietz, Stern, & Guagnano, 1999), so by reducing the amount of meat one consumes, Americans can be both personally healthier while reducing their negative impacts on the environment and society.

Organic food purchasing and production is generally seen "as a positive force for environmentalism" (Allen & Kovach, 2000, p. 221). Organic production refers to agriculture which does not use synthetic chemical fertilizers and pesticides, and where animals are reared in more natural conditions, without the routine use of drugs or antibiotics common in intensive livestock farming (Seyfang, 2006). Agriculture researchers have documented that organic farming creates less pollution and uses more renewable forms of energy compared to conventional agriculture as well as encouraging the use of natural and biological systems (i.e. micro-organisms and soil flora and fauna). These practices increase the long-term fertility of the soil (Rigby & Cáceres, 2001) as well as provide a healthier work environment for farmers (Allen & Kovach, 2000).

Many producers and consumers view local food purchasing as a promising alternative to the current, unsustainable, large scale, agro-industrial food production system (Stagl, 2002). While purchasing local food does not necessarily reduce a household's carbon footprint, as was once thought (i.e., by reducing food miles) (Weber & Matthews, 2008); purchasing local has been shown to have other benefits such as, increasing consumers' relationship with their food

producers and supporting local food economies (Stagl, 2002). Gail Feenstra, a community nutritionist, notes that local food systems "aim to be economically viable for farmers and consumers, use ecologically sound production and distribution practices and enhance social equity and democracy for all members of the community (1997, p. 28)." While many small farmers may not have formal organic certification, proponents of farmer's markets suggest that most of the farmers serving these markets go organic or beyond, using biodynamic and other sustainable techniques; therefore contributing many of or more environmental benefits than what is associated with organic agriculture (Stagl, 2002).

Processed foods (packaged and/or frozen) use more energy in the storage and packaging phases of the food life cycle as compared to fresh, whole foods (Sonesson, Mattsson, Nybrant, & Ohlsson, 2005). While the environmental impact of processed food is substantial, the social and economic costs associated with diets high in processed foods is a growing concern amongst nutritionists and health experts. Processed foods are generally high in salt, fat and sugar (He & MacGregor, 2010). A diet high in salt, fat, and sugar is associated with increased incidence of coronary heart disease, stroke, and cardiovascular disease (He & MacGregor, 2010). Childhood is an essential time to be developing healthy habits for life, but national data indicates that over half of boys and girls ages 4 to 18 consume less than five fruits and vegetables a day (Robinson-O'Brien, Story, & Heim, 2009). The obesity epidemic associated with the increased consumption of processed food and decreased consumption of whole foods also places a heavy burden on the economy.

Justifying waste behaviors

We focus in this study on widely accepted and researched waste strategies: 1.) reduce waste produced by the individual, 2.) choose reusable products over disposables (i.e., single-use products), and 3.) engage in waste recovery practices (recycling and composting). Each of these behaviors diverts waste from landfills which is one of the principal goals of a sustainable waste

system. US residents produce more garbage than anyone else in the world (Royte, 2006), averaging 4.4 pounds per person (Agency, 2011), with 2/3rds of that ending up in landfills. Landfills are environmentally, economically, and socially undesirable. First, in terms of human health, landfills increase the risk of adverse health effects (i.e., low birth weight, birth defects, cancer, nausea, migraines) amongst residents living nearby one or more landfills (Vrijheid, 2000). Numerous studies have found that minorities are disproportionately likely to live near waste facilities such as landfills, and therefore are unjustly more exposed to adverse health effects (D. G. Perkins, King, & Varner, 2012). The negative health effects as well as noise, odor, and air pollution associated with landfills has been shown to decrease property values for up to three miles from a landfill site (Hirshfeld, Vesilind, & Pas, 1992). Environmentally, landfill gas, such as methane and carbon dioxide—both of which are greenhouse gases—have negative impacts on vegetation, air quality, and particularly climate change (Hirshfeld, et al., 1992), while the liquid that seeps out of landfills, known as leachate, threatens groundwater and surrounding ecosystems (Salem, Hamouri, Djemaa, & Allia, 2008).

Currently, Americans compost only 2.5% of the food they don't eat, thereby making food waste the second largest single source of discarded trash for municipal solid waste (Heller & Keoleian, 2003). The Wall Street Journal reported that up to half of the food produced in the U.S. is thrown away (Anonymous, 2010). The annual cost of discarding food waste nationwide is estimated at $777 million (Heller & Keoleian, 2003). Decreasing the amount of food waste sent to landfills supports environmental health by conserving energy resources, reducing transportation of food waste, protecting microhabitats by reducing the need for landfills, and decreasing methane emissions and harmful leachate into the biosphere (Griffin, Sobal, & Lyson, 2009). Composting not only diverts food waste from the landfill but it also helps recoup some of the loss associated with wasted nutrients by turning food waste into usable soil.

Americans throw away over 2.5 million plastic bottles every hour (Rubens, 1992) while over 1 trillion plastic bags are used every year worldwide (Reuseit.com, 2012). Plastic bags are the second most common type of refuse in the ocean, where there is now more plastic than plankton (C. J. Moore, Moore, Leecaster, & Weisberg, 2001). Plastic bags and bottles are made from a non-renewable resource (petroleum), they have low waste recovery rates (e.g. less than 5% for plastic bags (LA County Plastic Bag Working Group, 2007) and they are a highly prominent and visible form of litter (Lewis, Verghese, & Fitzpatrick, 2010). A recent study on the life cycle of plastic, paper, single-use biodegradable and reusable bags found that reusable bags have the lowest environmental impact (Lewis, et al., 2010). Choosing reusable products such as bottles, bags, and napkins can essentially eliminate all of these unnecessary products from the waste stream.

The US Environmental Protection Agency estimates that only about 34% of US municipal solid waste is being recovered via recycling or composting (Agency, 2011). The exact benefits of recycling vary depending on the material, local situation and technology utilized, but the benefits have been shown to extend well beyond those of just eliminating waste from landfills. For example, recycling paper not only produces far less pollution and is slowing global deforestation but it also uses at least 25% less electricity than making paper from virgin pulp (Royte, 2006). The most dramatic example is the benefits gained from recycling aluminum which reduces by 95% the energy and emissions necessary to produce a soda can as compared to making one from virgin material (Das, Green, & Kaufman, 2010). According to the EPA "creating a strong market is key to completing the recycling process" (Agency, 2012). Purchasing products made from post-consumer (recycled) materials helps to create a market for these materials and raises the prices municipalities and companies receive from separating and recycling their waste, thus increasing their motivation to recycle. Overall, increasing recycling rates is one of the key components for transitioning to more sustainable waste systems.

Knowledge domains

Declarative knowledge typically addresses how environmental systems operate in factual, technical, mechanical or biophysical terms, such as information about the ecological structure, functioning of ecosystems, and social-ecological interactions (Kaiser & Fuhrer, 2003). Although research has suggested that this is the least effective type of knowledge in promoting pro-environmental behaviors, most educators focus on disseminating declarative knowledge (Pooley & O'Connor, 2000; Simmons & Volk, 2002). Declarative knowledge is emphasized in the Information-Deficit Model (IDM), whereby in a straightforward, linear fashion, environmental knowledge leads to awareness and concern, and ultimately, pro-environmental behaviors (Kollmuss & Agyeman, 2002). Psychologists and others have since refuted this simplistic model, noting that changing behavior is very difficult and information is simply not enough to spur the change itself (Kollmus & Agyeman, 2002).

Procedural knowledge refers to basic how-to information—such as how to sort garbage into recyclables and non-recyclables for proper disposal (Kaiser & Fuhrer, 2003; Monroe, 2003). Certain forms of procedural knowledge have been effective in promoting behavior change; for instance, information about how to participate in decision-making processes is a strong predictor of political engagement (Kaiser & Fuhrer, 2003). Procedural information provides answers to questions such as, 'where do I vote?' or 'how do I register?' but not value-laden questions such as 'what is the significance of my vote?' Procedural knowledge correlates closely with situational and structural factors that facilitate or constrain action (e.g., the presence or absence of a curbside recycling program impacts the how-to's of recycling).

Effectiveness, or impact, knowledge addresses the outcomes of different behaviors, essentially answering the question, 'is the behavioral sacrifice worthwhile?' (Kaiser & Fuhrer, 2003; Monroe, 2003). Stern's (2000) Value-Belief-Norm (VBN) model of pro-ecological behavior highlights two key behavioral determinants pertinent to effectiveness knowledge; the

first is the perceived consequences of behaviors, and the second is beliefs about who is responsible for environmental outcomes. The latter correlates to a person's "locus of control," which represents the confidence individuals have in their ability to bring about impactful change through their personal actions (Kollmuss & Agyeman, 2002; Monroe, 2003). Effectiveness knowledge influences behaviors through people's perceptions about how or even if their behaviors really impact the environment. As such, they are closely correlated to subjective beliefs and attitudes (Kaiser & Fuhrer, 2003; Monroe, 2003). For example, if an individual believes that recycling is not a cost-effective means of waste management, their negative perception about the effectiveness of that action may deter them from recycling.

Social knowledge encompasses information regarding the motives, intentions, and actions of other people (Kollmuss & Agyeman, 2002). Social knowledge embodies what is typically described as social norms by behavioral scientists (Stern, 2000; Trumbo & O'Keefe, 2001). Kaiser and Fuhrer (2003) use social knowledge to explain two types of norms; conventional norms refer to customs, traditions, and expectations associated with the need for social approval, while moral norms refer to the value or importance a person places on equity, human welfare, environmental impacts or other behavioral outcomes. Schultz et al. (2007) further distinguish between different types of norms; descriptive norms refer to perceptions of what is commonly done, whereas injunctive norms refer to what is approved or disapproved by others.

Changing the perception of what society approves or views as desirable has been the subject of much research and hundreds of marketing campaigns, ranging from smoking ads to recycling campaigns (McKenzie-Mohr, 2011). The importance of social norms as a predictor of behavior is especially critical in a normative field such as sustainability, where societal values are central in guiding what we ought to sustain and how. Classrooms provide an ideal environment for fostering sustainable social norms but if the educator does not view sustainable behaviors as

desirable or socially acceptable, it is unlikely that sustainability will become the norm in their classroom.

Methods

In creating this survey, we revised the questions based on a number of pilot tests with different audiences in order to establish its validity. After many revisions among the research team, the survey was disseminated to students pursuing an undergraduate or graduate degree in education and on list-servs that targeted working K-12 teachers. The following section details the creation, dissemination, and analytical techniques utilized.

Survey design

The survey regarding food consisted of fifty-one knowledge and behavior questions and the waste survey consisted of forty-nine knowledge and behavior questions. Both surveys utilized a 5-point Likert scale and concluded with a section of 16 demographic questions. The scales on both surveys were designed so that the most sustainable response varied between the right and the left side of the scale, since reversing the direction of the ordinal scale so that no single direction represents a 'sustainable' response can help reduce the incidence of respondents sticking to one side of the scale due to perceived social desirability (Fink, 1995). See Table 5 for more information regarding the question format and response scales (complete list of questions can be found in the Appendix A).

Table 5.

Question format and associated response scales

Question Format	5-Point Response Scales
How familiar are you with the following terms and concepts	'Never heard of' to 'Heard of & know a lot about'
How would you rate your knowledge about	'Poor' to 'Excellent'
How would you rate your ability to	'Poor' to 'Excellent'
How would you rate your awareness of	'Poor' to 'Excellent'
How would you rate your agreement with the following statements	'Strongly agree' to 'Strongly disagree'
Over the last year, how often have you made the following choices	'Never (not at all)' to 'Always (>90% of the time)'

The survey was first pilot-tested during June 2011 with three K-12 teachers who were pursing their masters in science education. At that point, the survey was a combined food and waste survey consisting of over a hundred questions and took the teachers around twenty-five minutes to complete. In order to reduce the length of the survey without reducing the robustness of the instrument, we broke the survey into two (one waste survey and one food survey). The next pilot-test of the survey was conducted with a class of sixty-five sustainability undergraduate students at a large public university (half of the students took the food survey and half took the waste survey). The students circled confusing questions and provided feedback during class. The final pilot-test was run with seven sustainability graduate students (PhD and Masters) at the same university. They took the survey and provided suggestions for improvement as part of an assignment on collecting quantitative data for one of their courses. Finally, the survey was checked for content validity by three experts in sustainability and survey design.

Table 6.

Example questions sorted by domain and behavior

Domain and # of questions on food (F), waste (W)	Sample Food Survey Questions	Sample Waste Survey Questions
Declarative F= 11 questions W= 11 questions	*How would you rate your agreement with the following statements…* -Eating lower on the food chain (eating plants instead of meat) results in lower environmental impacts. -Certified organic food is only food that is not processed such as apples and carrots. -Raising animals for food is a significant source of greenhouse gases.	*How would you rate your agreement with the following statements…* -My food scraps can be composted instead of thrown away. -Food that is thrown away is a very small part of the amount of waste sent to the landfill in the U.S. -Most plastic bottles are recycled in the U.S.
Procedural F= 8 questions W= 8 questions	*How would you rate your knowledge level regarding…* -How to read food labels to determine whether synthetic pesticides were used in the production of the food? -How to find organic foods in your grocery store. *How would you rate your ability to…..* -Consume a healthy amount of protein and iron without eating meat.	*How would you rate your ability to…* -Install a composting system at home? -Select paper made from post-consumer content? *How would your rate your agreement with the following statements…* -I have a strategy for remembering my reusable bags when I go to the grocery store.
Effectiveness F= 10 questions W= 11 questions	*How would you rate your agreement with the following statements…* -I can make choices about what I eat to lower my impact on the environment. -It is difficult for me to choose meat-free meal options -Purchasing locally grown food is inconvenient.	*How would you rate your agreement with the following statements…* -Collecting food scraps for composting creates unwanted odors. -Using reusable bags at the grocery store is inconvenient. -It is important to reduce the amount of waste I send to the landfill.
Social: F= 11 questions W= 9 questions	*How would you rate your agreement with the following statements…* -Purchasing organic food makes me feel good. -I like to eat meat every day. -My friends think it is weird to be a vegetarian (in other words, to not eat meat).	*How would you rate your agreement with the following statements…* -I like the taste of bottled water more than tap water -When I see others carrying a reusable water bottle, I think it is weird -My friends expect me to use a reusable water bottle.
Behavior F= 9 questions W= 9 questions	*Over the last year, how frequently have you made the following choices:* -I ate meals with no meat -Bought organic foods over non-organic ones -Bought food at a local farmer' market	Over the last year, how frequently have you made the following choices: -Composted your food waste at home. -Reused water bottles/used reusable water bottle -Purchased bottled water (in disposable bottle)

Construct reliability requires that several questions measure the same thing or closely related things and the responses by the survey participants are similar for related questions. For this survey, this meant developing a number of questions to measure each knowledge domain and associated behaviors (see Table 6), which were tested for internal consistency using Cronbach's alpha statistics (see more below).

The survey was built using Google Docs "Form" application, which enables one to create a survey with a unique web link where the data are automatically imported into a spreadsheet. The questions were put into groups of 3-5 questions with similar formats, depending on how best to fit the questions on each of the survey's pages. On the first page the participants were informed about the survey and their rights as agreed upon with Arizona State University's Institutional Review Board in their approval of the research project. In order to randomly distribute the participants to either the food or waste surveys, they were asked if their birthday was on an even or odd date. If they responded "even" they answered the questions about food and if they responded "odd" they answered the questions about waste.

Participants and recruitment procedures

The population targeted for this survey was future and current K-12 teachers because they will be imparting knowledge, modeling behaviors, and setting norms in schools—all of which shape how future generations think, reason, and act. A purposive, targeted approach was utilized in order to reach teachers and developing teachers. Through searching the online directory of a large university, we initiated contact with eighty-five education professors who taught undergraduate or graduate education majors. We sent those eighty-five professors emails that included a brief explanation of this study and a request that they send the survey to their students. Seven professors responded to the email. The seven professors taught a range of education courses including early childhood, history of teaching, technology and education, education policy, and science education. The professors agreed to post the survey link to their

classes' Blackboard site, email it out to their students, and/or send it out on list-servs that target K-12 teachers.

One of the professors inquired about sending the survey out nationally via the National Science Teachers Association (NSTA) list-serv. After making a few modifications to the survey (including adding a demographic question regarding in which state the respondent resides), the survey was sent to this professor, who then sent it on to the NSTA list-serv. In order to encourage responses, survey participants were entered into a drawing for 3, $25 gift cards (the winners were randomly chosen). We received a total of 346 responses, 154 to the food survey, and 192 to the waste survey.

The variables and data analysis

The data from the online surveys were entered into Microsoft Office Excel 2007 edition and spot checked for errors before being loaded into a statistical software package—IBM SPSS (Statistical Package for the Social Sciences) Statistics version 20.0. The waste and food responses were loaded into SPSS 20.0 as separate data sets. All subsequent analyses were completed using SPSS. The responses for both data sets were re-coded using the transform function so that 5 indicated the most sustainable response and 1 the least sustainable for all the knowledge and behavior questions.

In many statistical analyses outliers may distort the outcome and accuracy of the results. Therefore, we calculated the Cook's distance—the most widely used statistical test for measuring the influence of an individual observation (Kim & Storer, 1996)—to show which respondents exerted undue influence on the results. For the food survey, five respondents were found to be outliers with undue influence and therefore were removed; reducing the number of responses used in the data analysis to 149. For the waste survey, six respondents were found to be outliers and were removed, making the sample size for the waste survey 186.

In order to examine the knowledge domains as independent predictors of behavior (the dependent variable), composite scores were created for each knowledge and behavior domain. This was done by calculating an individual's mean response to each group of questions (e.g., there were 11 questions which measured the respondent's declarative knowledge about food sustainability, and the mean of the answers to these questions then forms the respondent's declarative knowledge score). When multiple items are used to measure the same thing, as was done in this survey, they should be correlated with one another (Bland & Altman, 1997); therefore the way an individual answers one declarative food question should be consistent with the way they answer the other declarative food questions. As seen in Table 7, the composite scores for each domain were internally consistent and reliable based on the Cronbach's Alpha.

Table 7.

Reliability measured by Cronbach's Alpha for knowledge domains and behavior indices

Domain	**Food (α, N)**	**Waste (α, N)**
Declarative	α= 0.739, N=11	α=0.768, N=11
Procedural	α=0.761, N=8	α=0.813, N=7
Effectiveness	α=0.769, N=10	α=0.766, N=12
Social	α=0.606 N=11	α=0.749 N= 9
Behavior	α=0.673, N=9	α=0.764, N=9

The Cronbach's alpha reliability coefficient normally ranges between 0 and 1 and the closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale (Bland & Altman, 1997). Only one composite index, social knowledge for food, scored below 0.7 (a general threshold for Cronbach's Alpha). The social knowledge index for food is however, acceptable based on the standards for a new, untested survey instrument and construct. Social knowledge is a complex construct and food is the more complex of the two behaviors, therefore social knowledge regarding food may require more questions in order to parse out the influence of family and friends on an individual's knowledge and behaviors.

Descriptive statistics were calculated for all of the socio-demographic items for both the food and waste survey respondents. In Table 8, the demographics of the respondents for this survey are compared to demographic information collected by the National Center for Education on public school teachers in the United States (Feistrizer, 2011). The sample populations are both similar to each other and to the general population of teachers in the US as collected by Feistrizer, demonstrating that a sufficiently representative sample was achieved.

Table 8.

Demographic information of survey respondents compared to larger teacher population

Demographic Information	Food Respondents (N=149)	Waste Respondents (N=186)	Feistritzer, 2011 (N=1076)
% Female	60%	66%	84%
% Anglo/White	83%	85%	84%
Age	12%	9%	21%
<30	25%	24%	27%
30-40	25%	28%	22%
40-50	38%	39%	31%
50+			

In addition to collecting demographic data regarding gender, race, and age, we gathered data regarding respondents' political affiliation, region of residence, income, and whether or not they have ever taken a sustainability course (see Table 9). Other researchers have found that gender, ethnicity, political orientation and income can impact sustainable values, attitudes, and behaviors (Gossard & York, 2003; Larson, Wutich, White, Muñoz-Erickson, & Harlan, 2011); therefore it was necessary to account for the contribution these variables might have in predicting sustainable behaviors. Additionally, we controlled for home ownership and whether or not the participant lived in a residence with a curbside recycling program because some researchers have found that household commingled recycling programs increase participation in recycling and single-family homes facilitate composting and may impact other sustainable waste behaviors (Gamba & Oskamp, 1994).

Table 9.

Summary statistics for independent and dependent variables

	Food, N=149	**Waste, N=186**
House (Yes)	79%	86%
Sustainability Course (Yes)	14%	15%
Region of Residence (Yes- AZ)	37%	50%
Political Orientations		
Very Liberal	9%	10%
Liberal	32%	27%
Moderate	32%	33%
Conservative	20%	18%
Very Conservative	1%	4%
Other	6%	8%
Income		
Under $20,000	4%	3%
$20,000-$34,999	11%	9%
$35,000-$59,999	24%	25%
$60,000-$89,000	26%	25%
$90,000 or more	22%	27%
Did Not Report	13%	11%
	Mean of Indices (standard deviation)	*Mean of Indices (standard deviation)*
Declarative Knowledge	3.58 (.53)	3.78 (.50)
Procedural Knowledge	3.28 (.72)	3.38 (.83)
Effectiveness Knowledge	3.24 (.56)	3.58 (.64)
Social Knowledge	3.42 (.47)	3.55 (.56)
Behavior	2.92 (.50)	3.38 (.65)

Since the survey population was drawn from K-12 educators, the respondents are all classified as ‘professionals’ and were either enrolled in undergraduate, masters, or PhD programs at the time of the survey or had already completed their college degrees. The high level of education among the surveyed population most likely resulted in higher mean scores in the knowledge domains (see Table 9). In addition to being a generally well-educated sample, fifty people reported that they had participated in a sustainability course.

Results

We used ordinary-least squares (OLS) regressions to assess the effect of the knowledge domains on sustainable behaviors while controlling for demographic characteristics and testing for multicollinearity. Race was collapsed into a dichotomous variable of 'white/anglo' or 'other'. Other dichotomous variables that were used included; gender, living in a house (which may impact the ability to partake in sustainable behaviors such as composting and recycling), living in Arizona (since a large portion of the respondents resided in Arizona we controlled for any regional effects), liberal political views (collapsed into two categories, liberal and very liberal as 'yes' versus moderate and conservative as 'no') and whether they had taken a Sustainability course (yes or no). Age and income were treated as continuous variables normalized to be between 1 and 5 (5 being the oldest and wealthiest group respectively).

As seen in Table 10, the OLS regression was run with the food and waste behavior indices as the dependent variables. Procedural knowledge and social knowledge best explained sustainable food behaviors. Declarative and effectiveness knowledge did not impact participation in sustainable food behaviors in a significant way. Procedural and social knowledge were important for both food and waste behaviors while effectiveness knowledge was critical for waste but not for food behaviors. Social knowledge has the strongest impact on both food and waste behaviors, as shown by the relatively high values of the standardized betas. Of the four knowledge domains, declarative knowledge is the only domain that was not shown to be significantly related to either domain of sustainable behaviors. Of the control variables, virtually none (the exception being race) were significant in terms of the effect they had on sustainable behaviors. Although negative findings are often under-reported (Fanelli, 2012), the lack of impact, for example, of participation in a sustainability education course on behaviors is worthy of noting here.

The Variance Inflation Factor (VIF) and tolerance are widely used measures for assessing multi-collinearity issues (O'brien, 2007). Typically a VIF of 10 or even one as low as 4 have been used as rules of thumb to indicate serious multi-collinearity. As seen in Table 10, none our independent variables exceeded a VIF of 4, indicating that collinearity was not a serious problem in our regression. Researchers suggest that tolerance values should be greater than 0.10 or 0.25 (O'brien, 2007) and all of the tolerance values for the independent variables were above 0.25, again reinforcing that our regression is stable.

Overall, the knowledge domains appear to provide a good model for predicting behaviors, with an R^2 value of .61 for the food behavior regression and .80 for the waste behavior regression. However, it is important to note that both the R^2 values and Cronbach's Alphas were higher for the waste regressions and indices as compared to those for food. Previous research has shown that food behaviors are more complex and opaque than waste behaviors (Redman, forthcoming), hence making them more difficult to predict. The differences in complexity, as well as the degree to which the knowledge domains predict food versus waste behaviors demonstrates that different behaviors are influenced by varying types of knowledge.

Table 10.

OLS regression coefficients and standard errors for food and waste behavior indices

Independent Variable	Food Behaviors				Waste behaviors			
Coefficients	Unstandardized		Standardized Beta	VIF	Unstandardized		Standardized Beta	VIF
	B	Std. error			B	Std. error		
Declarative Knowledge	.065	.065	.069	1.780	-.120	.068	-.091	2.351
Procedural Knowledge	.195	.063	.282**	2.944	.246	.050	.313***	3.498
Effectiveness Knowledge	.108	.077	.122	2.621	.308	.063	.302***	3.317
Social Knowledge	.465	.068	.437*	1.454	.472	.060	.404***	2.322
Income	-.026	.027	-.056	1.159	.040	.022	.070	1.256
Age	.036	.025	.089	1.269	-.002	.023	-.003	1.139
Gender (Yes-Female)	.009	.058	.009	1.155	.042	.050	.030	1.153
Race (Yes-white/anglo)	-.164	.075	-.125*	1.195	.169	.065	.091*	1.065
Political Views (Yes-liberal/very liberal)	.097	.060	.096	1.200	-.026	.050	-.020	1.179
House (Yes)	-.052	.070	-.043	1.133	-.068	.066	-.036	1.059
Geographical location (Yes- AZ)	-.074	.064	-.072	1.372	-.026	.049	-.020	1.226
Sustainability Course (Yes)	.099	.083	.069	1.162	.102	.065	.056	1.090
Curbside Recycling Bin (Yes)	----	-- --	---- -	----	.081	.052	.055	1.092
Constant	.237	.295			-.60	.244		
R^2	.611				.802			
Adjusted R^2	.577				.787			
F	17.807				53.445			
Sig.	<.001				<.001			
N	149				186			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As discussed in the background section, the food and waste behavior domains analyzed in this survey are made up of a number of distinct behaviors that have different drivers and benefits of action (e.g., people may eat less meat to reduce their carbon footprint and eat less processed foods for improved health). As such, we created sub-indices based on theoretical categorization

as well as correlation (based in Pearson's rho values amongst the behaviors). The indices created for food behaviors include (factors that represent the sustainable actions for each index are noted in parenthesis): 1.) meat eating behaviors (low levels of chicken and beef consumption and high frequency of meat-less meals), 2.) processed food purchasing (low levels of fast foods and pre-packaged food purchasing, and frequent purchasing of whole foods), and 3.) sustainable food purchasing (frequently purchasing organic, local, and sustainable foods). For waste we created three indices: 1.) recycling (frequently recycling at home and at campus/school), 2.) reducing waste through purchasing practices (purchasing products with less packaging, and products made from post-consumer materials and using reusable bags when checking-out at a store), 3.) reusing (frequently reusing bottles, napkins, and bags).

As seen in Table 11, declarative knowledge does not influence the different behaviors analyzed, while social knowledge is significant in influencing all of the behavioral indices. The impact of effectiveness knowledge is greater in the waste indices, with a positive and significant impact on three behaviors categories, recycling, reducing, and reusing behaviors. Meanwhile, procedural knowledge influences meat consumption as well as reducing and reusing products. While the control variables did not seem influential in the broader food and waste indices, a number of them were impactful when separating food and waste into more specific behavior categories. Similar to findings in other research, (Gamba & Oskamp, 1994), our regression showed that the presence of a curbside recycling program increased the participation in recycling. Having a house (as compared to an apartment or condo) decreased participation in waste reduction strategies. Race and age were significant in terms of recycling and reducing, with older, Caucasians being slightly more likely to reduce and recycle their waste.

Table 11.

OLS regression coefficients for food and waste behaviors separated into like categories

Independent Variable	**Meat eating Index** (n=3, α=.693)	**Processed Foods Index** (n=3, α=.454)	**Sustainable Food Index** (n=3, α=.556)	**Recycling Index** (n=2, α=.767)	**Reduce Index** (n=3, α=.652)	**Reuse Index** (n=3, α=.532)
Mean (std)	3.08(.64)	3.22(.58)	2.69(.69)	4.29(.89)	3.10(.80)	3.37(.87)
Unstandardized Beta (Standardized Beta)						
Declarative Knowledge	-.071(-.059)	.126(.116)	.065(.051)	-.252(-.142)	-.051(-.032)	-.020(-.011)
Procedural Knowledge	.268(.301)*	.075(.093)	.049(.051)	-.051(-.048)	.214(.222)**	.245(.234)*
Effectiveness Knowledge	-.144(-.126)	.175(.171)	.334(.274)**	.427(.307)**	.293(.233)**	.399(.293)***
Social Knowledge	.534(.387)***	.444(.360)***	.522(.356)***	.756(.477)***	.437(.305)***	.402(.258)***
Income	-.010(-.017)	-.035(.064)	-.034(-053)	-.111(-.128)	.019(.024)	.001(.002)
Age	.009(.017)	.030(.063)	-.035(-062)	.040(.051)*	.088(.127)*	.071(.094)
Gender (Yes-Female)	-.111(-.085)	.032(.027)	.098(.070)	-.137(-.073)	.004(.002)	.145(.079)
Race (Yes-white/anglo)	-.046(-.027)	-.096(-.063)	-.293(-.163)*	.408(.162)*	.404(.178)***	.067(.027)
Political Views (Yes-liberal/very liberal)	.031(.024)	.079(.068)	.107(.076)	-.110(-.060)	.081(.049)	.006(.003)
House (Yes)	-.236(-.152)	.017(.012)	.015(.009)	.224(.087)	-.399 (-.173)***	-.260(-.104)*
Geographical location (Yes- AZ)	-.136(-.103)	.028(.023)	-.185(-.130)	.081(.046)	-.086(-.053)	.067(-.039)
Sustainability Course (Yes)	.097(.052)	.117(.071)	.170(.086)	.078(.031)	.186(.083)	.171(.070)
Curbside Recycling Bin (Yes)				.460(.230)***	.086(.047)	.042(.021)
Constant (B)	1.424	.469	-.171	.692	-.464	-.419
R^2	.292	.370	.416	.456	.632	.580
Adjusted R^2	.229	.315	.365	.415	.604	.548
F	4.649	6.663	8.075	11.102	22.691	18.269
Sig.	<.001	<.001	<.001	<.001	<.001	<.001
N	149	149	149	185	185	185

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The survey asked two behavior questions concerning recycling: one regarding the frequency of at-home recycling and one regarding the frequency of at-school recycling (they were combined in the recycling index in Table 11). In order to explore the relationship between recycling at home and recycling at school, we ran a Pearson's correlation and found that recycling at home is strongly and significantly correlated with recycling at school (rho=.623**), indicating that there is a link between behaviors done at school and behaviors done at home.

Two of the waste behaviors, composting and purchasing disposable water bottles, did not fit theoretically or statistically with any other behavior indices. Theoretically composting is a waste-recovery behavior and as such could be grouped with recycling. However, recycling and composting were not correlated, and in fact, people who reported having curbside recycling were less likely to compost (see Table 12). Additionally, recycling was the most frequently engaged in behavior (with a mean of 4.29 on a 5-point scale, 5 representing 'always') and composting the least frequently engaged in activity, therefore from a statistical perspective we could not justify combining recycling and composting into a single index. Purchasing of bottled water also did not statistically fit into any of the other indices based on the Cronbach's Alpha and Pearson's rho. When we ran the bivariate correlation, infrequently purchasing bottled water was correlated with reusing water bottles (rho=.406**). When purchasing bottled water was added to the reuse index, however, it significantly lowered the Cronbach's alpha. Therefore, in Table 12, we show the OLS regressions for these individual behaviors.

Table 12.

OLS regressions for individual food and waste behaviors

Independent Variable	Bought Organic	Bought Local	Composted	Bottled Water
Mean (std)	2.58(.95)	2.45(.93)	2.18(1.4)	3.52(1.00)
Unstandardized Beta (Standardized Beta)				
Declarative Knowledge	.034(.019)	.007(.004)	.016(.006)	-.389(-.195)
Procedural Knowledge	.065(.049)	.065(.050)	1.051(.623)***	.257(.215)
Effectiveness Knowledge	.271(.160)	.496(.297)*	.001(.000)	.115(.074)
Social Knowledge	.747(.360)***	.261(.129)	.329(.132)	.345(.194)
Income	.029(.033)	-.052(-.059)	.245(.062)	.036(.037)
Age	-.046(-.059)	-.040(-.052)	.339(.084)	.074(.085)
Gender (Yes-Female)	.035(.018)	.192(.101)	-.030(-.008)	.078(.037)
Race (Yes-white/anglo)	-.369(-.145)	-.300(-.120)	-.051(-.018)	-.533(-.186)*
Political Views (Yes-liberal/very liberal)	.230(.120)	.079(.042)	-.040(-.014)	.047(.022)
House (Yes)	.105(.046)	.218(.097)	.077(.028)	.025(.009)
Geographical location (Yes- AZ)	.004(.002)	-.481(-.250)**	-.443(-.141)*	-.213(-.107)
Sustainability Course (Yes)	.091(.033)	.221(.082)	-.167(-.137)*	.110(.039)
Curbside Recycling Bin (Yes)			.149(.109)	.186(.083)
Constant (B)	-1.059	.091	-2.827	2.443
R^2	.296	.271	.516	.192
Adjusted R^2	.232	.205	.479	.130
F	4.659	4.143	14.027	3.118
Sig.	<.001	<.001	<.001	<.001
N	146	147	185	185

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

While the Cronbach's alpha and bivariate correlations justified separating composting and purchasing bottled water from the indices, the theoretical underpinnings of organic and local food purchasing prompted us to look at organic and local food separately (in Table 11 they are part of the sustainable food purchasing index). While purchasing local food and organic food

were found to be correlated (rho= .363**), our survey indicated that the drivers of action were different. For example, more survey respondents reported that purchasing food at a farmers market makes them feel good (mean response= 4.1), as compared to purchasing organic food (mean response=3.3). Additionally, other researchers have suggested that a strong motivator for purchasing local food is social interactions and community relationships (Stagl, 2002), where as many people purchase organic food for personal health reasons (Susanne & Carolyn, 2005). OLS regressions were run with each individual behavior (9 behaviors each for food and waste), but only purchasing organic and local food and composting and purchasing bottled water are reported above (Table 12).

As seen in Table 12, organic and local food are impacted by different knowledge domains; with social knowledge impacting organic food purchasing and effectiveness knowledge influencing local food purchasing. Geographic location influences local food purchasing, with Arizona residents being less likely to purchase local food as compared with participants from other states; this may be because Arizona's cities have fewer farmer's markets per capita than other comparable US cities (Jilcott, Keyserling, Crawford, McGuirt, & Ammerman, 2011). Procedural knowledge significantly impacts composting behaviors, with geographic location and curbside recycling being inversely related to composting behaviors. Purchasing bottled water does not appear to be impacted by knowledge in any domain, possibly because it is not a behavior that requires a great deal of thought to carry out.

Discussion

While there is variation in terms of how the knowledge domains interact with the individual behaviors, declarative knowledge is consistently *insignificant* in terms of its impact on behaviors. Our finding that declarative knowledge does not impact participation in sustainable behaviors is in line with other studies that have found technical information to be ineffective in promoting environmentally responsible behaviors (Kollmuss & Agyeman, 2002; Pooley &

O'Connor, 2000). The implication of this finding for sustainability education is that if we hope to foster transformative change, we must shift away from educational approaches that focus on declarative knowledge. Additionally, this survey found no correlation between participating in a sustainability course and behaving sustainability, reaffirming that current sustainability education is not sufficiently influencing behaviors.

The positive and significant impact that procedural, effectiveness, and social knowledge had on participation in sustainable behaviors (particularly in contrast to declarative knowledge) demonstrates the need to incorporate diverse domains of knowledge into our education strategies. In particular, social knowledge appears to be critical across a wide array of behaviors. In developing strategies for targeting social knowledge, sustainable behaviors should be positively reinforced (or rewarded) and positioned as 'normal' and 'desirable.' One way to do this is through consciously modeling sustainable behaviors in the classroom and building sustainable practices into the everyday operations at schools. By building sustainable practices (such as composting) into the classroom, students and teachers can gain the necessary knowledge regarding how-to compost (procedural knowledge), while creating a norm of behaving sustainably at school thus also increasing social knowledge. Integrating practices in schools that enhance knowledge in the relevant domains is not only critical to promoting sustainable behaviors, but can also encourage the transfer of knowledge from school to home (as shown by the Pearson's correlation between recycling practices).

In exploring the relationships between knowledge domains and behaviors, it is clear that the knowledge domains interact differently with different behaviors. The impact of effectiveness knowledge—most significant in terms of waste behaviors compared to food choices—exemplifies the variation that can be seen in the relationships between knowledge and behavior. This finding demonstrates that there are different barriers and drivers associated with individual behaviors. For instance, composting is tightly correlated with procedural knowledge suggesting that

participation in composting requires certain skills and knowledge regarding how-to set up and maintain a system. In contrast, using a reusable water bottle is more closely correlated with subjective knowledge (norms and perceptions about effectiveness) and not impacted by lack of technical (declarative or procedural) knowledge. Additionally, recycling behaviors are impacted by effectiveness knowledge, where as composting is not. Other researchers have speculated reasons for these differences; for instance, Tucker and Speirs (2003) suggest that some individuals feel that they do not generate enough waste to make recycling impactful or worthwhile. Understanding which knowledge domains are central to overcoming barriers and motivating action for each individual behavior is critical to educating for transformative change. Therefore more research needs to focus on the antecedents to action for individual behaviors rather than ecological behavior broadly.

While this research advanced the conceptualization of multi-dimensional constructs of knowledge, the knowledge domains, particularly the subjective domains of knowledge (social and effectiveness) should be explored further. In terms of social knowledge, future research should explore the degree to which a person is influenced by their perception of what their friends and family view as positive or negative. In order to assess this type of social knowledge, questions need to be asked about what the respondent thinks their friends/family do, how much they care about what their friends and family do, and how closely their perceptions are to reality. Other studies (on behaviors such as alcohol consumption) have shown that not only are individuals influenced by family and friends differently but also their perception of their peer environment varies from reality (H. W. Perkins, 2002). Examining the relationships amongst perception, reality, and peers versus family influence in terms of specific sustainable behaviors, especially given the importance of social knowledge, is a critical future step.

This research is predicated to some degree on the assumption that teachers shape the future of tomorrow by modeling behaviors and imparting knowledge to their students. Hence, we

suggest that if teachers lack the knowledge in a domain area, then their students are also going to lack that type of knowledge; and if teachers do not participate in a given sustainable behavior then they will not be role models for their students in terms of said behavior. Further research is needed to explore the relationship between teachers' behaviors and knowledge and how that translates into the classroom and influences the students by simultaneously surveying teachers and their students or by taking a more intensive, case study approach.

Chapter 5

OPPORTUNITIES AND CHALLENGES FOR INTEGRATING SUSTAINABILITY EDUCATION INTO K-12 SCHOOLS

Introduction

The transition towards sustainability requires preparing educators with the knowledge and skills to implement sustainability curriculum and practices in traditional K-12 classrooms. Although the summer sustainability program was implemented at a university rather than in a traditional classroom (Chapter 3), the curriculum and approach was created with implementation in a typical K-12 classroom in mind. In order to promote and facilitate sustainability education in Phoenix-area K-12 schools[7], I worked with and later interviewed a number of teachers over the course of my dissertation research. Herein I reflect on what I've learned from these K-12 teachers concerning the opportunities and barriers to integrating sustainability into a traditional classroom setting. This chapter concludes with recommendations for working within the difficult, cumbersome, and discipline-focused structure, while capitalizing upon existing opportunities, to advance the implementation of sustainability education.

Background Information

Traditional approaches to education, particularly in the closely related field of environmental education, focus on nature-centric, value-free, didactic methods (Blumstein & Saylan, 2007). Other scholars have noted that these traditional, mechanistic, and rote education methods have exacerbated sustainability problems by promoting simplistic, isolationist thinking (D. W. Orr, 2004; Williams, 2008). Progressing towards a more sustainable future requires changes in education structure, content, and process (Williams, 2008). Many sustainability education scholars have suggested that this shift necessitates educating for the whole person—not just for increased literacy and cognitive outcomes, but rather, for the head, heart, and hands as

[7] My K-12 sustainability education outreach programs were funded by the National Science Foundation, GK-12, Sustainable Schools Project and CAP-LTER's K-12 outreach program, Ecology Explorers.

well—in order to promote empathy, develop skills, and integrate multiple ways of knowing (Sipos, Battisti, & Grimm, 2008; Williams, 2008). The methods suggested throughout this dissertation support this call for change and for a shift away from modernist, positivistic approaches to education.

Fostering change within the education system, however, is not without significant barriers. One of the most commonly cited barriers to change within the K-12 system is the already over-crowded agenda. An education professor, John Stir, wrote that, "It sometimes seems that the curriculum is too crowded, the day is too busy" (2005, pp. 836). Teachers are expected to cover an ever-growing list of standards, prepare students for standardized tests, and equip them with the knowledge and skills they need for their future careers. In the face of all that educators are expected to do, sustainability education is often seen as an additional burden that teachers have neither the time nor resources to bear (Wheeler & Byrne, 2003).

A number of education scholars have noted that one of the greatest pressures facing teachers is the emphasis on achieving high standardized test scores (Wheeler & Byrne, 2003). Test scores are not only linked to funding but also often, "seal the fate and set the salaries of principals and teachers" (p. 27). This creates a barrier to implementing novel pedagogical approaches that target diverse domains of knowledge not only because teachers and students spend weeks of class time preparing for standardized tests but also because standardized tests reinforce the emphasis on technical or factual knowledge (Marzano, 1990). Education researcher, Robert Marzano writes, "a school or district that wishes to improve student scores on standardized achievement batteries should focus its curriculum on test-taking skills, content specific factual knowledge, and content specific procedural knowledge" (1990, p. 97). While my research suggests focusing on multiple ways of knowing, with an emphasis on subjective knowledge, through experiential, real-world approaches, the pressure placed on teachers to

achieve high standardized test scores reinforces didactic methods that target technical forms of knowledge (i.e., declarative and procedural).

The term 'sustainability' has begun to frequently appear in education documents or agendas because it is a 'hot topic,' but all too often it is simply being used in lieu of environmental education (Pepper & Wildy, 2008). In order to lead the way towards sustainability, educators must first have a deep understanding of sustainability, beyond the nature-centric focus attributed to environmental education. Sustainability is a distinct departure from environmental education, particularly in its emphasis on normative aspects underlying issues of equity and justice as well as the need to focus on social change and action (Sterling, 2004). Therefore, inserting sustainability as the new environmental education does a disservice to the goals of sustainability and impedes transformative change (Pepper & Wildy, 2008). To effectively educate for sustainability, teachers need to be go beyond a surface understanding of sustainability, move out from under the umbrella of environmental education, and develop strategies for change and action (Pepper & Wildy, 2008).

In order for teachers to lead the way towards sustainability, they need both external and internal support. A number of sustainability education researchers have called for universities, NGO's and businesses to provide external support for K-12 schools (Wheeler & Byrne, 2003). One of the ways that universities and NGO's commonly interact with K-12 teachers is through pre-service (i.e., undergraduate education programs) and in-service training (i.e., continuing education courses). Yet, education researchers, Wheeler and Bryne, lament that, "in pre-service education, sustainability is totally absent as a holistic concept," and "the net result is a near-absence of sustainability education in the K-12 system" (pp. 28, 2003). Universities and NGO's can help build acceptance for and enhance knowledge of sustainability concepts, while businesses can help incentive sustainable practices through providing supportive structures (e.g., schools' waste companies could implement price structures that incentivize recycling).

Educational change does not, however, come easily. Education scholars Hargreaves and Goodson (2006) note that in the last three decades pockets of change have succeeded but institutional-scale change has yet to spread or last. While sustainability scholars have called for dramatic changes to the education system in order to shift away from industrialized, assembly-line methods (D. Orr, 1991; Sterling, 2001), education scholars have pointed to complex bureaucracy and subject traditions as reasons for the rigidity to change within middle and high schools (Hargreaves & Goodson, 2006). The public education system is clearly over-burdened with standards, standardized tests, crowded classrooms, and constant budget crises. The teachers I worked with are, however, enthusiastic and passionate about sustainability even though they feel restricted by the system in which they are working. So in the following pages, I suggest ways for confronting some of the barriers to change in order to educate for sustainability and support teachers in their efforts to integrate sustainability into their classroom practices and curricula.

Interviews with Teachers

As part of my dissertation research, I collaborated with three K-12 teachers during the sustainability summer program (see Table 13 for more information on the teachers). During and after the program, I gathered data through surveys, interviews, and participant observations (see Appendix D for survey and interview questions). Each of the three teachers provided important insights about the applicability of the sustainability curriculum and practices in traditional classrooms as well as the major barriers to implementation.

In addition to these three teachers, I also interviewed a teacher who successfully integrated a number of the activities developed for the summer program into her classroom as part of a month-long sustainability unit in her 8th grade science classroom (for interview questions see Appendix D). She utilized the lesson plans, PowerPoints, and supplemental materials I developed for the summer program (passed on to her from one of the teachers who participated in the 2-week summer program). Our interview covered her experience with the curriculum, her

students' interest in the subject, her approach to evaluation and her experience in matching the sustainability content with the science standards. While she did not participate in the summer program, her insights are relevant to understanding how to integrate sustainability education into traditional classrooms and are thus reported here.

Table 13

Background information on teachers involved in my research

Teacher's Pseudonym	**Teaching Position** (at time of interview)	**Relationship**
Kelly	1st year 8th grade science teacher at inner-city charter school	Participated in STEM summer program as part of Master's degree
Kate	Applying for several positions as 8th grade math teacher	Participated in STEM summer program as part of Master's degree
Kylie	3rd year 6th grade science teacher at suburban public school	Participated in STEM summer program as part of Master's degree
Sue	4th year 8th grade science teacher at inner-city public school	Received the sustainability curriculum from Kelly

Barriers to Integrating Sustainability Education into K-12 Schools

If we are to educate for sustainability *now*, we must understand the barriers to implementation and find ways for working within these confines. Herein, I discuss the challenges of educating for sustainability, including standards, standardized tests, pressures on new teachers, lack of deep knowledge regarding sustainability, and a general lack of support for sustainability.

I. Standards & standardized tests

The teachers I have worked with stressed the importance placed on standards and standardized tests at their schools. Some remarked that although they would like to teach sustainability, they feel too overwhelmed by the standards required of them and their schedules are just too busy to fit sustainability in their curriculum. Kelly, for instance, noted that she did not use the sustainability lessons because of, "the pressure of state standards and making sure we get passing test scores." As a first year science teacher, Kelly spoke about the pressure she felt

about her students getting good AIMS (Arizona's Instrument to Measure Standards) test scores[8] and hoped that once the tests were finished she could move away from spending class time doing practice questions. She stated, "as soon as I have more time, as soon as AIMS is over, I will be able to do more."

Kate also discussed the difficulties of educating for sustainability while teaching traditional subjects and associated standards. When asked whether she thought sustainability curriculum would fit in her future classroom, she expressed concern about how to fit the sustainability lessons with the math standards. In particular, Kate suggested that sustainability seems to be a better fit with science standards, but when teaching math she would need support in learning how to create math-related sustainability lessons. Kate suggested that the most accepted sustainability issues in schools are those related to the environment, which also makes science the easiest subject for teaching sustainability.

In short, explicitly linking curriculum to standardized subjects and expected knowledge and skills will help teachers integrate sustainability into their classrooms. There are a number of actors who can support teachers in these efforts: 1) Universities can integrate sustainability education into their current teacher education programs in order to explicitly link sustainability to core subjects and standards; 2) NGO's can implement sustainability workshops (i.e., continuing education courses) that focus on linking standards to sustainability; 3) Outreach programs (whether a part of universities, NGO's or businesses) can focus on developing curricula that links sustainability to core standards while also collaborating with teachers to adapt the curricula to their local context.

[8] AIMS is a type of achievement test. Achievement tests are used by citizens and school boards to measure how well the school is doing and is often linked to funding. This is different from an aptitude test (e.g., ACT & SAT) which is used to assess how well a student will do at a future education setting and often used to accept or deny students admittance to said future education setting.

II. New teacher work-load

The teachers I worked with were all relatively new teachers at their schools, with less than five years at their schools or in their subject areas. The first couple of years are some of the most difficult for teachers because they have to prepare lessons, presentations, worksheets, and tests for a new subject that they may not even be that familiar with. In the interview with Kelly, she said that one of the barriers for her in implementing sustainability curriculum was her confidence regarding teaching science. She said:

> "I kind of got thrown into the science area. I think a lot of meshing standards [science standards with sustainability] that you see, I don't see because I don't have that science background. I think that has a lot to do with it being harder to implement [sustainability] in the classroom because a lot of the teachers don't have confidence in the science field."

For Kelly being a new science teacher is overwhelming but when she becomes more comfortable with teaching science she hopes to try many of the sustainability lessons and practices in her classroom. In this way, Kelly represents the trade-offs associated with working with new teachers. While younger teachers may be more attune to relatively new, emerging ideas such as sustainability, they lack the confidence and experience that seasoned teachers have. On the other hand, seasoned teachers may have the confidence or seniority to try more novel approaches but are generally less familiar with sustainability issues and practices.

As a result, I suggest the development of Professional Learning Communities (PLCs) focused on sustainability in order to encourage collaboration among seasoned teachers and new teachers. Professional Learning Communities already exist in many schools and are used to promote interdisciplinary collaboration, the development of new curriculum, and co-generation and maintenance of projects (such as school gardens).

III. Lack of deep knowledge regarding sustainability

Lack of knowledge regarding sustainability itself can be a barrier to implementing sustainability projects and curricula. Teachers want to feel knowledgeable about the topics they

are teaching and not being or feeling sufficiently knowledgeable can make them hesitant about teaching sustainability topics with which they are less familiar. Kelly felt that with more training, she could gain the requisite knowledge to integrate sustainability into her classroom but right now she finds it overwhelming.

This knowledge barrier applies to sustainability curriculum as well as sustainability practices. For example, Kate and Kelly both expressed interest in composting in their classrooms but they want to successfully maintain a composting system in their homes for some time before bringing the practice to the school. Kelly noted that bugs can be a problem with composting and she wants to figure out how to manage these problems at home before composting in her classroom. Kelly and Kate hope to be experts on composting before trying to implement this practice in their classrooms, hence making their lack of expertise a barrier to implementation. Kylie also expressed a desire to learn more on the topic of sustainable foods prior to implementing a lesson on food systems sustainability.

While Sue has a strong science background, she did note that implementing the sustainability unit was a learning process for her. Sue said, "I didn't really understand what I was getting myself into with the sustainability unit." She was learning and researching sustainability issues along with her students. While teachers traditionally like to be the 'experts' on a topic before teaching it, Sue demonstrated that as long as the teacher is willing to learn along the way, lack of deep knowledge does not have to be a barrier to implementing a sustainability unit.

From the interviews with the teachers, it is clear that some of them are more hesitant about diving into new topics and approaches while others are confident enough to learn through the process. Hence, in overcoming the knowledge barrier, it is not necessary that every teacher has perfect knowledge on the myriad of complex sustainability issues prior to integrating sustainability into their classrooms but it is important to link sustainability with topics that teachers are comfortable with (e.g., Kylie stated she would attend a workshop on integrating food

systems sustainability into K-12 classrooms). It would, therefore, be beneficial to structure workshops around the teachers' specific interests in order to delve deeper into a topic rather than focusing on surface understanding of sustainability broadly.

IV. Lack of external and internal support

The teachers I worked with suggested that professional development and training regarding educating for sustainability in the K-12 system is lacking and much needed. In terms of training, Kelly said, "I have always wanted to learn a more formal approach to introduce this topic [sustainability] in order to make students more aware." Through in-service training and professional development focused on sustainability, teachers could get the support they need to develop and implement sustainability curriculum and practices.

While external collaboration and support would be beneficial, teachers also need to feel supported in their efforts to educate for sustainability by the leaders within their schools. The teachers I interviewed were concerned about teaching topics that administrators and parents would find unacceptable. For example, Kate said: "talking about plant-based diets as opposed to eating meat is not as socially acceptable and probably would not be well accepted by administrators and parents." In addition to Kate, Kelly as a first-year science teacher suggested concern about pushing the boundaries of what is taught and how when she is so new to the school and sustainability is not traditionally a part of her school's science curriculum. If administrators were to come out as openly supportive of sustainability education then much of the concern expressed by Kelly and Kate would be alleviated.

Universities can be a part of enhancing both internal and external support. Administrators and teachers filter through the university system in order to get the undergraduate degrees (and often graduate degrees) necessary for their positions. Through integrating sustainability and diverse domains of knowledge into university courses, regardless of discipline, the graduates of

universities will, ideally, be supportive of these constructs in their future careers (be it as a teacher, administrator, or parent of a student).

Opportunities for Integrating Sustainability Education into K-12 Schools

The barriers to implementing sustainability education seem daunting, however, there are also opportunities that can be capitalized upon. In particular, the teachers I interviewed are interested in educating for sustainability and transformative change. They value a sustainable future and see K-12 education as a critical part of transitioning towards sustainability. The students are equally enthusiastic and when given the opportunity, engage deeply in sustainability issues. Additionally, sustainability curricula, when adapted by a knowledgeable teacher who has internal and external support, can meet the standards and increase students' understanding of the science topics targeted through the standards.

I. Enthusiastic teachers

Despite teachers heaving workload, each of the teachers I surveyed and interviewed expressed excitement about integrating one or more lesson/practice into their classroom (see Table 14 for more information). In the post-summer program survey, Kelly wrote, "I think all the material and ideas you presented were inspiring, meaningful, and important" and "I look forward to multiplying the effect in my classroom." Kate said that seeing the students' reactions to the sustainability material during the two-week program, reminded her how important it is for students to learn about sustainability and understand how everything is connected. Sue was also enthusiastic about sustainability education and felt that the sustainability unit that I created was moving and powerful. She said, "I don't care what subject I am teaching I really want to teach this (sustainability) every year." The enthusiasm expressed by the teachers demonstrates that if they were to have support in implementing sustainability curriculum and practices they would be happy to do so.

Table 14

Sustainability lessons and practices selected by the teachers as their 'favorite'

Teacher	**Favorite Activity**	**Justification** *(how & why the activity fits in with the teacher's classroom)*
Kelly	Composting & eating healthy as part of everyday classroom practices	Kelly is overwhelmed by the standards so she prefers to integrate sustainability into her classroom practices (e.g., recycling) rather than in formal lessons or curriculum.
Kate	Sorting trash activity	Kate stated that through watching the students sort their trash into compostable, recyclables, and landfilled piles, she was able to physically see what they had learned about waste management. In this way the lesson served both as a hands-on, real-world relevant activity and as an assessment of what the students learned.
Kylie	Ecological Footprint activity	Kyle wrote that she used the Ecological Footprint activity with her students on Earth Day because, "it really helped them see the impact of consumer choices" and "raise consciousness among students regarding the choices they make."
Sue	Cereal re-design	Sue used the cereal box re-design lesson as her first activity in the sustainability unit because it allowed her students to engage in the inquiry process (which is Strand 1 of the 8th grade science standards).

As previously discussed, the teachers I interviewed are relatively new teachers so it is possible that more seasoned teachers will see sustainability as just another "wave of reform" (Hargreaves & Goodson, 2006, p. 18) and may, therefore, lack the excitement expressed by the new teachers. Other scholars have found that mature teachers with longer careers, often see reform and change as another phase that will ultimately not last so rather than engaging in the suggested change, they just try to ride it out (Hargreaves & Goodson, 2006). Thus, in order to capitalize on the enthusiasm of the new teachers while also utilizing the experience of seasoned teachers, I reiterate the need for Professional Learning Communities as a method of bringing new and mature teachers together.

II. Student interest and empowerment in sustainability topics

Teachers are constantly seeking ways to increase student interest in learning and educating for sustainability certainly seems to get students excited and engaged in learning. Sue explained: "about 99% of her students said the sustainability unit was the most important thing they learned all year." She said, "Even kids who I have never been able to touch all year long, I've had a whole entire year with them, kids that I have never been able to break through to, they are stopping after class asking questions, coming in at lunch, wanting to know more information." Sue was surprised at all the outside of class time her students were spending on sustainability because typically homework is seen as a burden but with the sustainability unit the students were, "just off on their own doing their own investigating." The students commented on how because of the sustainability unit, they saw sustainability issues all around them and felt that the topic was relevant to their lives and the real-world. The problems presented in class were relevant and tangible (real-world based) and spurred conversations with the students' peers and families.

In sustainability, we often discuss how to get ideas and practices to diffuse throughout society. Getting students to influence their parents to behave more sustainably is one way to increase the diffusion of sustainability practices. Sue's students expressed interest in changing their food purchasing behaviors so they spent many class periods discussing how to influence change in their households. She said that her students expressed frustration with their parents, "not getting it." However, many of the students wrote in their final exams about small victories at home. One student wrote, "We always stop at Wendy's on the way home and now I tell my mom that we can just wait, so that I can eat something healthier at home." Many other students noted that they were eating less meat and choosing fruits and vegetables as snacks rather than processed foods.

III. Adaptability of sustainability lessons

Sue used many of the activities and materials that I created but adapted them and changed the order in which she presented the material. The first lesson she used during her sustainability unit was the cereal redesign lesson in which students redesign cereal boxes based on the ingredients in the product (see the full lesson plan in Appendix E). She said the students loved this activity and were horrified by how the boxes could look healthy but really were full of sugar and corn-based products. The students commented that, "the box lies!" and from there began to question what else was in their food that they didn't know about (see Figure 9 for an example student cereal box redesign). By the end of this activity, the students were asking broader food system questions regarding nutrition, chemicals, and food marketing.

Figure 9. Frosted Flakes cereal box redesign created by one of Sue's students as part of the sustainability unit

Building upon the students' curiosity, Sue presented information on the food system beginning with the Green Revolution and industrial agriculture. She tied the Green Revolution

into previous science units by having the students use this case to discuss the relationship between ethics and science. By starting with a fun, creative, hands-on activity, Sue was able to get the students asking questions and investigating on their own. Development of questions and subsequent investigation is a critical part of the inquiry process that is emphasized in the 8th grade science standards and complements the problem-based learning approach that I emphasize throughout the lessons I have created.

In addition to changing the order in which she presented the activities, Sue also modified some of the details of certain activities. For instance, I developed a lesson on evaluating three different types of salsa (organic, conventional, and local) based on environmental, economic, and social equity criteria. For this activity I used Amy's organic, Pace Picante, and Timoteo (a local Phoenix brand) as representatives of the different approaches to production (see lesson plan in Appendix E). I researched each of these three companies, contacted the companies for further information, and wrote a narrative about their practices and policies regarding employees, farming practices, and distribution. Sue, on the other hand, had the students bring in the salsa they most frequently ate at home, including homemade salsa. In class, the students then had a 'salsa party' in which they ate the salsa. After they finished, the students were asked to look at the packaging and learn more about their salsa.

During this part of the activity, they realized that the homemade salsa created the least amount of waste because the homemade types were already brought to class in a reusable container (Sue noted that one of the students brought in homemade salsa in an old coffee can). Next, the students were asked to evaluate all the different kinds of salsa using the criteria I developed for the lesson. The students had a few days to research the salsas and return to class with their findings regarding the life cycle of their salsas, including labor and farming practices, production and shipping operations as well as end of life management (waste processes). The students even found an article about a company that produced one of their brands of salsa

describing how it had polluted a lake next to their processing facility. The way in which Sue adapted this activity was very smart because she not only used real-world salsa brands, as is done in my original lesson, but she went beyond and used brands (or homemade equivalents) that were present in the students' everyday lives. Sue said that it also helped that the lesson plan provided suggestions for how the lesson can be linked to school standards (see the standards section of the 3 E's of salsa lesson in the Appendix E).

IV. Sustainability curriculum and science standards

During the interview Sue went through her Arizona standards book (Cambridge-based curriculum) with me and pointed out how the sustainability unit fit into each of the standards, strands, and concepts. For instance, Sue explained that with *Strand 2: History and Nature of Science* they discussed the history of science as a human endeavor while integrating food issues regarding the pros and cons of biotechnology, pesticides, and the mechanization of the food industry. Sue also discussed how well the sustainability unit fit with the scientific process and inquiry (*Strand 1: Inquiry Process*): "applying scientific processes, observing questions, comparing, classifying, all of this has to do with sustainability issues, it all fits well with the sustainability unit."

She explained that the sustainability unit allowed her to expand on other standards such as the changing environment, analyzing environmental risks, analyzing environmental benefits of human interactions with biological or geological systems, science and technology in the environment, and science in personal and social perspectives. For instance, life science standards include populations of organisms and ecosystems, and analyzing the relationship among organisms and their environment, so the students looked at monocultural farming and how it has wiped out ecosystems. Then, by comparing food chains and food webs, they looked at the bio-accumulation of pesticides in the environment due to industrial agriculture.

Sue, having an undergraduate degree in biology, felt that any teacher with a strong science background could easily integrate sustainability into their science class. Overall she felt that the sustainability unit:

> "totally tied in every concept that we covered this year. It wrapped it up in a beautiful package and put a beautiful bow on it. They could just see how every aspect of science came together in the sustainability unit, from chemicals to pollution, and chemical reactions and physical and chemical properties and Newtonian mechanics. They could see how there were connections with everything they have learned. It was amazing because it [the sustainability unit] brought everything together."

Table 15 below illustrates Sue's approach to integrating sustainability with the state science standards for her classroom.

Table 15

Integrating sustainability education with 8th grade Arizona science standards

Strand 1: Inquiry Process Concept 1: Observations, Questions, and Hypotheses Concept 2: Scientific Testing Concept 3: Analysis and Conclusions Concept 4: Communication	Sue had a school garden in which students conducted experiments about how plants grow under different conditions. For instance, students could grow plants using purchased soil, hot-compost, and vermin-compost and then discuss the sustainability implications as well as the plant growth.
Strand 2: History and Nature of Science Concept 1: History of Science as a Human Endeavor Concept 2: Nature of Scientific Knowledge	Sue discussed the Green Revolution with the students and they reflected on how the technology (pesticides, GMOs, fertilizers) had negative cascading effects. They discussed how plants developed in the U.S. were spread to other countries in which the culture (customs) and even climate made the crops less successful than was anticipated.
Strand 3: Science in Personal and Social Perspectives Concept 1: Changes in Environments Concept 2: Science and Technology in Society	Sue assigned her students to read chapters from the book Garbology (by Edward Humes). They discussed the problem and watched a video on the Great Pacific Garbage Patch. Then they brainstormed solutions (composting, recycling, reusing) and we asked to present at least one solution on their sustainability unit exam.
Strand 4: Life Sciences Concept 1: Structure and Function in Living Systems Concept 2: Reproduction and Heredity Concept 3: Populations of Organisms in an Ecosystem Concept 4: Diversity, Adaption, and Behavior	In 8th grade this strand is primarily focused in concept 2. Sue discussed Genetically Modified Organisms with her students and explained genetic drift (gene migration from GMO crops to non-GMO crops). They also discussed how this has led to monocultures and reduced genetic diversity.
Strand 5: Physical Science Concept 1: Properties and Changes of Properties in Matter Concept 2: Motion and Forces Concept 3: Transfer of Energy	When discussing the transfer of energy, students learn about entropy. Through entropy students examine what happens when we eat higher on the food chain (loss of energy, 10% rule). Students can clearly see that eating higher on the food chain results in greater energy loss.
Strand 6: Earth and Space (no performance objectives for grade 8)	There are no concepts for 8th grade science in regards to this strand.

Recommendations

Based on research in academic literature, the interviews with the teachers as well as experience at other schools, I recommend: 1) Teacher training focused on integrating sustainability lessons into the standards; 2) Professional Learning Communities (PLCs) focused on supporting each other in developing sustainability lessons; 3) Internal and external support for integrating sustainability into the school and classroom. This is not to say that these are the only plausible recommendations for integrating sustainability into K-12 schools but these are the recommendations that immerged from the key barriers and opportunities elaborated on here. I have briefly introduced each of these recommendations in the above text in regards to confronting specific barriers or capitalizing upon unique opportunities. Herein, I revisit each of these recommendations and explain how they build support for sustainability education.

I. Provide teacher training (pre- and in-service) focused on sustainability

Some teachers, like Kelly, do not have strong science backgrounds and need support in linking sustainability curriculum to their required standards. During Kelly's interview, she stated that she would like to have a teacher in-service training that focuses on sustainability. Through external support from universities and NGO's on how to integrate sustainability into their subjects and standards, some of the burden would be taken off already over-committed teachers. Teachers are currently required to take continuing education classes every year so devoting one of the sessions to sustainability would not add to their already busy schedule. Additionally, integrating sustainability into undergraduate and graduate education programs would contribute to increasing knowledge regarding sustainability while fostering support for sustainability education generally.

There are currently NGO's, such as the Green Education Foundation (GEF, 2013) and the Sustainability Education Network (Wheeler & Byrne, 2003), that are focusing on developing in-service training for teachers regarding sustainability. Additionally, universities, such as Arizona State University, have outreach programs that are tasked with supporting and collaborating with

teachers and students to integrate sustainability into schools (http://sustainableschools.asu.edu/). Yet, many of the existing programs still have a nature-centric approach and focus on global issues rather action and individual responsibility (Blumstein & Saylan, 2007). While it is progress to see a growing number of organizations and institutions focusing on sustainability education in the K-12 sector, in order to promote the transformative change need to progress towards sustainability, the training needs to move out from under the approaches common to environmental education.

II. Develop Professional Learning Communities (PLCs) focused on sustainability education

While teacher training would be useful for many teachers, some teachers such as Sue already have a clear understanding of how sustainability relates to their subject and standards. For teachers like Sue, having a Professional Learning Community (PLC) that focuses on sustainability lessons, projects, and practices would be helpful. Sue manages the school garden and she started composting in her classroom but if more teachers got involved with sustainability education, she could have support with some of these school-wide projects rather than managing them by herself. PLC's typically bring together a group of teachers and staff in order to collaborate, learn from each other, and share responsibility for the targeted project (LaFee, 2003); so while Sue would benefit from having others to share the responsibility of the garden, teachers like Kelly would benefit from learning how Sue integrated sustainability with the science standards.

PLC's have also been known to increase buy-in of new projects or ideas (LaFee, 2003), therefore the development of a sustainability PLC may also encourage seasoned teachers to engage with sustainability and support newer teachers in their efforts to try novel pedagogical methods. Members of PLC's can also share their lessons and successful adaptations with their colleagues, hence reducing the workload of each individual teacher. Many schools, including one that I worked at during the GK-12 fellowship, already have PLCs and have set aside time during

the school day for PLC meetings. Building upon these existing programs and structures allows for the teachers to focus on integrating sustainability without adding to their already over-crowded schedules.

III. Increase internal and external support for sustainability education

Schools can be tricky political environments. In the interview with Kate she talked about how careful she will have to be when integrating values and subjective knowledge into the classroom. In particular, new teachers have a difficult time pushing the boundaries of what is typically taught. Kate said that while she understands that declarative knowledge on its own is not enough to create change, the behaviors that can be advocated for and the values that can be taught are largely dependent upon the school environment. In terms of integrating subjective knowledge into the classroom, Sue had strong support from her administration. Sue openly discussed behavior change in her classroom and even had questions on the students' exam about how they were going to change the way they ate. In terms of her administration's reaction to this approach, Sue said: "in my final evaluation [the principle] said this is exactly our mission statement, we want kids to be competitive in a global society and we want them to be community builders, we want them to make big changes at the local level and this [sustainability unit] totally goes along with everything that our school stands for."

Unfortunately, many schools are still generally stuck in the positivist view of science—in which science is value-free and the teachers should not be advocating for certain behaviors or teaching controversial topics but rather just imparting 'facts' and other types of declarative knowledge. Sue was able to integrate subjective knowledge and discuss values, attitudes, and behaviors in her classroom because her principal was incredibly supportive of her efforts to integrate sustainability. This support enabled Sue to fully engage her students in the normative aspects of sustainability and if more schools can take this approach to education and see it as an opportunity to foster community leaders and change agents then sustainability can much more

successfully diffuse throughout our society. In order to increase internal support for sustainability, universities (e.g., through undergraduate and outreach programs) and NGO's could also tailor programs for administration in order to increase awareness and acceptance of subjective forms of knowledge.

Even with supportive administration, there needs to be supportive infrastructure for many of the sustainable behaviors suggested in this dissertation to be modeled. For instance, having the water-bottle refilling stations at the schools allows teachers to model using and refilling their water-bottles. Also, having a school-wide recycling program is essential to create the norm of recycling within the school. Many school programs are run by outside businesses or the infrastructure is installed by outside businesses. If the external businesses could support schools in their sustainability initiatives by providing monetary incentives or materials at little cost (e.g., recycling bins), then the behaviors would be far easier for money-strapped school to engage in. For behaviors like recycling, supportive infrastructure is as critical as supportive policies, hence businesses are a central part of creating change within schools.

Conclusion

Although, there may be resistance to novel methods of educating for sustainability in K-12 schools, the teachers who participated in the summer program were most interested in those activities which targeted procedural, effectiveness, and social knowledge, over those more traditional ones which only targeted increasing declarative knowledge. Kate, Kelly, and Kylie all said they would enjoy a teaching environment that allowed them to integrate sustainability curriculum and practice further and would be interested in professional development that fostered the necessary skills. They want to move away from the didactic approach because when they were the observers they found themselves tuning out after fifteen minutes when a traditional didactic approach was taken. However, changing the school environment requires structural change (adding things like water bottle filling stations), institutional and financial support (to

build gardens and composting systems like Sue did), as well as increased support from administrators and parents.

Prominent K-12 sustainability education scholar, Keith Wheeler (2003) explained the challenge if education for sustainability is going to take hold:

> "Those interested in fostering sustainability still must convince the school boards, educators, and citizens-at-large that our current practices are interfering with the ability of all people, now and into the future, to have fulfilling, secure lives-and convince them that a focus on sustainability can produce more options, more fulfillment, and a more secure and prosperous future. Higher education leaders, in partnership with K-12 sustainability education leaders, are capable of accomplishing such a transformation. The seeds are sown and the opportunity is before us."

Drawing from the experiences, difficulties and aspirations of active teachers interested in sustainability, I have identified several key lessons and actions which can be taken to promote education for sustainability and lead the way towards the transformation that Wheeler so eloquently calls for. The challenge of educating for sustainability and transformative change in K-12 schools is not just in the hands of teachers and principals, but rather is a burden that must be shared by universities, researchers, NGO's, and even parents. Through collaboration and a commitment to change and action, we can build education processes that promote systems thinking, encourage long-term strategizing, and place a value on the future while empowering the next generation of leaders to be agents of change for sustainability.

Chapter 6

DISCUSSION AND CONCLUSION

This dissertation examined how education programs can enhance competence in sustainability and foster behavior change through the integration of behavioral theories into education pedagogy. Specifically, my research focused on educating for sustainability in the K-12 sector with an intensive case study (Chapter 3) as well as an extensive survey (Chapter 4) that analyzed the relationship between various knowledge domains and sustainable behaviors. I targeted four domains of knowledge (declarative, procedural, effectiveness, and social) in order to develop both technical and subjective knowledge through experiential, real-world pedagogical approaches (theoretical approach outlined in Chapter 2). During the year-long case study, I applied and evaluated the approach outlined in Chapter 2 with adolescents. Both the case study and extensive survey specifically examined the relationship between knowledge and behaviors with regard to food and waste systems.

In this final chapter, I revisit the research questions proposed in Chapter 1 to answer and discuss: how diverse knowledge domains (declarative, procedural, effectiveness, and social) influence sustainable behaviors, both in general (extensive survey) as well as before and after a sustainability education program (intensive case study). Then, based on our understanding of knowledge domains and pedagogy: How can we motivate sustainable behavioral change through education? What are barriers hindering educational approaches to changing behaviors?

I conclude this chapter with a discussion of implications of the findings for both further research and practice. Therein, I address how the findings of this research have pushed the boundaries of the fields from which it has drawn. In addition, I put forth recommendations for future research broadly. Finally, I briefly reflect on what I have learned along the way, as well as on my personal, future research aspirations.

Synthesis of Findings:

How do diverse knowledge domains influence sustainable behaviors?

One of the most important findings of this research is empirical support for the inadequacy of declarative knowledge fostering behavior change on its own. Declarative knowledge was the only knowledge domain that did *not* predict increased participation in *any* of the food or waste behaviors studied in the extensive survey. In terms of the education program, the highest average post-program knowledge was for declarative knowledge regarding food. Yet despite the greater shift in declarative knowledge about food, waste behaviors changed more than food behaviors. This suggests that the substantial increase in declarative knowledge did *not* result in an equivalent shift in the associated behaviors.

The three other knowledge domains all had some influence on one or more sustainable behaviors, but social knowledge was found to be the most influential across food and waste behaviors overall (though to varying degrees depending on the specific behavior). In addition to the extensive quantitative survey, the education program also supported these findings in that rigidity in social knowledge was associated with a corresponding rigidity in behaviors, and where social knowledge increased, participation in the associated behaviors also increased. Additionally, the findings suggest that social knowledge regarding food is more difficult to change than social knowledge regarding waste, because food behaviors are tied to a complex array of social influences (i.e., parental control of food choices, lack of school options, cultural underpinnings), thereby making social knowledge about food difficult to measure let alone change.

Procedural and effectiveness knowledge were to varying degrees also significant in terms of an individuals' level of participation in sustainable behaviors. Procedural knowledge was significant when looking broadly at the food and waste behaviors, but its significance varied when examining specific behaviors. For instance, procedural knowledge strongly influenced

whether or not people composted but did not influence whether they used reusable water bottles. This makes sense because composting requires substantial procedural knowledge regarding how to sort organics and how to build and maintain the system, whereas reusing a water bottle requires significantly less start-up, how-to knowledge.

While not influential on composting behaviors, effectiveness knowledge was found to be important in terms of recycling behavior. In the extensive survey, effectiveness knowledge had a greater impact on sustainable *waste* behaviors overall, as compared to food behaviors. This finding is supported by other researchers who have found that people often feel sorting recyclables is not worthwhile because they do not generate enough waste to make it worth the trouble (Tucker & Speirs, 2003). The education program further demonstrated that enhanced effectiveness knowledge was critical when the students were trying to convince others to change their behaviors, since realizing the impact of changing their own behaviors was a necessary foundational step to educating others and trying to get them to change.

Due to the differential relationship between the domains of knowledge and varying behaviors, an effective strategy for educating for behavior change and broader competence in sustainability is to target all four knowledge domains. The students that participated in the case study demonstrated (via multiple surveys and interviews) enhanced knowledge in the four domains, all of with which they drew upon in developing sustainability strategies with their peers and household members. Although declarative knowledge was not linked to sustainable behaviors in this study, a fundamental understanding of socio-ecological interactions is still important. First and perhaps foremost, declarative knowledge is primarily what is targeted and tested through standardized exams in the K-12 education system; it therefore remains a central part of the education agenda. Additionally, sustainability change agents should be able to intelligibly communicate the importance of environmentally responsible consumption in terms of sustainability, which requires some basic declarative knowledge. However, technical knowledge

on its own is not going to be enough to progress towards a more sustainable society now and into the future.

Text Box 1. Understanding the relationship between knowledge domains and behaviors

1. Declarative knowledge does not impact participation in sustainable behaviors.
2. Social knowledge is the most influential knowledge domain across diverse behaviors.
3. Procedural and effectiveness knowledge influence varying behaviors differently, demonstrating that not all knowledge domains are equally important across diverse behaviors.
4. Targeting all four knowledge domains is likely the most effective strategy for fostering sustainable behaviors.

How do we motivate sustainable behavioral change through education programs?

Education programs can motivate sustainable behavioral change first by avoiding information-intensive, teacher-centered approaches that focus solely on declarative knowledge. In departing from the outdated information-deficit model of education, not only must the pedagogy shift from lecture-mode to student-centered processes, but the content imparted must also move beyond factual, technical information toward more experience-based, real-world learning. My findings indicate that students and teachers prefer hands-on, action-oriented pedagogy; as compared to lecture-based approaches (many of them stated on the post-program survey that their favorite activities were experiential and their least favorite lessons were lecture-based). The preference for action-oriented sustainability activities has the added bonus that it provides an excellent opportunity for teachers to model sustainable behaviors and positively reinforce students' participation in said behaviors. These different forms of pedagogy are also more effective at increasing knowledge in other domain areas—which is critical to behavior change.

For instance, the hands-on activity in which students sorted their trash into recyclable, landfill, and compostable, and then further broke down the paper products (which were all recyclable) by post-consumer content or virgin materials, was particularly effective. In contrast to a didactic approach, which would include a teacher lecturing students about how to dispose of different materials (possibly by showing pictures or using a PowerPoint), this activity was

experiential as well as being directly connected to their personal lives because they were sorting trash from their homes. During this activity, the students gained procedural knowledge, which is the most critical domain for composting behaviors per the extensive survey, and the teachers remarked that it was a great way to evaluate the skills and knowledge the students gained through the program. The 'sorting trash' activity was also listed as the favorite activity of the program for three of the six student participants, again indicating that students enjoy hands-on curricula. Lastly, the findings from the long-term follow-up surveys and interviews demonstrated that students retained much of the knowledge they learned during hands-on activities, which bolsters other research (Segalàs, Ferrer-Balas, & Mulder, 2010) that found improved cognitive outcomes (i.e., greater understanding) result from more experiential pedagogical approaches.

Moving away from declarative knowledge as the main (and often sole) focus of education also means acknowledging that there are other ways of knowing, or in other words, that knowledge is multidimensional. In particular, the results of this research support incorporating subjective forms of knowledge that recognize diverse values and pluralistic perspectives, especially if transformative action is an educational goal. The extensive survey results demonstrated the importance of different domains of knowledge on varying behaviors, indicating that the type of knowledge needed is largely dependent on the behavior targeted; therefore indicating that if the sole goal of the program is behavior change (which is different than the approach taken here due to the coupled focus on behavior change and competence in sustainability), a targeted approach to the domains could be taken. In terms of pedagogy, other researchers have established that direct experiences through hands-on activities improves behavioral outcomes as compared to traditional, didactic approaches (Duerden & Witt, 2010). Therefore, coupling novel pedagogy with diverse knowledge domains (as depicted in the Logic Model in Chapter 3) is likely to improve student engagement and enhance behavioral outcomes.

Problem-based learning is often proposed as a pedagogical alternative to the common lecture format. However, it is important that the problems selected resonate with the students' lives, rather than being focused on seemingly insurmountable challenges (i.e. loss of rainforests or melting ice caps), because problems which do not have tangible, actionable solutions can be disempowering and result in emotional distancing from the subject material. During the case study, students noted improved confidence due to the successes they had in implementing change in their own lives and among their families. Such victories proved critical in encouraging and empowering the students to later take action in their schools, as they felt comfortable promoting behaviors and practices that they had already successfully implemented in their homes. Had I started with large-scale problems (e.g., global health problems or climate change) the students would likely have struggled to grasp such seemingly distal challenges.

Sustainable practices need to be integrated into the classroom in order to build habits and foster pro-sustainability norms. It is not enough to talk about sustainable behaviors or suggest strategies for students to implement when they are at home. Instead, teachers need to model sustainable behaviors and positively reinforce sustainable practices (Higgs & McMillan, 2006). Only then are sustainable behaviors likely to become the norm embedded in social knowledge. During the case study, the students composted and recycled, were assigned to go grocery shopping using reusable bags, and were given 'points' for using their reusable water bottles and reusable utensils. This approach to building acceptance for behaviors through continual exposure to behaviors, proved to be successful in fostering long-term change. Whether the justification for building sustainable practices into the classroom is about progressing towards being a "Green School" or fostering sustainable social norms and habits, the bottom line is that developing sustainable classrooms and school operations is crucial to achieving transformative change.

A diverse array of sustainable practices should be supported in the school environment but when selecting strategies for implementing sustainability at home, students should be given

choice. During the summer program, not only were the students encouraged to select their own strategies for implementing sustainability practices but they were given assignments that required input from household members. For instance, I asked the heads of the households to select the types of waste recovery strategies they were most interested in implementing (indoor composting, outdoor composting, and/or recycling). Including household members in the decision-making allowed for a more participatory process that integrated the students' social context with their classroom assignments and in-class activities. This process of providing choice to the students and the household members is especially critical given the importance of social context to sustainable behaviors. The autonomy that the students and households had in selecting sustainable strategies that best suited their values and needs also contributed to long-term success because the students felt ownership over their decisions. As has also been found by other researchers, providing students with choices increases their motivation to engage in the targeted behaviors and increases learning outcomes and confidence (Patall, Cooper, & Robinson, 2008).

Text Box 2. Strategies for motivating sustainable behavioral change through education programs

1. Avoid information-intensive, teacher-centered approaches that focus solely on declarative knowledge by shifting to student-centered, experiential processes that include diverse perspectives and values.
2. Target diverse domains of knowledge through innovative pedagogical methods.
3. Begin with problems at a scale that resonates with students' lives while presenting solutions that are tangible, actionable, and real-world based.
4. Integrate sustainable practices into the classroom and school in order to position sustainability as the norm and build sustainable habits.
5. Provide students with choice so they can co-develop sustainable strategies with their household members.

What are barriers hindering education approaches to changing behaviors?

The most commonly mentioned barrier to educating for sustainability within the traditional K-12 school system (at least in the United States) are the numerous standards that teachers feel constrained and overburdened in attempting to follow. In her interview, Kelly

mentioned that she was so busy preparing her students for standardized tests that she simply didn't have time to integrate any of the sustainability curricula into her already over-crowded schedule. Unfortunately, standardized tests overly-simplify complex issues into right or wrong while subject standards re-enforce traditional disciplinary approaches to education. However, the system of standards and tests is not going to change overnight. In working within the current system, teachers (such as Sue), who have a deep understanding of science and external and internal support for implementing sustainability education, can overcome this standards barrier because they are able to articulate how sustainability curriculum can meet those standards (e.g., linking conventional/organic agriculture practices to the *History of Science as a Human Endeavor* or the linking the impact of garbage, landfills, and litter on the environment to *Changes in the Environment*).

In many cases, administrators and the culture of schools (i.e. parents' expectations) can be a barrier to educating for sustainability. As demonstrated through the interview with Sue (Chapter 5), sustainability can fit into science courses when the schools' administrators are supportive of this action-oriented, value-laden approach to education. However, without this internal support, the other teachers interviewed felt uncomfortable with pushing the boundaries of what is taught in their schools. During the interviews, the teachers expressed support for incorporating subjective knowledge into their classroom but were concerned about how their administrators and students' parents would respond to explicitly advocating for behavior change. Other researchers have also suggested that administrators, especially principals, are largely responsible for establishing a culture of change in which the teachers feel supported to implement innovative strategies (Fullan, 2002). In order to overcome this barrier, a shift in the way that administrators and teachers think about the role of education needs to occur because currently education is used as a tool for disseminating information rather than as an intervention point for fostering change.

The lack of support for discussing values is often linked to the traditional positivistic approach to education, particularly science education. To effectively integrate subjective knowledge into classrooms and schools, a shift away from the traditional, positivistic view of science needs to occur. This involves embracing the post-normal and normative elements inherent to sustainability and cross-cutting throughout the key sustainability competencies (Ravetz, 2006; Wiek, Withycombe, & Redman, 2011). Other scholars have noted that the typical approach to science classes is for the student to passively receive information from the teacher and not be an active inquirer or critically challenge the ideas being presented (Hurd, 1998). As long as K-12 schools are operating under the 'experts disseminate truths and pupils absorb them' view of science, pluralism of perspectives and co-generation of knowledge is going to be nearly impossible. However, if universities can embrace a change to post-normal science, teachers who receive their training at these universities will become aquatinted with science through this more participatory and inclusive approach.

Another barrier to the successful integration of sustainability into education practices and processes is a lack of deep understanding regarding sustainability. A number of other researchers have found that educators typically have only a surface understanding of sustainability and rarely include action and change as a fundamental component (Pepper & Wildy, 2008; Stir, 2006). The findings from my extensive survey indicate that indeed, teachers often have a shallow understanding on sustainability that is generally limited to declarative knowledge and often neglects action or subjective beliefs and opinions. Similarly, in my interviews with the K-12 teachers, Kelly acknowledged that her lack of knowledge regarding sustainability inhibits her from truly integrating sustainability curriculum and practices into the classroom. In order to support teachers in developing the knowledge and skills necessary to effectively educate for sustainability, greater collaboration amongst sustainability scholars and teachers needs to occur.

In particular, I suggest workshops in which sustainability education scholars and teachers co-generate action strategies and curriculum as part of the teachers' professional learning credits.

Text Box 3. Key barriers to educating for sustainability

1. Teachers are overburdened by standards and have limited time with which to cover all the topics to which they are already committed.
2. Administrators often impede educating for sustainability by creating a school culture in which teachers feel uncertain about advocating for change and positioning the students as agents of change.
3. The traditional positivist approach to science and science education impedes the education processes recommended in this research.
4. Teachers typically lack a deep and broad-based understanding of sustainability and how to link knowledge to education standards.

Implications for Research and Practice

Advancing the interdisciplinary approach to educating for sustainability:

In Chapter 1 (Introduction), I justified the interdisciplinary approach taken throughout this dissertation based on the underlying problems associated with sustainability research, behavior change research, and education pedagogy. In these concluding pages, I reflect on how this research has furthered our knowledge in each of these fields of study and contributed solutions to the aforementioned problems (see Figure 13 below). In examining the implications and contributions of this research, I reflect upon the importance of moving away from 'business as usual' for sustainability while also acknowledging the challenges associated with changing long-standing traditions in the academy and other educational settings.

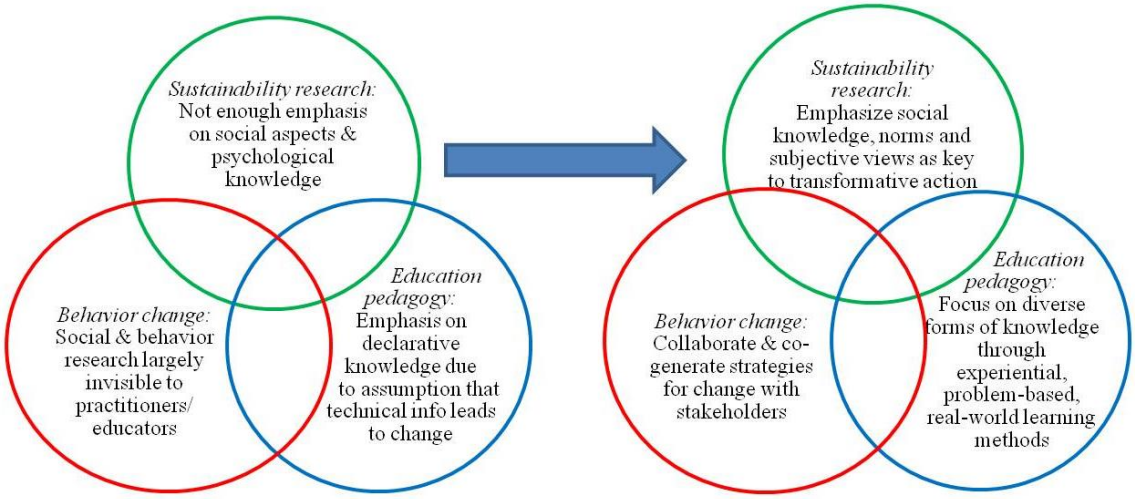

Figure 13. Progressing towards a solution

Sustainability research as a new frontier

Sustainability scientists suggest research techniques that are interdisciplinary (or multi- and trans-disciplinary), inclusive of stakeholders, and address critical problems while acknowledging uncertainty (Kates & Clark, 2000; Wiek, et al., 2011). This makes sustainability science fundamentally different than traditional science in which "uncertainties are managed automatically, values are unspoken, and foundational problems unheard of" (Funtowicz & Ravetz, 1993, p. 740). Rather, sustainability science is a prime example of post-normal science; a new conception of science that focuses on aspects of problem solving that tend to be neglected in traditional accounts of scientific practice, especially in terms of addressing uncertainty, values, and a plurality of legitimate perspectives (Funtowicz & Ravetz, 2003, p. 1). The approach taken throughout my dissertation implies that successful sustainability research must embrace the principals of post-normal science. In particular, I emphasize the need to incorporate diverse perspectives from multiple fields of study as well as from outside academia in order to embrace the normative aspects of sustainability.

Key competencies have been the focus of much of the dialogue on educating for sustainability (Wiek, Withycombe, & Redman, 2011). However, we cannot hope to educate for sustainability or competence in sustainability with didactic, information-intensive, nature-centric

education techniques that neglect values and subjective knowledge as the underpinnings of action and change (Barth, Godemann, Rieckmann, & Stoltenberg, 2007; Segalàs, Ferrer-Balas, & Mulder, 2010; Steinemann, 2003). Through the integration of knowledge and perspectives from multiple fields of research and practice, I was able to create a cohesive, interdisciplinary approach that builds upon and expands the dialogue on sustainability competencies and pedagogy. The creation of this novel, interdisciplinary framework was not only fundamental to successfully educating for sustainability but is also a critical element of post-normal research.

In addition to being interdisciplinary, my research was also transdisciplinary. McKenzie-Mohr has often lamented that psychological research is invisible to practitioners and will remain so unless researchers collaborate with those outside the Ivory Tower to develop and implement strategies for change (McKenzie-Mohr, 2011). My research furthers builds upon McKenzie-Mohr's call to action by suggesting that not only should researchers work with practitioners but researchers should also learn from them. I suggest that researchers, educators, and students work together, merging their knowledge and skills in order to best develop strategies for transformative change. By positioning the students and teachers as experts on how to integrate sustainability and strategies for change into their lives and classrooms, I was able to learn from these key stakeholders and incorporate their diverse perspectives into my research. The input from the stakeholders added to the robustness of my research and in turn I supported the stakeholders in the development and implementation of their own sustainability action plans; hence demonstrating a two-way flow of knowledge.

Systemic challenges of educating for sustainability

While I have already discussed the specific barriers facing K-12 teachers in educating for sustainability, K-12 schools are connected to broader systemic challenges. Hargreaves and Goodson (2006) remark that school change processes are embedded in an interrelated set of larger change forces. One of the forces impeding change and hindering the uptake of novel pedagogical

practices within the K-12 school system is the continual need to standardize and the ever-growing use of standardized tests (Hargreaves & Goodson, 2006). Education researchers, Hargreaves and Goodson, suggest that the emphasis placed on standardization has stifled innovative education change from diffusing throughout the K-12 system (2006). The challenge of educating for sustainability through novel pedagogical methods is, therefore, not simply a challenge for the K-12 system and its actors, but also one that requires us to confront the interrelated and converging forces that support standardization within K-12 schools.

The standardization of education processes is in a large part, due to the prevalence of standardized tests[9] in both K-12 schools (i.e., achievement tests mandated by national policies) and universities (i.e., aptitude tests that determine admission or scholarships). Education researchers, Marzano and Costa, examined thousands of questions on standardized tests and found that performance on standardized tests has little to do with the cognitive ability of the students or the effectiveness of schools and teachers to enhance "thinking skills" (Marzano & Costa,1988, p. 70). Rather, standardized tests primarily measure how well students have learned factual or declarative knowledge (Marzano & Costa, 1988). The emphasis on standardized tests throughout university and K-12 systems supports the traditional focus on declarative knowledge, making the shift to emphasizing other domains of knowledge all the more difficult.

In addition to the challenges associated with standardized tests, the approach to sustainability education advocated for here is also hindered by the positivistic views of science and research prevalent at universities. Due to positivistic views of science, K-12 science teachers have for decades taught the scientific method, which posits that there is one step by step method that all scientists use (Loving, 1997). In this traditional approach to science education, students are passive recipients of truth that is disseminated by scientists who are free from "human

[9] There are two types of standardized tests: 1) Aptitude tests (e.g., ACT & SAT): used to assess how well a student will do at a future education setting and often used to accept or deny students admittance to said future education setting and 2) Achievement Tests (e.g., AIMS): used by citizens and school boards to measure how well the school is doing and is often linked to funding.

foibles" (Loving, 1997, p. 443). Loving (1997), an education researcher, noted that the intense debate about positivist or post-normal science methods is even more critical with regards to pedagogical and sociological reasons than it is for scientific reasons. Loving writes, "If the teacher of science is too dogmatic in dismissing all but empirical processes of inquiry, he or she also dismisses—or inadvertently casts aspersions on—the cultural background of some minority students and their potential as successful students" (1997, p. 437). The relationship between scientific research, approaches to pedagogy, and science education makes this debate not only a critical one for the emergence of sustainability science, but also for the integration of sustainability education and associated innovative pedagogical approaches into classrooms.

The interconnectedness between university environments and K-12 schools can present a challenge but can also provide opportunities and pathways for change when universities blaze the trail towards post-normal science and embrace the normative aspects of science and sustainability. However, there are numerous trade-offs and cascading effects associated with creating change across K-12 and university systems. For instance, standardized tests reinforce traditional approaches to education that focus on declarative knowledge, therefore impeding educating for sustainability as presented here; but how do we create accountability in schools without standardized tests and what does a university admission process look like without standardized tests to streamline the process? This research progresses the effort to promote transformative change via sustainability education but there is still much work to be done to achieve the necessary paradigm shift in how we research, educate, and evaluate success.

Reflection: Looking Backward and Forward

In hindsight

In reflecting on my research, I have identified several missed opportunities. Firstly, a competence-oriented approach to education stresses outputs but I did not directly evaluate the attainment of competencies as an output of my education program or the accompanying year-long case study. I focused my research instead on evaluation instruments that examined knowledge in the four domains and sustainable behaviors. Thus, future work could focus on assessing sustainability competencies as outputs of innovative pedagogy, further linking competencies to the knowledge domains and sustainable behaviors.

Often, as a researcher, it is necessary to delegate certain tasks to those with whom we are collaborating. Such was the case with the recruitment of students for the summer program. Staff members in the education department were charged with the task of recruiting students for all twelve STEM summer programs, including mine. I had prepared for and written a grant to purchase supplies for thirty students but only had six ultimately enroll in my summer program. However, the small sample size allowed me to collect intensive, long-term qualitative data on the students, thus making for an in-depth exploration into the motivations and impediments to change. In order to compliment this rich qualitative approach, future research could focus on quantitative relationships between education and behavior change through expanding the sample population in both size and diversity.

Looking back, the primary change I would make to the survey would be with regards to the social knowledge questions. In developing the survey, I aimed for parallel construction amongst the knowledge domains, meaning there was roughly the same number of questions asked regarding each knowledge domain. However, not all of the knowledge domains are equally complex and the number of questions asked did not account for differences in complexity. The questions asked about social knowledge focused on the subjective interpretation of what others

are doing. However, social knowledge is influenced by norms (the prevalence of a certain action or belief in a given environment) and by the respondents propensity to be influenced by others. These two key influences on social knowledge were not well captured in the survey. Based on our still basic understanding of social knowledge, an overly large portion of the survey would have had to be focused on this one domain to fully capture the complexities (from which one could hopefully winnow out the less significant aspects for sustainable behaviors for future studies). Social knowledge is especially critical for sustainable behaviors so understanding the range of impact within this nuanced construct is important to furthering our understanding of how to foster sustainable change.

Future directions

This research took the first steps in exploring the relationship between four domains of knowledge and sustainable behaviors. Through future research endeavors, I hope to examine how the knowledge domains interact with other behaviors not studied here (i.e., water or energy). I will continue to draw upon psychological literature in order to enhance the conceptualization of the knowledge domains as multi-faceted constructs that influence diverse behaviors. The novel, interdisciplinary approach developed here provides a solid foundation for my continued exploration into the relationship between knowledge and sustainable behaviors and the promotion of sustainability concepts, skills, and actions.

As discussed previously, social knowledge, with all its complexity, needs significant further research. In exploring social knowledge further, I may go beyond the framework of the knowledge domains in order to include assessments of descriptive and injunctive norms as well as other attitudinal judgments that are known to influence behaviors(Ajzen, 1985; Cialdini, Kallgren, & Reno, 1991). While I focused on knowledge domains because of their relevance to education and palatability for teachers, further research should expand to consider structural and situational influences and delve further into the complexities associated with social pressures.

The knowledge domains provided firm reasoning for stressing the importance of modeling and reinforcing behaviors in schools, but in assessing what influences participation in sustainable behaviors more broadly, I may extend beyond the knowledge domains in the future.

In educating for sustainability, I hope to not only target transformative change as an outcome but also increase competence in sustainability. The competencies call for stakeholder engagement, trans-disciplinary research, and change agency; all of which are a departure for the subject-based, expert-driven, stand-on-the-sidelines approach typically taken in academia. Also, in continuing to promote behavior change, I hope to educate for and evaluate personal transformation as a result of the program (see outputs in logic model below, Figure 14) while also positioning sustainability as the norm by working with the students to develop strategies to create a more sustainable campus (see activities in logic model. Figure 14).

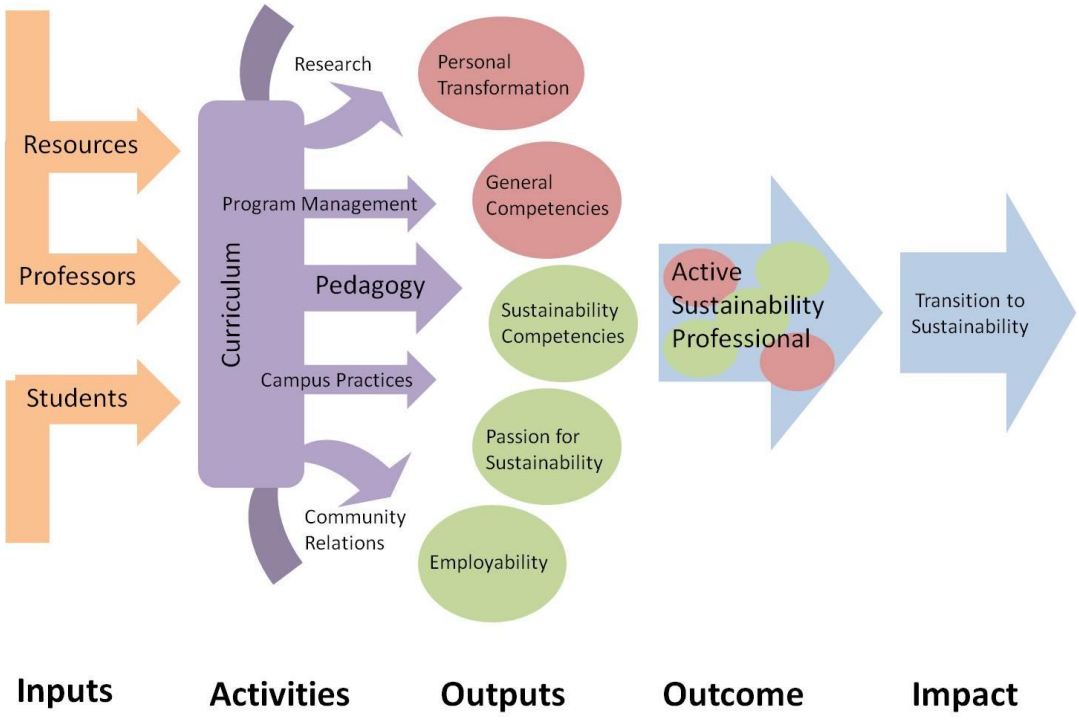

Figure 14. Logic model created for sustainability degree program at UNAM created by Redman & Redman.

The development of Figure 14 is based on the logic model approach used in this dissertation (Chapter 3) but adapted for sustainability undergraduates. In my immediate future, I will be turning my attention towards developing and implementing a sustainability undergraduate program at UNAM (Universidad Nacional Autónoma de México). While working with university level students is a departure from the focus of this research, one of the key components of the UNAM program will be building relationships with the community (under activities in logic model), including K-12 students and teachers.

The logic model (Figure 14 above) demonstrates some of the ways that I am integrating my dissertation research into my future work. I will continue to work on integrating innovative pedagogical approaches with sustainability competencies, in order to achieve better learning outcomes. In addition (mentioned in the activities section) the program will push students to build relationships with community members, hence breaking the 'expert/lay-person' boundary. Students will also be expected to participate in building a sustainable campus, thus placing on value on change and action. The targeted outputs of the program also go beyond the traditional cognitive outputs, focusing on competencies and including personal transformation as key goals. And finally, the broader impact I would like to make through my research and education endeavors (including this degree program) is to facilitate a general transition towards sustainability. Sustainability will not be achieved with idle hands, even if enhanced awareness (and declarative knowledge) is achieved. Therefore the desired impact of progressing towards sustainability dictates action and change as essential components.

Sustainability is an outcome-oriented field that has come into existence due to complex problems that could not be addressed through traditional disciplinary approaches. The challenges we are facing are not going to be solved neither through information-intensive education methods nor through traditional research processes. Progressing towards sustainability requires that we must often muddle through the uncertainty and chart a course for change without waiting for

absolute certainty. The path towards sustainability will be dynamic and flexible so as researchers, we too must be dynamic and flexible. This dissertation represents the beginning of my path, the start of my trajectory, and I am sure much will change in the coming years. But my research stands as a representation of my dedication to sustainability, transformative change, collaborative research processes, and K-12 education.

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APPENDIX A

PRE- AND POST-SURVEY FOR THE SUMMER PROGRAM

Developing the pre- and post-survey

On both the pre- and post- survey the scales were designed so that the most sustainable response varied between the right and left side of the scale. Rotating the direction of the ordinal scale so that no single direction always represents a positive response can help reduce the incidence of respondents sticking to one side of the scale due to perceived social desirability (Fink, 1995). The surveys were taken in-class during the summer program so that students could ask questions and to ensure that they took their time and focused on providing honest and complete responses. The pre-survey was taken at the beginning of the first day of the summer program and the post-survey was taken on the last day of the summer program.

Content and construct validity

In developing the survey instruments, several steps were taken before implementing it with the target population (Fink & Litwin, 1995). First, validity was evaluated. In order to effectively assess content validity, I revised my survey extensively based on input from other researchers. My target population for this survey was high/middle school students; therefore, I also asked a colleague of mine if his son, who is in high school, could take my survey. Together, father and son discussed the questions and responses, and provided me in-depth feedback.

Construct validity also requires that survey participants respond similarly to several questions measuring the same thing or closely related things. For my survey, I developed several questions to measure each knowledge domain with regard to both food and waste as well as several questions related behaviors (see Table 14). Food sustainability is more complex than waste behaviors generally; therefore there are more questions for each domain regarding food. For social knowledge, I included a set of questions regarding personal perception (e.g. 'I prefer,' 'I enjoy') and the perception of others (e.g. 'My family thinks,' 'My friends enjoy'). When determining construct validity the two different types of social knowledge should be separated for both food and waste.

Table 16.

Number of questions & formats used per domain

Domain	# of Food Questions	# of Waste Questions	Question Format	Scale: 5-point Likert Scale
Declarative	18	7	How familiar are you with the following terms and concepts? How would you rate your knowledge about? How would you rate your agreement with the following statements?	Never heard of (1) to Heard of and know a lot about (5) Poor (1) to Excellent (5) Strongly Agree (1) to Strongly Disagree (5)
Procedural	7	4	How would you rate your knowledge about? How would you rate your agreement with the following statements?	Poor (1) to Excellent (5) Strongly Agree (1) to Strongly Disagree (5)
Effectiveness	11	7	How would you rate your ability to? How would you rate your agreement with the following statements?	Poor (1) to Excellent (5) Strongly Agree (1) to Strongly Disagree (5)
Social	9 (5 personal/ 4 others)	7 (3 personal/ 4 others)	How would you rate your awareness of? How would you rate your agreement with the following statements?	Poor (1) to Excellent (5) Strongly Agree (1) to Strongly Disagree (5)
Behavior	7	7	Over the last year/over the next year/over the last seven months… How often have you made the following choice?	Never (1) to Daily (5)
Total	**52**	**32**		

In developing related questions in order to verify construct validity, I utilized Thogerson's (2004) categorization of related environmentally responsible behaviors. Behavior categories refer to single acts that are similar in at least one of the following elements: action, context, time, and target (Fishbein & Ajzen, 1975; Thøgersen, 2004). For recycling behaviors, questions asked about recycling glass, paper, aluminum, and plastic as well as composting of organic materials. In addition to recycling and composting, I also asked about reusing products and reducing waste because these are important for reducing the amount of waste produced and disposed in landfills or other means (see Table 15 for example questions). The questions

regarding environmentally responsible food behaviors encompassed purchasing organic or local products, reduced meat consumption and selecting whole foods over processed foods. The food questions covered skills and knowledge regarding reading labels and interpreting designations such as USDA organic and Fair-trade, while also contrasting that with the conventional methods of production, including issues like pesticide use and confined factory animal operations.

Table 17.

Example survey questions and associated knowledge domains

Knowledge Domains	Example Questions—Likert Scale—Strongly Agree to Strongly Disagree, 5-point scale
Declarative	Food: The majority of farms in the United States are family-run and operated. Eating lower on the food chain (eating plants instead of meat) results in lower environmental impacts. Waste Most plastic bottles are recycled in the U.S. Food that is thrown away is a very small part of the amount of waste produced in the U.S.
Procedural	Food There are places to purchase organic food in my neighborhood or nearby. There is a specific labeling system in the U.S. for organic foods. Waste My food scraps can be composted instead of thrown away. My neighborhood has curbside recycling.
Effectiveness	Food I can make choices about what I eat to lower my impacts on the environment. I would enjoy eating more vegetarian (meat free) meals. Waste I can make choices about products I buy to reduce the amount of waste I create. Using a reusable water bottle is inconvenient.
Social	Food My friends think it is cool to be a vegetarian (in other words, to not eat meat). I prefer to simply enjoy what I eat without worrying about the consequences. Waste My friends think using a reusable water bottle is cool. I prefer to use disposable products rather than reusable products.

APPENDIX B

EXTENSIVE SURVEY QUESTIONS

This appendix includes all of the questions asked about the knowledge domains and sustainable behaviors on both the food and waste domains, organized and group by domain/behavior.

Table 18.

Food questions sorted by domain

Question Text	Knowledge Domain (or Behavior)	Most Sustainable Response
The majority of farmland in the United States is run by families.	Declarative	Strongly disagree
How different farming practices impact farmers and farm workers?	Declarative	Excellent
How different farming practices impact the environment?	Declarative	Excellent
Food that is thrown away is a very small part of the amount of waste sent to the landfill in the U.S.	Declarative	Strongly disagree
Eating lower on the food chain (eating plants instead of meat) results in lower environmental impacts.	Declarative	Strongly agree
How food is grown (produced) in the U.S.?	Declarative	Excellent
Certified organic food is only food that is not processed, such as apples and carrots.	Declarative	Strongly disagree
Raising animals for food is a significant source of greenhouse gases.	Declarative	Strongly agree
Factory Farms	Declarative	Heard of and know a lot about
Farmer's markets	Declarative	Heard of and know a lot about
Sustainability	Declarative	Heard of and know a lot about
How to find organic foods and drinks in your grocery store?	Procedural	Excellent
How to compost food waste?	Procedural	Excellent
There are places to purchase sustainable food in my neighborhood or nearby.	Procedural	Strongly agree
I know how to identify certified organic foods at the grocery store.	Procedural	Strongly agree
How to find food grown or produced locally in Phoenix and surrounding areas?	Procedural	Excellent
How to read food labels to determine whether synthetic pesticides were used in the production of	Procedural	Excellent

the food?		
Select sustainable food choices?	Procedural	Excellent
Cook tasty vegetarian meals	Procedural	Excellent
Consume a healthy amount of protein and iron without eating meat.	Procedural	Excellent
Change the types of foods you eat?	Effectivness	Excellent
Make food choices that promote healthy working environments for the farm workers?	Effectivness	Excellent
Reduce the amount of waste you produce through your food purchasing decisions?	Effectivness	Excellent
Reduce your personal impact on the environment through your food choices?	Effectivness	Excellent
I can make choices about what I eat to lower my impacts on nature and the environment.	Effectivness	Strongly agree
Change the types of foods your friends eat?	Effectivness	Excellent
I can make choices about what I eat to improve the lives and livelihoods for farmers or farm workers.	Effectivness	Strongly agree
It is difficult for me to choose meat-free meal options.	Effectivness	Strongly disagree
Purchasing locally grown food is inconvenient.	Effectivness	Strongly disagree
I can make choices about what I eat which improve animal/livestock welfare	Effectivness	Strongly agree
I like to eat meat every day.	Social	Strongly disagree
I would like to purchase more organic foods.	Social	Strongly agree
I care what my friends think about my food choices	Social	Strongly agree
I like the taste of bottled water more than tap water.	Social	Strongly disagree
My friends enjoy eating at fast food restaurants.	Social	Strongly disagree
I enjoy eating vegetarian (meat free) meals.	Social	Strongly agree
My friends think it is weird to be a vegetarian (or, in other words, to not eat meat).	Social	Strongly disagree
I admire people that eat sustainably.	Social	Strongly agree
Purchasing organic food makes me feel good.	Social	Strongly agree
Purchasing food at a local farmer's market makes me feel good.	Social	Strongly agree
I feel pressured to eat meat by my friends	Social	Strongly disagree
I tend to simply enjoy what I eat without worrying about the consequences.	Behavior	Strongly agree
I ate meals with no meat (chicken, beef, pork, etc.) at all.	Behavior	Always (more than 90% of the time)
Composted your food waste at home.	Behavior	Always (more than 90% of the time)
Chose food with little or no packaging.	Behavior	Always (more than 90% of the time)

Bought organic foods over non-organic ones.	Behavior	Always (more than 90% of the time)
I ate chicken with meals.	Behavior	Never (not at all)
Bought food at a local farmers' market.	Behavior	Always (more than 90% of the time)
I ate out at a fast food restaurant (McDonalds, Taco Bell, etc.).	Behavior	Never (not at all)
I ate beef with meals.	Behavior	Never (not at all)

Table 19.

Waste questions sorted by domain

Question Text	**Knowledge Domain (or Behavior)**	**Most Sustainable Response**
Composting	Declarative	Heard of and know a lot about
Recycling	Declarative	Heard of and know a lot about
Sustainability	Declarative	Heard of and know a lot about
Paper grocery bags are the environmentally friendly option.	Declarative	Strongly disagree
My food scraps can be composted instead of thrown away.	Declarative	Strongly agree
Food that is thrown away is a very small part of the amount of waste produced in the U.S.	Declarative	Strongly disagree
Most plastic bottles are recycled in the U.S.	Declarative	Strongly disagree
How food waste decomposes or breaks down in the environment?	Declarative	Excellent
The environmental impact of using disposable plastic bags?	Declarative	Excellent
How much food is thrown away in the United States?	Declarative	Excellent
The environmental impact of using disposable plastic bottles (water/soda bottles)?	Declarative	Excellent
I have a strategy for utilizing reusable beverage containers when I am on-the-go.	Procedural	Strongly agree
I have a strategy for remembering my reusable bags when I go to the grocery store.	Procedural	Strongly agree
How to compost food waste?	Procedural	Excellent

How to sort recyclables such as bottles and cans correctly?	Procedural	Excellent
Install a composting system at home?	Procedural	Excellent
Manage a composting system at home?	Procedural	Excellent
Select paper made from post-consumer content?	Procedural	Excellent
I could easily compost my food scraps.	Effectivness	Strongly agree
Collecting food scraps for composting creates unwanted odors.	Effectivness	Strongly agree
Using reusable bags at the grocery store is inconvenient.	Effectivness	Strongly disagree
Remembering a reusable water bottle is difficult for me.	Effectivness	Strongly disagree
It is important to reduce the amount of waste I send to the landfill.	Effectivness	Strongly agree
I know how to make choices about products I buy to reduce the amount of waste I create	Effectivness	Strongly agree
Reduce the amount of waste you produce through your food purchasing decisions?	Effectivness	Excellent
Reduce your personal impact on the environment through your waste decisions?	Effectivness	Excellent
Reduce the amount of waste you create by using reusable cups or bottles for your beverages?	Effectivness	Excellent
Reduce the amount of waste your household produces?	Effectivness	Excellent
The quantity of waste you could divert from the landfill by composting your food waste?	Effectivness	Excellent
The quantity of waste you could divert from the landfill by using reusable bottles/bags/napkins instead of disposable products.	Effectivness	Excellent
I like the taste of bottled water more than tap water	Social	Strongly agree
I prefer to use disposable products rather than reusable products.	Social	Strongly disagree
My friends expect me to use a reusable water bottle.	Social	Strongly agree
I admire people who are conscious about their waste decisions.	Social	Strongly agree
When I see others carrying reusable bags in the grocery store, I think it is weird.	Social	Strongly disagree
When I see others carrying a reusable water bottle, I think that it is weird.	Social	Strongly disagree
Composting makes me feel good	Social	Strongly agree
Whether your friends recycle or not?	Social	Excellent
Whether your friends compost or not?	Social	Excellent

Recycled plastic bottles, metal cans, and/or paper products while on campus.	Behavior	Always (more than 90% of the time)
Reused water bottles/used a reusable water bottle	Behavior	Always (more than 90% of the time)
Recycled plastic bottles, metal cans, and/or paper products while at *home*.	Behavior	Always (more than 90% of the time)
Used reusable, washable napkins instead of paper ones.	Behavior	Always (more than 90% of the time)
Composted your food waste at home.	Behavior	Always (more than 90% of the time)
Used cloth or other reusable bags at stores (instead of using plastic or paper bags given at checkout counters).	Behavior	Always (more than 90% of the time)
Chose food with little or no packaging.	Behavior	Always (more than 90% of the time)
Purchased bottled water (in disposable bottle)	Behavior	Never (not at all)
Purchased paper made from post-consumer content.	Behavior	Always (more than 90% of the time)

APPENDIX C

ADDITIONAL ANALYSIS OF EXTENSIVE SURVEY DATA

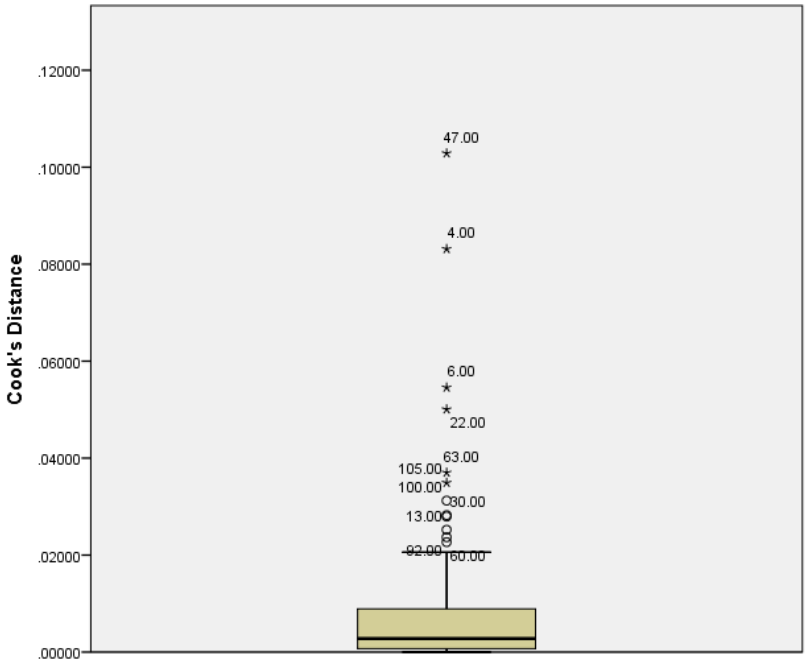


Figure 12. Cook's distance used to identify outliers in the food survey data

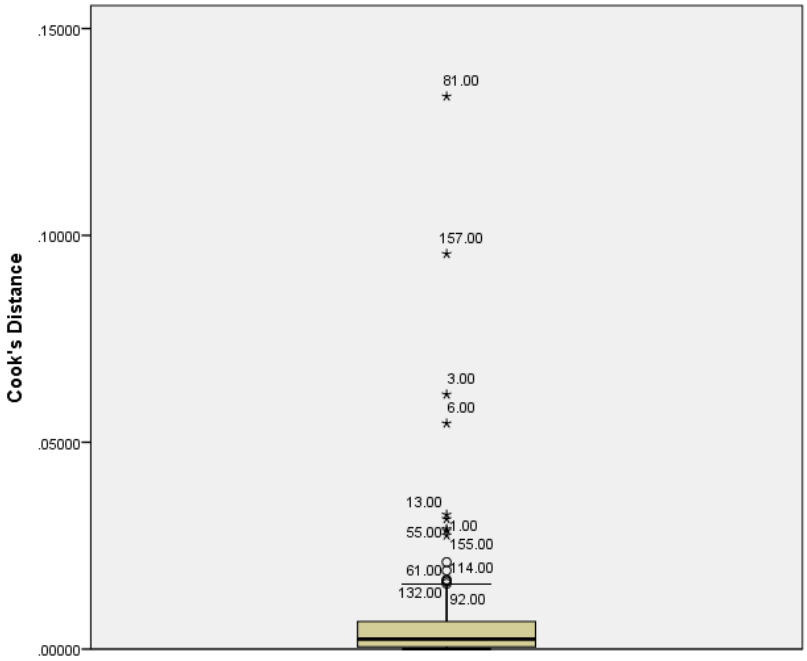


Figure 13. Cook's distance used to identify outliers in the waste survey data

Table 20.

Correlations between food behaviors (utilized in created indexes)

		How would you rate your agreement with the following statements? [18) I tend to simply enjoy what I eat without worrying about the consequences.]	Over the last year, how frequently have you made the following choices? [35) I ate meals with no meat (chicken, beef, pork, fish, etc.) at all]	Over the last year, how frequently have you made the following choices? [36) Composted your food waste at home.]	Over the last year, how frequently have you made the following choices? [37) Chose food with little or no packaging.]	Over the last year, how frequently have you made the following choices? [38) Bought organic foods over non-organic ones.]	Over the last year, how frequently have you made the following choices? [44) I ate chicken with meals.]	Over the last year, how frequently have you made the following choices? [45) Bought food at a local farmer's market.]	Over the last year, how frequently have you made the following choices? [46) I ate out at a fast food restaurant (McDonald's, Taco Bell, etc.)]	Over the last year, how frequently have you made the following choices? [47) I at beef with meals.]
How would you rate your agreement with the following statements? [18) I tend to simply enjoy what I eat without worrying about the consequences.]	Pearson Correlation	1	.282**	.163*	.219**	.305**	.115	.195*	.313**	.195*
	Sig. (2-tailed)		.001	.050	.008	.000	.166	.018	.000	.019
	N	148	146	146	146	145	147	146	147	145

Over the last year, how frequently have you made the following choices? [35) I ate meals with no meat (chicken, beef, pork, fish, etc.) at all]	Pearson Correlation	.282**	1	.080	.105	.103	.430**	.120	.224**	.507**
	Sig. (2-tailed)	.001		.334	.204	.217	.000	.149	.006	.000
	N	146	147	147	147	146	147	146	147	145
Over the last year, how frequently have you made the following choices? [36) Composted your food waste at home.]	Pearson Correlation	.163*	.080	1	.339**	.304**	.226**	.183*	.107	.005
	Sig. (2-tailed)	.050	.334		.000	.000	.006	.027	.199	.954
	N	146	147	147	147	146	147	146	147	145
Over the last year, how frequently have you made the following choices? [37) Chose food with little or no packaging.]	Pearson Correlation	.219**	.105	.339**	1	.286**	.024	.369**	.113	.196*
	Sig. (2-tailed)	.008	.204	.000		.000	.772	.000	.172	.018
	N	146	147	147	147	146	147	146	147	145
Over the last year, how frequently have you made the following choices? [38) Bought organic foods over non-organic ones.]	Pearson Correlation	.305**	.103	.304**	.286**	1	.021	.363**	.167*	.029
	Sig. (2-tailed)	.000	.217	.000	.000		.805	.000	.044	.733
	N	145	146	146	146	146	146	145	146	144
Over the last year, how frequently have you	Pearson Correlation	.115	.430**	.226**	.024	.021	1	-.041	.242**	.343**

made the following	Sig. (2-tailed)	.166	.000	.006	.772	.805		.621	.003	.000
choices? [44) I ate chicken with meals.]	N	147	147	147	147	146	148	147	148	146
Over the last year, how	Pearson Correlation	.195*	.120	.183*	.369**	.363**	-.041	1	.016	.033
made the following	Sig. (2-tailed)	.018	.149	.027	.000	.000	.621		.850	.695
choices? [45) Bought food at a local farmer's market.]	N	146	146	146	146	145	147	147	147	145
Over the last year, how	Pearson Correlation	.313**	.224**	.107	.113	.167*	.242**	.016	1	.377**
made the following	Sig. (2-tailed)	.000	.006	.199	.172	.044	.003	.850		.000
choices? [46) I ate out at a fast food restaurant (McDonald's, Taco Bell, etc.)]	N	147	147	147	147	146	148	147	148	146
Over the last year, how	Pearson Correlation	.195*	.507**	.005	.196*	.029	.343**	.033	.377**	1
made the following	Sig. (2-tailed)	.019	.000	.954	.018	.733	.000	.695	.000	
choices? [47) I at beef with meals.]	N	145	145	145	145	144	146	145	146	146

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 21.

Correlations between waste behaviors (utilized in created indexes)

		Over the last year, how frequently have you made the following choices? [37) Recycled plastic bottles, metal cans, and/or paper products while on campus.]	Over the last year, how frequently have you made the following choices? [38) Reused water bottles/used a reusable water bottle.]	Over the last year, how frequently have you made the following choices? [39) Recycled plastic bottles, metal cans, and/or paper products while at home.]	Over the last year, how frequently have you made the following choices? [40) Used reusable, washable napkins instead of paper ones.]	Over the last year, how frequently have you made the following choices? [41) Composted your food waste at home.]	Over the last year, how frequently have you made the following choices? [42) Used cloth or other reusable bags at stores (instead of using the plastic or paper bags give at checkout counters).]	Over the last year, how frequently have you made the following choices? [43) Chose food with little or no packaging.]	Over the last year, how frequently have you made the following choices? [44) Purchased bottled water (in disposable bottles).]	Over the last year, how frequently have you made the following choices? [45) Purchased paper made from post-consumer content.]
Over the last year, how frequently have you	Pearson Correlation	1	.310**	.623**	.259**	.296**	.293**	.315**	.145*	.278**

made the following choices? [37) Recycled	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.049	.000
plastic bottles, metal cans, and/or paper products while on campus.]	N	186	186	183	186	185	185	185	185	183
Over the last year, how frequently have you	Pearson Correlation	.310**	1	.303**	.274**	.201**	.335**	.323**	.406**	.105
made the following choices? [38) Reused	Sig. (2-tailed)	.000		.000	.000	.006	.000	.000	.000	.157
water bottles/used a reusable water bottle.]	N	186	186	183	186	185	185	185	185	183
Over the last year, how frequently have you	Pearson Correlation	.623**	.303**	1	.168*	.188*	.383**	.256**	.059	.285**
made the following choices? [39) Recycled	Sig. (2-tailed)	.000	.000		.023	.011	.000	.000	.431	.000
plastic bottles, metal cans, and/or paper products while at home.]	N	183	183	183	183	182	182	182	182	180
Over the last year, how frequently have you	Pearson Correlation	.259**	.274**	.168*	1	.465**	.243**	.441**	.098	.277**
made the following choices? [40) Used	Sig. (2-tailed)	.000	.000	.023		.000	.001	.000	.184	.000
reusable, washable napkins instead of paper ones.]	N	186	186	183	186	185	185	185	185	183

Over the last year, how frequently have you made the following choices? [41) Composted your food waste at home.]	Pearson Correlation	.296**	.201**	.188*	.465**	1	.235**	.382**	.129	.278**
	Sig. (2-tailed)	.000	.006	.011	.000		.001	.000	.082	.000
	N	185	185	182	185	185	184	184	184	182
Over the last year, how frequently have you made the following choices? [42) Used cloth or other reusable bags at stores (instead of using the plastic or paper bags give at checkout counters).]	Pearson Correlation	.293**	.335**	.383**	.243**	.235**	1	.471**	.163*	.320**
	Sig. (2-tailed)	.000	.000	.000	.001	.001		.000	.027	.000
	N	185	185	182	185	184	185	184	184	182
Over the last year, how frequently have you made the following choices? [43) Chose food with little or no packaging.]	Pearson Correlation	.315**	.323**	.256**	.441**	.382**	.471**	1	.205**	.395**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.005	.000
	N	185	185	182	185	184	184	185	184	182
Over the last year, how frequently have you made the following choices? [44) Purchased bottled water (in disposable bottles).]	Pearson Correlation	.145*	.406**	.059	.098	.129	.163*	.205**	1	.030
	Sig. (2-tailed)	.049	.000	.431	.184	.082	.027	.005		.692
	N	185	185	182	185	184	184	184	185	182

Over the last year, how frequently have you made the following choices? [45) Purchased paper made from post-consumer content.]	Pearson Correlation	.278**	.105	.285**	.277**	.278**	.320**	.395**	.030	1
	Sig. (2-tailed)	.000	.157	.000	.000	.000	.000	.000	.692	
	N	183	183	180	183	182	182	182	182	183

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 22

OLS regressions using different potential models

(unstandardized B) Standardized Beta	Food Model 2	Food Model 3	Food Model 4	Waste Model 2	Waste Model 3	Waste Model 4
Declarative Knowledge	(.118).125	(120).128	(.072).077	(-.099)-.076	(-.029)-.022	(-.010)-.008
Procedural Knowledge	(.208).299**		(.255).368***	(.243).310***		(.358).457***
Effectiveness Knowledge	(.097).109	(.267).301***		(.301).295***	(.452).443***	
Social Knowledge	(.490).461***	(.492).463***	(.476).448***	(.491).421***	(.566).485***	(.553).473***
Income		(-.031)-.066	(-.026)-.056		(.043).076	(.029).051
Age		(.033).081	(.038).093	(.031).054	(-.012)-.019	(.010).016
Gender (Yes-Female)		(-.015)-.015	(.024).024		(-.007)-.005	(.050).036
Race (Yes-white/anglo)	(-1.56)-.119*	(-.147-.112	(-.173)-.132*	(.160).087*	(.163).088*	(.195).105**
Political Views (Yes- liberal/very liberal)		(.113).112	(.089).088		(-.020)-.014	(-.046)-.034
House (Yes)		(-.036)-.030	(-.056)-.046		(-.057)-.030	(-.082)-.043
Geographical location (Yes-AZ)		(-.094)-.091	(-.061)-.059		(-.034)-.026	(-.021)-.016
Sustainability Course (Yes)		(.102).071	(.110).077		(.130).071	(.082).045
Curbside Recycling Bin (Yes)					(.084).057	(.061).042
Constant	-.040	.089	.321	-.120	-.371	-.044
R^2	.588	.584	.605	.794	.773	.774
Adjusted R^2	.574	.550	.574	.787	.758	.758
F	40.865	17.476	19.106	114.667	49.225	49.419
Sig.	<.001	<.001	<.001	<.001	<.001	<.001
N	149	149	149	186	186	186

APPENDIX D
SURVEYS AND INTERVIEW QUESTIONS FOR TEACHERS

Table 23.

Post-program teacher survey

What was your favorite activity we did during the program? Why?
What activity (s) do you think you will try with your own classes? Why?
What activity(s) did you like the least? Why?
What, if anything, made you feel inspired during this program?
What activity/message, if anything, made you feel motivated to make a sustainable change in your own life? Why?
Do you think this program impacted the students' attitudes towards sustainability? Circle: Yes/No, Explain why below.
Do you think this program change any of the students' behaviors?
Did this program impact any of your behaviors?
How do you feel about using 'norm-setting' as a tool for changing behaviors?
Did this program increase your interest in educating for sustainability? Circle: Yes/No Please explain why below.

Table 24.

*Long-term follow-up interview questions used with K-12 teachers***

Since the *Progressing Toward Sustainability* summer program, have you utilized any of the sustainability curriculum or practices demonstrated during the program? *Optional prompts:* - Why or why not - Is yes, what? -If used multiple, which ones where most successful in terms of student engagement?
Are there any sustainability practices that were demonstrated during the program that you have continued to do in your personal life? *Optional prompts:* -If yes, what?

-If doing multiple sustainability practices, which one(s) have been the most difficult to undertake? -Did you have to go out a purchase something to undertake the behavior?
You received various sustainability products (produce bags, composting bins, reusable utensils etc.) during the program, are any of them still in use? *Option prompts:* - Which ones? - How frequently? -Why this product over others? Can you show me the sustainability products that are with you right now? (This is a simple yes no question, if yes, can I see?)
It has been 8 months since the program has completed, what are some of the key things you remember about food and sustainability? *Optional prompts:* - In terms of the impact of eating meat, what do you remember? -What do you remember about the impact of choosing organic foods over non-organic foods?
What are some of the key things you remember about waste and sustainability? *Optional prompts:* -What do you remember about post-consumer content? -What do you remember about composting? - What do you remember about the relationship between greenhouse gas emissions and landfills?
The *Progressing Towards Sustainability* program focused largely on values, perceptions, attitudes, and behaviors. Do you think there is a place in traditional K-12 education for this type of approach? *Optional Prompts:* - Do you think that most knowledge is factual and value-free? -Do you think we can teach sustainability without a value-based approach?
Anything else you would like to add?

** With permission from the teachers and the Institutional Review Board, the interviews were recorded using my cell phone recorder function and transcribed by an undergraduate sustainability student that was assisting me with my research.

Table 25.

*Interview questions used with Sue***

Can you describe the sustainability unit that you used in your classes?
How long and how much class time did you dedicate to the sustainability unit?
What were your goals for the sustainability unit? *Optional prompts:* -In terms of knowledge? -In terms of skills? -In terms of actions (behaviors)?
Can you describe how you adapted the lessons for your classes?
Which lessons did you enjoy teaching the most?
Which lessons did your students seem to enjoy the most?
Which lessons best fit the required standards?
Did the unit focus on food or waste or both?
How did you evaluate the success in the sustainability unit? *Optional prompt:* -Did the students get graded on projects, presentations, participation, and/or tests?
Did you feel that the sustainability lessons changed your students'…….. a. -Knowledge? How? b. Values? How? c. Behaviors? How?
Do you feel that the sustainability lessons changed your…… a. Knowledge? How? b. Values? How? c. Behaviors? How?
How did your administration feel about you doing a sustainability unit?
How did other teachers feel about you doing a sustainability unit?
Did any parents comment about you doing a sustainability unit?
What grade level, subject area, and class sizes did you implement the sustainability unit in?
What additional materials and/or resources would be useful in the future?
What would you modify or change in the future when doing a sustainability unit?

**With permission from the teacher (signed waiver) and the Institutional Review Board, I recorded and transcribed this interview.

APPENDIX E

LESSON PLANS, SCHEDULES AND OTHER DETAILS OF SUMMER PROGRAM

Schedule summaries for summer program

Day One- Ecological Footprint

Overview/Background: During day one of the summer program, the students will first complete as survey establishing a baseline of their current behaviors and knowledge in regards to food and waste. Then in order to get to know each other and to emphasize the importance of the student's perspectives, the students are each going to create a life map that highlights key moments or events that have shaped their lives as well as suggesting a future path. Next, we will discuss the expectations for the program such as composting, recycling, using reusable water bottles, and daily journaling. The students will be rewarded for participating in these positive, sustainable behaviors at the end of each week. Then we will begin our principle activity for the day- calculating our ecological footprints. Each student will use one designated ecological footprint calculator during class and will be assigned to do one at home with their families. We will finish the day with the journaling assignments.
Fundamental Concepts/Essential Questions: What do you know about food and waste systems (survey)? What sustainable food and waste behaviors do you engage in (survey)? What important events have helped shape who you are and where you are in your life (life map)? What do you envision for your future (life map)? What can you do to reduce your ecological footprint (ecological footprint & journaling)? What does your ecological footprint imply about your food and waste behaviors (ecological footprint)? What is the impact of eating meat upon your ecological footprint? What resources does it take to produce our food? Where on the food chain do you eat?
Themes Emphasized Systems Thinking: Dynamics, Tradeoffs, Cascading Effects, Ecological/Social systems interactions Action-orientation: Setting guidelines for sustainable actions in the classroom
Key Concepts: Ecological footprint: estimation of the amount of land and ocean area required to sustain your consumption patterns and absorb your wastes on an annual basis Sustainability (there are many different definitions, so here are 2): Living equitably within the means of nature Sustainability: A societal conversation about the kind of world we want to live in, informed by some understanding of the ecological, social and economic consequences of our individual and collective actions Food web: interconnections between species Food chain: a one-directional flow of energy
Learning Outcomes/Objectives (both knowledge & skills): At the end of the lesson, students will be able to… 1. Understand what an ecological footprint calculator is and how it works

2. Understand how human actions impact the environment and natural resources

3. Sort waste into compostable, recyclable, and landfilled (as part of class expectations)

4. Understand ways to reduce their ecological footprint

5. Understand patterns of consumption locally and globally

7. Understand the impact eating meat has upon our ecological footprints

Agenda for Monday, June 20th

9:00am-9:30am Pre-program survey followed by discussion on survey questions and responses

Were there any questions that were confusing?

Was there anything they didn't understand?

Why did they respond the way they did?

9:30-10:00 am Ice-breaker: get to know each other with "Life Map Activity"

Life maps: Each student prepares a 'map' of the important things that have shaped their lives thus far and the direction they hope to head in the future using pictures, narratives, or any other medium of their choosing.

10:00-10:30am Setting Class Expectations and Handing out materials
Expectations: Explain composting, recycling, and use of reusable water bottles, along with reward system for being 'caught doing something sustainable.' Hand-out note-books and pens, explain daily journaling expectations. Discuss the camcorder in the back of the classroom.

10:30-11:15 am Calculating our Ecological Footprint
Ecological Footprint Calculators: Each student will calculate their ecological footprint using this website: http://myfootprint.org/en/
They will calculate it once as themselves and once as a heavy beef consumer and once as a vegetarian

11:15am-11:40 Presentation

11:40-noon Concept Mapping

Noon-12:30 Meatrix video: http://www.themeatrix.com/ and Discussion

12:30-1pm Snack Time: Explain sustainable snack selection

Assignment: Journal about ways that you are going to reduce your ecological footprint? What are the barriers to making that change?

Save the packaging from food you eat on Monday afternoon/evening and Tuesday. Bring in the packaging on Tuesday and Wednesday.

Background Information: All organisms, including people, consume natural resources and generate waste. This daily cycle of life in turn impacts the environment in a variety of ways. Ecologists use the concept of carrying capacity to predict how the interplay between resource consumption and waste generation may limit the population of any given organism in its local ecosystem. Typically if a population of organisms consumes more resources (like food) than is available in its ecosystem or generate more waste than can be processed in its ecosystem, then the organism's population declines. Sometimes this is referred to as exceeding a population's carrying capacity. In the early 1990's graduate student, Mathis Wackernagle, and professor, William Rees created a mathematical model that applied the ecological concept of carrying capacity to people's impact on the environment. They originally called this concept "appropriated carrying capacity" and eventually replaced that term with "Ecological Footprint". They published a book in 1996 entitled *Our Ecological Footprint: Reducing Human Impact on the Earth.* All Ecological Footprint calculators are based to some extent on this original model and this is reflected in the basic definition of Ecological Footprint. Ecological Footprints are not predications about future carrying capacity of the earth but a measure of past and present human impacts.

Day Two- Understanding Agricultural and Food Systems

Overview/Background: Day 2 of the program will begin with students showing the labels they have saved and sharing their ideas for reducing their ecological footprints. After journal sharing/discussion, we will watch a 10 minute video clip from the movie "Food Inc." After the movie, I will give a presentation on agriculture; during organic agriculture discussion we will watch 3 minute video from Rodale Institute. I will provide the worksheets on local vs. industrial system from Nourish. Next we will run the "Food Systems are Dynamic" activity followed by a short discussion. We will finish the day talking about (and eating) salsa- students will evaluate social, environmental, and economic issues associated with conventional, local, and organic salsa brands.

Fundamental Concepts/Essential Questions:

What are some of the unintended consequences associated with our homogonous industrial food system (Food Inc video)?

How has the US moved from family farms to industrial agriculture (presentation)?

What was the Green Revolution (presentation)?

What have been the impacts of the Green Revolution (presentation)?

What are alternatives to industrial agriculture (presentation)?

What is the relationship between water quality and agriculture (systems activity)?

What is the relationship between food prices and labor practices (systems activity)?

How do economic, social, and environmental components of the food system interact with on another (systems activity)?

What is a life cycle analysis (LCA activity)?

What is the difference between cradle to cradle and cradle to grave (LCA activity)?

What are the trade-offs to consider when purchasing conventional, organic, or local products (3E's activity)?

Competencies Emphasized

Systems Thinking: Focusing on trade-offs and cascading effects. The green revolution resulted in a series of cascading effects (India case study) and there are trade-offs associated with purchasing different types of products.

Change Agency: We will discuss the students as agents within the food system and the importance of the food decisions they make.

Key Concepts:

Green Revolution: introduction of new technologies including synthetic pesticides, synthetic fertilizers, expanded irrigation systems and hybridized seeds which has transformed agriculture in the US and globally.

Organic Agriculture: farming with no non-natural chemicals, no genetic engineering, and managing the farm as an agro-ecosystem.

Systems Activity (see definitions on lesson plan)

Food Miles: The average distance a single food item travels from farm to table is 1500 miles

Life Cycle Analysis: a method for looking at the impacts of a product through its entire *lifespan* in order to compare its sustainability with other products.

3 Es of Sustainability: key focus areas in sustainability include- the environment, the economy and equity.

Learning Outcomes/Objectives (both knowledge & skills):

At the end of the lesson, students will be able to…

1. Understand the change in the US farm system from family to industrial farms.

2. Understand the green revolution and explain its main components.

3. Understand the impacts of the green revolution and the urgency to find alternative farming strategies.

4. Understand some of the alternative farming strategies and how they can support them.

5. Discuss the dynamic, interconnected, self-organizing nature of food systems

6. Consider how understanding the nature of systems can help us to find sustainable solutions

7. Understand how a change in one issue can positively and negatively affect a change in another issue (cascading effects).

8. Understand the importance of sustainability for the future

9. Understand how to make a balanced decision by using sustainability criteria, evaluating trade-offs, understanding the perspectives of others, and drawing conclusions from available data.

Agenda for Tuesday, June 21st

9:00am-9:30am	Share journaling assignment on ways to reduce ecological footprint and hand-in the food labels you have collected
9:30-9:40 am	Watch the Food Inc video: http://www.youtube.com/watch?v=GPaUjEj65MI
9:40-10:30am	Presentation on agricultural system/ green revolution- 3 minute video during presentation: http://www.youtube.com/watch?v=XH6-MKuehdk&feature=related
10:30-11:15 am	Systems are Dynamic Activity
	Materials: Name tags
11:15am-Noon	LCA presentation & LCA Salsa activity (the students will be given jars of salsa and asked to read the labels, read the description, and discuss what goes into that product from the raw materials all the way to the end of life)
	Materials: White board, markers, salsa jars, hand-outs
Noon-1:00pm	Evaluate your salsa based on environmental, economic, and social indicators (enjoy a healthy snack with the salsa that we have been looking at all morning!)
	Materials: rulers, markers, triangle posters

Assignment:

Discuss your household food decisions with your family; in particular with the person that is the primary grocery shopper:

How do they decide what to purchase?

What are their priorities in terms of food decisions (price, organic, local, packaging, freshness, brand)?

Is sustainability part of their food decision-making process?

Would they be interested in purchasing food that is more sustainable?

Remember to again bring in food packaging/labels!

Day Three- Understanding Agricultural and Food Systems

Overview/Background: Day 3 of the program will focus on nutrition labels, packaging, and marketing. Although we should be eating food based on our bodies nutritional needs, all too often people choose foods based on brand recognition and successful marketing campaigns. We will start the day with a presentation on different products and their associated slogans. Students will fill in the tag-lines that have immersed themselves in our society- including Kit Kat's "Give me a Break, Break me off a piece of that kit-kat bar" and Sprites' "Obey your Thirst." After discussing what they do know (slogans and ads) we will ask questions about calories, percentage of vegetable/fruit on the plate- nutrition questions- which many students will likely not know the answer to. After the presentation, we will do the "Food Clues" activity which involves looking at the labels of the food products the students brought in- they eat this stuff but do they actually know what's in it? After the labels activity we will move into the cereal box redesign. In this activity students will look at both healthy and unhealthy cereals and then they will design new labels based on the actual ingredients. We will end the day with students by discussing healthy alternatives to common snacks and by actually providing them with a healthy snack!

Fundamental Concepts/Essential Questions:

Why would someone choose a to eat a twinkie rather than a carrot (video)?

How has marketing influenced what we eat (presentation)?

How many calories a day should we eat (presentation)?

What percentage of your meal should be fruits and vegetables based on the USDA food plate (presentation)?

What ingredients are in foods you commonly eat (food story clues)?

How can you tell if something is a whole food or a processed food (food story clues)?

What does the packaging of a product say about the nutrition value (cereal box redesign)?

How can you reduce your sugar consumption (cereal box redesign)?

What are healthy alternatives to high-sodium and high-sugar snacks (sustainable snack)?

Competencies Emphasized

Foresighted thinking: Even if unhealthy eating isn't effecting your lifestyle at age 12 or even 20, if you continue eating junkfood, how healthy will you be at age 50, 60, or 70?

Change Agency: We will actually eat healthy foods and discuss alternatives to the commonly consumed

junk food.
Key Concepts: Processed foods: Foods that have been canned, jarred, froze, dehydrated, pasterized Whole Foods: Foods that are in the form they were when harvested Daily Caloric Intake: For teenagers, ranges between 1500 and 2500 calories per day Refined White Flour: When flour is refined, it is not just bran that is removed. The wheat germ, an important part of the grain containing oils and the nutrients in the grain that are responsible for the potential for life and growth in the grain, is removed also. The remaining white starch is relatively devoid of nutritional variety.
Learning Outcomes/Objectives (both knowledge & skills): At the end of the lesson, students will be able to… 1. Understand the difference between processed and whole foods. 2. Understand the difference between refined white floor and whole grains. 3. Understand how to read food labels and determine based on the label whether the food is healthy or not. 4. Understand the impact marketing has upon our diets. 8. Understand the importance of eating whole foods. 9. Understand the environmental impact of eating highly processed and packaged foods.

Agenda for Wednesday, June 22nd

9:00am-9:30am Share journaling assignment on household food decisions and hand in the labels you have collected

9:30-9:40 am Watch the Michael Pollan video: Video on twinkies vs. carrots: Video on Twinkie vs. Carrot: http://www.nourishlife.org/videos/twinkie-vs-carrot/

9:40-10:15pm Presentation on marketing, nutrition, and you!

10:30-11:15 am Food Story Clues- labels and packaging investigation
After completing the worksheets- hang up the labels around the room from least to most sustainable- how did you make those decisions (packaging, nutrition, ecological footprint)
Materials: worksheets, labels

11:15- 11:30	Package Dissection: How many layers of packaging does each of the food products have?
11:30am-12:30pm	Cereal Box ReDesign
12:30pm-1pm	Brainstorming: What changes can you make to your diet in order to stay healthy?
	How is eating healthy related to sustainability?

Assignment:
First look in your cupboards and record the packaging details on your worksheet. Then, based on what you learned in terms of packaging, health, and ecological footprint, create an action plan with your household members:

-Talk with households members about ways to reduce your meat consumption, consumption of unhealthy processed foods, and reducing your overly packaged items.

-Come up with at least 3 things that you can start doing NOW to eat more sustainably.

-Take notes in your journal and be prepared to share your thoughts with your class.

Day Four- Taking Action

Overview/Background: Day 4 will begin with sharing the packaging worksheets- what were things you found at home? Can you think of how to reduce your food packaging? After the packaging worksheet discussion, we will move onto the journaling discussion- what does your family think they could commit to, what 3 action strategies did you select? Next we will create formal action plans using the action plan worksheet. Then the students will make a public commitment to take action and share their ideas and reason for making this change with one other person. The students will share their commitments with the class. Then we will review the concepts and terms through a brainstorming activity and through Food Jeopardy. We will end the day with a talk from a local food sustainability change agent- Braden Kay.

Fundamental Concepts/Essential Questions:

How can you reduce packaging at your house (packaging homework)?

How can you reuse the packaging from those products (packaging homework)?

What changes are feasible for you to make in order to eat more sustainably (action plan)?

What changes are your families willing to make in order to eat more sustainably (action plan)?

What are the barriers to making these changes (action plan)?

What do you need in order to achieve your food sustainability action plan (action plan)?

What opportunities are there in Phoenix to get involved with the local food sustainability movement (guest speaker)?

How are youth in Phoenix making a difference in the sustainable food movement (guest speaker)?

Competencies Emphasized

Change Agency: This day is really focused on the students feeling empowered to be agents of change and creating plans for action. Stakeholder Engagement: It is important for the students to engage with people that are active in the local food movements here in Phoenix. They will have the opportunity to prepare and ask questions about community gardens and youth food activism.
Key Concepts: Action Plan: A feasible plan that considers the barriers to achieving the goals as well as the resources needed. Review of previously defined terms during the jeopardy game: organic, conventional, food miles, sustainability, ecological footprint, life cycle analysis
Learning Outcomes/Objectives (both knowledge & skills): At the end of the lesson, students will be able to… 1. Understand how to develop a plan of action. 2. Understand how to overcome perceived barriers to achieving their goals. 3. Understand how to reduce the packaging at their homes. 4. Understand opportunities available for youth in the Phoenix food movement.

Agenda for Thursday, June 23rd

9:00am-9:30am	Share worksheet on packaging. Discuss possible solutions: bulk purchasing, bring your own bags, and purchasing post-consumer content. Next share action ideas you created with your family!
9:30-10:15 am	Develop action plans further using the "Action Plan" worksheet. Write commitment pledges to do at least one action and to share at least one action with another person. (Photocopy pledges to keep one for Erin and one for the student)
10:15-10:30am	Review- As a group, brainstorm responses to the following questions, record responses: 1. What inputs are associated with industrial (conventional agriculture), organic agriculture (or sustainable agriculture)? 2. What food purchasing decisions can you make to reduce your ecological footprint? 3. What is feasible or seems easiest for you to do based on your circumstances?

	4. What would be the benefits to the environment and society if everyone made the changes that you have now committed to making?
10:30-10:50am	Food Systems Jeopardy- Reviewing terminology through a familiar game (we did not get to this game on this day)
10:50-11am	Prepare questions to ask Braden Kay today and for Cindy Gentry tomorrow
11am-12:30	Braden Kay is speaking and providing snack
12:30-1pm	Discuss insights from speaker and finish eating

Assignment:
Journaling: Describe what a sustainable food system looks like to you? What do people eat, how is the food grown, where is the food grown and what is a farmer's life like?
How does your chosen action fit into your vision of a sustainable food future?

Day Five- Visioning

Overview/Background: Day 5 will begin with sharing our journaling responses. I will start the presentation and just present slides 1 to 4 for the first activity in which the students create their vision. The students will work in groups based upon their interests.Their vision boards should include a narrative, impacts, and pictures (drawn or from magazines).
Fundamental Concepts/Essential Questions: What do you envision for the future in terms of food sustainability (desired outcomes)? What are the essential components necessary to achieve that vision? What are some mile stones that will indicate you are progressing towards your vision? What opportunities are there in Phoenix to get involved with the local food sustainability movement (guest speaker)? How are youth in Phoenix making a difference in the sustainable food movement (guest speaker)?
Competencies Emphasized Foresighted Thinking: Students are going to think about the kind of future they want to see and create a vision board that encompasses the diverse perspectives of the group. Stakeholder Engagement: It is important for the students to engage with people that are active in the local food movements here in Phoenix. They will have the opportunity to prepare and ask questions about local farmers markets and food movements.
Key Concepts: Visioning: What does it mean to think about a vision for the future

Foresighted thinking: Think back to your action plans from yesterday, how do your action plans include long-term planning? Intergenerational equity: How do we ensure that we do not limit the options of future generations?
Learning Outcomes/Objectives (both knowledge & skills): At the end of the lesson, students will be able to… 1. Understand how to develop a vision with a narrative and pictorial component. 2. Understand how to integrate foresighted thinking into their action plans. 3. Understand concepts about intergenerational equity. 4. Understand opportunities available for purchasing local food in Phoenix.

Detailed Agenda of Friday June 25th

9:00am-9:30am	Share your journaling responses: Describe what a sustainable food system looks like to you? What do people eat, how is the food grown, where is the food grown and what is a farmer's life like? How does your chosen action fit into your vision of a sustainable food future?
9:30-10:15 am	Erin presents the idea of visioning
10:15-10:30am	Review as a group what our 'current state' is
10:30-10:50am	As a group brainstorm ideas about where we would like to be in 30 years
10:50-11am	Break into groups based on interest and create vision boards
11am-12:30	Cindy Gentry is speaking and providing local food from the Phoenix Urban Grocery
12:30-1pm	Eat food provided by Cindy Gentry

Assignment:
Go grocery shopping with your family using the gift card. Interview store managers (using worksheet provided). Prepare a sustainable meal with your family using the ingredients purchased. Save all packaging to bring in on Monday and bring in completed worksheet with interview and recipe that you used to prepare the sustainable food. Bring receipts.

Day Six- Transitioning from Food Issues to Waste Issues

Overview/Background: Begin with journal sharing- what did you purchase, why is it sustainable, what did the Fry's managers say about sustainable sourcing? Food terms Jeopardy in order to review what we covered last week. Transition into waste conversation with TED video: http://www.youtube.com/watch?v=en4XzfR0FE8

Give presentation on the waste problem and then have students work in pairs of two with the teachers and do the change by converting worksheet. Finish with the track your trash homework assignment.

Fundamental Concepts/Essential Questions:
What is the difference between organic and conventional agriculture (jeopardy)?

How can you shop sustainably (homework assignment)?

What is in our landfills?

What is the environmental impact of landfills?

How do landfills impact out air quality?

How do landfills impact our water quality?

How do landfills impact the economy?

Competencies Emphasized

Change Agency: The student went to their neighborhood grocery stores and shopped sustainably- using reusable bags and purchasing the most sustainable food they would eat and could find.

Systems Thinking: The students will be learning how waste impacts our environment, economy, and society

Key Concepts:

Methane: A greenhouse gas that has 21 greater trapping capacity than CO2

Leachate: Toxins that leach out of landfills into the groundwater

Learning Outcomes/Objectives (both knowledge & skills):

At the end of the lesson, students will be able to…

1. Understand how landfills impact the environment
2. Understand how landfills impact society and the economy.
3. Understand the composition of our waste stream.
4. Understand the environmental issues associated with methane.

Agenda for Monday, June 27th

9:00am-10am Journal Review- what did you purchase, why did you purchase it, what did the grocery store manager say about purchasing sustainable products, and how do you plan to prepare the foods? What was

it like using the reusable bags? Were other people using reusable bags at the grocery store?

10am-10:30am Review of food terms through Jeopardy
10:30-10:40am TED talk Charles Moore video:
http://www.youtube.com/watch?v=en4XzfR0FE8
10:40-11:20am Presentation of waste issues
11:30am During presentation, watch Van Jones video:
http://amermaidstear.blogspot.com/2011/02/tedx-great-pacific-garbage-patch.html

11:30-noon Change by converting worksheet

Noon-12:30 Assign Tracking your Trash worksheet

12:30-1pm Kelly (teacher) brings lunch and explains her food choices, we eat

Assignment:
Journaling: Ask your parents what they would be willing to do- is composting possible- indoor or outdoor?
Track your trash- record every single item of garbage you throw away and how you dispose of it- do you recycle, compost, or landfill it. We will discuss ways to reduce this waste.

Day Seven- The plastic problem

Overview/Background: Day 7 will begin with a discussion on plastic items (bottles, bags, utensils).
Fundamental Concepts/Essential Questions: How much trash to you produce? What do you currently do with that trash? What are the environmental, economic, and social impacts of plastic? What can I recycle in my neighborhood? What are alternatives to single-use disposables?
Competencies Emphasized Foresighted Thinking: We are discussing the cumulative impact of plastic build up over time. Stakeholder Engagement: Alana works on ASU waste issues and she will share some methods for reducing waste and show products that are repurposed from waste

Key Concepts:

Accumulation: Plastic accumulates over time because it does not break down

Biodegradable: Plastic does not biodegrade (meaning that it will always be around)

Cradle to Grave: A term used in sustainability to describe analyzing the life cycle of a product from its origin (cradle) to its final resting place (grave).

Learning Outcomes/Objectives (both knowledge & skills):

At the end of the lesson, students will be able to…

1. Develop strategies for reducing their waste by switching away from single-use disposables.
2. Understand how waste is recycled: up-cycled or down-cycled.
3. Understand how to reduce the packaging at their homes.
4. Understand the life cycle of a plastic bottle versus using a reusable bottle

Agenda for Tuesday, June 28th

9:00am-9:30am Share worksheet Tracking Your Trash

9:30-9:40 am Video on Pacific Island Garbage Patch: http://www.youtube.com/watch?v=uLrVCI4N67M

9:40-10:20am Presentation on Plastic and during presentation show Tapped Trailer: http://www.youtube.com/watch?v=72MCumz5lq4

10:20-11am Do the Brita Water Worksheet & then follow up with the LCA activity (see LCA lesson plan in the Lesson Plan section below)

11am-11:15 Brainstorming reusable products

11:15-11:30am Create posters for our homes that indicate how to sort trash. What is actually recyclable in your neighborhood? Are you interested in composting? If so, create a poster for composting.

11:30-12:30 Guest Speaker: Alana (Recycling Program Manager for Arizona State University)

Assignment:

Journaling: Continue tracking your trash and look around your home for disposable products- what can you do to make the switch to reusable?

Day Eight-Progressing towards a solution

Overview/Background: Day 8 will begin with sharing our journaling responses. I will present information on composting, FAVE bags, and post-consumer content. The students will sort paper products (wrappers from paper products) in order to determine post-consumer or not. The students will also generally sort the trash into recyclable, compostable, or trash. At 11:15am we will leave for engrained.
Fundamental Concepts/Essential Questions: How can we purchase more sustainably? How can we compost? Why should we compost? Why should we purchase paper made from post-consumer content? What is hot in the sustainable restaurant movement?
Competencies Emphasized Systems Thinking: Students will make connections between the natural environmental (decomposition by worms) and their at-home waste decisions. We will also discuss how restaurants are capitalizing on the sustainability movement (connecting sustainable waste decisions with the economic sector) Stakeholder Engagement: The students will go to Engrained (a restaurant focused on sustainable food) and eat lunch while talking with the restaurants chef and director of sustainability. Change Agency: Students will take home forms with different sustainable waste options and discuss with their parents about what system their household is going to commit to.
Key Concepts: Composting, decomposition, vermin-composting, post-consumer content.
Learning Outcomes/Objectives (both knowledge & skills): At the end of the lesson, students will be able to… 1. Sort their garbage based on recyclable, compostable, or landfilled 2. Determine if paper is post-consumer or made of virgin materials. 3. Understand how restaurants such as Engrained have interpreted sustainability.

Agenda of Wednesday, June 29th

9:00am-9:30am Share your Tracking you Trash journaling and homework.

9:30-10:15 am Presentation: begin with Machillas video:
http://www.youtube.com/watch?v=EDMpwwIToTc&feature=related

10:15-10:45am Sort post-consumer and recycled content

10:45am- 11:15am Sort all the garbage into landfilled, recyclable, compostable

11am Walk to Engrained, eat lunch and talk with chef and director of sustainability for the restaurant

12:30pm Return to classroom and discuss journaling assignment

Assignment:
Journaling: How do your food decisions relate to your waste decisions? What sustainable waste actions are you willing to commit to? What waste actions are your family members willing to commit to? What are the barriers to making the change stick?

Day Nine- Taking Action

Overview/Background: Day 9 will being with sharing our journal responses. The first activity will be led by Deepa-she will lead us in discussing the various sustainable waste solutions and where they fit on the continuum of sustainability. Next the students will commit to taking action, fill out an action plan and fill out a pledge card. After the action commitments we will go up to the ground floor and do the web of interconnectedness activity. After we finish the activity, we will return downstairs to create final commitment tree that incorporates the students' food and waste commitments in an artistic fashion.

Fundamental Concepts/Essential Questions:
How are food issues connected to waste issues?

Can things be sustainable but not the most sustainable?

How can I take action?

How can I be an agent of change?

If things are connected, what happens if there is a shift in one area (like consumer choices)?

What does commitment take?

What are the barriers to changing behaviors?

Competencies Emphasized
Change Agency: Action plans and commitments to personal change as well as to spreading the word. Systems-thinking: The interconnectedness activity with the food and waste concepts and the string is really about understanding the intertwined concepts of food and waste.
Key Concepts: Action plan, commitment strategies Review terms: composting, methane, biodegradable, anaerobic decomposition.
Learning Outcomes/Objectives (both knowledge & skills): At the end of the lesson, students will be able to… 1. Share their plan of action for being more sustainable with their waste decisions with their friends and family (they commit to sharing their plan with at least one family member and one friend) 2. Determine how they can take action to be more sustainable in their waste decisions. 3. Understand how food and waste issues are interconnected.

Detailed Agenda for Thursday, June 30th

9:00am-9:30am Share journaling

9:30-10:00am Deepa will lead an activity about the sustainability continuum associate with various products and choices

10-10:30am Develop an action plan for reducing, reusing, and recycling your waste

10:30-10:40am Fill out commitment card

10:40-11:20 Web of Interconnectedness (string, concept cards)

11:20-11:45 Create tree of commitments- both food and waste

11:45-noon Discuss final day—get head count on who's family is attending end of program festivities

Noon- 12:30 Eat and socialize

Day Ten- Program Closing

Overview/Background: Day 10 will begin will begin with a fun icebreaker in which we share things we admire about the people we met through this program! Then we will split into groups based on the waste activities- some students will build composting bins, others will prepare indoor recycling bins, and others will build vermin-composting bins. After the completion of these bins, the students will complete the end of program survey. Then, parents arrive and we share our camp experience with the parents.
Fundamental Concepts/Essential Questions: How do you build a composting bin out of everyday materials? How has this program changed your knowledge and behaviors? What have you learned that you can share with your parents?
Competencies Emphasized Change Agency: The students are showing their parents how they have become sustainability change agents! Systems Thinking: The interconnectedness activity with the food and waste concepts and the strings is really about understanding the intertwined relationships of food and waste. Action-orientation: The students are physically building the worm bins!
Key Concepts: Composting: taking organic materials and making soil Vermi-composting: using worms to turn your garbage into soil Biodegradable: only things that are biodegradable should be put into the composting bin
Learning Outcomes/Objectives (both knowledge & skills): At the end of the lesson, students will be able to… 1. Sort their garbage based on recyclable, compostable, or landfilled 2. Determine how they can take action to be more sustainable in their waste decisions. 3. Understand how food and waste issues are interconnected.

Detailed Agenda for Friday, July 1st
9:00am-9:30am Fun closing activity (everyone share something they admire about another person in the program—we handed out slips of paper so that everyone is talked about evenly)!

9:30-10:30am Building/preparing your sustainable waste bin (recycling or composting)

10:30-11am Students will create signs for the new sustainable bins in order to inform their household members how to sort their garbage

11-11:30am Take the closing survey

11:30-12:30 Share your work with your families. What can you tell them about the vision poster you created? Or the bins you built?

End- Eat, socialize, and say our Good-byes!

Lesson plans used during the summer program

Lesson 1: The 3 E's of Salsa

Adapted from Pfizer Inc.
Green Chemistry Triangle Triage Lesson
http://www.beyondbenign.org/K12education/highschool.html

Approximate Time: 60 minutes
Grade Level: 6^{th}- 9^{th}
Background: Sustainability is commonly defined as: "Meeting the needs of current generations without compromising the needs of future generations" (Bruntland Report, 1987). In order to determine if something is sustainable, three elements must be considered: economics, environment, and social equity. These are known as the '3 Es.'

- Economic factors might be (but are not limited to): jobs, work environment, profitability, human hours, prospects for growth, efficiency in supply chain (is there a lot of waste?)

- Environmental factors might be (but are not limited to): air quality, water quality, impact on biodiversity, wildlife preservation, nature conservation, carbon emissions, ecological footprint, soil degradation
- Social Equity factors might be (but are not limited to): diverse populations, equal opportunity, exploitation of labor, impact on people's health and well-being, lifestyle implications

The descriptions of the salsa brands were composed using web-site information and personal emails. In some instances, it is difficult to get full disclosure from the company concerning their practices; therefore the descriptions for the brands may have gaps in the information. As a consumer, you have to make decisions based on the available knowledge, even if that knowledge is not complete. This lesson is a practice in conscious consumerism and the trade-offs associated with attempting to make the most sustainable decision.

Objectives:

The students will:

- Understand the importance of sustainability for the future.
- Become familiar with trade-offs.
- Brainstorm and prioritize long-term goals.
- Draw conclusions.
- Use components to make a balanced decision.
- Rationalize their decisions.
- Understand the perspectives of others.
- Develop criteria and data to quantify their decisions.
- Draw connections to their lives.
- Standardize criteria to evaluate their products.

Science Standards:

- **S1-C2-GR5-GR6-GR7GR8** Inquiry Process; Observations, Questions, Hypothesis
- **S1-C2-GR5-GR6-GR7-GR8** Inquiry Process; Scientific testing
- **S1-C3-GR5-GR6-GR7-GR8** Inquiry Process; Analysis and conclusion
- **S1-C4_GR5-GR6-GR7-GR8** Inquiry Process; Communication
- **S2-C2-GR5-GR6-GR7** History and the nature of science; Nature of scientific knowledge
- **S3-C1-GR7-GR8** Science in social and personal perspectives; Changes in the environment
- **S3-C2-GR5-GR6-GR7-GR8** Science in social and personal perspectives; Science and technology in society

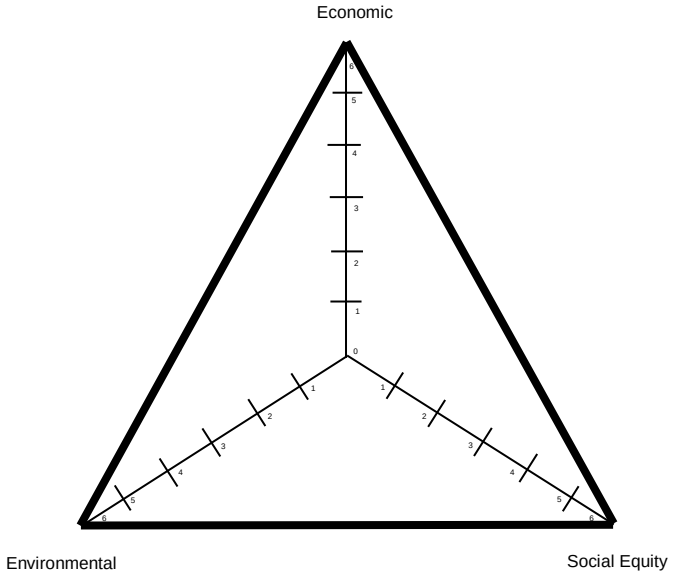
Preparation/Materials:

- A copy of the accompanying student hand-out for each student in the class
- 1/3 of the class should get an information sheet about Salsa Timoteo (the local salsa)
- 1/3 of the class should get an information sheet about Amy's Organic Salsa (the organic salsa)
- 1/3 of the class should get an information sheet about Pace Salsa (the conventional salsa)
- Each of the three E groups should get a hand-out regarding information about creating criteria for the E that they are assigned to assess.

- Sidewalk chalk, masking tape, or large sheets of poster/butcher paper (one per salsa group). If you would like to do the lesson outside, prior to class, use the chalk to draw 3 large triangles on the sidewalk. In the classroom, you can either tape 3 large triangles on the floor, or draw a large triangle on each one of the three poster/butcher papers.
- Each of the 3 salsa groups should be given a ruler to draw their triangle with.
- Label one triangle Organic, one Local, and the third one Conventional.

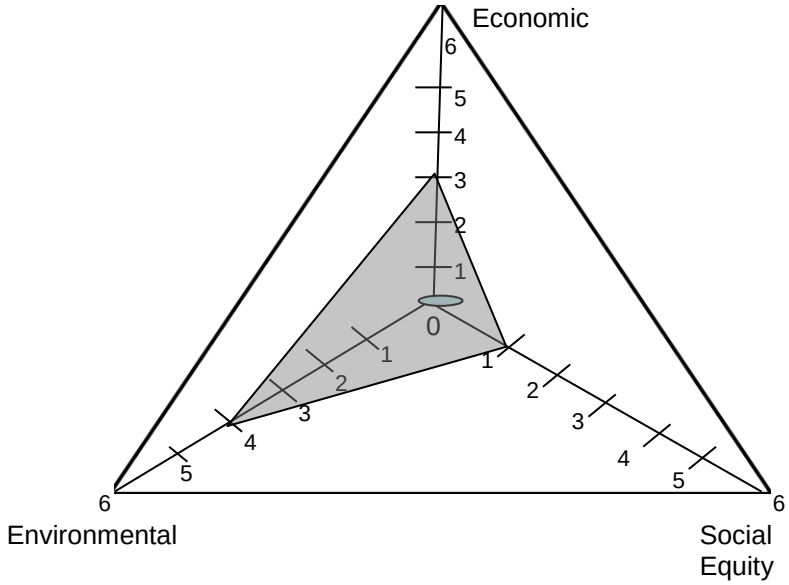
Procedure:

1. Draw a triangle on the board or use PowerPoint to project the triangle below:



2. Explain to the students that they will be using the triangles as part of a graphic tool for making decisions involving two or more possible choices
3. Split the class into 3 groups and give each group a different salsa brand to analyze (organic to one group, conventional to another and local to the third group). Pass out the corresponding hand-out (for example, the group analyzing Amy's salsa will get a hand-out describing the production of Amy's salsa).
4. These groups will be analyzing the advantages and disadvantages of their assigned salsa using the criterion on the student worksheet. The students are given three criterion for each E category with which to rate their salsa on.
5. Explain to the students that they are going to help the class determine which brand is the most sustainable by analyzing the 3 E's of Sustainability.
6. Pass out the Environmental, Economic, and Social Equity information sheets to each salsa group. These sheets can be used to further explain the criteria.
7. Within their salsa groups, the students will discuss the criteria and as a team rate each E for their salsa, recording their values on the *Evaluating the 3 E's of Salsa* student hand-out.
8. After all criterions have been rated, average the rating for each E.

9. Mark the rating for each E on the triangle grid provided (for example, if the average rating for the environmental sector is 5.5, place a dot between the 5 and the 6 tick mark on environmental section of the triangle).
10. Connect all of the points to make a triangle within the triangle grid.
11. After plotting the numbers and connecting the points, shade in the area of the triangle. The shaded area below was based on a rating of 3 for Economic, 4 for Environmental, and 1 for social equity.



12. Additionally, use the average of all three ratings (add up the average rating for economic, environmental, and social equity and divide by 3) to compare the overall sustainability of the product.
13. Have each salsa group share their results. Which one has the largest area? Which salsa is the most environmentally sustainable, economically sustainable, or socially sustainable?

Evaluation:

- Each group will have successfully created criteria, rated the salsa, and plotted the points on the triangle grid.
- Each student should be evaluated based on their participation in this activity.

Extension:

- If you want to further challenge your students with this lesson, you can have them create their own Sustainability criteria with which to rate the salsa. When allowing the students to create their criteria, you can split them into the 3 E's groups (for example: allow the Environmental group to agree upon environmental criteria that all the salsa groups are going to be using).
- The students could create their own salsa brand. In creating their salsa, they need to think about how it can achieve 6's in all three of the sustainability categories. Possible questions for the students to think about are: How is the salsa produced, where is it

produced, with what products, by whom, what are the working conditions, what is the cost of the product, what is the profit margin, how is it going to be marketed?

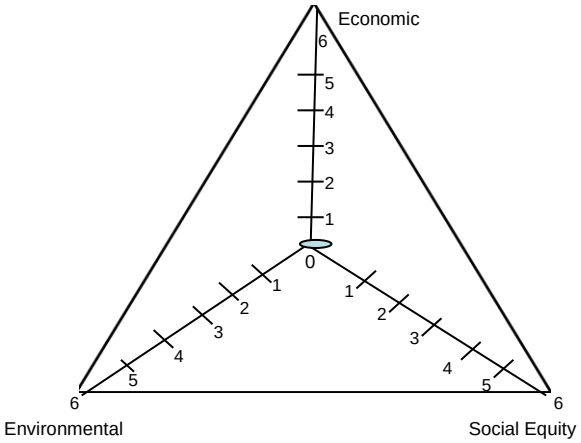
Student Worksheet: **Evaluating the 3 E's of Salsa**

The 3 E's-, **E**nvironmental, Social **E**quity, **E**conomic

- Environmental factors might be (but are not limited to): air quality, water quality, impact on biodiversity, wildlife preservation, nature conservation
- Social Equity factors might be (but are not limited to): diverse populations, equal opportunity, exploitation of labor,
  impact on people's health and well-being,
  lifestyle implications
- Economic factors might be (but are not limited to): jobs, work environment, profitability, human hours, prospects for growth, prospects for success into the future (long-term economic viability)

Rating Scale:

6- Meets all of the criterion
5- Meets nearly all of the criterion
4-Meets most of the criterion
3-Meets some of the criterion
2-Meets few of the criterion
1-Meets almost none of the criterion
0-Meets absolutely none of the criterion



Criteria	Supporting Data	Ratings
Environment		
1. Carbon Neutrality: Examine transportation distances in order to infer carbon emissions. Greater transportation distances are likely to lead to greater carbon emissions. *For a 6, the company should be Carbon Neutral.*		
2. No harmful effects on water quality. Examine the pesticide and chemical use involved in making this product in order to infer the impact on water quality. *For a 6, the company would not use any pesticides, chemicals, or synthetic fertilizers.*		

3. Producing this salsa does not negatively impact land use. For this criteria, look at the waste stream. Land-fills require that natural/wildlife areas be transformed into a storage area for garbage. *For a 6, the packaging is composted (not land- filled) and there is minimal waste involved with the production.*		
Average Rating:		
Social Equity	**Supporting Data**	**Ratings**
1. All the workers involved in producing this salsa are paid a living wage and have a comfortable work environment. *For a 6 rating, all the farmers, manufacturers, producers, suppliers are paid fairly for their work and are not exposed to harmful chemicals during work.*		
2. This product is accessible to the consumer (not overly expensive) and does not negatively impact the health and well-being of the consumer. *For a 6, this product would be inexpensive, widely accessible, and healthy to eat (ie. Not high in fats and artificial ingredients).*		
3. All the employees and laborers involved in making this salsa are seen as valued parts of this company and are in no way disposable and the community is seen as a valued part of the company. *For a 6, this company treats the employees as part of their family and is concerned and involved in the community at large.*		
Average Rating:		
Economic Impact	**Supporting Data**	**Ratings**
1. The company is profitable. *For a 6, this company should be one of the best sellers in the market and has the potential to keep up its success.*		
2. This company shares their monetary success with the employees. *For a 6, when this company is successful, all the farmers, manufacturers, laborers share in the benefits and profits of the success.*		
3. This company's economic success benefits the local community. Statistically speaking, less money from the sales of global businesses gets filtered back into the local economy. *For a 6, this company would have to buy ingredients locally, sell their product locally, and*		

employ only local workers.		
Average Rating:		
Total Average: (add up the average ratings for Environment, Economic, and Equity, then divide by 3)		

Student Hand-out with Salsa Brand Information:

Salsa Timoteo (local salsa):

Company History:

Timoteo was born and raised in Phoenix, Arizona. All through High School and College, Timoteo worked in the restaurant business specializing in Mexican Food. After Graduating college and getting trabajo (work) in the medical field, Timtoeo still held on to his passion of cooking and started "Tim Willhite Foods" featuring "Salsa Timtoteo". Timoteo has always had a dream of opening up his own Mexican Food Restaurant some day so he can share his many recipes with the customers he serves.

Now living in Glendale, Arizona with his Senorita Julia, together they continue the family tradition of "Salsa Timoteo". Hopefully someday Timoteo and Julia will make enough Pesos to open up "Timoteo's" and their hijos (kids) will be able to carry on Timoteo's legacy.

Production:

Prepared in Tempe, Arizona, Salsa Timoteo™ contains real tomatoes, fresh green chiles, onions, jalapenos, cilantro, and a multitude of spices that are a family secret. Salsa Timoteo™ contains no artificial colors, flavorings, or chemicals. The salsa is canned in the same way that grandma used to make salsa.

Salsa Timoteo is made by Timoteo and his wife Senorita Julia. They have no other employees so you can be sure that every jar is made with special care by the founders of this company. They do not have a separate production factory; the salsa is made in their home kitchen. When you buy the salsa, you are purchasing it from local Phoenicians, not from a company or factory (this could help funnel money back into the local economy). The label and graphics for the salsa jar were also made by a local Phoenician; a close friend of Timoteo.

Salsa Timoteo is shipped to retailers (grocery stores) in Phoenix, Flagstaff, and Tucson. Salsa Timoteo is AJ's Fine Food's best selling salsa! Due to their success, they have even diversified to tortilla chips. If you are not in the Phoenix area, you can order Salsa Timoteo online and they will ship it directly to you. When you buy the salsa, you are purchasing it from local Phoenicians, not from a company or factory (this could help funnel money back into the local economy). They also attend special events, where you can meet Timoteo and buy the salsa directly from him!

Salsa Timoteo is a truly local product. However, Salsa Timoteo is made from non-organic food products and therefore contributes to some environmental degradation associated with the use of petroleum-based chemicals. But because of the small, local scale of the product, Timoteo did not

have to buy large processing equipment or build a factory to produce the salsa so that saves both land, materials, and energy. Additionally, the glass jars are made in the United States.

Amy's Organic Salsa (USDA certified organic):

Company History:

Amy's Kitchen is a family business… with every member of the family taking part. The company was started in 1987, when Amy was born. Her mom and dad, Rachel and Andy Berliner, carefully nurtured the company as well as the child, paying constant attention to every aspect of its day to day activities.

We didn't set out to become the nation's leading natural frozen food brand. All we wanted to do was create a business that would allow us to earn a living by providing convenient and tasty natural vegetarian meals for people like ourselves, who appreciated good food, but were often too busy to cook "from scratch."

We started on a "shoestring," using our own house and barn as headquarters. The founding meetings were held in the same room where we were married and where our daughter Amy was born.

This was in 1987, before the idea of "organic" food had become well known, and when there were very few frozen meals available for vegetarians to eat, either in health food stores or supermarkets. We were, however, very fortunate in being in the right place at the right time. The number of vegetarians had increased dramatically, as had consumer awareness of the harmful effects on their health and the environment of chemicals in the food supply.

Amy's has created over 88 frozen meals. In 1999, we introduced a grocery line that now includes canned soups, beans and chili as well as jarred pasta sauces and salsas. Our foods are carried by natural food stores, supermarkets and some club stores in the United States, Canada and abroad.

Both Andy and Rachel like to keep in touch with the needs and interests of the company's more than 1,600 employees and with Amy's customers.

In spite of the fact that many companies now produce similar products, Amy's is still #1 in popularity and sales. Our total commitment to quality has made the difference.

Production Particulars:

At Amy's we value the notion of creating communities. One of the ways we do this is with the farmers who grow our fruits and vegetables. We know most of our growers by name and have been working with some of them since our humble beginnings.

Amy's is fortunate to be nestled into one of the world's premier growing regions for many crops. Over fifty percent of our vegetables are grown within 200 miles of our "kitchen".

Our onions are sourced from 15 local organic growers. Most of these are family farms that have been with us for many years. The onions are delivered to Amy's fresh, and a small group of people from our kitchen peels them by hand.

Organic leeks are another crop that is grown by local family farmers, just a few miles to the west of Amy's. Our produce managers will visit the farms throughout the growing season and discuss ideas for new crops and new ways of using fresh ingredients in our food. This is truly a

"sustainable" approach to the community.

Pace Picante Salsa:

Company History:

In 1947, a young Texan named David Pace had a passion for producing the freshest tasting picante sauce. Determined to create a product that lived up to his expectations, David experimented with ingredients and bottling techniques. The final product became Pace Picante Sauce. After WWII, David went into business creating the first commercially available picante sauce.

In 1990, Pace Foods sent 2,000 bottles of their Pace Picante Sauce to U.S. troops in the Saudi Arabian desert. "Many of the soldiers complain about their bland C-rations," said president Rod Sands. In 1991, Mexican sauces famously overtook ketchup as the top-selling condiment in the United States in total dollar sales, with Pace salsa and Picante sauce leading the trend.

For years, Pace and its major rival brand, Old El Paso, had legal battles over marketing and packaging. When David Pace died in 1993, his invention claimed a 27 percent share of the salsa market, with Old El Paso at 21 percent.

Kit Goldsbury, David Pace's former son-in-law, had bought out the Pace family's interest in the business and was its chief executive officer in November 1994. That's when Campbell, a company dating to 1869 with more than 44,000 employees, announced it would buy the Pace picante brand for $1.1 billion.

Closure of the sale in 1995 gave Pace the soup company's marketing power and helped get the salsa to more stores on the East Coast. Pace reported $250 million in sales in 1996, up from $13 million in 1982.

In 1998, Campbell announced it would move production of the salsa from San Antonia, Texas to Paris, in East Texas, where it already had about 1,000 employees producing Prego spaghetti sauce and other products. About 370 local Pace workers were left without jobs, but given severance deals that included four weeks' pay, plus one week for each year with the company, the Express-News reported.

Currently, Americans consume nearly 170 million pounds of "Pace" salsas each year and one-quarter of U.S. households have a bottle of "Pace" picante sauce or chunky salsa in their homes.

Production:

Today, Pace Foods still uses David's original recipe. Pace uses over 25 million jalapeños a year to make the Pace Picante Salsa. These jalapeños are produced across the Southern U.S. and Mexico. The jalapenos, tomatoes, onions, and other ingredients in Pace Salsa are grown using pesticides and synthetic fertilizers (both derived from petroleum products). Pace products are shipped throughout the globe.

Lesson 2: Dynamic, Interconnected Concepts of a Food System

Approximate Time: 60 minutes

Grade Level: 6^{th}- 9^{th}

Overview/Abstract:

Using concepts of a food system, students will experience the dynamic, interconnected, self-organizing nature of systems. Through this exercise, the students will not only move around in an open space trying to keep an equal distance between themselves and two other people but they

will also have to explain why the concept they have connects to the concepts the of the two people they are following.

Fundamental Concepts/Essential Questions:

What is the relationship between water quality and agriculture?

What is the relationship between food prices and labor practices?

What is the relationship between organic certified foods and pesticides and fertilizers?

What is the relationship between food miles and fossil fuels?

How do economic, social, and environmental components of the food system interact with one another?

Learning Outcomes:

At the end of the lesson, students will be able to…

1. Discuss the dynamic, interconnected, self-organizing nature of food systems

2. Consider how understanding the nature of systems can help us find sustainable solutions

3. Understand how a change in one issue can positively and negatively affect a change in another issue (cascading effects).

Suggested Procedure

Introduction:

1. Ask the students to define a "system." What are some defining features of a system?

- Systems have many parts that work together
- If you change one part, how does it impact others
- If you remove or add something how does it affect the whole system
- A system is made of interconnected parts

2. Ask students to brainstorm components of a Food System. What are the interconnected parts of a food system? What things do you need to grow food, ship food, package food, and eat food? What about people, where do they fit into the system, what are their roles?

3. Explain to the students that they are going to do an exercise to help them understand the dynamic nature of the food system.

Activity:

1. Hand each student a card with one primary food concept on it and 2 other interconnected food concepts that relate to two other students cards. Have the students write their primary food system concept on a name tag (the students should *not* write their interconnected concepts on the name tag) and put that name tag on.

2. Each student will stand up and share their primary food concept but not the 2 they are connected to. The students must mentally keep note of the people they are interconnected to without sharing it out-loud.

3. The students will be tasked with following the two people that are holding the 2 interconnected food concepts.

For example: Student A has a card that has *soil fertility* has its primary concept and *water quality* and *fertilizers* as the interconnected concepts. Student A is tasked with staying an equal distance between the student with the *fertilizer* concept card and the *water* concept card.

3. Instructions for how to interact with the 2 other people you are connected to:
*Move so as to keep equal distance between you and each of these 2 people at all times. This does
not simply mean remaining at the midpoint between them.

4. To pursue the objective, students begin to circulate, each movement triggering many others in an active, interdependent fashion.

5. Introduce disturbances to the system. You can first introduce drought—move the student with the water quality card to the other side of the room.

6. After drought has played its role, let the activity continue without intrusion for another minute then add in *"Organic Food Market Triples."* Have the student (or yourself) move the Organic food card/student away from the main activity (these disturbances should make every single student move).

6. Let the movement continue for 5 to 6 minutes.

7. While the students are still standing in the places they ended the activity in, have them share the concept they are connected to.

Debrief and Reflection:

1. Hand each student an interconnectedness worksheet. Explain that the students should write their primary concept in the middle bubble and their interconnected concepts in the outer two. They will have a few minutes to write their thoughts as to how the 3 concepts they had on their card are related.

2. Ask the students to share with the class their thoughts on how the 3 concepts on their card are related (if the students get stuck, there are references below).
*Do they negatively or positively impact each other?
*What happens when there is a change in one of the concepts they are interconnected to?

3. How did they experience these relationships in the activity? Discuss concepts such as interdependence and seeking and maintaining balance.

4. Ask the students where their attention was focused during the activity.
*Were you focused on the big picture or the small details?
*Were you focused on your own actions or the actions of others? Why is this perception important?

5. How did one change impact the entire system? Introduce the term cascading effect and explain that growth in the organic food sector may lead to many cascading effects.
*How did the growth in the organic food market impact the entire system? Do you think it positively or negatively impacted the system (parts or all)? How do you think growth in the

organic food market
would impact fossil fuels, fertilizers, pesticides, water, farmers, and food prices?

6. Why is it helpful to understand system dynamics and interconnectedness?
*How does this related to Sustainability? How can this help us figure out possible Sustainable solutions?
*What might the implications be for making a positive change (one positive change can impact the
entire system)?

7. Do you think a system can ever stop moving (reach stability)?

Notes for Teachers (Terms and Relationships):

Possible relationships to be aware of:

1. The amount of miles our food travels (*food miles*) has increased due to a shift from subsistence farming to *industrial agriculture*. The increase in food miles associated with our industrialized, global food system has led to an increased use of fossil fuels in our agriculture system. Fossil fuel energy inputs occur at pretty much every phase in the industrialized system.

2. Industrial Agriculture is associated with high inputs of pesticides and fertilizers.

3. Fertilizer is used to increase yields by improving degraded soil. Fertilizer is often synthetic and hence made from fossil fuels.

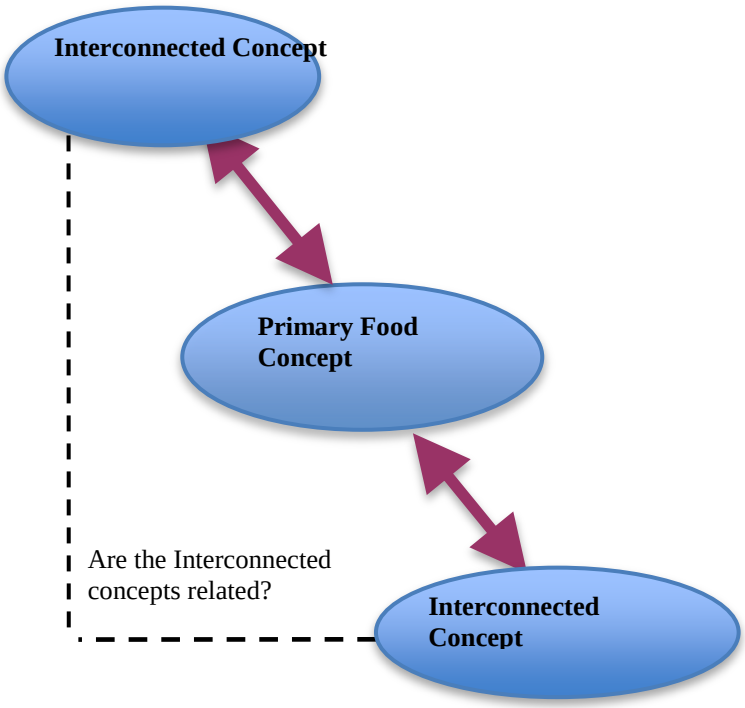
4. Pesticides are known carcinogens (cause cancer) and exposure to pesticides is a health problem for farm workers. Additionally, traces of pesticides have been found in US drinking water.

5. Organic food production means that the food was produced without the use of synthetic pesticides and fertilizers. Because run-off from agriculture fields has been shown to negatively impact water quality, organic production may be a more water quality friendly alternative.

Term	**Explanation**
Soil Fertility	Fertile soil is rich in nutrients such as nitrogen and phosphorus, supports a range of microorganisms that support plant growth, and allows for sufficient drainage of water while maintaining moisture. Soil is the life support system for agriculture.

Water Quality	Water quality is often impacted by farm run-off. Fertilizers and pesticides often get washed into waterways by rain or flood and lead to poor water quality. Degraded water quality negatively impacts future farmers as well as the Sustainability of people all over the world.
Water Quantity	To grow food, we need enough water (quantity) to prevent drought and to moisten the soil. But water is a valuable and limited resource (especially in the desert) and some agricultural products take more water to produce (ie. beef and cotton are both AZ products that are water intensive)
Fertilizer	Fertilizers are applied to farm fields to enhance the soil characteristics. Most fertilizers contain nitrogen, phosphorus, and potassium. Fertilizers can be derived from compost, animal wastes, or other organic material. However, most conventional fertilizers are petroleum-based and composed of synthetic rather than natural ingredients.
Pesticides	Pesticides are substances that are meant for destroying pests. Pests can be insects, mice, unwanted plants (weeds), bacteria, viruses, fungi, or a variety of other animals that may be seen as a nuisance. Many conventional pesticides are petroleum-based and kill harmful as well as beneficial microorganisms. Eliminating beneficial microorganisms from the soil can impact the soil fertility.
Food Prices	Food prices can be impacted by a variety of things. Recently, we have seen the increase in fuel prices lead to an increase in food prices. This is because in agriculture petroleum is used to fuel the tractors, as well as the trucks/planes/boats used for transporting the food. Increasing petroleum prices also increases the prices of pesticides and fertilizers, even further increasing food prices.
Fossil Fuels	Fossil fuels are non-renewable resources because they take millions of years to form. Coal, natural gas, and petroleum/oil are all forms of fossil fuels.
Organic Food	Certified Organic food is food that is grown without the use of pesticides or synthetic fertilizers. Often the farmers will still use natural fertilizers such as compost to enhance their soil fertility.
Farmer workers	Farmer workers grow and harvest the crops. Farmer workers used to be the owner of the family farm. However, in our industrialized factory farm system, farm workers are often poorly paid laborers.
Fair Trade	Fair Trade is an organized social movement and market-based approach that aims to help producers in developing countries and promote sustainability. The movement advocates the payment of a higher price to producers as well as social and environmental standards. Fair trade aims to increase wages to farmers.
Composting	Composting is a method of converting organic waste into nutrient rich fertilizer. The organic waste used to make compost can vary from food scraps (apple cores, banana peels, coffee grinds) to landscaping waste (grass clippings, leaves, branches) to animal waste (cow manure).

	Compost is high in nitrogen, phosphorus, and many other nutrients as well as rich in beneficial microorganisms.



Note: You can either make a worksheet or put diagram in ppt. or just explain on white board

Cards for students (cute out boxes and give one card to each student):

#1

Primary Food System Concept: Food Miles
Interconnected Concept: Industrial Agriculture
Interconnected Concept: Fossil Fuels

#2

Primary Food System Concept: Industrial Agriculture
Interconnected Concept: Pesticides
Interconnected Concept: Fertilizer

#3

Primary Food System Concept: Fertilizer
Interconnected Concept: Soil Fertility
Interconnected Concept: Fossil Fuels

#4

Primary Food System Concept: Pesticides
Interconnected Concept: Farm workers
Interconnected Concept: Water Quality

#5

Primary Food System Concept: Organic Food
Interconnected Concept: Water Quality
Interconnected Concept: Pesticides

#6

Primary Food System Concept: Fossil Fuels
Interconnected Concept: Organic Food
Interconnected Concept: Pesticides

#7

Primary Food System Concept: Water Quality
Interconnected Concept: Pesticides
Interconnected Concept: Organic Food

#8

Primary Food System Concept: Farm workers
Interconnected Concept: Organic Food
Interconnected Concept: Pesticides

#9- Option 1: Use this option if there are ***only 9*** students in each group

Primary Food System Concept: Soil Fertility
Interconnected Concept: Pesticides
Interconnected Concept: Water Quality

#9- Option 2: Use this option if there are ***more*** than 9 students in each group

Primary Food System Concept: Farmer workers

Interconnected Concept: Fair Trade
Interconnected Concept: Composting

#10

Primary Food System Concept: Fair Trade
Interconnected Concept: Organic Food
Interconnected Concept: Composting

#11- if you have 12 students in a group, you can make one of them act as the 'organic food market triples.'

Primary Food System Concept: Composting

Interconnected Concept: Fossil Fuels
Interconnected Concept: Fertilizers

Lesson 3: Cereal Box Redesign
Cereal Box ReDesign: Written by the Green Education Foundation & Adopted for the Progressing Towards Sustainability Program (Summer 2011)
Objectives:
Students will be able to…
- Demonstrate an understanding of nutrition and diet.
- Examine nutrition labels.
- Apply basic math skills and problem solving strategies to other disciplines.
- Begin to connect our food purchases to broader food systems concepts
-Examine the impact of marketing on our food choices
Materials:
- Cereal Boxes (a healthy cereal like Cheerios, Fiber One, and Kashi Go Lean and unhealthy cereal like Raisin Bran Crunch, Cinnamon Toast Crunch, and Chex Multigrain)
Note: To make this more personal, ask the students to bring in cereal boxes from home so they can examine the food they typically eat
- Rulers
- Clear Tape
- Roll of White Paper (large enough to wrap a cereal box like a present)
- Pencils and Erasers
- Markers
- "Breakfast Cereal: Healthy or Unhealthy in Disguise?" worksheet created by the Green Education Foundation

Overview: Studies show that breakfast is the most important meal of the day. It is our first opportunity to make a healthy meal choice. Skipping breakfast often causes us to over compensate by eating more calories later on in the day than we would if we ate breakfast. A healthy breakfast should contain between 400 and 500 calories and contain fiber and some protein. Fiber and protein, like those found in cereal, can help curb our hunger and keep us full and satisfied throughout the day. However, many of these cereals obtain over 40% of their caloric content from sugar. In order to maintain a healthy diet, cereal shouldn't have more than 25% percent of calories from sugar. Excess amounts of sugar, gets stored as fat in the body, and can lead to health problems such as weight gain and diabetes. To calculate the percentage of calories in a cereal that comes from sugar, multiply the number of grams of sugar per serving by four (because there are four calories per gram of sugar). Next, divide that answer (calories from sugar) by the total number of calories per serving. Then multiply that number by 100 to get the

percentage.

One of the main causes of sugary cereal consumption is misleading package design. Some cereals say that they are healthy by emphasizing the high fiber and nutrients they contain, while actually containing up to 20 grams of sugar. That's like drinking a half a can of soda for breakfast if you consume the recommended portion size. By examining the food labels and package designs more closely, we can make healthier choices.

Kid Speak: Cereal is a great choice for a healthy breakfast. It helps keep us feeling full throughout the day. However, not all cereals are good for us. Some are unhealthy cereals in disguise. Companies alter package design to emphasize some of the healthy things in the cereal or use fun designs, so we don't notice the unhealthy things like sugar in the cereal. By looking at food labels and package designs, we can make healthier food choices.
Eco-Fact: Forty-nine percent of Americans eat cereal for breakfast, contributing to 2.7 billion boxes of cereal being sold every year.
Procedure:
Introduction:
1. Show students the front of a box of cereal that seems healthy, but is high in sugar like Raisin Bran Crunch and ask the students: What do you notice first on the box? Accept all answers and make a list on the board.
2. Ask the class if they see a pattern in the answers? Then explain that package designers use an art term called *emphasis* to make us notice certain things first.
3. Ask students: Why do you think you noticed the things listed on the board first? Explain that package designers emphasize things, or make you notice them first, by making things really big, using bright colors, creating interesting shapes, or by placing things in the center.
4. Ask the class: Do you think this cereal is a healthy breakfast choice? Explain that although this cereal seems healthy, and has a fun package design, it actually contains 20 grams of sugar. That is like drinking a half a can of soda for breakfast.
5. Explain that today we will be examining cereal package designs to help us decide if the cereal is a healthy choice or not. Then next class we will be re-designing the package design to make the cereal box reflect its ingredients. For example, Raisin Bran has lots of sugar; we could redesign the package to let buyers know it is not a healthy choice by replacing the delicious looking cereal in the bowl, with a bowl of sugar.
Initial Activity:
1. Explain that we will be working in groups today, to uncover the truth about our cereals. Your group's goal is to determine if the cereal is a healthy or unhealthy choice. Everyone will be receiving a cereal box, and the worksheet: "Breakfast Cereal: Healthy Choice or Unhealthy in Disguise?" Examine the cereal box and answer the questions as best you can.
2. Explain that we will be focusing on how much fiber and sugar the cereal has. In order to maintain a healthy diet, cereal **shouldn't have more than 25% percent of calories from sugar.** Excess amounts of sugar, gets stored as fat in the body, and can lead to health problems such as weight gain and diabetes.
To calculate the percentage of calories in a cereal that comes from sugar, follow these steps:
- Multiply the number of grams of sugar per serving by four (because there are four calories per gram of sugar).

- Next, divide that answer (calories from sugar) by the total number of calories per serving.
- Then multiply that number by 100 to get the percentage.
Here is an example of this calculation from Kellogg's Cornflakes:
- It contains two grams of sugar per serving. To calculate how many calories that is, multiply the two grams of sugar by four. The answer should be eight.
- Then divide that answer, by the total number of calories per serving. In this case, the number of calories per serving is 100. Eight divided by 100 is .08.
- To get the percentage, multiply that answer by 100. The percentage of calories from sugar in Kellogg's Cornflakes would then be 8%.
A cereal should also contain **at least five grams of fiber or more.** Fiber helps keep you full and satisfied throughout the day.

3. Split the class into groups of two to four students.
4. Have students help hand out materials: one worksheet per group, one pencil, and one cereal box (half the groups will receive a healthy cereal like Cheerios, Fiber One, and Kashi Go Lean. The other half will receive an unhealthy cereal like Raisin Bran Crunch, Cinnamon Toast Crunch, and Chex Multigrain).
5. Students will complete the "Breakfast Cereal: Healthy or Unhealthy in Disguise?" worksheet (provided below.)
6. Have a class discussion:
- What cereals were healthy and which ones were not?
- How did you decide if a cereal can be called healthy or unhealthy?
- If some of these cereals aren't a healthy choice, then why does the packaging make it seem healthier than it is? (Explain that package designs can be misleading in order for companies to sell the product.)
-Are the same cereals that are healthy, also sustainable? Why of why not?
-What is the relationship between health and sustainability?

Cereal Box Redesign Activity:
1. Explain that we will now be re-designing the cereal boxes to reflect their ingredients. Healthy cereal boxes will be made to look even healthier, and unhealthy cereal boxes will be made to look unhealthy.
2. Ask the class: How do you think you could redesign your cereal box to make it seem unhealthy? Also ask: What things would you emphasize, or make more noticeable, and what things would you de-emphasize, or make less noticeable?
3. Ask students: How do you think you could redesign your cereal box to make it seem healthier? Also ask: What things would you emphasize, or make more noticeable and what things would you de-emphasize, or make less noticeable?
4. Have the students sketch their redesign on a scrap piece of paper before creating the final design. Students will discuss their ideas with their group members, and then draw their initial sketch on the worksheet.
5. Once their designs are complete, demonstrate how to wrap the cereal box with white paper and clear tape (like a present) and then draw their designs on the box with pencil using a ruler for areas like the nutrition label and text. Then the box can be colored in with marker.
6. Have students help pass out the rest of the materials: one large sheet of white paper (enough to

cover the cereal box), tape, pencils, erasers, and markers per group. It can take between one and two class periods for students to finish the box, depending on the classes pace.

Closing Activity:

1. Once students have completed their boxes, have each group present their box to the class. They can describe what their cereal is, whether it is a healthy or unhealthy choice, and the design choices they made such as what they emphasized, and de-emphasized.

2. Groups can also talk about what challenges they faced, and how they overcame those challenges.

Student Worksheet:

Breakfast Cereal: Healthy or Unhealthy?

Directions: Examine the cereal box your group has been given. Locate the nutrition label and fill out the questions below. Your goal is to decide if the cereal is a healthy or unhealthy choice. Remember a healthy cereal shouldn't have more than 25% of its calories from sugar.

1. Name of cereal:
2. Where is the nutrition label located?
3. What was the first thing you noticed when you looked at the box?
4. If this is a cereal that you eat, what made you choose this particular product?
5. How many calories per serving does it have?
6. How many grams of sugar does it have?
7. To find the number of calories from sugar per serving multiply the number of grams per serving by 4 grams of sugar per serving:
8. Divide the answer above by the number of calories per serving (see the answer in #5 for calories per serving), calories from sugar:
9. To find the percentage of calories from sugar, multiply the answer above by 100% of calories from sugar per serving:
10. How much fiber does the cereal have?
11. How much protein does the cereal have?
12. Does it have any other vitamins or mineral listed? If so what:
13. Where was the cereal made?
14. Are the ingredients in the cereal organic?
15. Do you think this cereal would make a healthy choice for breakfast? Explain:
16. Do you think this cereal would be a sustainable choice? Explain:

Lesson 4: Life Cycle Analysis of Tap Water vs. Bottled Water

Written by: Erin Redman

Approximate Time: 60 minutes

Grade Level: 6^{th}- 8^{th} grade

Background Information:

This activity is an introduction to product life cycle assessment and the cradle to grave ethic. A product's life cycle begins with its raw materials and then moves on to its production, manufacture, distribution, use and finally its disposal. Many companies are incorporating these types of assessments to optimize the environmental performance of their products. The students will create their own circular diagrams of the life cycle of bottled water and tap water.

Terminology-
Cradle to Grave: A term used in sustainability to describe analyzing the life cycle of a product from its origin (cradle) to its final resting place (grave).

Some of the more common U.S. types of bottled water are listed below:

Artesian Water	Originates from a confined aquifer that has been tapped
Fluoridated Water	Contains fluorine added within the limitations set by the FDA
Mineral Water	Contains at least 250 parts per million total dissolved solids (TDS) and comes from a source tapped at one or more bore holes or springs, and originates from a geologically and physically protected underground water source. No minerals may be added to this water
Purified Water	Has been produced by distillation, deionization, reverse osmosis, or other suitable processes. Purified water may also be referred to as "demineralized water"
Sparkling Water	Contains the same amount of carbon dioxide that it had at emergence from the source. The carbon dioxide may be removed and replenished after treatment
Spring Water	Comes from an underground formation from which water flows naturally to the Earth's surface

Examples of Life Cycle Images

	Tap Water	**Bottled Water**
Extraction of Raw Materials	Canals, rivers, local sources of water	Drilling for oil, exotic water sources (e.g. Fiji water, bottled water from the Alps)
Materials Processing and Design	Water Treatment Facility	Oil Refinery, bottling facility
Transport and Retailing	Pipes, hydrants, faucets	Semi-trucks, boats, or any other image that represents transporting a product to a store, bottled water in a store, vending machine
Consumption and Use	Running water from a faucet, a glass of water	Someone purchasing/drinking bottled water
End of Life Management	Waste water treatment facility, image of a place where the water is reused (in Arizona- a golf course)	Litter, landfills, recycling bins

Objectives:

- The students will be able to illustrate their knowledge of the life cycle of bottled and tap water through a visual and verbal representation.
- The students will be able to compare and contrast some costs and benefits associated with bottled and tap water.

- The students will be able to translate what they have learned about life cycles into their lives and decisions.
- The students will be able to evaluate the environmental benefits of a cradle to grave analysis.

Standards:
Science

- **S1-C3-GR6-PO2** Form a logical argument about a correlation between variables or sequence of events (e.g., construct a cause-and-effect chain that explains a sequence of events).
- **S2-C2-GR4-PO2** Describe the interaction of components in a system
- **S3-C2-GR6-8-PO1** Propose viable methods of responding to an identified need or problem
- **S3-C2-GR6-8-PO2** Compare solutions to best address an identified need or problem
- **S3-C2-HS-PO1** Analyze costs, benefits and risks of dealing with needs or problems

Social Studies

- **S4-C5-GR8-PO2** Describe why humans modify ecosystems.
- **S4-C5-GR7-PO3** Describe how humans modify environments (e.g., conservation, deforestation, dams) and adapt to the environment.
- **S4-C5-GR8-PO3** Explain how changes in the natural environment can increase or diminish its capacity to support human activities.
- **S4-C5-GR7-PO4** Describe the positive and negative outcomes of human modification on the environment.
- **S4-C5-GR8-PO4** Explain how technology positively and negatively affects the environment.
- **S4-C5-GR8-PO5** Analyze changing ideas and viewpoints on the best use of natural resources (e.g., value of oil, water use, forest management).
- **S4-C5-GR7-PO7** Compare different points of view and research on environmental issues (e.g., land use, natural resources, wildlife, biomes).
- **S5–C1-GR7-8-PO2** Analyze how scarcity, opportunity costs, and trade-offs influence decision making.

Advanced Preparation

- Print and cut out pictures to correspond with the life cycle of bottled water and tap water. Each group should have one set of pictures which include both life cycles.
- Print one hand-out of tap vs. bottled facts for each group of students.
- Print one worksheet for each student.
- On one large sheet of paper, draw in the steps of the life cycle. Post this example in the front of the room for all the students to see.

Materials

- Large sheets of paper
- Tape or glue

- Markers
- Chalk board, white erase board, or another sheet of large paper
- Chalk or erase board markers

Suggested Procedure

1. Engagement: We need to drink water every day. How do students get their drinking water? List on the board possible ways to get drinking water. Two of the options will be from the tap and from bottled water. Explain that the water that we get from the tap or from bottles is a product that requires several steps to get from its source to us. Explain that every product has a life cycle- the steps it takes to get to you and where it goes when you are done with it.
2. Break the students into groups. Have each group put their desks together so they have a large working space.
3. Hand out 2 large sheets of paper to each group.
4. Hand out the pictures, descriptions, and tape or glue.
5. Tell the students that the pictures and text they were handed describe the life cycle of bottled water and tap water. It is their job to figure out which images/text goes with which product (bottled or tap) and for which step of the life cycle.
6. The students can tape or glue the images and text to the corresponding part of the life cycle diagram. (~10-15 minutes)
7. Distribute the facts about tap & bottled water to each group and a student worksheet to each student. Allow the students to answer the questions based on their life cycle diagrams and the handout. (~15 minutes)
8. Facilitate a discussion with the students based on the handout, worksheet, and life cycle diagrams. You may wish to create a costs and benefits table for both bottled water and tap water. Allow the students to share their thoughts on the trade-offs of each product.

Evaluation

- Each group should have completed presentable diagrams.
- Each student should be evaluated based on their participation in creating the diagrams, completing the handout, and providing input for the costs and benefits discussion.

Extensions

- Ask students to create a diagram of the life cycle of another everyday product that they use or eat. Suggestions: a hamburger, cell phone, soccer ball

Resources

New York Times Editorial: In Praise of Tap Water. Published: August 1, 2007
http://www.nytimes.com/2007/08/01/opinion/01wed2.html

Zwillich T. (September 11, 2008) CBS News. Bottled Water Debate Splashes Congress: Critics Tell Lawmakers Bottled Water Hurts Environment; Industry Says Consumers Deserve Choices.
http://www.cbsnews.com/stories/2008/09/11/health/webmd/main4440045.shtml

Munro C. (2006) EPA Victoria. Bottled Water the new 'eco-disaster.'
http://www.epa.vic.gov.au/students/activities_lifecycle/lifecycle_activity4.asp

Stossel, J. (2005) ABC News, 20/20. Is Bottled Water Better Than Tap?
http://abcnews.go.com/2020/Health/story?id=728070

Owen, J. (2006). National Geographic News. Bottled Water Isn't Healthier Than Tap Water Report Reveals.
http://news.nationalgeographic.com/news/2006/02/0224_060224_bottled_water.html

City of Phoenix. (2008). Phoenix Water and Waste Water Facts.
http://www.ci.phoenix.az.us/WATER/wtrfacts.html

Avent, S., A. Wutich, B. Crona, P. Gober, M. Seetharam, and P. Westerhoff. An Ethnohydrologic Evaluation of Water Quality in Phoenix.
http://dcdc.asu.edu/dcdcmain/pdf/gates_etal.pdf

Student Handout: Some Facts about Tap and Bottled Water

	Bottled Water	Tap Water
Raw Materials	• Water comes from a variety of sources. These could include underground aquifers, spring water, or tap water • The plastic used to make bottled water is derived from oil. The energy required to make water bottles in the United States is equivalent to 17 million barrels of oil annually. Globally, the bottling industry uses the equivalent of nearly 100 million barrels of oil each year, excluding transportation. • Nearly 7 times as much water is used to make bottled water than is	• Water- About **95 percent** of the water used by Phoenix comes from **surface sources**, Salt, Verde and Colorado rivers; the remaining **5 percent** comes from **wells. Surface water is delivered to the city through the canal projects- the Central Arizona Project (CAP) and the Salt River Project (SRP)** • Materials for water treatment facility

		actually in the bottle of water (1 liter of bottled water takes 7 liters to produce)- some sources site that it takes 26 liters of water to produce one liter of bottled water (http://hubpages.com/hub/bottled_water).	• Materials for pipe to transfer water from facility to home

Design and Processing	• The crude oil has to be processed at an oil refinery plant • The refined oil then has to be molded into plastic • The plastic, paper for label, and water, then have to be assembled • Water may come from a local well or be transported to the bottling plant	• Water treatment facilities are usually run by local cities and staffed by city employees. They make sure the tap water meets federal water quality standards for drinking water.
Transportation and Retailing	• Fossil fuels are burned to transport the bottled water by truck, train, or boat. For example, the Fiji brand of bottled water sold in Phoenix traveled about 2,000 miles from the source to the store. • In 2006, the industry spent $162.8 million on advertising bottled water in the United States. • Bottled water is sold in a large variety of places from grocery stores to food stands.	• Water is piped from a water treatment facility to your faucet. • Water is delivered to customers in the city of Phoenix through more than **6,790 miles** of water mains. • There are **51,345 fire hydrants** connected to the city of Phoenix water system.
Consumption and Use	• Bottled water sales in the United States reached 8.82 billion gallons in 2007, worth $11.7 billion. • Bottled water consumption grew by 208% from 1983-1993; comparatively, the soft drink consumption has only grown by 22% during that time period Source: Environmental Health Perspectives http://www.ehponline.org/docs/1995/103-4/forum.html	• In Phoenix, 1.5 million residents are provided with water from the municipal system. • One of the major consumer complaints concerning tap water in Phoenix is the chlorinated, salty, or bitter taste (Avent, et.).
End of Life Management: Reuse, Recycling, Disposal	• Bottled water produces up to 1.5 million tons of plastic waste per year. • In the United States, less than 20 percent of water bottles are recycled, according to the Container Recycling Institute. • Buried water bottles can take up to 1,000 years to biodegrade.	• Depends on the glass or drinking utensil. • Most of the water lost down your sink, shower, or even toilet is recovered and reused

Student Worksheet: Bottled Water and Tap Water

1. One of the main differences between bottled water and tap water is that tap water comes directly to your house and you have to provide the container (like a glass) in order to drink it. Bottled water comes in its own container. Looking at your life cycle diagram and the handout, list some of the advantages and disadvantages of bottled vs. tap water.

Advantages:

Tap	Bottled

Disadvantages:

Tap	Bottled

2. Both the bottled water industry and the municipal (local) water industry provide jobs. However, the location of employment for these two industries differs. For example, the Fiji brand of bottled water may employ people at the bottling facility in Fiji and the Phoenix water treatment facility employs people in Phoenix. Based on the pictures and your handout, list any local jobs you think might be part of the following steps of the bottled and tap water

life cycles.

	Bottled Water	**Tap Water**
Processing		
Transport and Retailing		
Consumption and Use		
End of Life Management (disposal, recycling, reuse)		

3. Given the information you have learned today, which would you choose bottled or tap water. Why?

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4. Cradle to Grave is a term used in sustainability to describe analyzing the life cycle of a product from its origin (cradle) to its final resting place (grave). Many companies conduct life cycle analysis for their products. List at least one benefit that could result from doing a product life cycle analysis.

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