A Dissertation on Sustainability Competence: Directions for Nursing

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Nursing)
in the University of Michigan
2020

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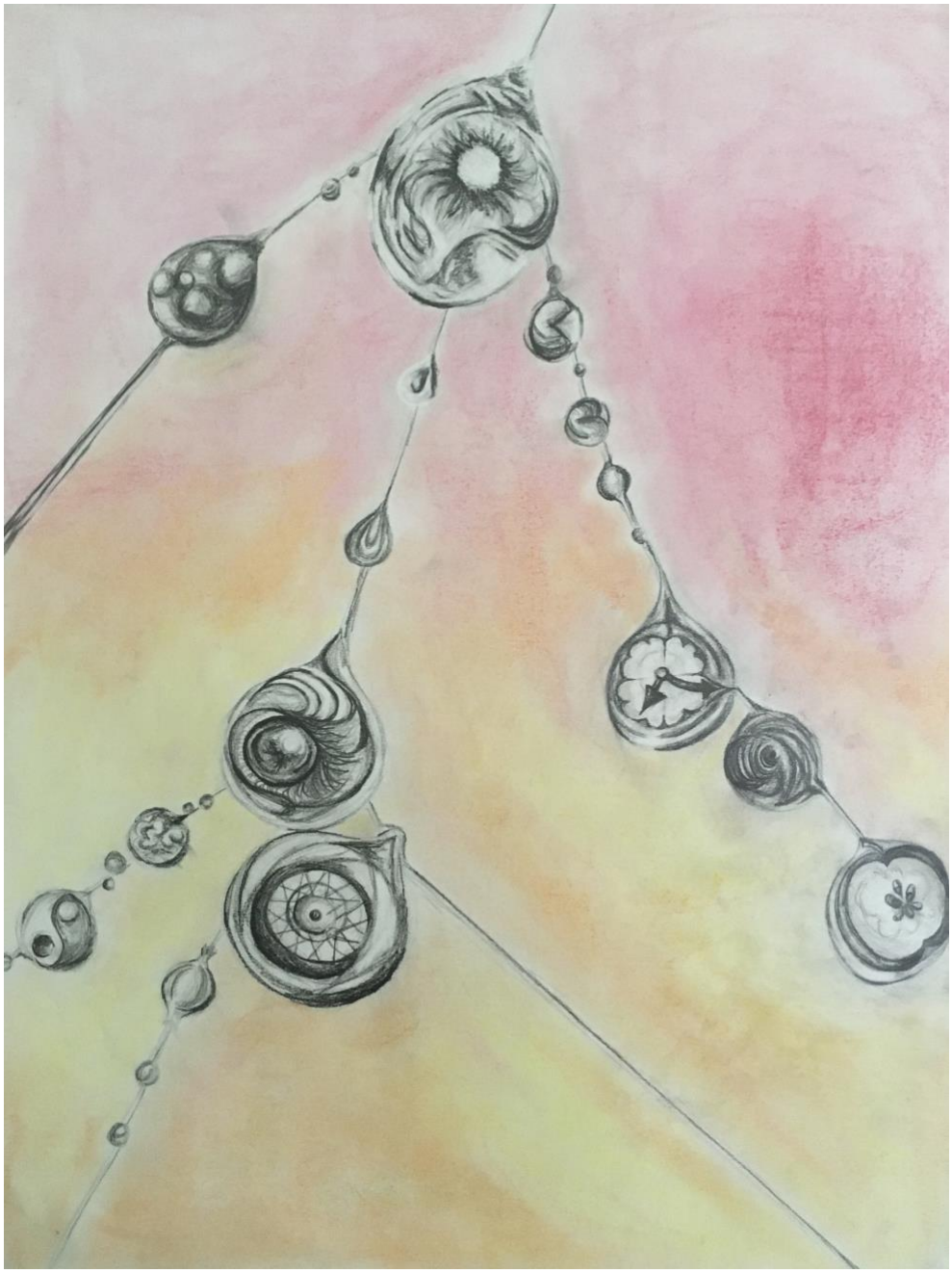

What is Line?
Czerwinski, 2010, graphite & pastel.

“Injustice anywhere is a threat to justice everywhere.
We are caught in an inescapable network of mutuality,
tied in a single garment of destiny.
Whatever affects one directly, affects all indirectly.”

- Dr. Martin Luther King Jr. (1963, p.77)

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DEDICATION

To Granny,

Thank you for our 27 years together, before passing me the baton.

I promise to run as fast and hard as I can while I've got it.

Meet you on the hills up north when my leg is up.

XOXO,

Meggie

ACKNOWLEDGEMENTS

This research was supported by funding from the Hillman Scholars Program in Nursing Innovation from the Rita and Alex Hillman Foundation, by a Rackham Graduate Student Research Grant from the University of Michigan, and research assistantship from Adira Cohen and Jennifer Cruz.

I could not have asked for a stronger, smarter, more compassionate group of humans to help me across this finish line. Each of you has guided me through critical parts of this journey. Dana, thank you for being an early example of the wonderful things nurse scientists can do, including the long run – a teacher that has taught me lessons I have been too stubborn to learn anywhere else. Olga, thank you for challenging and toughening me, all while loving me. Rebecca, thank you for welcoming me into your expansive web of caring, letting me look around with curiosity, and helping me rest. Yasamin, thank you for sharing your patience and immense courage. I hope to emulate all of you as scholars, women, and mothers.

Thank you to Bob, Patti, Joe, Ayşe, Toni, MinKyoung, Vic, Julie, Sue Anne, Connie, Jan, Tex, Tony, & Ryanne for protecting and fanning my flame. Thank you to my family – from those who left us years ago to those who joined us months ago.

To everyone I know, and many I do not – thank you. I will be working to express my gratitude for a long time. Y'all cannot know how many ways – big and small – you have helped me along.

Chi-miigwech.

PREFACE

This dissertation research was conducted at the University of Michigan, named for Michigami, the world's largest freshwater system, and located on the ancestral, traditional, and contemporary lands of the Anishinaabe peoples, also known as the Three Fires Confederacy of the Ojibwe, Odawa, and Bodawadimi. In the 1817 Treaty of Fort Meigs, these nations ceded 3,840 acres of land, half being for a college in which their children could enroll (American Indians at the University of Michigan, 2011). Proceeds from this gift remain the largest contribution in the University of Michigan's endowment today.

I knew the path was thorny when I began, years ago.
Along the way I have learned much, from many beings.
And I have been humbled, seeing more clearly how far we have yet to go.
This work is but one step.

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ABSTRACT

Human health and wellbeing are rooted in the environment, and thus are threatened by environmental degradation. The healthcare industry, as the largest sector of the economy by volume and workforce, is a significant contributor to environmental degradation. Sustainable solutions mitigate environmental degradation and protect future generations. Sustainability – defined as the optimization of inclusive human health and wellbeing – is well aligned with the goals of nursing. As members of the most trusted and largest healthcare profession, nurses have a unique opportunity to be change agents by promoting sustainable solutions in practice, research, advocacy, and education. However, sustainability problem-solving is complex and requires advanced critical competence. Sustainability competence is the complex of knowledge, skills, and attitudes that enables sustainability problem-solving. This dissertation explores sustainability competence in nursing education through three specific aims: 1) to describe sustainability competence among a sample of undergraduate and graduate nursing students; 2) to examine whether sustainability competence increases with additional years of nursing education; and 3) to evaluate a sustainability learning intervention (SLI) for its effectiveness at improving sustainability competence among undergraduate students.

To address Aims 1 and 2, a baseline survey was electronically distributed to University of Michigan School of Nursing (UMSN) students (*n*=1,008) using validated

measures of sustainability competence from the Sustainability Cultural Indicators Program (SCIP) questionnaire. Sample descriptive statistics of sustainability competence and its components were calculated. Student-level multiple regression analyses investigated associations between years of nursing education and sustainability competence. To address Aim 3, a two-arm randomized pilot of the SLI – a four-hour (two hours of pre-learning, two hours in-class) multimedia case study focused on a local water quality issue from Gala (learngala.com) – compared to a standard curriculum control was conducted in the Fall 2018 UMSN Community Health Nursing course. Five clinical sections (*n*=38 students) integrated the SLI into standard curriculum and four received a standard curriculum alone (*n*=30 students). Pre-intervention data was abstracted from the baseline survey. An identical post-intervention survey was distributed in December 2018. Baseline-adjusted difference in differences models estimated intervention effects on sustainability competence.

The baseline sample included 380 nursing students. Mean sustainability competence was 4.3, SD=1.0, on a scale from 1 (low) to 10 (high). Component scores ranged from 3.9, SD=1.4 (knowledge), to 4.5, SD=0.8 (skills), to 4.4, SD=1.8 (attitudes). Association of sustainability competence with years of nursing education was not significant (β=-0.05, p=0.237). Among the competence components, knowledge was non-significantly associated (β=-0.05, p=0.360); skill was significantly negatively associated (β=-0.07, p=0.046); and attitude was non-significantly associated with years of nursing education (β=-0.03, p=0.685). The SLI evaluation sample included 35 students among intervention (*n*=26) and control (*n*=9) groups. The change in total sustainability competence between the SLI and control groups was not significant

(β=0.84, p=0.066). Among the competence components, a significant increase in knowledge (β=1.76, p=0.017), no significant difference in skills (β=0.49, p=0.186), and no significant difference in attitudes (β=0.27, p=0.670) were observed.

This dissertation research documents a moderate baseline level of sustainability competence among nursing students, indicating room for improvement. However, results suggest that current nursing curricula may not be effective in developing sustainability competence in students. The SLI improved sustainability competence with medium-to-large effect sizes, indicating potential significance in higher-powered studies. Integrating SLIs into nursing curricula may be an effective and feasible way of increasing sustainability competence among nursing students.

Chapter 1 Introduction

Statement of the Problem

The foundation of human health and wellbeing is rooted in the environment. This fundamental premise is reflected in Native Medicine wheels (National Institutes of Health & Health and Human Services, 2020) and the Yin Yang theory (Fuqin Liu & Harrell, 2015), among other ancient cultural philosophies of health from around the globe. The term “environment” is used in its broadest sense here to refer to the ecological community including all beings – plants, animals, fungi, etc. – and natural elements, such as air, water, and land. Without air to breathe, water to drink, and land to grow plants and animals for food and shelter, humans cannot live. However, human activity has caused environmental degradation that threatens human health and wellbeing for generations (American Nurses Association, 2007).

Air quality has been degraded by expansions in fossil fuel-dependent manufacturing, transportation, and energy sectors, among others (Sherman et al., 2019; Farmer et al., 2014). Air pollution exacerbates existing heart and lung conditions (American Nurses Association, 2007). Community air pollution also contributes to a broad range of adverse health effects across the lifespan including low birth weight, preterm birth, neural tube defects, allergies, insulin resistance, stroke, chronic

obstructive pulmonary disease, and anxiety (Wellbery & Sarfaty, 2017; Farmer et al., 2014).

Water contamination and freshwater scarcity are stressing communities around the globe. Factors negatively affecting water supplies include droughts, diversion for industry and agriculture, fossil fuel spills and pipeline leaks, infectious pathogens, industrial chemicals such as pesticides, fracking, PFAS, dioxane, lead, coal ash, and uranium, and contamination from human consumption such as human waste and landfill leachate (Cook, Curtis, & Huffling, 2017; Ziemba et al., 2016). Health effects of contaminated water include neurotoxicity and resulting developmental and cognitive disruptions, obesity, cancer, and endocrine disorders, such as diabetes (Ziemba et al., 2016). Inadequate water supplies not only make communities vulnerable to dehydration and heat stroke, but also inhibit cooking, cleaning, and bathing and can aggravate existing chronic health conditions (Kummu et al., 2016).

Land has also been altered in ways that threaten human health and wellbeing (Gochfeld & Goldstein, 1999). Widespread deforestation has resulted in significant losses in biodiversity, destabilizing ecosystems and disrupting food chains (Karjalainen, Sarjala, & Raitio, 2020). Loss of tree cover in urban areas, as well as features of the built environment, contribute to urban heat island effects (Heaviside et al., 2017) that put residents at greater risk of heat stroke, dehydration, and exacerbation of existing cardiovascular disease (Hajat, O'Connor, & Kosatsky, 2010). Monoculture agriculture has led to depletion of soil nutrients and desertification of land, which has in turn lead to less nutritious food and unstable production (Hillel & Rosenzweig, 2005). Declines in native plants, among other factors, have led to devastation in native bee and other

pollinator populations that are critical to agriculture and food production (Cane & Tepedino, 2001). Industrial mining has also scarred the land, sometimes uprooting entire communities (Lewis et al., 2017).

Expansions in fossil fuel use over the last three centuries have allowed for new technology but contributed to accumulating greenhouse gases in the atmosphere that have destabilized the Earth's climate patterns (Intergovernmental Panel on Climate Change [IPCC], 2018). Climate change now poses a severe threat to public health (Haines & Patz, 2004; McFarlane, 2010; Adlong et al., 2013). Global average temperatures have risen 1-degree Fahrenheit above pre-industrial levels (IPCC, 2018) and climates are becoming more unpredictable and severe (Houghton et al., 2001). The health and wellbeing effects of climate change include flooding, extreme heat events, increases in vector-borne illness, food insecurity, water contamination, and physically and psychologically traumatic disasters (Centers for Disease Control and Prevention [CDC], 2020; Haines and Patz, 2004).

Many sustainability challenges are interconnected and exacerbate social inequality by disproportionately harming marginalized and vulnerable populations (Levy & Patz, 2015). Racial and income disparities persist in exposure to toxic waste, pollution, and landfill sites (Washington, 2019; Taylor, 2014; Bullard, 1996; Goldman, 1994). Many indigenous communities are uniquely vulnerable to climate change (Ford, 2012). Black and brown communities also bear a disproportionate burden of environmentally related chronic illness and socioeconomic vulnerabilities, which in turn leads to greater morbidity and mortality in disasters, as we are seeing during the COVID-19 pandemic (Wilson et al., 2020; Bullard, 2007).

A fundamental contradiction in the relationships between healthcare industries and the environment undergirds this dissertation's sense of urgency. On one hand, the healthcare industry is increasingly tasked with responding to environmental harms as they manifest in maladies like cancers, reproductive health, digestive or cognitive disruptions, and more (Frumkin, 2001; Ziemba et al., 2016). Yet healthcare also significantly contributes to this environmental degradation. As the largest sector of the economy by volume and workforce (Thompson, 2018), healthcare generates 29 pounds of waste per patient day and more than 5 million tons of waste each year (Practice Greenhealth, 2020). Hospital waste includes regulated medical waste, and solid and hazardous waste. Pharmaceutical waste also contaminates water supplies and seafood (Scutti, 2018). Waste incinerators expel toxic fumes into the air, which affect the health of entire communities (Muñoz, 2012). Supply and industrial food production used in healthcare settings contribute to mining, desertification, and deforestation (Cohen, 2014). The healthcare industry is also responsible for 10 percent of national carbon emissions (Eckelman & Sherman, 2016), which contribute to climate change. This situation is not sustainable.

A refocusing on the most upstream determinants of health – our water, air, land, and climate – is possible and urgently needed (Falk-Rafael & Betker, 2012). The healthcare system can be transformed into one that supports a healthy population and a healthy planet (Cohen, 2014). Efforts can continue to ensure reverence of all life and respect towards all members of the ecological community (Goodin, 2013). Indeed, this work has already begun. One Health is an international approach advancing health through integrated efforts that recognize the connections among humans, animals,

plants, and the environment (CDC, 2020). Healthcare Without Harm is an international organization that aims to transform healthcare into a sector that generates sustainable solutions, rather than contributes to crises of environmental degradation (Healthcare Without Harm, 2020). Practice Greenhealth is affiliated with Healthcare Without Harm, as its national arm that focuses specifically on sustainability in hospitals (Practice Greenhealth, 2020). Each year, Practice Greenhealth awards hospitals for their efforts towards sustainability overall and in eleven key areas: buildings, chemicals, climate and health, energy, engaged leadership, greening the operating room (OR), sustainable procurement, transportation, waste, and water. The next section will examine in more detail the goals of sustainability efforts broadly.

Sustainability

In recent decades, world leaders coalesced around the need for sustainability, as evidenced by the adoption of the United Nations Development Programme's Sustainable Development Goals (SDGs) in 2015. The word 'sustainable' is defined as the capability for something to be sustained or maintained (Merriam-Webster, 2020). Wider definitions specify human health and wellbeing as the things to be sustained, and the period of time involved as many generations. For example, Clark, Matson, and Andersson (2016), define sustainability as the optimization of inclusive human health and wellbeing. Inclusive human health and wellbeing imply equity, both within and across generations. Wiek et al (2016) defined sustainability in terms of human societies. The capability of a society to be sustained over long periods of time is intergenerational equity. The ability of a society to allow other societies to sustain

themselves today is intragenerational equity (Clark, Matson, and Andersson, 2016). The UN (2015) defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Ancient and contemporary notions of sustainability alike focus on human health and wellbeing, while acknowledging that our membership in the interdependent ecological community on Earth necessitates that we care for all life. Due to this interconnectedness, the UN Sustainable Development program (2015) outlines intermediate goals related to ecological integrity, social inclusion, and economic growth that work together to sustain and optimize human health and wellbeing.

The work of sustainable development is expansive but provides unlimited opportunities for action. Sustainability challenges involve multiple generations, stakeholders, sectors, and constituencies (Wiek et al., 2011). Therefore, sustainable solutions can and must be pursued at all levels: individual, familial, community, institutional, regional, national, and global. No solution is trivial. Every sustainable action – big and small – contributes to a sustainable future for us all.

Alignment of Nursing Practice with Sustainability Science

Sustainability science is the interdisciplinary field of study focused on solutions to complex sustainability challenges (Wiek et al., 2011). Many knowledge fields and professional communities are engaged (Smith et al., 2015), from engineering (Schroer et al., 2015; Rose et al., 2015) to law, to construction (Clevenger & Ozebek, 2013), and from social sciences to natural sciences (Van Wynsberghe & Moore, 2015).

The nursing profession also contributes to sustainability science as the goals of the profession are well-aligned with those of the field of sustainability. The definition of nursing given by the American Nurses Association's (ANA) Scope and Standards of Practice document (2015) is as follows: *"*Nursing is the protection, promotion, and optimization of health and abilities, prevention of illness and injury, facilitation of healing, alleviation of suffering through the diagnosis and treatment of human response, and advocacy in the care of individuals, families, communities, and populations" (p. 1). This definition has clear parallels to that of sustainability – focused on the optimization of health in the care of individuals, families, communities, and populations (Clark et al., 2016). Table 1.1 illustrates that the definitions of sustainability and nursing are nearly identical.

Table 1-1: Definitions of Sustainability and Nursing

Sustainability	**Nursing**
Sustainability is the optimization of inclusive human health and wellbeing within and across generations. (Clark et al., 2016)	*"Nursing is the … optimization of health …. in the care of individuals, families, groups, communities, and populations."* (ANA, 2015, p. 1)

The social role of the nursing profession is centered on improving and sustaining holistic human health and wellbeing (ANA, 2015), also in alignment with the stated goals of sustainability efforts (Clark et al., 2016). Nurses practice to promote the health and wellbeing in the whole patient, community, or population under their care (ANA, 2015), which echoes the varied scales at which sustainability efforts may be focused. Holistic nursing care addresses all determinants of health and wellbeing, including

factors based in biology, cognition, emotion, spirituality, socioeconomic status, and the natural environment (ANA, 2007) – just as sustainability efforts are inclusive of all sectors. The nursing profession also strives to practice under the principles of equity and justice (ANA, 2015), akin to the intergenerational and intragenerational equity that guides sustainability efforts.

The national scope and standards of nursing practice set by the ANA include environmental health nursing practices (ANA, 2007). ANA (2015) Standard of Practice 17 addresses the natural environment as a foundational determinant of health. In its Code of Ethics, the International Council of Nurses (ICN) states that sustaining and protecting the natural environment is an ethical obligation of the nursing profession (ICN, 2012). The ANA (2015) makes a similar assertion within the final section (9.4) of the final provision of the *Code of Ethics for Nurses with Interpretive Statements*, stating that, “human life and health are profoundly affected by the state of the natural world that surrounds us” (p. 37).

Opportunity

The nursing profession has a unique opportunity to catalyze change for sustainability. Often called the nation’s most trusted profession, nursing has ranked highest for honesty and ethics in Gallup surveys for sixteen years running (Reinhart, 2020; Saad, 2015). On the frontlines of care, nurses have nuanced understanding at the intersection of systems and human health and wellbeing. Nursing is the largest healthcare profession with over three million nurses across the Unites States (Health Resources and Services Administration, 2010) active at all levels of health promotion,

disease prevention, and healing – in hospitals, schools, homes, prisons, and communities. The holism and diversity in the nursing profession matches the complexity and interconnectedness of sustainability challenges. These strengths may also be used to communicate abstract sustainability issues in terms of tangible health and wellbeing effects and actions for patients, families, and communities. For these reasons, nurses are poised to emerge as leaders in sustainability problem-solving to create a sustainable healthcare system and future for all.

Nursing Engagement in Sustainability

The Alliance of Nurses for Healthy Environments (ANHE), a national organization that grew out of Healthcare Without Harm to foster nursing collaboration on sustainability challenges, identifies four avenues of nursing impact on sustainability: practice, advocacy, research, and education (ANHE, 2019).

Practice

In practice, nurses work to use resources responsibly, reduce waste, and support environmentally preferable purchasing (Muñoz, 2012). They also work with patients and in schools to establish healthy, sustainable behaviors (Sendall et al., 2013); and to help communities adapt and build resilience to climate change (Alvarez-Nieto et al., 2017). Sandy Worthington, a women's health nurse practitioner and midwife in New York and Director of Medical Education at the national office of Planned Parenthood, coordinated a project to help staff and patients avoid exposure to toxic chemicals by developing risk assessment and educational tools (Huffling, 2019). Sue Anne Bell, an

emergency response nurse in Michigan with expertise in disasters (Bell et al., 2019), has been deployed to aid in community recovery efforts following climate change related disasters such as Hurricane Irma, Hurricane Maria (Meyers, 2018) and in response to the COVID-19 pandemic (Bell & Bailey, 2020).

Advocacy

Nurses advocate to change policies at many levels: in local communities, within their own care institutions, regionally, nationally, and internationally. Barbara Sattler, a registered nurse in Maryland, led efforts to change institutional policy and help Maryland hospitals serve more sustainable food to patients and start farmer's markets within hospitals (Huffling, 2019). Adelita Cantu, a public health nurse from Texas, worked with the City of San Antonio as it developed its local Climate Action and Adaptation Plan (Huffling, 2019). She and student activists helped to ensure that the needs of the city's most vulnerable citizens were considered in the plan. Nurses advocate for protection of air, water, and land (Ziemba et al., 2016) and have a national voice in policy, through organizations and unions, which they use to promote sustainability. Lauren Underwood, a nurse and the youngest African American women ever elected to Congress, includes sustainability among her top eight issues (Underwood, 2019). She announced her support for the 100 percent Clean Economy Act of 2019, which calls for 100% clean energy and carbon neutrality by 2050 (United States Federal Government, 2020).

Research

Nurse researchers are also generating knowledge to promote environmental health and sustainability (Polivka & Chaudry, 2018). Elizabeth Schenk, a nurse from Montana, studies beliefs surrounding healthcare-generated pollution (Huffling, 2019).

Sue Anne Bell, the emergency response nurse mentioned above, also researches the effects of disasters on the elderly and other vulnerable populations, as well as community strategies for resilience (Bell et al., 2018; Bell et al., 2019). Other nursing researchers are investigating the effects of green health promotion such as carbon-free commuting, time spent in nature, and gardening to increase fresh, local food consumption (Sendall et al., 2013; Zuzelo, 2016; Hansen-Ketchum et al., 2009).

Education

Nurses educate patients, families, communities, and the next generation of nurses and healthcare professionals in the prevention and mitigation of health effects of environmental degradation. In 2011, the American Association of Colleges of Nursing (AACN) issued a report of recommendations from its Task Force on Environmental Sustainability. Recommendations included actions to make nursing schools more sustainable, as well as changes to nursing education to address sustainability including the responsible use of supplies and management of healthcare waste (AACN, 2011). Avery (1996) proposed the development of an eco-wellness nursing approach aimed at helping people to sustain personal and environmental wellness by emphasizing the connections between humans and the natural environment. Many universities, including the University of Michigan, signed the Health Educators Climate Commitment, pledging to prepare health practitioners to address the health ramifications of climate change (Potempa, 2015).

The Gap

The sustainability work by nurses outlined above is exceptional. However, the profession is not yet firmly positioned among the disciplines leading sustainability science. Sustainability in nursing is still an emerging area of research, as evidenced by the slow and relatively limited uptake of nursing research addressing the Sustainable Development Goals (Benton & Schaffer, 2016), and despite emerging arguments that nursing education has a central role to play in these efforts (Goodman, & East, 2014; Slettebo, 2015; Leffers et al., 2017; McDermott-Levy et al., 2019; Potter, 2019). The Disciplinary Associations Network for Sustainability (DANS) was created through the U.S. Partnership for Education for Sustainable Development to promote sustainability education across academic disciplines (DANS, 2020). More than 50 academic and professional societies have joined DANS. However, nursing is yet to become involved.

The overarching objective of this dissertation is to explore sustainability competence in nursing education. To realize the potential of an empowered nursing profession to lead sustainability efforts now and for generations to come, it is imperative that nursing education focus on equipping students with the ability to engage in sustainability problem solving. The theoretical framework below describes the concepts and mechanisms that may make this possible.

Theoretical Framework

The theoretical framework guiding this dissertation (Figure 1.1) illustrates the development and application of sustainability competence to create sustainable solutions (Wiek et al., 2011). Inherent in this framework is the notion that sustainability challenges are characterized by a high degree of complexity. Local and global sustainability challenges involve intersecting constituencies, systems, and scales. According to the framework, sustainable solutions require balancing complex trade-offs as optimal resolutions are rarely immediately apparent (Wiek et al., 2011, Grootjans et al., 2013). Sustainability competence, therefore, enables proactive navigation of this complexity and makes possible the transformations of economic, social and ecological behavior and systems that are necessary to ensure health and wellbeing for generations to come.

Sustainability competence is a functionally linked set of interdependent knowledge, skills, and attitudes that enable effective problem-solving (Spady, 1994; Baartman et al., 2007) with respect to real-world sustainability problems, challenges, and opportunities (Wiek, Withycombe, and Redman, 2011, p. 204). Effective sustainability education, therefore, will develop students' sustainability knowledge, skills, and attitudes required "to analyze and solve sustainability problems, to anticipate and prepare for future sustainability challenges, as well as to create and seize opportunities for sustainability" (Wiek et al., 2011, p. 204). Basic competencies, such as critical thinking and communication, are the foundation upon which sustainability competence may be built (Wiek et al. 2016).

Sustainability competence may develop slowly and non-linearly. The definition above is all-encompassing, describing advanced, critical sustainability competence. The concept exists on a continuum – from novice to expert – and progressive development may be measured (Wiek et al., 2016). Different sustainability competence components – knowledge, skills, and attitudes – may be developed differently among individuals and disciplines (Remington-Doucette et al., 2015). Varying levels of knowledge, skills, and attitude may contribute to sustainability competence as it is applied to different problems, topics, contexts, and scales.

Contextual variables, such as individual characteristics and cultural norms, may also influence the development of sustainability competence (Remington-Doucette & Musgrove, 2013). For example, as students age, gaining life experience and deepening their nursing practice, sustainability competence may naturally be augmented. Other individual demographic characteristics, such as gender, race, ethnicity, family income, and parents' education, may also influence differential development of sustainability competence. Collectively, these characteristic measures may illuminate socio-economic-status based disparities in sustainability competence. Cultural norms (hometown and community norms, political context, and infrastructure, such as recycling services and public transportation, etc.) may also impact a student's sustainability competence. For example, a student who grew up in a town that provided recycling infrastructure may have greater sustainability competence related to waste reduction challenges. Ongoing research is needed to understand the contextual variables that influence the development of sustainability competence.

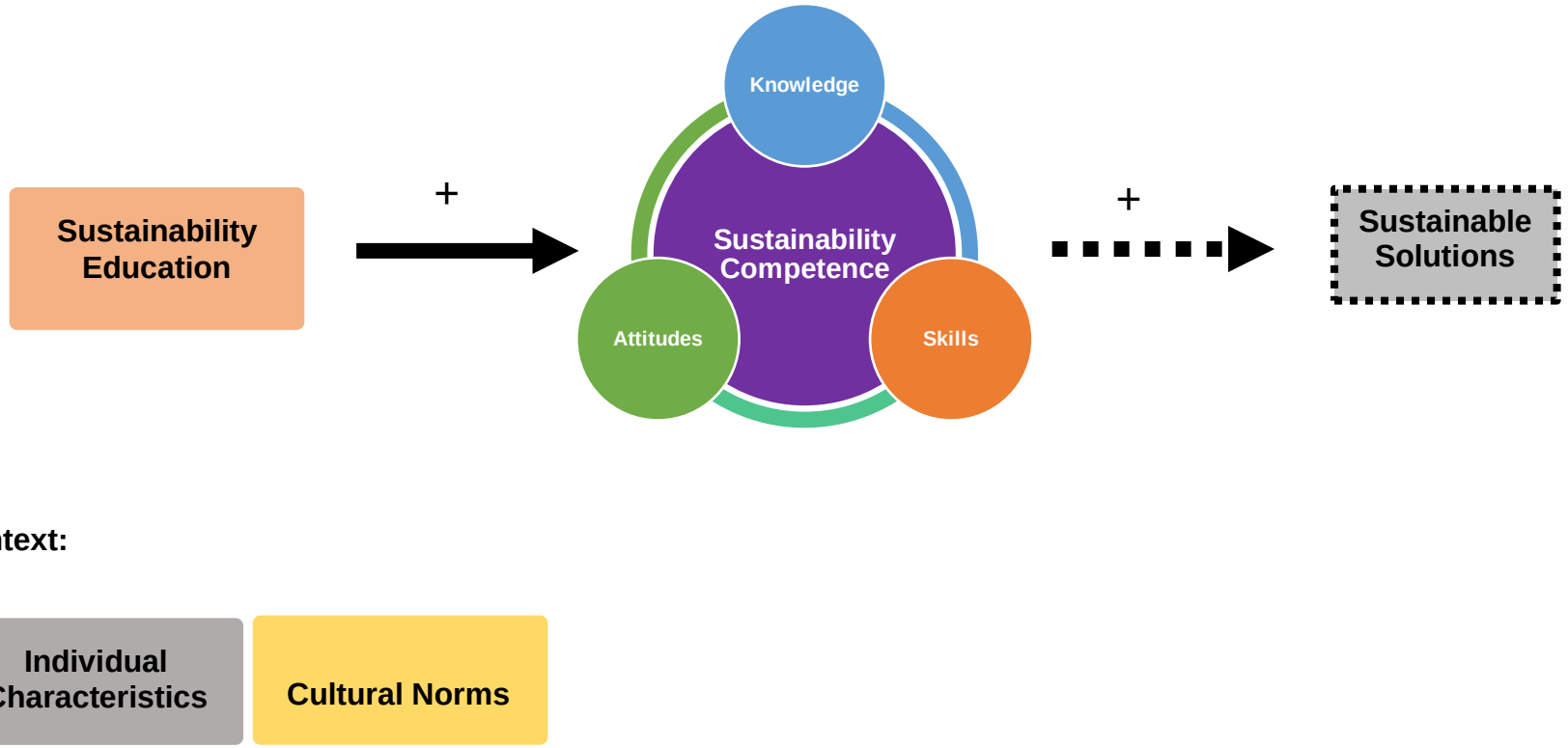


Figure 1-1: Theoretical Framework of Sustainability Competence Development and Application

Specific Aims

This dissertation explores sustainability competence in nursing education via three specific aims:

1) to describe sustainability competence among a sample of undergraduate and graduate nursing students;

2) to investigate the association of sustainability competence with years of nursing education. If current nursing curricula contain sustainability education content, then according to the theoretical framework, sustainability competence would be expected to increase with additional years of exposure to nursing education. *Therefore, I hypothesize that sustainability competence will increase with years of nursing education;*

3) to evaluate a sustainability learning intervention (SLI) for its effectiveness at improving sustainability competence among undergraduate students. Participation in the SLI will increase a student's dose of sustainability education, which should lead to increased sustainability competence. *Therefore, I hypothesize that students receiving the sustainability learning intervention will show greater improvements in sustainability competence, as compared to students who receive a standard curriculum.*

Chapter 2 Literature Review

This chapter reviews existing literature related to the relevance of environment and sustainability in nursing practice, sustainability education, and sustainability competence in nursing and broader settings.

Environment and Sustainability in Nursing

Several traditional nursing theories underpin the relationship between the environment and human health and wellbeing. Martha Rogers' *Science of Unitary Human Beings* (Butcher & Malinski, 2015), describes how nurses work between the "human field" and the "environment field." These fields are also reflected in Barbara Dossey's *Healing and Meta-Paradigm of Nursing* (2015) by her theory's "person" and "environment" components, respectively. Sustainability solutions may be directed towards the environmental field, via water protection for example, or the human field, via direct patient care, or the interaction between the two fields (Dossey, 2015). Action in the environment field to prevent and minimize environmental degradation is equivalent to primary prevention or the prevention of illness or harm from developing. Action in the human field to treat harm or illness is equivalent to tertiary prevention that mitigates the effects of disease. Action at the interface of the two fields is equivalent to secondary prevention and may include screening patients for environmental risks and intervening.

For example, after observing elevated blood levels in children in Flint, Michigan, health care professionals were able to advocate for intervening actions to protect the citizens from further harm from lead-contaminated drinking water (Ruckhart et al., 2019; Hanna-Attisha et al., 2016). The interrelationship between human and environment fields ensures that all efforts in either field will influence human health and wellbeing either directly or indirectly.

Foremothers of the nursing profession also understood the role of the environment in nourishing human health and wellbeing. They were healers who used herbs, animal products, and other natural elements from the environment to heal. Many practiced independent of external oversight and used empirical reasoning to care for their communities (Ehrenreich & English, 2010). Early nursing pioneers also emphasized links between human health and wellbeing and the environment including Florence Nightingale (1860), Walt Whitman, Mary Seacole, Dorothea Dix, and Lillian Wald (Petiprin, 2016). At some point, however, the connection of nursing practice to environment was severed, or at least injured (Kangasniemi et al., 2014). Modern nursing scarcely considers the role of the environment in nourishing human health and wellbeing (Barna et al., 2012).

Sustainability Competence

Studies of nurses' current attitudes show that nurses believe sustainability is relevant to their practice and patients' health. The Sustainability Attitudes in Nursing Survey (SANS) showed general agreement among students from four European countries that sustainability and climate change are important to nursing and should be

included in curricula (Richardson et al., 2017). A recent cross-sectional study of Saudi Arabian nursing students (Cruz et al., 2018) found similar results, with students reporting extremely positive attitudes towards sustainability in health care and moderate pro-environment attitudes. No existing studies have explored the attitudes related to sustainability of nursing students in the United States, though Van Dongen (2002) reported belief in the relevance of the environment for health in a sample of registered nurses in Wisconsin. Despite exhibiting positive attitudes towards sustainability, nursing students and nurses may lack the knowledge and skills to act effectively in these areas. The sample of Wisconsin nurses cited above reported feeling poorly prepared to address environmental health issues in practice (Van Dongen, 2002).

Sustainability Education

Despite the mandate to incorporate sustainability into nursing education described in the introduction, little is known about how prepared nursing students are to address sustainability challenges and few sustainability learning interventions have been evaluated in nursing curricula. The integration of sustainability education in nursing is a newly emerging area of research. Though Álvarez-Nieto and colleagues (2017) summarized relevant sustainability competence in nursing education literature, no studies to date have investigated the evidence base for sustainability learning interventions in nursing curriculum. This gap motivates the following search and synthesis.

Search Strategy

Joanna Briggs Institute (JBI) Methodology for Scoping Reviews (2015) was employed to identify existing interventions. Initially, two databases were searched: Cumulative Index to Nursing and Alliance Health Literature (CINAHL) and Web of Science. Search terms included: sustainability, nursing, education, curriculum, teaching, and learning. Titles, abstracts, and keywords of retrieved articles were examined. This initial search revealed several additional terms for inclusion in the final search strategy including school, training, university, college, and competence. Table 2.1 displays the search terms and query strategy.

The final search strategy was deployed in four databases on March 10, 2018: the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Public Medicine (PubMed), Web of Science (WOS), and Scopus. Upon later crecommendation, a fifth relevant database, Education Resources Information Center (ERIC), was searched on April 30, 2018. Together these databases include two large healthcare databases, the primary educational database, and two interdisciplinary, citation databases. The reference lists of included articles were hand-searched for further relevant literature. No additional articles were identified through hand-searching. To minimize bias, the author and an undergraduate nursing student research assistant independently made all inclusion and exclusion decisions, reconciling any conflicting judgments.

Table 2-1: Literature Search Strategy

Search Terms	Search String	Limit(s)
Sustainability, nursing, education, learning, curriculum, school, training, university, college, competence.	sustain* AND nurs* AND (educat* OR learn* OR teach* OR curricul* OR school* OR train* OR universit* OR colleg* OR competen*)	English language

Inclusion Criteria. Inclusion criteria included English-language articles describing a sustainability learning intervention implemented in a nursing curriculum with an evaluation component. Relevant articles were required to be inclusive of three lenses comprising sustainability: ecosystem, society, and economy. If the broadest lens, ecosystem, was not represented, the intervention was not included.

Exclusion Criteria. Exclusion criteria included interventions taking place outside of the nursing discipline or higher education (i.e. unit-level or continuing education interventions). In order to capture the full development of the subfield, no date limitations were imposed.

Analysis. Search results were aggregated, and duplicates removed. Title, abstracts, and full-text were screened for eligibility. The *Covidence* online platform, from Cochrane, was used to manage the eligibility process (Cochrane, 2018). Intervention data, including publication date, dose/length of intervention, and topical and pedagogical themes were abstracted from the articles (Table F.1). To evaluate the rigor of the identified interventions, information was abstracted regarding level of evidence, design, sample characteristics, setting, and evaluation measures (Table F.2). Kirkpatrick's (1994) hierarchy of levels of evaluation was utilized to assess the outcomes measured by the intervention evaluations. This hierarchy helps to discern the maturity of evaluation of each included intervention. Figure 2.1 illustrates the progress from simple evaluation of student reaction to an intervention through learning and behavior change, and finally to the most difficult and complex type of evaluation, that of results or impact on society. Results of these outcome evaluations were also extracted (Table F.3).

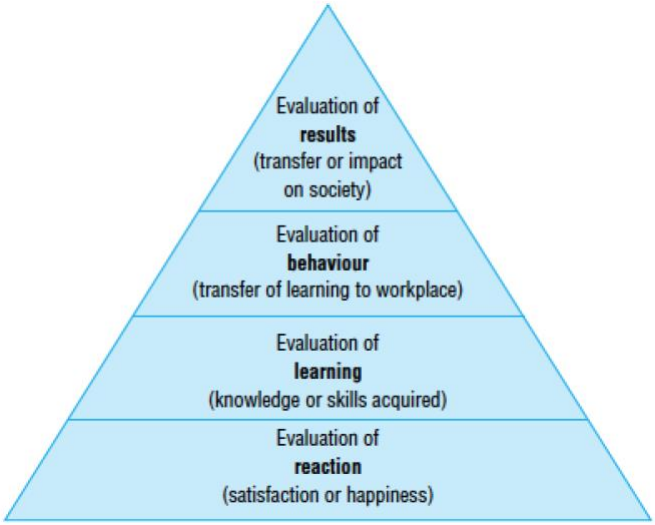


Figure 2-1: Kirkpatrick's Levels of Evaluation (reprinted from Hutchinson, 1999)

Search Results

The initial search of all databases yielded 18,332 results. Upon inspection for duplicates, 9,015 articles were removed. Titles and abstracts of 9,317 articles were subsequently screened for relevance. Studies on unrelated topics such as life-sustaining measures and financial sustainability were excluded (*n*=8,940). Next, the full texts of 377 articles were examined with inclusion and exclusion criteria applied. An additional 364 articles were excluded at this stage. The majority (*n*=230) were excluded again for having no topical relevance to sustainability as defined above. Sixty-four studies took place outside of higher education, evaluations of continuing education or hospital unit-based nurse education for example. Thirteen studies were related to sustainability education in other disciplines, i.e. medicine, engineering, and business. Eleven studies described a sustainability education intervention in a nursing curriculum, but included no evaluation component. An additional 10 duplicate articles were

identified that the *Covidence* platform matching algorithm failed to identify. Four studies were not available in English, and the full text of one study could not be located. Figure 2.2, the PRISMA flow diagram (Moher et al., 2009; Liberati et al., 2009), illustrates the search process from database extraction to final inclusion.

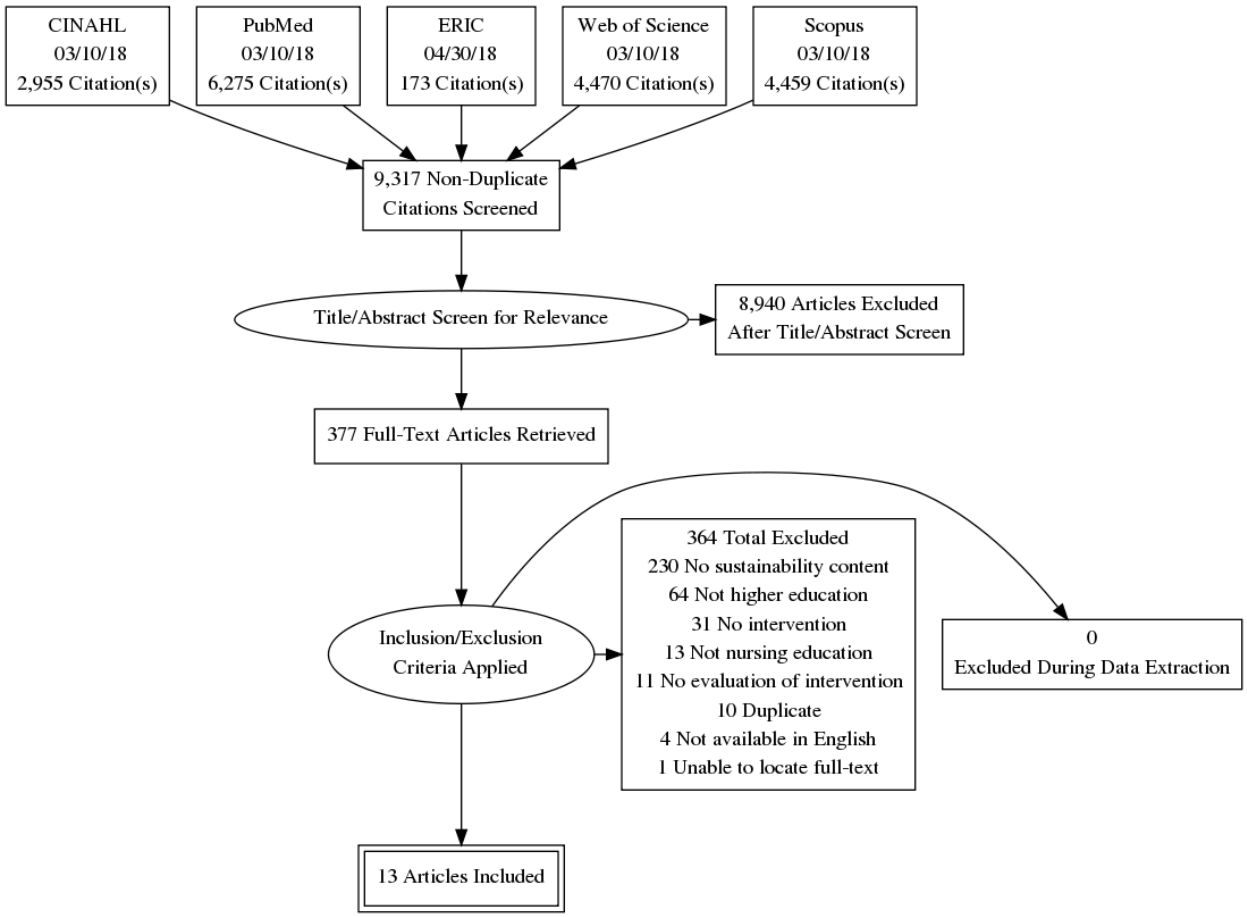


Figure 2-2: PRISMA Flow Diagram of Search Process (generated by PRISMA, n.d.)

Inclusion Summary. Thirteen articles met the inclusion criteria, describing seven distinct interventions. Tables F.1-3 in Appendix F detail the characteristics of each article and intervention. By dose, the identified interventions include: one single-day session interventions, two multi-day module interventions, and four full-semester

courses with embedded sustainability content or a sustainability lens applied throughout. Descriptions of the interventions and their evidence bases follow.

All SLI evaluation articles were published since 2000, and ten (>75 percent) of these were published in the last 5 years. Recent years have seen a steadier stream of published SLI evaluations in nursing. Figure 2.3 shows publication years of these articles.

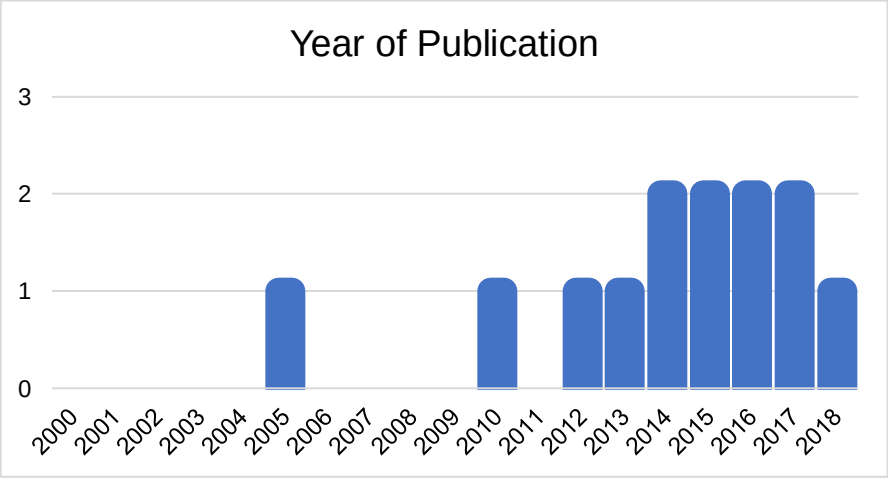


Figure 2-3: Publication Years of SLI Evaluations in Nursing Education

Geographic distribution of study corresponding authors was also examined (Figure 2.4). A majority of the included articles (*n*=7) were authored by researchers in the United Kingdom (Aronsson, 2016; Richardson et al, 2014; Richardson et al, 2015; Grose & Richardson, 2016; Richardson et al, 2017; Richardson et al, 2014; Grose et al, 2015). The remaining articles were published by scholars from Brazil (*n*=1) (de Souza e Silva, 2010), Canada (*n*=1) (Johnston et al, 2005), Latvia (*n*=2) (Renigere, 2012; Bogdanova et al, 2017), Spain (*n*=1) (Álvarez-Nieto et al, 2018), and the United States (*n*=1) (Woeber, 2013).

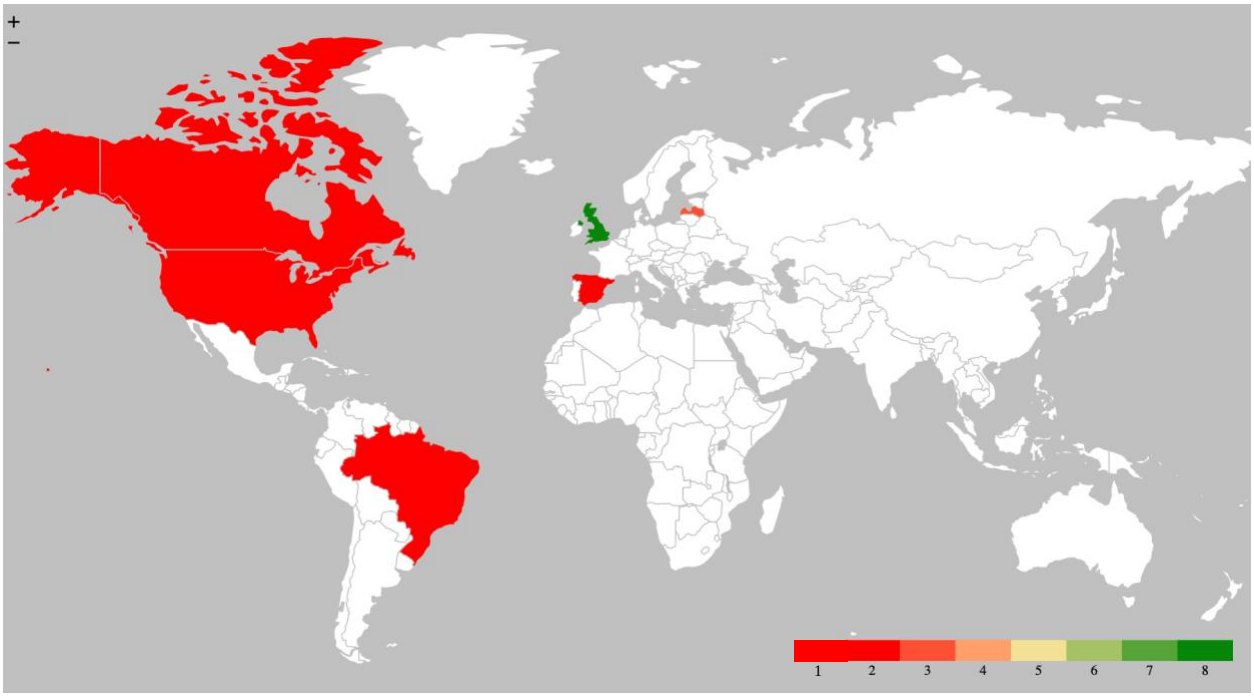


Figure 2-4: Country of Corresponding Author of Included Articles (Count) (generated by Bing Maps – Microsoft Corporation, 2019)

Three dose levels of educational intervention were identified. Of the thirteen studies, six reported single-day sessions (Richardson et al, 2014; Richardson et al, 2015; Grose & Richardson, 2016; Richardson et al, 2017; Richardson et al, 2014; Grose et al, 2015), all of which are variations on one scenario developed at Plymouth University in the southwest of the United Kingdom (UK). Two studies described multi-day modules embedded in courses (Álvarez-Nieto et al, 2018; Aronsson, 2016). Lastly, five articles described four full courses with elements of sustainability embedded throughout (Renigere, 2012; Bogdanova et al, 2017; de Souza e Silva, 2010; Johnston et al, 2005; Woeber, 2013).

Pedagogical and topical themes were identified in each intervention. Common pedagogical themes were variations of active and problem-based learning, with aims to holistically engage the student (Aronsson, 2016; Richardson et al, 2014; Richardson et

al, 2015; Grose & Richardson, 2016; Richardson et al, 2017; Richardson et al, 2014; Grose et al, 2015; Renigere, 2012; Bogdanova et al, 2017; Johnston et al, 2005; Woeber, 2013). Frequent topical themes were waste management (Richardson et al, 2014; Richardson et al, 2015; Grose & Richardson, 2016; Richardson et al, 2017; Richardson et al, 2014; Grose et al, 2015), resource depletion (Álvarez-Nieto et al, 2018), globalization (Johnston et al, 2005), and sustainable health promotion (Renigere, 2012; Bogdanova et al, 2017). Each sustainability learning intervention is described in more detail below, in addition to a brief summary of the evaluation findings.

Single-Day Sessions.

Plastic Resources Scenario. Developed at the Plymouth University in the UK, the Plastics Resources Scenario is typically employed with groups of 8 nurses during clinical skills session (Grose and Richardson, 2016; Richardson et al., 2014; Richardson et al., 2014; Richardson et al., 2015; Richardson et al., 2017). The scenario is about the potential for plastic to become scarce or expensive. First, students are given time to discuss where plastic comes from and its impact on delivery of healthcare. Next, students are given a selection of everyday clinical practice plastic items and asked to sort them from high to low impact on patient care if supply were to be interrupted. Finally, students discuss and choose the appropriate disposal method and cost of disposal of each item. The scenario activities last about 50 minutes.

Multidisciplinary Plastic Resources Scenario. The Plastic Resources Scenario above was conducted with nurses and design students at Plymouth University. Nursing students also observed as the design students participated in the scenario. Both groups of students then brainstormed, prototyped solutions, and exchanged feedback (Grose et al., 2015; Richardson et al., 2014).

Six articles evaluated the plastic resources scenario (Richardson et al, 2014; Richardson et al, 2015; Grose & Richardson, 2016; Richardson et al, 2017; Richardson et al, 2014; Grose et al, 2015). One showed positive open-ended student feedback to the multidisciplinary version of the scenario with quotes of student responses (Richardson et al., 2014). Three studies found that samples of nursing and design students believed the scenario to be realistic and helpful (Grose and Richardson 2016) and reported improved awareness in the related topic areas of peak oil, resource scarcity, and waste management (Grose et al., 2015; Richardson et al., 2015). Two studies evaluated the effect of the intervention on student attitudes towards sustainability and climate change as they relate to nursing using the SANS_2 survey validated instrument with mixed findings (Richardson et al., 2015; Richardson et al., 2017). Three studies demonstrated preliminary improvements in sustainability knowledge and attitudes (Richardson et al., 2014; Richarson et al., 2015; Richardson et al., 2017).

Multi-Day Modules.

Sustainability Module. One study developed and implemented a three-part reflexive approach to integrating sustainability education into an early course of

the nursing program at Plymouth University, UK (Aronsson, 2016). Before lecture, nursing students were first invited to lead a 'Tweetchat' discussion about health promotion on the social media platform Twitter. They then engaged in an instructor-led group exercise during lecture, followed by reflection on their own health behaviors and discussion on the interdependency of human and planetary health. The intervention was evaluated informally, as students were prompted to give open-ended feedback on Post-It notes at the end of the class. Comments were generally positive with appreciation for the reflexive and holistic approaches used and references to the intervention as "thought-provoking."

***NurSus Toolkit*.** One study evaluated the NurSus Toolkit among students and professional evaluators (faculty and curricular experts) in the UK, Spain, and Germany (Alvarez-Nieto et al., 2018). The NurSus Toolkit is an online, open source collection of digital education materials on a range of topics related to environmental sustainability in nursing. Each topic set includes a description of materials, teacher guide, lecture, PowerPoint presentation, lecture notes, activities, and resources. This article evaluated the NurSus Toolkit content using a modified version of a validated instrument, the Spanish Standard for the assessment of Digital Education Material Quality at University Level Questionnaire (COdA), in 11 domains: coherence/understandability, content quality, ability to generate learning, adaptability, interactivity, motivation, format and design, reusability, portability, interface accessibility, and content accessibility. The NurSus Toolkit materials scored favorably (7.98 and 8.50 out

of 10) in all domains among students and professional evaluators respectively, and most favorably in content quality and format and design.

Full Courses.

An Ecological Approach to Patient Care Course. Two articles evaluated the Ecological Approach to Patient Care full-course intervention at the University of Latvia (Renigere, 2012; Bogdanova et al., 2017) The course was structured around three basic building blocks: 1) education for sustainable development and sustainability/sustainability development in healthcare practice, 2) Bronfenbrenner's ecology of human development theory (Bronfenbrenner & Morris, 1998), and 3) deep ecology and ecosophy concepts developed by Naess (Naess, 1991; Naess & Haukeland, 2008). Renigere (2012) evaluated student learning with a pre- and post-intervention survey of familiarity with and knowledge of ecological concepts, namely educational and medical ecology. Student familiarity increased markedly after the course. Bogdanova et al. (2017) evaluated student essays (*n*=30) following the course for evidence of ecological competence and consciousness, showing the majority of the essays were consistent with forming and developing both ecological competence and consciousness on the basis of presence of several themes.

A Human Biology Course. One Brazilian study evaluated the application of an eco-pedagogy lens in a human biology course that entailed integrating health and eco-pedagogy approaches via readings, didactic videos, films, reflections,

and discussions (De Souza e Silva, 2010). Informal, open-ended student reactions were elicited in a mixed class of undergraduate students from biological sciences, physical education, chemistry, pedagogy, physiotherapy, and nursing. All students reacted positively to the use of an eco-pedagogy lens in the class.

A Nursing in the Global Context Course. The course was designed with five main premises in mind: 1) health as a function of environment, social, and political structures; 2) globalization means our challenges know no boundaries; 3) inter-generational interdependence; 4) effective learning engages mind, heart, and soul; and 5) relevant nursing science will increasingly grapple with the meaning of global health (Johnston et al, 2005). The course was evaluated via informal student feedback on end-of-term course evaluations. Generally, positive responses were reported.

A Health Care Ethics and Leadership and Immersive Clinical. This was a two-course series with a didactic exploration of sustainability in healthcare in the US followed by an immersion clinical course (Woeber, 2013). Student groups partnered for two weeks with various local, distant, or international community partners to identify and begin to address a sustainability challenge at the site. The courses were evaluated with an informal survey given to students upon course completion. A majority of the students enjoyed the experience, felt it was effective, and viewed sustainability as relevant for the curriculum.

All the sustainability learning interventions described above reported positive student reactions, and some showed evidence of improvements in sustainability knowledge and attitudes (Richardson et al., 2014; Richardson et al., 2015; Richardson et al., 2017). Opportunity exists for expanded content in sustainable health promotion, sustainable food systems, and water protection. Different educational doses were observed, but nearly all interventions emphasized integration into the curriculum at multiple points via integration of sustainability education pedagogy or perspectives into existing courses. This strategy aims to address barriers to integration of sustainability in nursing curricula including already crowded curricula and reluctant instructors (Butterfield et al., 2014). As outcomes varied widely across studies, it is difficult to discern an optimal dose. The notion of applying a sustainability lens throughout seems to have face validity to scholars in the area. However instructor uptake may be a significant barrier due to time constraints in training and class time, as well as cultural resistance to change (Butterfield, 2014). Although evidence is limited at this time, problem-based, active, holistic learning pedagogies appear most effective in this area. Strategies for improving different aspects of sustainability competency – knowledge, skills, and attitudes – may differ.

Most studies (*n*=11) were cross-sectional post-intervention evaluations (Richardson et al, 2014; Richardson et al, 2015; Grose & Richardson, 2016; Richardson et al, 2014; Grose et al, 2015; Álvarez-Nieto et al, 2018; Aronsson, 2016; Bogdanova et al, 2017; de Souza e Silva, 2010; Johnston et al, 2005; Woeber, 2013). Two studies employed pre- and post-intervention evaluation time points (Richardson et al, 2017; Renigere, 2012). The majority of the studies (*n*=12) did not have control groups

(Richardson et al, 2014; Grose & Richardson, 2016; Richardson et al, 2017; Richardson et al, 2014; Grose et al, 2015; Álvarez-Nieto et al, 2018; Aronsson, 2016; Renigere, 2012; Bogdanova et al, 2017; de Souza e Silva, 2010; Johnston et al, 2005; Woeber, 2013). Richardson et al (2015) did have a control group of 28 adult health nursing students, compared to 29 child health nursing students who participated in the Plastic Resources Scenario. Three studies used validated measures in their evaluation surveys (Richardson et al, 2015; Richardson et al, 2017; Álvarez-Nieto et al, 2018). No studies employed randomization.

In the majority of studies (*n*=12) evaluation outcomes focused primarily on student reactions to the intervention (Richardson et al, 2014; Richardson et al, 2015; Grose & Richardson, 2016; Richardson et al, 2017; Richardson et al, 2014; Grose et al, 2015; Álvarez-Nieto et al, 2018; Aronsson, 2016; Bogdanova et al, 2017; de Souza e Silva, 2010; Johnston et al, 2005; Woeber, 2013), with some (*n*=8) evaluating learning outcomes (Richardson et al, 2014; Richardson et al, 2015; Richardson et al, 2017; Grose et al, 2015; Álvarez-Nieto et al, 2018; Renigere, 2012; Bogdanova et al, 2017; Woeber, 2013). No studies evaluated the upper two levels of Kirkpatrick's hierarchy: student behavior change and resulting impacts on society. The Spanish Standard for the assessment of Digital Educational Material Quality at University Level Questionnaire (COdA) (Alvarez-Nieto et al., 2018) and Sustainability Attitudes in Nursing Survey (SANS_2) (Richardson et al., 2015; Richardson et al., 2017) were cited as previously validated measures. Ten studies did not use validated evaluation measures (Richardson et al, 2014; Grose & Richardson, 2016; Richardson et al, 2014; Grose et al,

2015; Aronsson, 2016; Renigere, 2012; Bogdanova et al, 2017; de Souza e Silva, 2010; Johnston et al, 2005; Woeber, 2013).

Best Practices and Pedagogies

More rigorous, experimental research designs are needed to advance the evidence base for existing sustainability learning interventions in nursing curricula. Studies are also needed to develop and adapt existing sustainability learning interventions for use in nursing schools in the United States. Because the literature surrounding sustainability learning interventions in nursing is limited, the following section will review sustainability best practices and pedagogies, as well as sustainability learning interventions employed in other disciplines.

The United Nations Decade of Education for Sustainable Development (2005-2014) catalyzed efforts to advance sustainability education (United Nations Education, Scientific and Cultural Organization (UNESCO), 2014). Programs were implemented in primary, secondary, and higher education settings (Smith et al., 2015). Sustainability education efforts also emerged in communities, professional training, and informal learning environments. Schools and colleges dedicated to educating sustainability professionals have emerged (Smith et al., 2015). Sustainability education has also been successfully embedded in the curricula of many disciplines (Schroer et al., 2015; Rose et al., 2015; Clevenger & Ozebek, 2013; Van Wynsberghe & Moore, 2015).

The ability to competently navigate complex sustainability challenges cannot be developed through rote learning of facts and tasks alone. Innovative pedagogy is needed to prepare students with guiding principles, as well as experience applying

adaptive sustainability problem-solving to local contexts and cultures. Problem-based learning, case-based learning, and participatory action research are a few such innovative pedagogies that have been implemented (Hardin et al., 2016; Scholz et al., 2006; Smith et al., 2015).

Case-based sustainability learning lends itself to nursing curricula that already incorporates case-based learning as one a mainstream pedagogical approach (Chan et al., 2016; Hanson, 2015; O'Flaherty and Phillips, 2015). Engineering, business, and law have shown success by embedding sustainability education in existing curricula via case-based learning (Schroer et al., 2015; Rose et al., 2015; Golrokhian et al., 2016; Boone et al., 2018). However, little is known about sustainability cases in nursing curricula. Given the established effectiveness of sustainability cases in other disciplines, it is important to assess the potential for a similar approach in nursing education to improve sustainability competence and problem-solving.

Auditory materials such as podcasts and oral history pieces may also decrease barriers to the integration of sustainability content in packed curricula. Multimedia materials and multimodal learning tools may also enhance engagement and educational outcomes (Djamas et al., 2018; Dousay et al., 2019; Komalasari, 2019). Rather than burdening instructors with the development of new content units or modules, multimedia modules may embed sustainability content throughout the curriculum, encouraging critical thinking in context rather than teaching rote facts or techniques alone (Hardin et al., 2016; Scholz et al., 2006).

Summary

Nurses' attitudes towards sustainability are largely positive, but few sustainability learning interventions have been evaluated in nursing curricula. Seven distinct sustainability learning interventions (SLIs) targeted to improve sustainability competence among nursing students have been evaluated and disseminated in thirteen articles. Of the identified interventions, most were evaluated in Europe and only one (Woeber, 2013) was evaluated in a sample of nursing students in the United States. Consistent pedagogical themes for sustainability in nursing and other disciplines including active, engaged, and case-based learning.

With this literature base in mind, the methods for this dissertation research build on research at the University of Michigan about sustainability efforts across campus and leverage digital innovation efforts that span educational fields with sustainability science-based content.

Chapter 3 Methods

This dissertation research explores sustainability competence in nursing education through three specific aims: 1) to describe sustainability competence among a sample of undergraduate and graduate nursing students; 2) to examine whether sustainability competence increases with additional years of nursing education; and 3) to evaluate a sustainability learning intervention (SLI) for its effectiveness at improving sustainability competence among undergraduate students. Aim 1 utilized a descriptive design, Aim 2 a correlational design, and Aim 3 was a cluster-randomized pilot experimental design testing an SLI. The data were obtained via a baseline student survey (September-October 2018) and a post-intervention follow-up student survey (December 2018- January 2019). Aims 1 and 2 used the baseline survey data only. Aim 3 examined changes in students' survey responses from baseline to follow-up, to measure intervention effectiveness.

Voluntary consent was obtained from all participants. Human subjects approval exemption was granted by the University of Michigan Health Sciences and Behavioral Sciences institutional review board for the baseline assessment survey (HUM00152212) and for the pilot intervention study and post-intervention survey (HUM00155208). Figure 3.1 below details the full data collection timeline.

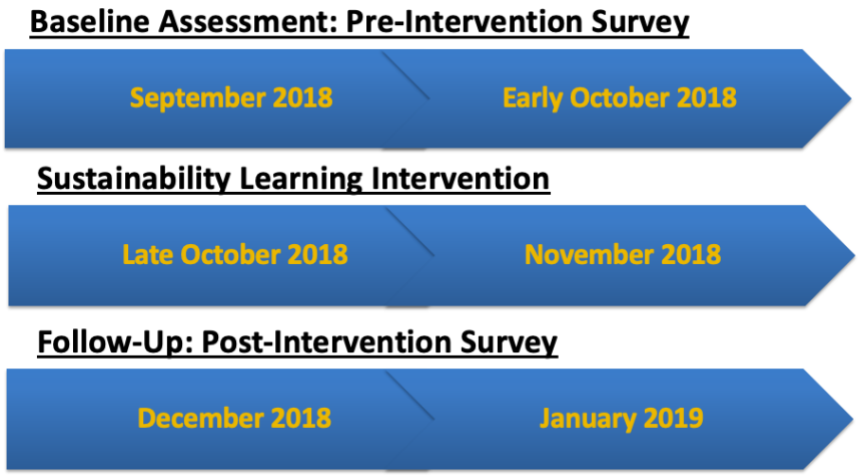


Figure 3-1: Data Collection Timeline

Design and Data Collection

Baseline Assessment (Aims 1 and 2)

We cross-sectionally measured sustainability competence in a sample of undergraduate and graduate nursing students (*n*=1,008) at the University of Michigan School of Nursing (UMSN) in Ann Arbor, Michigan in the Fall of 2018. UMSN offers highly ranked bachelor's, master's, and doctoral nursing programs in a range of specialties at a research-intensive institution with an associated university medical system (University of Michigan School of Nursing, 2020).

Recruitment was carried out electronically, via an email from school administrators containing a brief description of the survey and its purpose and a survey link. Additional recruitment included email reminders from administrators and faculty, as well as in-person prompting in large classrooms by the author. All UMSN students were invited to participate in the baseline survey. The follow up survey was administered

only to a subsample of students who were included in the pilot randomized intervention evaluation study (both treatment and control groups). Both surveys were available for one month. The surveys were supported by *Qualtrics* (2020), a secure cloud service that creates and distributes surveys and stores data.

Both the baseline and the follow up surveys utilized an adapted version of the Sustainability Cultural Indicators Program (SCIP) questionnaire (Marans & Callewaert, 2013), a locally developed and validated tool, to measure sustainability competence. The electronic questionnaire contains 108 items measuring sustainability competence and demographics. The surveys were written in English and took approximately 15 minutes to complete (Appendix A: Pre-Intervention Survey). The post-intervention survey was identical to the baseline assessment survey except for the addition of two questions to determine the course section and intervention/control status of each student participant (Appendix B: Post-Intervention Survey).

Anonymous personal identification codes (IDs) were collected to allow for longitudinal tracking of the responses in the pilot testing student subsample from baseline to post-intervention follow up. Student participants were instructed to create their IDs through a series of questions based on stable characteristics such as parents' names, address, and phone number. To account for possible entry error, students were instructed to enter their ID at the beginning and end of both surveys (Appendix 1: Pre-Intervention Survey.)

Incentives and reminders were used to increase the response rate (Boyd, 2002; CDC, 2008; CDC, 2010). The survey invitation emails announced a raffle of fifty $25 prizes. Participants were given the opportunity to opt in, with 1-in-20 odds of winning.

Prizes consisted of $20 cash and a $5 token to a nearby local produce city market. Per Michigan law, up to four raffles were held each day, or as soon as twenty additional students completed the survey. The incentive procedure used in the baseline assessment (pre-intervention-survey) was repeated in the post-intervention survey. Because unclaimed prizes in the pre-intervention survey raffle rolled over into the post-intervention survey, students had greater odds, approximately 1 in 2, of winning in the post-intervention survey raffle.

Intervention Evaluation (Aim 3)

A two-arm randomized experimental pilot study was used to evaluate the sustainability learning intervention (SLI). Description of the intervention is provided in the SLI Evaluation (Aim 3) section below. All students enrolled in the Community Health Nursing course at UMSN during Fall 2018 were invited to participate. The course is required and is limited to senior undergraduate nursing students. Each of nine course sections was randomized to SLI (intervention) or standard curriculum (control) groups in a 1:1 ratio using a computer-generated random numbers table. Five course sections were randomly assigned to receive the SLI (n=38); four sections were randomly assigned to receive standard curriculum (n=30). All students in the intervention sections were required to participate in the SLI, as it was integrated into the curriculum. To be included in the SLI evaluation study analytic sample, students had to give voluntary consent to participate in both baseline and post-intervention surveys.

SCIP Questionnaire

Housed in the Graham Sustainability Institute at the University of Michigan (U-M), SCIP developed a survey to measure sustainability culture in the U-M community beginning in 2012 (Marans and Callewaert, 2013). The SCIP questionnaire is a self-report, indirect assessment of sustainability competence. It comprises fourteen distinct indices. The indices fall into three categories: sustainability awareness, behaviors, and attitudes, which correspond to the aspects of sustainability competence described in earlier chapters: knowledge, skills, and attitudes, respectively. Each index contains between one and nine items. Most item responses lie on four-point Likert scale. For example, one item from the Travel & Transportation Awareness index reads, “How much do you know about biking in Ann Arbor?” and possible responses include A lot/A fair amount/A little/Nothing. The Travel Behavior index deviates from this pattern by asking respondents to choose a categorical option that represents how they most often travel to and from campus (i.e. walk/bike/drive a car). The Sustainability Engagement Generally index also deviates from the Likert response scales by asking respondents to answer Yes/No if they have ever volunteered for an organization or advocacy group supporting sustainability issues, voted for a candidate for public office because of her/his position on sustainability issues, etc. Despite these deviations, all index items are readily coded into more and less sustainable responses. Descriptions of the SCIP index questions are available in Table 3.2.

The fourteen SCIP indices were developed through exploratory factor analysis in a sample of 46 UM students (Marans and Callewaert, 2013). SCIP uses the questionnaire to longitudinally track changes in sustainability culture by annually

surveying a random sample of UM students, staff, and faculty. To measure internal consistency reliability, Cronbach's Alpha coefficients of the indices were calculated, ranging from poor (0.36) to excellent (0.93). Table 3.1 below shows a taxonomy of each SCIP index, a description of the items, and the validated Cronbach alpha coefficient, as well as the observed alpha coefficient in this dissertation's baseline assessment analytic sample. Observed Cronbach's alpha coefficients were equivalent to the SCIP values (+/- 0.05) in all but four indices. The Travel and Transportation Awareness index showed a higher Cronbach's alpha coefficient than the SCIP data. The Waste Prevention Behavior, Sustainable Food Purchases, and UM Sustainability Engagement indices all showed lower Cronbach's alpha coefficients. These discrepancies may be due to differences in the student samples. The original SCIP indices were validated in a sample of undergraduate engineering students at the University of Michigan (Marans & Callewaert, 2013).

The low (<0.7) alpha values on some indices may be reflective of different elements of the same construct, not necessarily divergent constructs (Marans and Callewaert, 2013). For example, the Conservation Behavior index, which reported a Cronbach's alpha coefficient of 0.38, asks respondents about the frequency with which they turn off lights when leaving a room, as well as the frequency of turning off their computers. Respondents may answer these two items very differently, yet both contribute to energy conservation and have been deemed valid content on the Conservation Behavior index by experts (Marans and Callewaert, 2013).

Sustainability Competence. An overall *Sustainability Competence Index* and three *Composite Scores* (Knowledge, Skills, and Attitudes) were created. For the Sustainability Index, Likert scale responses were averaged to generate the score for each SCIP index. All items in each index were weighted equally. All indices were then normalized to a 0 to 10 scale. High scores indicated high sustainability competence. Lows scores indicated low sustainability competence. Composite scores of knowledge, skills, and attitude indices were derived by averaging the SCIP index scores in each component category. A total sustainability competence index was then derived as the mean of the composite knowledge, skills, and attitude index scores.

Table 3-1: Taxonomy of SCIP Index Subscales (adjusted from Marans & Callewaert, 2013, p.98)

Sustainability Competency Index	**Number of Items**	**SCIP Cronbach's Alpha Coefficient (*n*=380)**	**Observed Cronbach's Alpha Coefficient (*n*=46)**
Knowledge (Awareness)	**28**		
Waste Prevention	5	0.84	0.83
Natural Environment	4	0.83	0.78
Sustainable Food	7	0.93	0.92
Travel & Transportation	4	0.52	0.66*
U-M Sustainability Initiatives	8	0.90	0.90
Skills (Behaviors)	**22**		
Waste Prevention	4	0.36	0.23*
Protecting the Natural Environment	3	0.86	0.81
Sustainable Food	3	0.78	0.19*
Travel & Transportation	1	~	~
U-M Sustainability Engagement	3	0.64	0.36*
Conservation	4	0.38	0.39
General Sustainability Engagement	4	0.56	0.56
Attitudes	**4**		
Sustainability Disposition	3	0.89	0.88
Commitment to Sustainability	1	~	~
Composites			
Knowledge	5	~	0.68
Skills	7	~	0.43
Attitude	2	~	0.56
Total Sustainability Competence	3	~	0.56
**Cronbach's alpha coefficients that differ from the observed SCIP values by more than 0.05.*			

Table 3-2: SCIP Index Item Descriptions (reprinted from Marans & Callewaert, 2013, p.98)

Index	Item Descriptions
Climate Action	
Conservation Behavior	turn off lights, use computer power-saver, turn off computer, use motion sensor
Travel Behavior	most often mode of travel to campus since fall semester
Waste Prevention	
Waste Prevention Behavior	printer double-sided, recycle paper, etc., use reusable cups, etc., use property disposition
Healthy Environments	
Sustainable Food Purchases	buy sustainable food; organic; locally-grown
Protecting the Natural Environment	use fertilizer, herbicides, water lawn
Community Awareness	
Sustainable Travel and Transportation	AATA, U-M buses, biking, Zipcar rental
Waste Prevention	recycle glass, plastic, paper, electrical waste; property disposition
Natural Environment Protection	dispose hazardous waste; recognize invasive species; residential property; protect Huron River
Sustainable Foods	locally grown; organic; fair trade; humanely-treated; hormones-free; grassfed; sustainable fish
U-M Sustainability Initiatives	save energy; encourage bus or bike; promote ride sharing, recycling, sustainable food,; reduce greenhouse gas; maintain grounds; protect Huron River
Sustainability Engagement at U-M	participate in sustain. Org; Earthfest, sustain class
Sustainability Engagement Generally	give money, voting, volunteering, serving as officer
Sustainability Commitment	how committed to sustainability
Sustainability Disposition	willingness to pay items

Contextual Variables

The survey collected data on individual and cultural norm characteristics. Age in years was a continuous variable. Family income was an interval variable with nine categories beginning at less than $10,000 and continuing in increments of $20,000. All other variables, including home country (United States / international), gender (female / male / other / choose not to respond), housing status (residence hall / community apartments / off-campus apartment / off-campus house / Greek life housing / co-op housing / parents' house / other), race (Asian / Black / Hawaiian or Pacific Islander / American Indian or Native American / White / two or more / other / choose not to respond), Hispanic or Latina/o ethnicity (yes / no), and parents' education (less than high school/high school/some college/bachelor's/graduate degree) were categorical.

Categories in several variables were combined for analysis. Family income was condensed into four categories (<$30K / $30-70K / $70-110K / >$110K). Parents' education was condensed into three categories (<bachelor's / bachelor's / >bachelor's). Housing status was condensed into four categories (on campus / off campus / Greek life / parents' house). Gender responses of 'Choose not to respond' (*n*=1) were combined with the largest category, 'Female' (*n*=346).

Racial responses were coded for analysis as follows. Responses identified as Black, even if identified as multiple races, were combined. Responses identified as Asian, even if identified as multiple races, were combined. Finally, racial responses of Hawaiian or Pacific Islander (*n*=1), American Indian or Native American (*n*=2), two or more races (*n*=7), 'Other' (*n*=4), and 'Choose not to respond (*n*=2) were combined with the largest category, White (*n*=302).

Figure 3.2 illustrates the conceptual operationalization of the theoretical framework with the measures described. Table 3.3 summarizes the independent variable, dependent variables, contextual covariates, and analysis, by aim. Stata statistical computing software was used for all analyses (StataCorp, 2017).

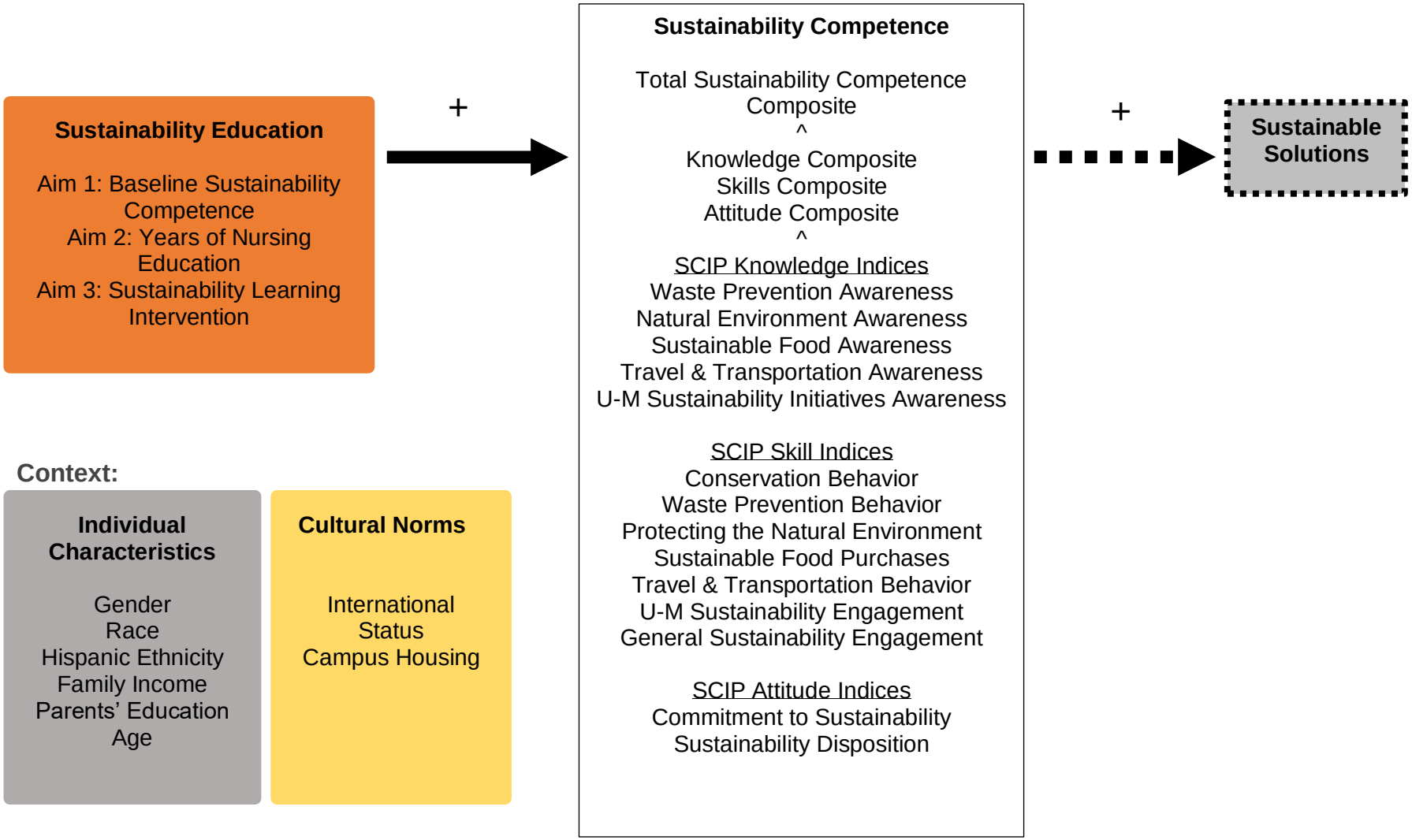


Figure 3-2: Theoretical Framework with Concept Operationalizations

Table 3-3: Variable and Analysis by Specific Aim

Independent Variables	Dependent Variables	Contextual Controls	Analysis
AIM 1 • Not applicable AIM 2 • Years of Education ○ continuous AIM 3 • Treatment group ○ dichotomous	• Total Sustainability Competence composite ○ continuous • Knowledge composite • Skills composite • Attitude composite ○ Refer to Tables 3.1 & 3.2 for details of the SCIP indices	• Gender ○ categorical • Age ○ continuous • International ○ dichotomous • Housing status ○ categorical • Race ○ categorical • Hispanic Ethnicity ○ binary • Parents' Education ○ categorical • Family Income ○ interval	AIM 1 • Means, standard deviations • Categorical distributions AIM 2 • Multiple regression AIM 3 • Baseline-adjusted difference in difference analysis

Sustainability Competence and Association with Years of Nursing Education (Aim 1 and Aim 2)

Analytic Sample

Of the 1,008 eligible UMSN students, 55% voluntarily consented to participate in the survey (*n*=553). To be included in the baseline assessment analytic sample, UMSN students had to complete at least 50% of the survey (*n*=439). Respondents were also required to have complete contextual data (*n*=392). Twelve respondents completed the survey twice, as identified by identical anonymous ID codes. For these duplicate responses, the first survey completed was included in the sample and the second dropped. This resulted in an analytic sample of 380 undergraduate and graduate nursing students.

Missing Data Protocol

There was 3.6% missing data at the item level and 4.1% missing data at the SCIP index level that was imputed. Several methods for imputing missing sustainability competence responses were implemented and compared on the baseline assessment data for the sustainability competence variables, including: item-level sample modal replacement, item-level multiple imputation, index-level multiple imputation, index-level mean imputation within observations, index-level sample mean replacement, and complete case analysis. Differences in results among methods were minimal based on descriptive statistics. Missing data in dependent outcome items – those comprising the fourteen SCIP indices – were imputed using the protocol developed by SCIP (Marans &

Callewaert, 2013). This method involved assigning the modal value of all other respondents to the non-response item. For three-item indices, this method was applied for up to one non-response item. For indices with four or more items, this method was applied for up to two non-response items. To keep sample sizes consistent across indices, any remaining missing index scores were assigned the mean sample index score.

Of the 54 SCIP items, 8 had more than 5 missing observations (3.6% total missing). Of the fourteen SCIP indices, 2 had more than 5 missing observations (4.1% total missing). Two indices with high levels of missingness – Sustainable Food Purchases (*n*=69 at baseline assessment) and Protecting the Natural Environment Behavior (*n*=137 at baseline assessment) – were treated per the protocol outlined above. However, it should be noted that missingness in these indices was statistically significantly associated with respondent age. These results may be driven by unmeasured contextual variables that are correlated with age. For example, The Protecting the Natural Environment index included questions about home yard maintenance. Older students may be more likely to own their own homes and be responsible for yard maintenance. Younger students in housing situations without these responsibilities may have skipped these questions.

Analysis

Aim 1. To describe current sustainability competence, descriptive statistics including means, standard deviations, and categorical distributions of sustainability

competence indices were calculated. Analysis of variance in sustainability competence across contextual variables was also conducted.

Aim 2. To investigate the development of sustainability competence throughout current curriculum, student-level linear multiple regression analysis was used to investigate associations between years of education and sustainability competence.

Students reported their standing in the nursing program which was translated into a years of education variable to approximate the amount of nursing content received. First (freshman) year students in the bachelor's nursing program were assigned an education years value of 13, with each year of undergraduate study following linearly. Masters students were assigned an education years value of 18. DNP and PhD students were assigned an education years value of 20.

The following model was used to examine associations between years of education (*Ed*) and each sustainability competence index and composite (*Y*). The coefficient of interest, β, represents the change in sustainability competence with each additional year of nursing education. The Z term represents a matrix of coefficients corresponding to the associations of the control contextual variables and sustainability competence.

$$Y_i = \alpha + \beta Ed_i + \gamma' Z_i + \varepsilon_i$$

H0: $\beta > 0$; *sustainability competence will increase with years of nursing education*.

T tests of significance were conducted with an alpha value of 0.05. Eighteen models were run – one for each sustainability competence index and composite score (Y_i).

Table 3.3 details the independent variable, dependent variables, contextual covariates, and analysis by aim.

Sustainability Learning Intervention (SLI) Evaluation (Aim 3)

SLI Description

As sustainability challenges and considerations vary with context, a locally developed and relevant sustainability learning intervention (SLI) was chosen. The SLI was created and evaluated through the Michigan Sustainability Cases (MSC) initiative, based at the University of Michigan School for Environment and Sustainability (UMSEAS) (Hardin et al., 2016). Each case consists of a narrative, an accompanying podcast, embedded multimedia links to related content, and an engaged learning exercise. Each MSC follows a decision-maker as he/she navigates a complex, but specific, sustainability challenge. The cases are hosted on Gala (www.learngala.com) (Regents of the University of Michigan, 2020), an open access and open source platform also developed at UMSEAS. Gala aims to connect learning, research, and practice for smarter sustainability. The platform hosts more than 5,000 users and producers, more than 80 multimedia sustainability cases, and has been used in over 150 classes and learning communities.

The chosen intervention entitled: *Dioxane Plume Pollution: Who should deal with groundwater contamination in a university town?* (Prushinskaya et al., 2016), follows the decision by the Ann Arbor City Council to apply for Superfund designation to aid the

cleanup of the 1,4-dioxane plume, a probable carcinogen, affecting groundwater in a large portion of the City of Ann Arbor's west side since the 1980s. The SLI case study is available via open access at www.learngala.com/cases/dioxane-plume. Learning objectives correlated to each component of sustainability competence. For the knowledge component, the intervention aimed to prepare students to describe how water contamination affects health and wellbeing. For the skills component, the intervention aimed to prepare students to negotiate diverse stakeholder perspective to reach sustainable solutions. For the attitude component, the intervention aimed to prepare students to reflect on the uncertainty, risk, and complexity that characterize sustainability challenges.

Students completed approximately two hours of pre-learning on the Gala platform. The online case includes a narrative including the history of the contamination and the experiences of affected citizens. Students could also peruse embedded multimedia resources called edge-notes, as well as listen to a podcast conversation with local and national experts in dioxane water contamination.

The online pre-learning was followed by 2 hours of in-class participation facilitated by the author. Students were assigned real stakeholder roles to research and represent in class in a mock town hall exercise. Half of the students were assigned citizen stakeholder roles including a real estate agent, local water activist and data analyst, business owner, and renter with a contaminated well. The other half of students were assigned regulatory official roles including the City of Ann Arbor mayor, a Michigan state legislative representative, a United States Congress representative, and the Michigan Department of Environmental Quality (MDEQ) site project manager.

These stakeholders represented a range of views on the issue of pursuing Superfund designation. For example, local water activists generally support Superfund application because this designation would make federal funds and resources available for the cleanup. However, homeowners, real estate owners and business owners expressed concerns about effects on property values and economic implications of Superfund designation. The SLI aimed to familiarize students with the social and ecological complexity that complicate sustainability efforts.

Measures

Independent Variables. For Aim 3, the treatment status was the independent variable. Each student was assigned a treatment status indicator (1=SLI intervention; 0=standard curriculum control) based upon the random assignment of his or her course section. Students self-reported their treatment status in the follow-up survey.

Dependent Variables and Context. Measures for the dependent variable – sustainability competence – and context used in the sustainability learning intervention evaluation were identical to those used in the baseline assessment. (See the SCIP questionnaire and context variables, in the baseline assessment section.)

Analytic Sample

Of the 68 eligible students in the Fall 2018 UMSN Community Health Nursing course, 75% voluntarily consented to participate in the post-intervention survey (*n*=51).

The response rate in the intervention treatment group was 89.5% (*n*=34). The response rate in the control group was 56.7% (*n*=17). To be included in the SLI evaluation analytic sample, UMSN students had to complete at least 50% of the post-intervention survey (*n*=44), as measured by the *Qualtrics* platform. Respondents were also required to have complete contextual data (*n*=44). Three respondents completed the survey twice, as identified by identical anonymous ID codes. For these duplicate responses, the first survey completed was dropped and the second included in the sample, to capture the most recent levels of sustainability competence.

After ID code matching, 6 post-survey responses without pre-survey matches were dropped. Pre-survey responses were merged with matching post-survey responses. This resulted in an analytic sample of 35 undergraduate nursing students: 26 students in the intervention group and 9 students in the control group. Missing data in the sustainability competence outcome variables was handled via the same protocol described previously in the Baseline Assessment section.

Analysis

Sample descriptive statistics (means, standard deviations, categorical distributions) of contextual variables were calculated and compared by treatment group with T-tests and Chi_2 tests. To evaluate changes after the sustainability learning intervention, student-level baseline-adjusted difference in differences analysis investigated effects on sustainability competence. This method, described in the equation below, involves estimating a linear regression in which the treatment status (SLI/ control), response timepoint (Post/ Pre), and the interaction of these two indicators

(SLI*Post) predict the sustainability competence outcome (Y). Figure 3.3 illustrates the interaction of the treatment and timepoint variable, with the standard curriculum control group and pre-intervention survey response timepoint serving as the reference categories. The coefficient of interest, β, represents the change in sustainability competence after the SLI in the intervention group, as compared to the control group. As responses were tracked and matched from pre-intervention to post-intervention surveys, each individual also serves their own control at baseline.

$$Y_i = \alpha + \delta SLI_i + \eta Post_i + \beta(SLI_i * Post_i) + \varepsilon_i$$

Hypothesis: $\beta > 0$; students receiving the intervention would show greater improvements in sustainability competence in the post-intervention survey, as compared to students who received a standard curriculum.

T tests of significance were conducted with an alpha value of 0.05. Eighteen models were estimated – one for each SCIP index, three for the knowledge, skills, and attitudes composite scores, and the last for total sustainability competence (Y_i).

	Control	Intervention
Pre	Control Group Pre-Survey Mean Competence (a)	Intervention Group Pre-Survey Mean Competence (b)
Post	Control Group Post-Survey Mean Competence (c)	Intervention Group Post-Survey Mean Competence (d)
Difference in differences	Improvement in competence in the intervention group (d-b) MINUS change in the control group that's unrelated to intervention (c-a): **β = (d-b) - (c-a)**	

Figure 3-3: Baseline-Adjusted Difference in Difference Analysis

Chapter 4 Results

Sustainability Competence and Association with Years of Education (Aims 1 & 2)

Sample Characteristics

The sample was predominantly female (91%), with an average age of approximately 23 years. A majority of respondents were White (83.7%), with Asian (13.4%) and Black (2.9%) minorities represented. Hispanic-identified students accounted for 4.7% of the sample. Senior undergraduate nursing students were most heavily represented in the sample (22.9%), though every undergraduate and graduate standing level was represented by at least 3% of respondents. Almost half of respondents had parents who received education beyond a bachelor's degree (46.6%), while those whose parents have bachelor's degrees (26%) or less (27.4%) were less predominant. Family income within the sample was varied with 40.3% of respondents' families earning greater than $110,000, 20.8% earning $70-110,000, 30.5% earning $30-70,000, and 8.4% earning less than $30,000. Four students (1%) identified as international students. A majority of student respondents (65.8%) resided in off-campus housing, with fewer students living on campus (24.7%), in Greek Life housing (4.2%), and with parents (5.3%).

The mean years of education obtained by respondents – the independent outcome variable for Aim 2 – was 15.9 years, which is equivalent to senior undergraduate standing. Table 4.1 provides the distributions of all contextual and explanatory variables.

Table 4-1: Baseline Assessment Sample Characteristics

	Percent	*(n)*
Individual Characteristics		
Gender		
Female	91.32	347
Male	8.68	33
Age M(SD)	22.95	6.83
Ed Years M(SD)	15.86	2.20
Race		
White	83.68	318
Asian	13.42	51
Black	2.89	11
Hispanic	4.74	18
Standing		
Freshman	17.63	67
Sophomore	16.58	63
Junior	11.05	42
Senior	22.89	87
Fifth-Year Undergrad	3.16	12
Masters	17.63	67
DNP	7.11	27
PhD	3.95	15
Parents' Education		
< Bachelor's	27.37	104
Bachelor's	26.05	99
> Bachelor's	46.58	177
Family Income		
<$30K	8.42	32
$30-70K	30.53	116
$70-110K	20.79	79
>$110K	40.26	153
Cultural Norms		
Housing		
Campus	24.74	94
Off-campus	65.79	250
Greek Life	4.21	16
Parents' House	5.26	20
International Status	1.05	4
Total	100	380

The analysis of variance in total sustainability competence scores showed no significant differences by sample characteristics, with the exception of gender. The mean total sustainability competence score among female nursing students was 4.2 (SD=1.01) out of 10, while the mean score among male nursing students was 4.7 (SD=1.15). Table 4.2 shows the F statistics and p values of the analysis of variance by each contextual variable.

Table 4-2: Analysis of Variance in Total Sustainability Competence

Variable	F Statistic	P value
Individual Characteristics		
Gender	5.21	**0.023**
Race	2.33	0.099
Hispanic Ethnicity	0.45	0.503
Family Income	1.18	0.316
Parents' Education	0.25	0.779
Age	1.45	0.148
Cultural Norms		
International Status	0.52	0.471
Campus Housing	0.23	0.874

Aim 1: To Describe Sustainability Competence Among a Sample of Undergraduate and Graduate Nursing Students.

Table 4.3 reports the means, standard deviations (SD), and ranges for total sustainability competence; the composites of knowledge, skills, and attitude components; as well as the SCIP indices of each component.

Table 4-3: Sustainability Competence Component and Index Descriptive Statistics

(n=380)	Mean	SD	Min	Max
Knowledge Composite	3.9	1.4	0.9	8.6
Sustainable Travel & Transportation	3.3	2.1	0.0	10.0
Waste Prevention	3.6	2.1	0.0	10.0
Natural Environment Protection	2.7	2.1	0.0	9.2
Sustainable Foods	4.7	2.3	0.0	10.0
U-M Sustainability Initiatives	5.3	2.2	0.0	10.0
Skills Composite	4.5	0.8	2.0	7.0
Conservation Behavior	6.3	1.8	0.0	10.0
Travel Behavior	6.1	4.4	0.0	10.0
Waste Prevention Behavior	7.0	1.1	3.3	10.0
Sustainable Food Purchases*	5.5	1.8	0.0	10.0
Protecting the Natural Environment*	7.7	2.3	0.0	10.0
Sustainability Engagement at U-M	0.6	1.6	0.0	10.0
Sustainability Engagement Generally	1.8	2.4	0.0	10.0
Attitudes Composite	4.4	1.8	0.0	10.0
Sustainability Commitment	6.0	2.0	0.0	10.0
Sustainability Disposition	2.8	2.3	0.0	10.0
Total Sustainability Competence	4.3	1.0	1.6	7.6

The mean total sustainability competence composite score of the sample was 4.3 (SD=1.0) out of 10. Among the components, the knowledge composite score was 3.9 (SD=1.4), the skills composite score was 4.5 (SD=0.8), and the attitude composite score was 4.4 (SD=1.8). Figure 4.1 below shows these composite scores in comparison to each other on the range of possible scores.

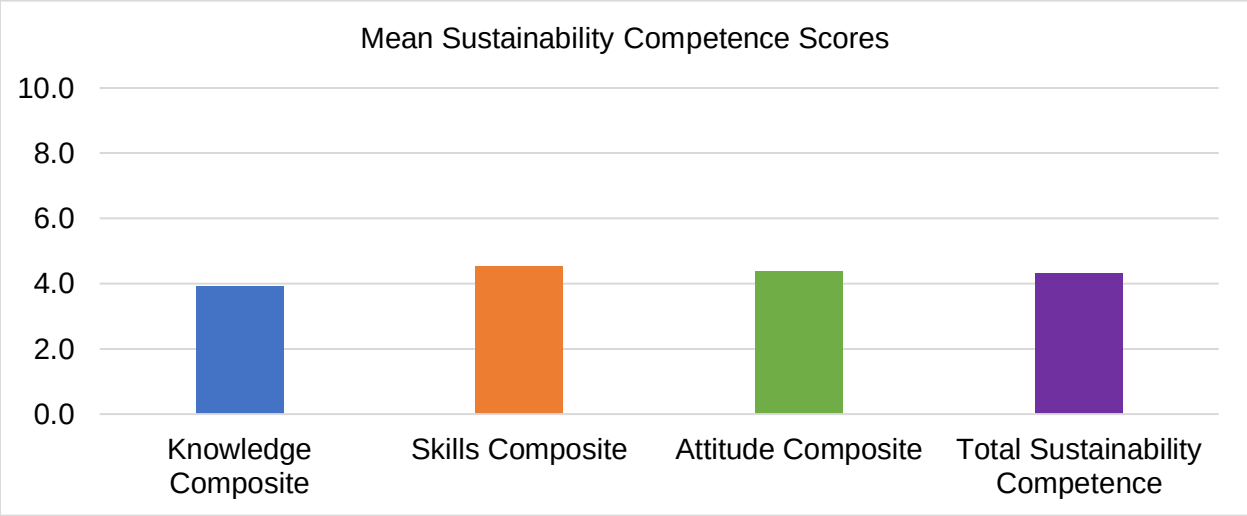


Figure 4-1: Total Sustainability Competence and Component Means
(0 = low sustainability competence, 10 = high sustainability competence)

The SCIP index means are compared in Figure 4.2 below. From highest to lowest, mean index scores for the knowledge component indices were: U-M Sustainability Initiatives Awareness (5.3, SD=2.2), Sustainable Foods Awareness (4.7, SD=2.3), Waste Prevention Awareness (3.6, SD=2.1), Sustainable Travel and Transportation Awareness (3.3, SD=2.1), and Natural Environment Protection Awareness (2.7, SD=2.1). The skills component mean index scores were: Protecting the Natural Environment (7.7, SD=2.3), Waste Prevention Behavior (7.0, SD=1.1), Conservation Behavior (6.3, SD=1.8), Travel Behavior (6.1, SD=4.4), Sustainable Food

Purchases (5.5, SD=1.8), Sustainability Engagement Generally (1.8, SD=2.4), and Sustainability Engagement at U-M (0.6, SD=1.6). The attitude component mean index scores were: Sustainability Commitment (6.0, SD=2.0) and Sustainability Disposition (2.8, SD=2.3).

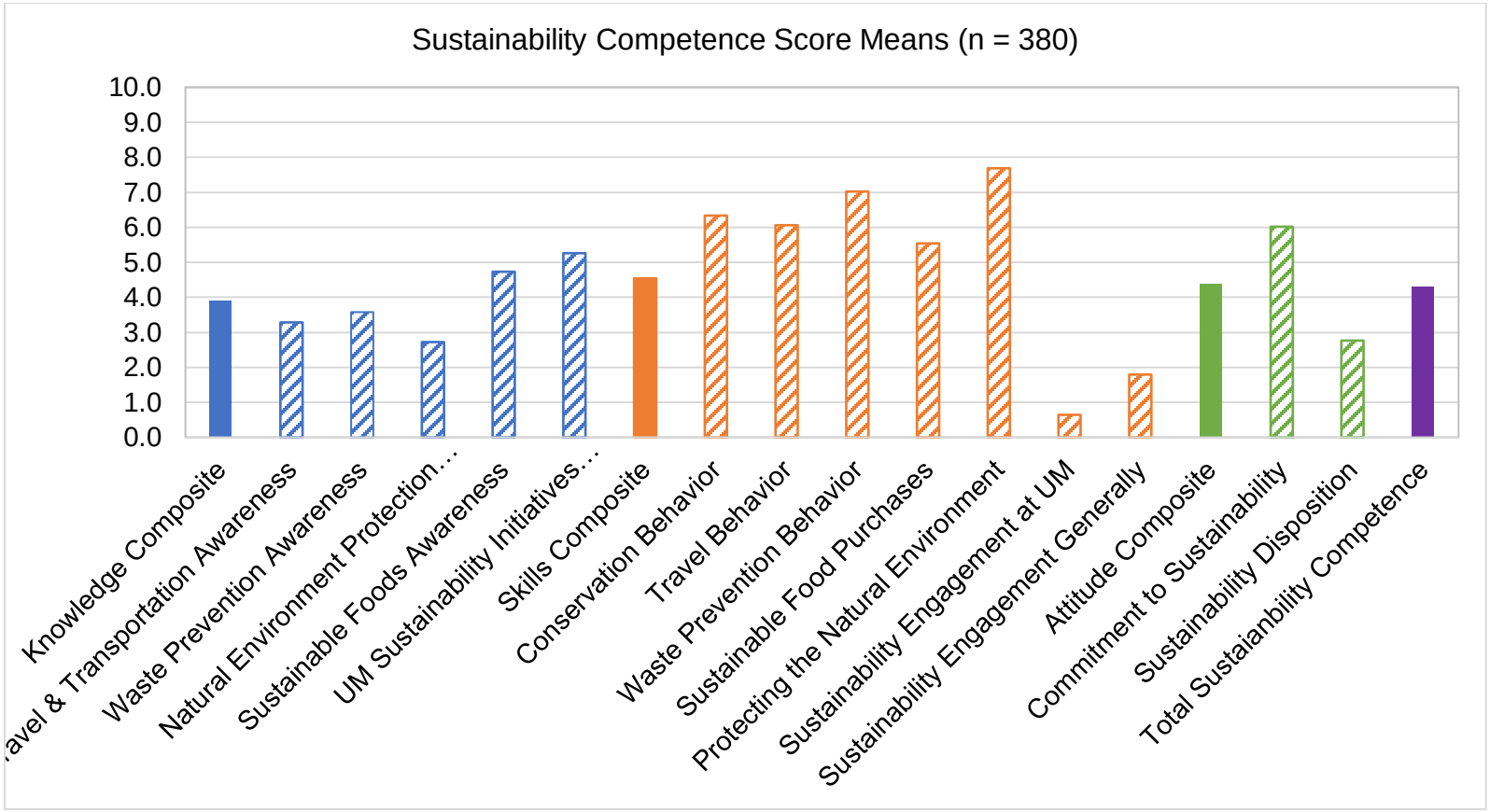


Figure 4-2: Sustainability Competence, Component and Index Means (Solid = Composite, Striped = SCIP Indices)

Aim 2: To Investigate the Association of Sustainability Competence with Years of Nursing Education.

The second aim of this dissertation was to examine whether sustainability competence increases with additional years of nursing education. The association of total sustainability competence with years of nursing education was not significant (β=-0.05, p=0.237), failing to reject the null hypothesis of no association. Among the competence components, knowledge was non-significantly associated (β=-0.05, p=0.360), skills were significantly negatively associated (β=-0.07, p=0.046), and attitudes were non-significantly associated (β=-0.03, p=0.685). Figure 4.3 describes these associations with error bars representing the 95% confidence interval for each association estimate. Table C.1 in Appendix C reports detailed regression results for each of these models including contextual variable association estimates.

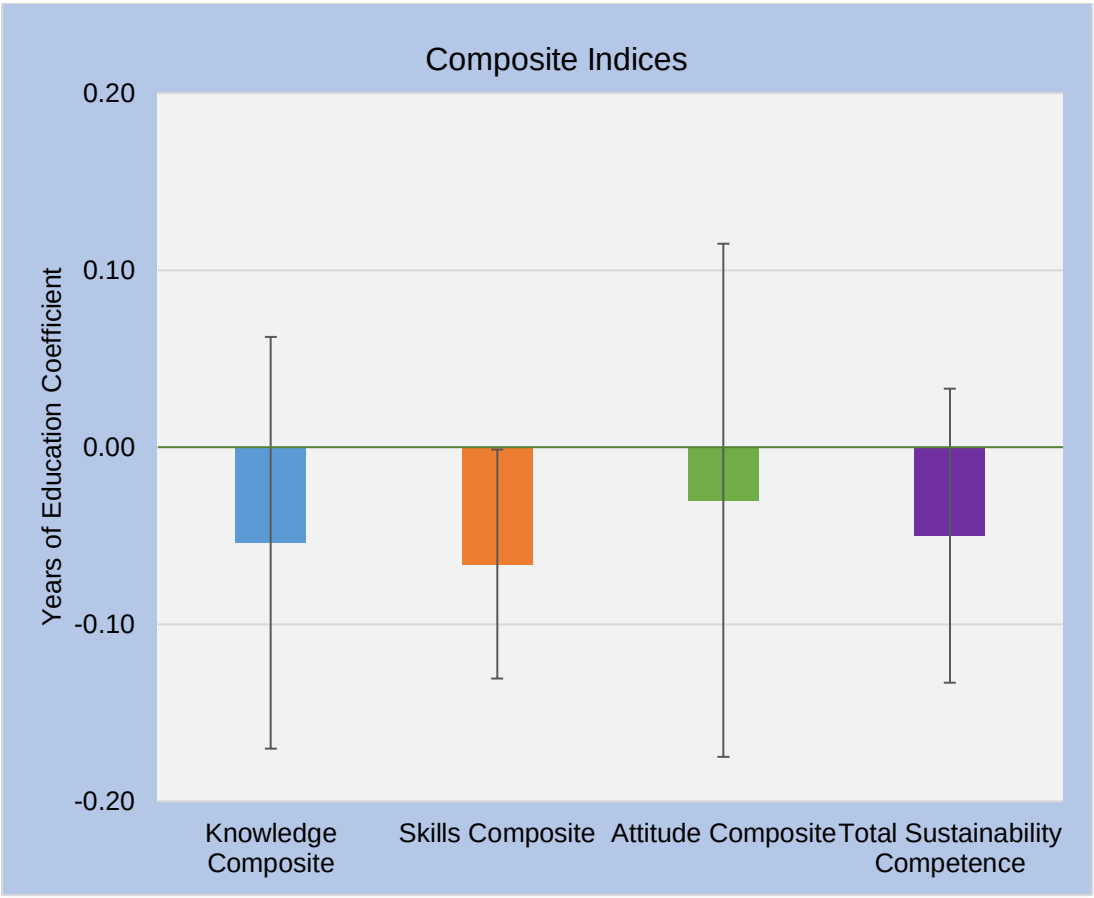


Figure 4-3: Total Sustainability Competence and Component Associations with Years of Nursing Education

Among the knowledge indices, Sustainable Travel and Transportation Awareness (β=0.00, p=0.981), Waste Prevention Awareness (β=-0.15, p=0.077), Natural Environment Protection Awareness (β=-0.04, p=0.659), and Sustainable Foods Awareness (β=0.15, p=0.103) were non-significantly associated with years of nursing education. U-M Sustainability Initiatives Awareness was significantly negatively associated (β=-0.24, p=0.010). Figure 4.4 describes these associations with error bars representing the 95% confidence interval for each association estimate. Table C.2 in Appendix C reports detailed regression results for each of these models including contextual variable association estimates.

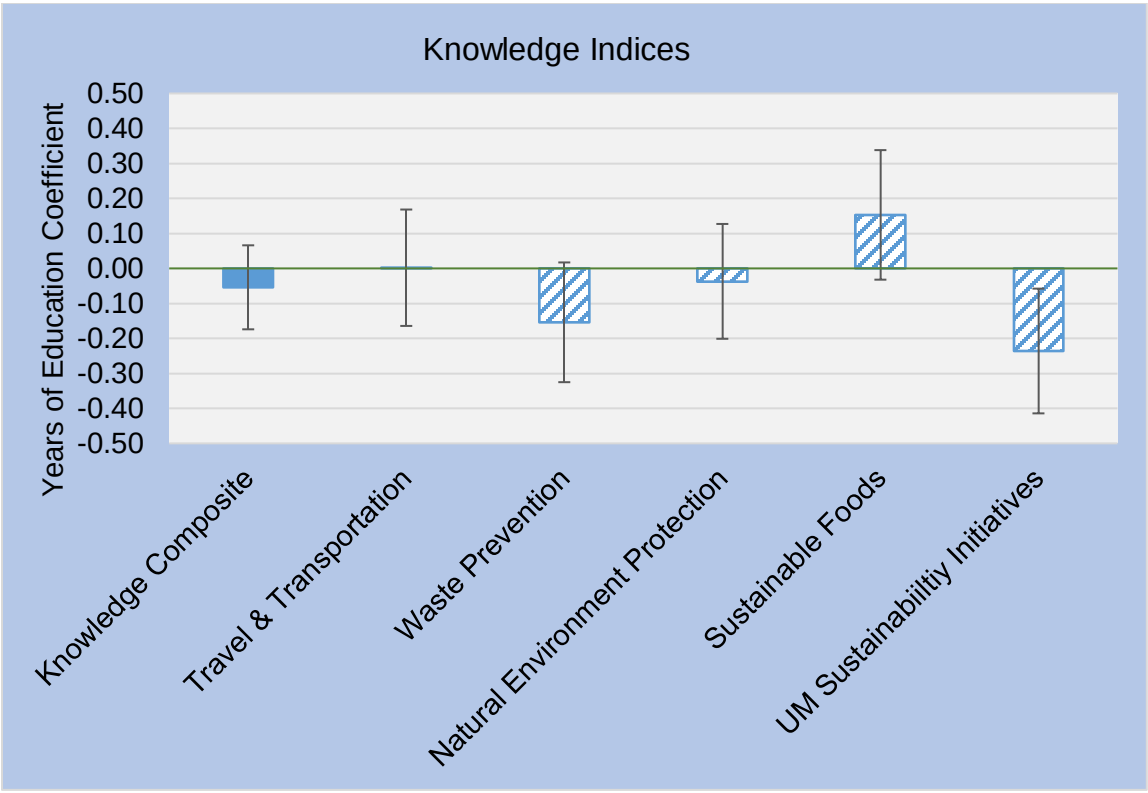


Figure 4-4: Knowledge Index Associations with Years of Nursing Education (Solid = Composite, Striped = SCIP Indices)

Among the skills indices, Conservation Behavior (β=-0.11, p=0.129), Waste Prevention Behavior (β=-0.02, p=0.694), Sustainable Food Purchases (β=-0.07, p=0.313), Protecting the Natural Environment (β=-0.10, p=0.273), Sustainability Engagement at U-M (β=-0.04, p=0.501), and Sustainability Engagement Generally (β=0.01, p=0.936) were not significantly associated with years of nursing education. Travel Behavior was significantly negatively associated (β=-0.66, p=0.00). Figure 4.5 describes these associations with error bars representing the 95% confidence interval for each association estimate. Table C.3 in Appendix C reports detailed regression results for each of these models including contextual variable association estimates.

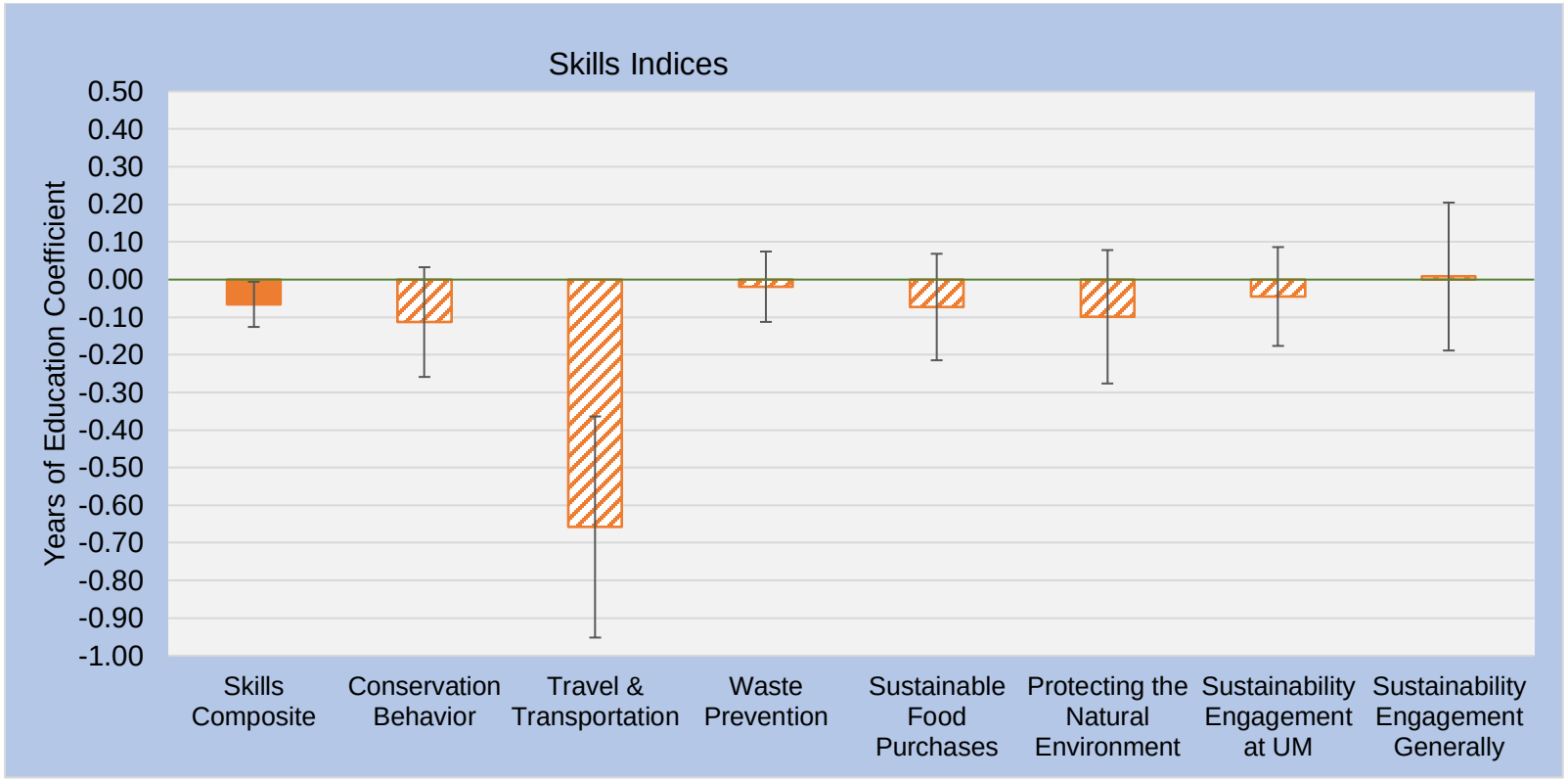


Figure 4-5: Skills Index Associations with Years of Nursing Education (Solid = Composite, Striped = SCIP Indices)

Among the attitude indices, Sustainability Commitment (β=-0.09, p=0.256) and Sustainability Disposition (β=0.03, p=0.717) were both not significantly associated with years of nursing education. Figure 4.6 describes these associations with error bars representing the 95% confidence interval for each association estimate. Table C.4 in Appendix C reports detailed regression results for each of these models including contextual variable association estimates.

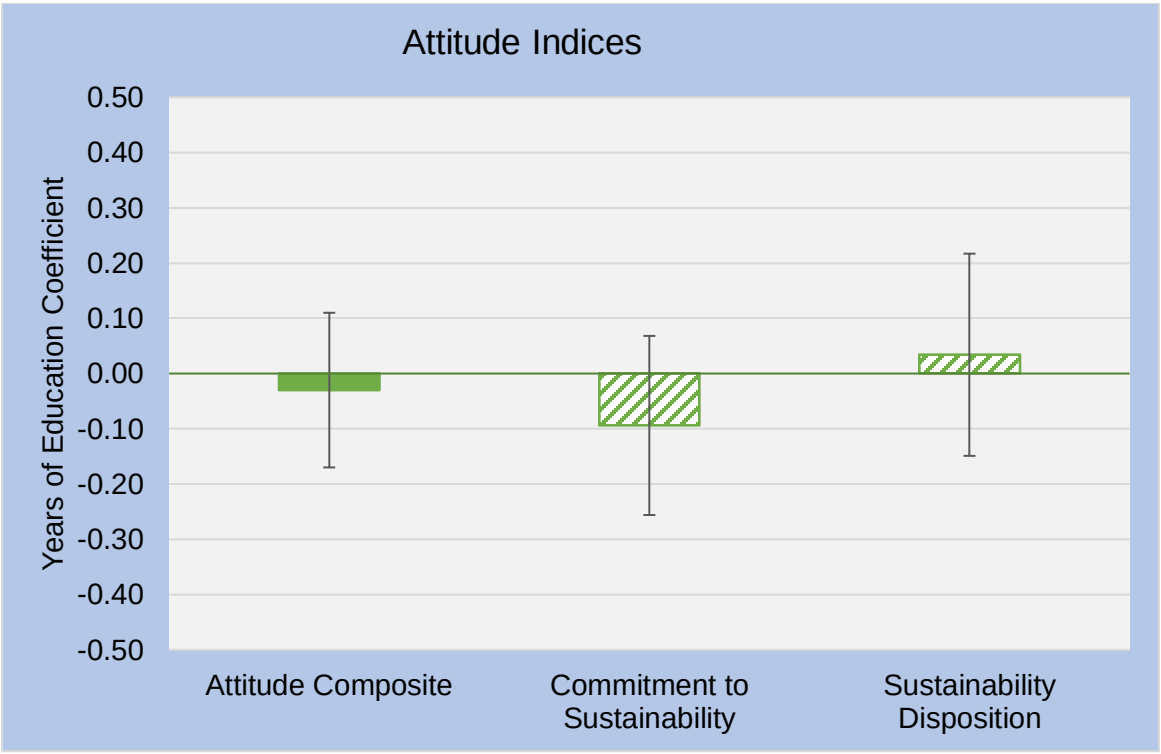


Figure 4-6: Attitude Index Associations with Years of Nursing Education (Solid = Composite, Striped = SCIP Indices)

Because age and years of nursing education were highly correlated (Pearson correlation = 0.673), a sensitivity analysis without age as a control variable was conducted. Results were comparable in this sensitivity analysis with the skills composite showing the only significant correlation with years of education (β=-0.065, p=0.012).

Tables E.1 – E.4 in Appendix E report detailed regression results for the sensitivity analysis models without age as a covariate.

Sustainability Learning Intervention Evaluation (Aim 3)

Sample Characteristics

The total analytic sample for the SLI evaluation was *n*=35 students, with *n*=26 in the intervention group and *n*=9 in the control group. Both intervention and control groups were majority female with a mean age of approximately 21 years. All participants were either senior (4th year) or 5th year undergraduate nursing students. Students in both groups were predominantly white (92.3% in the intervention group, 88.9% in the control group), with no Hispanic or International student representation. Majorities in both groups had parents with more than a bachelor's degree (54.9% in the intervention group, 77.8% in the control group). Family income above $110,000 was most common, with 42.3% of students reporting this income level in the intervention group, and 55.6% of students in the control group. A majority of students lived in off campus housing in the intervention (100%) and control (77.8%) groups.

Except for housing (Chi_2=6.1, p=0.047), there were no significant differences in contextual variables between the groups. Full sample characteristics for the intervention and control groups, including tests of difference, are available in Table 4.4. Contextual variable data from the pre-intervention survey was used for analysis.

Table 4-4: Sustainability Learning Intervention Evaluation Sample Characteristics

	Intervention Group (*n*= 6)		Control Group (*n*=9)		Difference	
Characteristic	*Percent*	*(n)*	*Percent*	*(n)*	*Chi₂/T statistic*	*P value*
Individual Characteristics						
Gender						
Female	88.46	23	100	9		
Male	11.54	3	0	0	1.1358	0.287
Age M(SD)	21.31	0.55	21.00	0.00	-1.6646	0.1055
Race						
White	92.31	24	88.89	8		
Asian	0	0	11.11	1		
Black	7.69	2	0	0	3.5897	0.166
Hispanic	0	0	0	0	~	~
Standing						
Senior	92.31	24	100	9		
Fifth-Year Undergrad	7.69	2	0	0	0.7343	0.392
Parents' Education						
< Bachelor's	19.23	5	11.11	1		
Bachelor's	26.92	7	11.11	1		
> Bachelor's	53.85	14	77.78	7	1.6266	0.443
Family Income						
<$30K	3.85	1	11.11	1		
$30-70K	30.77	8	11.11	1		
$70-110K	23.08	6	22.22	2		
>$110K	42.31	11	55.56	5	1.8811	0.597
Cultural Norms						
Housing						
Campus	0	0	11.11	1		
Off-campus	100	26	77.78	7		
Greek Life	0	0	0	0		
Parents' House	0	0	11.11	1	6.1279	0.047*
International Status	0	0	0	0	~	~
Total	100	26	100	9	100	35

Aim 3: To Evaluate a Sustainability Learning Intervention (SLI) for its Effectiveness at Improving Sustainability Competence among Undergraduate Students.

The baseline-adjusted difference in differences of total sustainability competence improvement between intervention and control groups was not significant (β=0.84, p=0.066), failing to reject the null hypothesis of no difference. Among the competence components, a significant increase in knowledge (β=1.76, p=0.017), no significant difference in skills (β=0.49, p=0.186), and no significant difference in attitudes (β=0.27, p=0.670) were observed. Figure 4.7 describes the baseline-adjusted differences between groups with error bars representing the 95% confidence interval for each difference estimate. Tables D.1 in Appendix D reports detailed regression results for each of these models. *Post hoc* power analysis showed medium-to-large effect sizes of the sustainability learning intervention on sustainability competence (Cohen, 1988; Sullivan & Feinn, 2012).

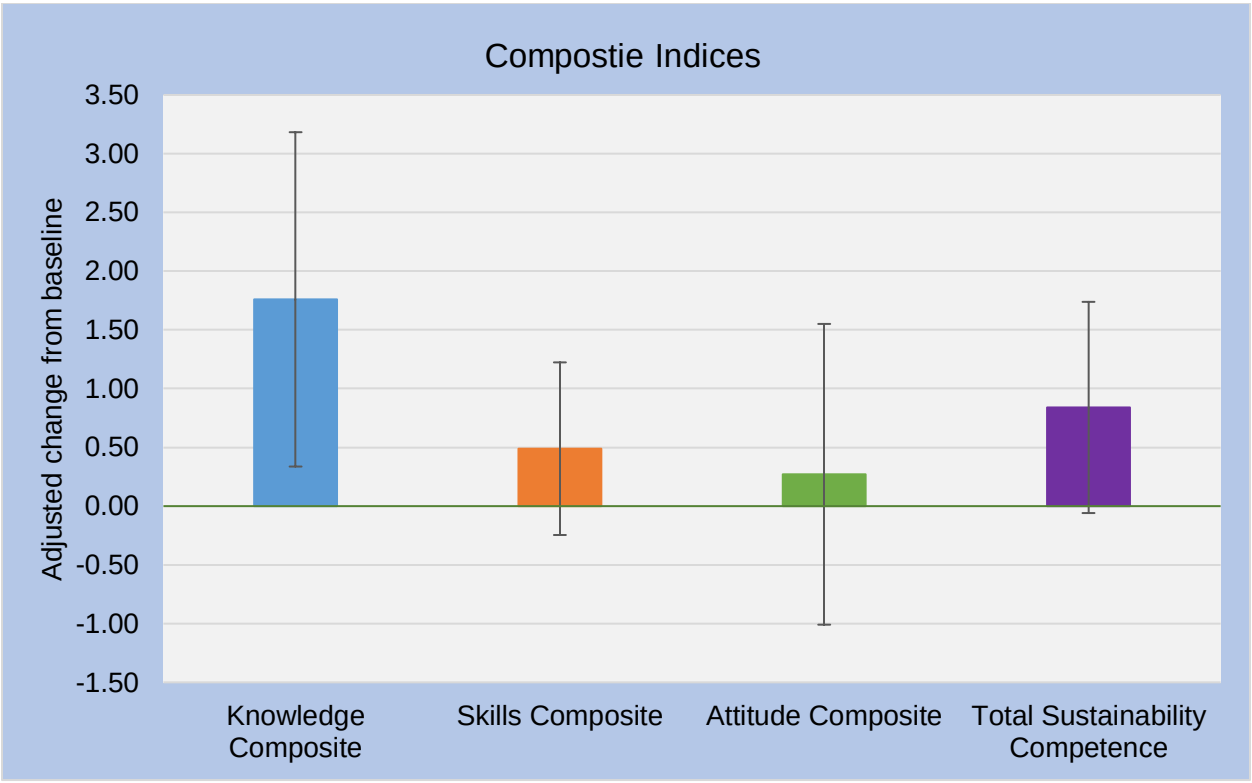


Figure 4-7: Total Sustainability Competence and Component Baseline-Adjusted Differences

Among the knowledge indices, significant increases in the intervention group post-SLI, as compared to the control group, were observed in Sustainable Travel and Transportation Awareness (β=2.43, p=0.031) and U-M Sustainability Initiatives Awareness (β=2.23, p=0.01). No significant differences were observed in Waste Prevention Awareness (β=2.46, p=0.068), Natural Environment Protection Awareness (β=0.87, p=0.327), and Sustainable Foods Awareness (β=0.82, p=0.539). Figure 4.8 describes the baseline-adjusted differences between groups with error bars representing the 95% confidence interval for each difference estimate. Table D.2 in Appendix D reports detailed regression results for each of these models.

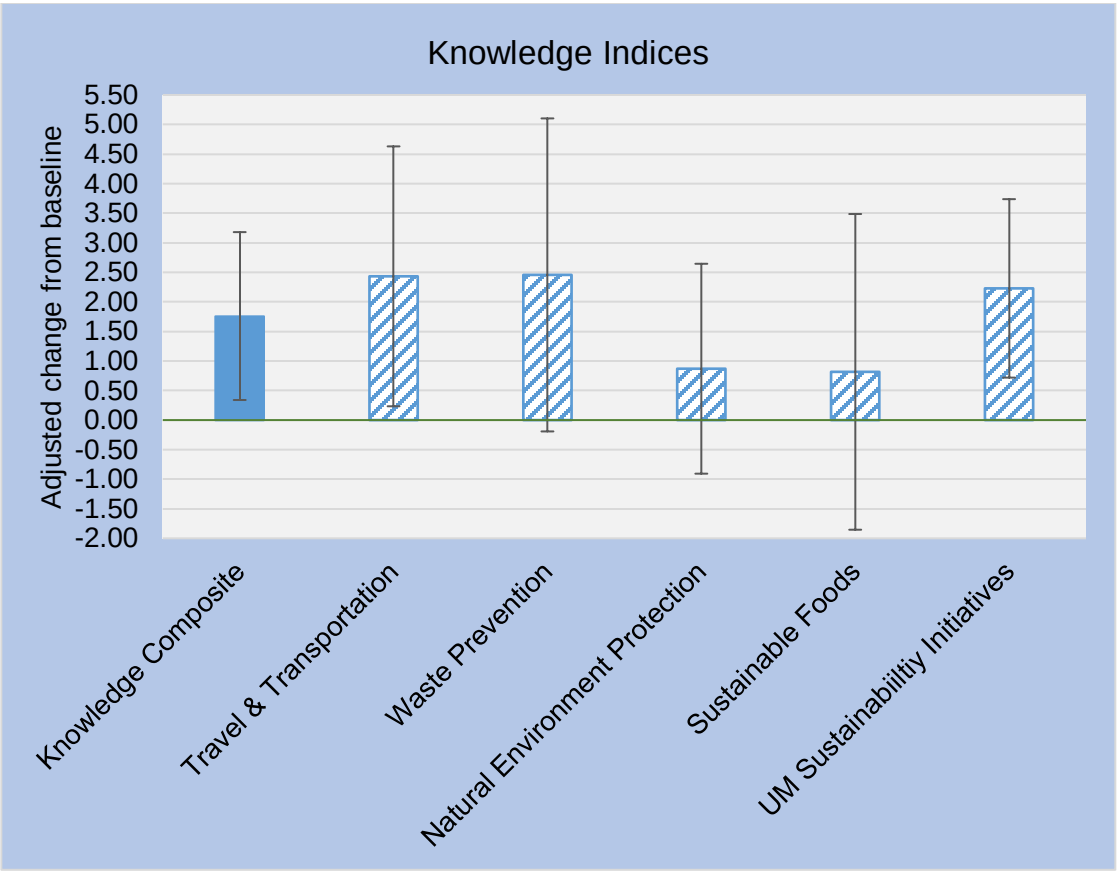


Figure 4-8: Knowledge Index Baseline-Adjusted Differences
(Solid = Composite, Striped = SCIP Indices)

Among the skills indices, no significant differences in the intervention group post-SLI, as compared to the control group, were observed in Conservation Behavior (β=0.78, p=0.346), Travel Behavior (β=1.30, p=0.357), Waste Prevention Behavior (β=0.51, p=0.428), Sustainable Food Purchases (β=0.29, p=0.679), Protecting the Natural Environment (β=0.90, p=0.200), Sustainability Engagement at U-M (β=0.39, p=0.516), and Sustainability Engagement Generally (β=0.58, p=0.684). Figure 4.9 describes the baseline-adjusted differences between groups with error bars representing the 95% confidence interval for each difference estimate. Table D.3 in Appendix D reports detailed regression results for each of these models.

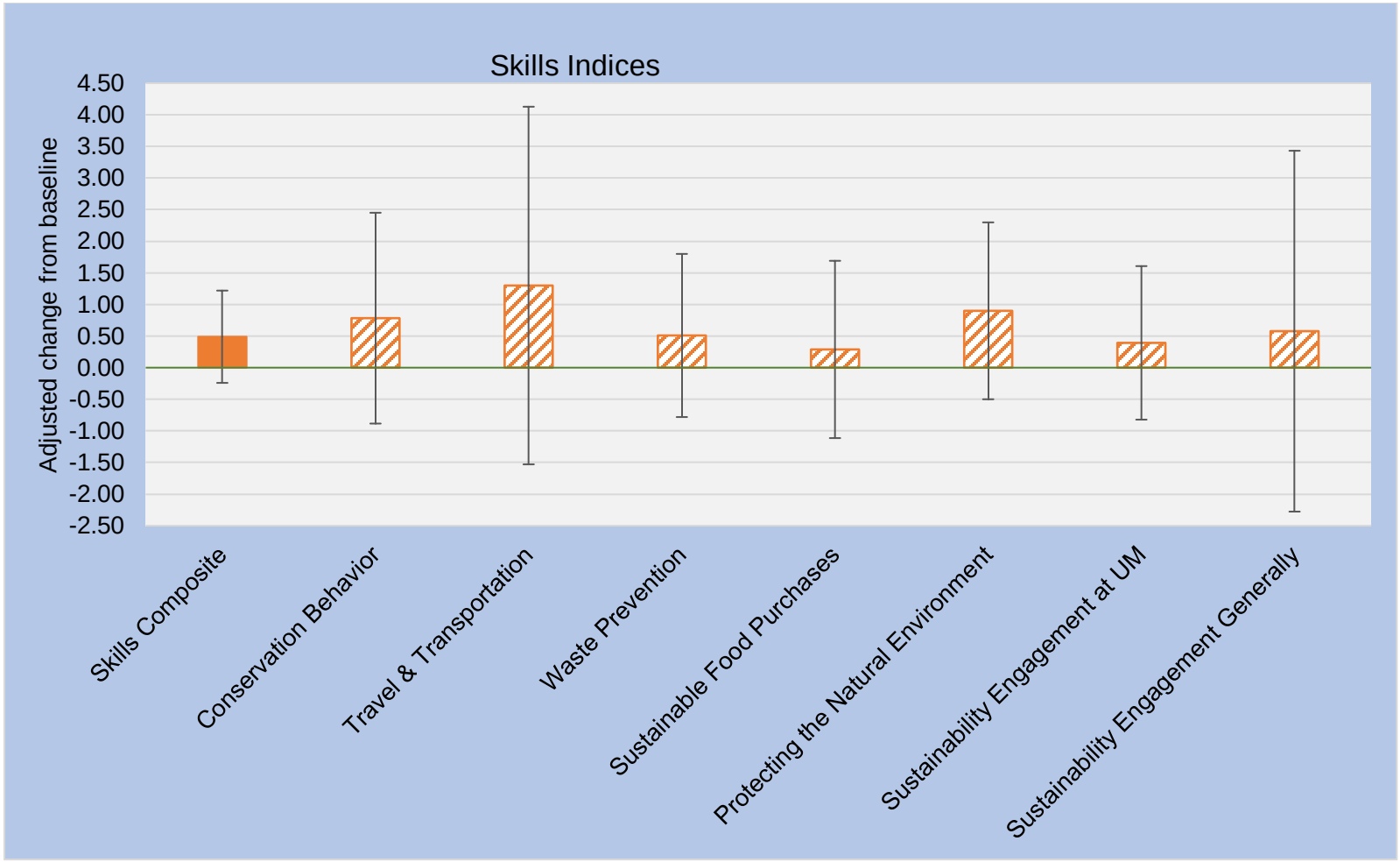


Figure 4-9: Skills Index Baseline-Adjusted Differences (Solid = Composite, Striped = SCIP Indices)

Among the attitude indices, no significant difference in the intervention group post-SLI, as compared to the control group, was observed in Sustainability Commitment (β=0.13, p=0.844) or Sustainability Disposition (β=0.41, p=0.721). Figure 4.10 describes the baseline-adjusted differences between groups with error bars representing the 95% confidence interval for each association estimate. Table D.4 in Appendix D reports detailed regression results for each of these models.

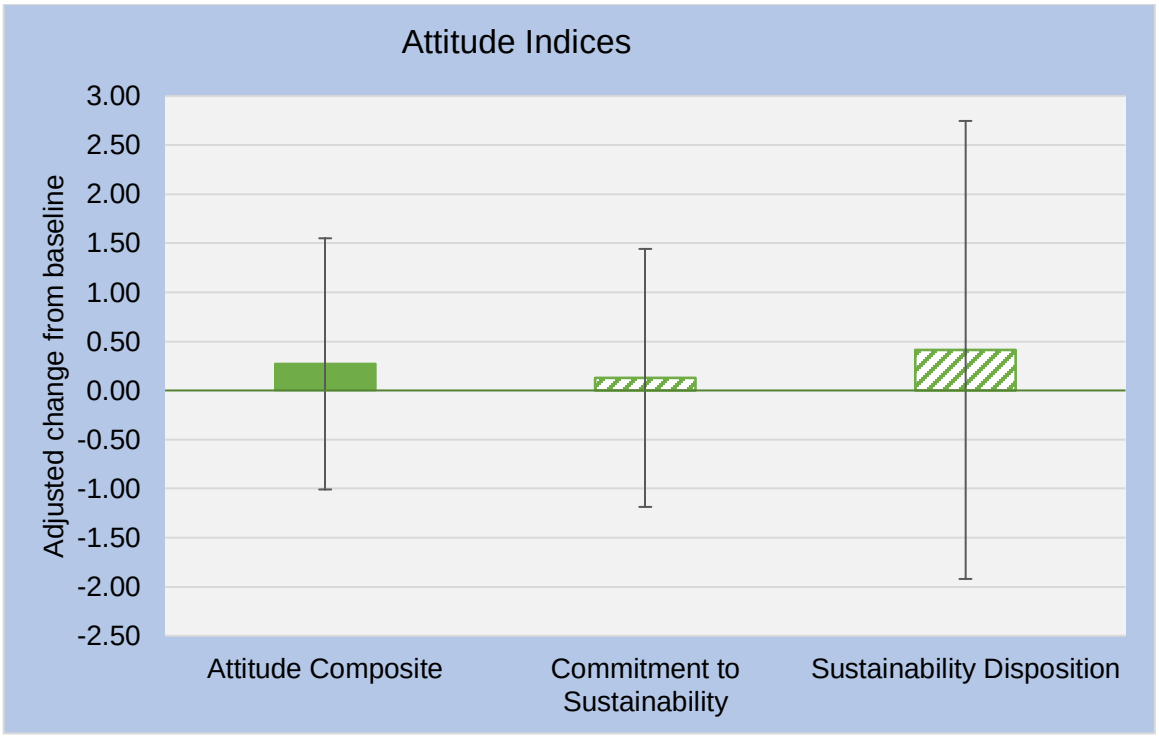


Figure 4-10: Attitude Index Baseline-Adjusted Differences (Solid = Composite, Striped = SCIP Indices)

Chapter 5 Discussion and Conclusion

This dissertation explores sustainability competence in nursing education via three specific aims: 1) to describe sustainability competence among a sample of undergraduate and graduate nursing students, 2) to examine whether sustainability competence increases with additional years of nursing education, and 3) to evaluate a sustainability learning intervention (SLI) for its effectiveness at improving sustainability competence among undergraduate students.

Aim 1

Results of Aim 1 showed moderate total sustainability competence in the sample of nursing students. This sample of nursing students exhibited mean SCIP indices scores comparable to those in a sample of students of all disciplines also studying at the University of Michigan (Marans, Callewaert, & Webster, 2018), suggesting that nursing may not be the only discipline with opportunity to further develop sustainability competence in students. With the results of this baseline assessment, the changes in sustainability competence of nursing students may be tracked longitudinally, which will render abstract measures of sustainability competence more meaningful as trends over time are observed.

Collectively, the students scored highest – most competent – in the skills component of sustainability competence and lowest – least competent – in the knowledge component. These results are contrary to previous studies of sustainability competence among nurses, which report high awareness (knowledge) of sustainability issues and their relevance to human health and wellbeing, along with low self-efficacy (skills) in addressing the issues (Van Dongen, 2002). This discrepancy may be due to differing measures of sustainability competence and access to infrastructure. For example, Dongen (2002) surveyed a sample of Wisconsin nurses working in the clinical setting. The institutions where these nurses worked may have had fewer options for recycling and sustainable transportation than the University of Michigan nursing students in this sample.

Results at the SCIP index level may also shed some light on this discrepancy. Both of the highest mean SCIP index scores were observed in skills component in the Protecting the Natural Environment and Waste Prevention Behavior indices. The lowest SCIP index mean scores were also observed in the skills component in the Sustainability Engagement at U-M and Sustainability Engagement Generally indices. The divergent results within the skills component may be reflective of the scale of action represented in the different indices. The items in the Protecting the Natural Environment and Waste Prevention Behavior indices ask about skill engaging in individual level sustainable behaviors, such as turning off the lights when you leave a room. The items in the Sustainability Engagement at U-M and Sustainability Engagement Generally indices ask about skill engaging in community-level sustainable actions, such as participating in a campus or community organization advocating for

sustainable policies. Nursing students appear to be skilled in sustainability problem-solving at an individual behavior level, but may need to be further empowered to engage in sustainable problem-solving at institutional and policy levels (Richardson et al., 2017). Study of historical oppression, power dynamics, and their effects on contemporary norms in the nursing profession may help to contextualize and inform efforts to encourage and empower nurses in sustainability problem-solving at structural levels (Ehrenreich & English; Muff, 1982).

Analysis of variance results showed significant differences in total sustainability competence by gender with male nursing students scoring a half a point higher than their female counterparts, on average. This finding was driven by the Travel and Transportation and Natural Environment Protection Awareness SCIP indices. However, the accompanying skill indices – Travel Behavior and Protecting the Natural Environment – were not significantly different among female and male nursing students. More research is needed to understand this finding; however, differences in the socialization of males and females, especially surrounding interactions with the environment (Taylor, 2009; Taylor, 2016), may be related.

Aim 2

Results of Aim 2 showed no significant association between total sustainability competence and years of nursing education. This finding is consistent with literature citing a lack of environment and sustainability content in nursing curricula (Barna et al., 2012; Goodman, 2011) and reinforce the opportunity to integrate more sustainability content into nursing curricula. However, it is also possible that sustainability

competence develops slowly, and longitudinal follow-up is needed to discern the true effects of nursing education on this complex phenomenon.

All components, as well as total sustainability competence, were negatively associated with years of nursing education, although this association was only significant in the skills component. However, of the SCIP indices that comprise the skills component, only the Travel Behavior index was significantly negatively associated with years of nursing education. This finding may be influenced by unmeasured confounding variables such as the distance of student housing to campus. The survey asked students what type of housing they live in, but not where the housing is specifically located. Students further along in their nursing education may be more likely to live farther from campus with less access to sustainable means of transportation such as walking or biking to class or utilizing the Ann Arbor area's public transportation system.

Negative associations between sustainability competence and advancing nursing education may also be a reflection of cognitive and emotional overload. Students may become overburdened with course loads and growing demand on their physical and cognitive resources as they progress through the program. Nursing students integrate increasingly technical nursing knowledge and advanced care responsibilities on their way to becoming practicing nurses. Such intensity may make it difficult for students to develop sustainability competence, especially if sustainability content is not embedded in the nursing curriculum.

At the SCIP index level, associations with years of nursing education were not uniformly negative. For example, Sustainable Food Awareness, Sustainability

Engagement Generally, and Sustainability Disposition were positively, though not significantly, associated with years of education. It is possible that current nursing curricula includes content that develops some aspects of sustainability competence, but not others. Increases in income with additional years of education may also enable more awareness and ability to pay for sustainable foods as well as willingness to contribute monetarily to support sustainability. While family income was controlled for in the analysis, this is not be a perfect measure of students' own disposable income.

Overall, these results suggest that current nursing curricula have room to improve the promotion of the sustainability competence development in nursing students, providing evidence to bolster the calls for more environmental health and sustainability content in nursing curricula (Goodman, 2011; AACN, 2011; Barna et al., 2012). However, existing literature also describes a myriad of barriers to the incorporation of sustainability content in nursing education, such as an already packed curriculum that must keep pace with ever-changing technology in the industrial medicine system (Birchenall, 2002).

Aim 3

No statistically significant change in total sustainability competence was observed in the intervention group after the SLI, as compared to the control group. Though not significant, increases in total sustainability competence, as well as all component composites and SCIP indices, were observed. Post-hoc power calculations suggest that the study may have been underpowered (Cohen, 1988; Sullivan & Feinn, 2012) and higher-powered studies may find significant differences in total sustainability

competence between treatment and control groups post-SLI. These findings will allow for power analysis and effect size estimation in future studies.

The increases in the knowledge component score and two of its SCIP indices (Travel and Transportation Awareness and U-M Sustainability Initiative Awareness) were statistically significant, suggesting that the current SLI may especially target the development of sustainability knowledge. Another possible explanation is that sustainability knowledge develops most quickly, while the skills and attitude components require longer periods of time to evolve. Bloom's taxonomy of learning, illustrated in Figure 5.1, supports this explanation as conceptual knowledge is represented as lower order learning than critical thinking and application tasks, which may align with skills and attitude components (Bloom & Krathwohl, 1956; Anderson & Krathwohl, 2001). Sustainability learning intervention studies with repeated longitudinal follow-up assessments will help to clarify how SLIs affect development of sustainability competence.

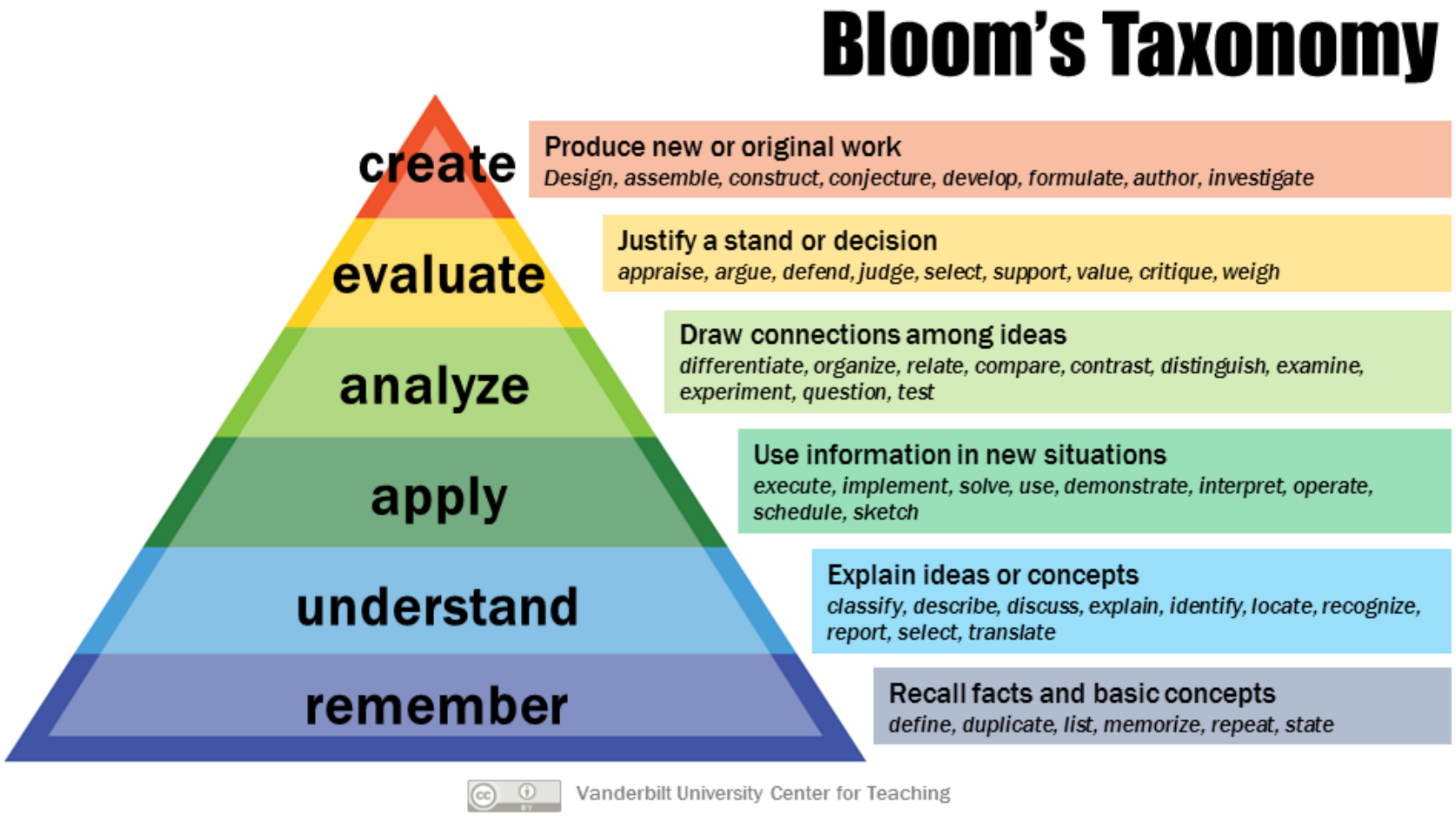


Figure 5-1: Bloom's Taxonomy of Learning (Reprinted from the Vanderbilt University Center for Teaching, 2020)

Limitations

This dissertation research has several limitations. Generalizability of the results is limited, due to a potential lack of diversity in individual characteristics and cultural norms of nursing students in one mid-western high-ranking university. The sample consisted predominantly of female, white students from high socioeconomic status families. The University of Michigan and the surrounding town, Ann Arbor, provided a unique and homogeneous exposure to cultural norms for all students in the sample. This setting also provided infrastructure for sustainable behavior that may not be available everywhere – such as on-site recycling and public transportation. Replication in more sites with more diverse nursing student populations will strengthen the generalizability of the results. Future studies may also benefit from measurement of more contextual variables, such as student hometown and distance of housing to campus.

The need for hand-matching of the anonymous ID codes to pair pre- and post-intervention responses is also a limitation. Though care was taken to prevent matching errors, false matches may have occurred. Individualized links or pairing based on IP address may ease this limitation in future studies. Though missing data rates were relatively low, the need to impute data remains a limitation. Strategic survey design may help to further decrease this issue in future studies.

The sustainability learning intervention evaluation was limited by low sample sizes and disparity between the response rates in the intervention and control groups. The cross-sectional nature of the baseline assessment and the short time to follow-up in the SLI evaluation study is also a limitation. Sustainability competence likely develops

gradually over long periods of time and would benefit from repeated longitudinal measurement.

Results may have been affected by social desirability bias (Melnyk & Morrison-Beedy, 2012), skewing results towards higher reported sustainability competence. This effect may have been especially potent in the intervention group of the SLI evaluation, for these students interacted with the author during the mock town hall in-class facilitation. To limit this potential in future studies, the facilitators of the SLI should also engage with control group for a class period, but with non-sustainability related content.

There was also potential for control group exposure and contamination in the SLI evaluation study. Standard curriculum variation among control group sections and other potential exposure to sustainability education, as in other courses, may have increased control group sustainability competence, suppressing the observed effects of the SLI. However, external exposure was also possible in the intervention group, leading to potentially overestimated effects of the SLI. Though intervention group students were asked not to share the SLI materials with students in other sections, it is also possible, especially since the intervention was a case study hosted on an open access platform, that students in the control group were exposed to the SLI. Future studies will benefit from efforts to record content covered in standard curriculum control groups and exposure to external sustainability education.

The fact that the water contamination crisis covered in the case continues to unfold in Ann Arbor must also be considered. Student respondents in the SLI evaluation study may have been exposed to information on the issue from news articles, local events, etc. However, throughout the facilitation of the mock town halls in

the intervention group sections such exposure was never mentioned. Conversely, several students noted surprise that they had been in Ann Arbor for several years without ever hearing of the dioxane groundwater contamination.

Sustainability competence is a broad and abstract concept, and the SCIP questionnaire may not have measured all aspects of it. Additionally, as the SCIP tool was originally validated in undergraduate engineering students, more research is needed to establish the validity and reliability of the SCIP tool in populations of nursing students. Operationalization is still ongoing, as several "laundry lists" of aspects of sustainability competence have been published (Glasser & Hirsh, 2016), including one specifically aligned with the nursing profession (Alvarez-Nieto et al., 2017). However, comprehensive, standardized, evaluated measures of sustainability competence are still in development. Some of this work is outlined below in directions for future research. In the absence of a gold standard measure, the Sustainability Cultural Indicators Program (SCIP) indices provides a locally relevant and validated measure of sustainability competence that can be tracked over time.

Conclusions

This dissertation establishes a baseline of sustainability competence among nursing students, which may be used to anchor longitudinal assessments. The findings of moderate sustainability competence among nursing students, along with little evidence of increasing competence throughout the nursing program, suggest an opportunity for nursing curricula to improve sustainability competence in students. The promising pilot results of the sustainability learning intervention evaluation suggest that

a drastic overhaul of nursing curricula may not be needed to develop sustainability competence in students. Rather, a modular integration of sustainability content at strategic points in current curricula may be effective. Small doses of education may be enough to prompt nursing students to begin applying a sustainability problem-solving lens to their practice. However, more evidence and further research is needed.

Future Research

Multi-site, large-sample studies of sustainability learning interventions are needed in diverse cultural settings to establish effectiveness at improving sustainability competence in nursing students. Further operationalization and instrument development are also needed to ensure comprehensive assessment of sustainability competence.

Many relevant sustainability competency frameworks have been developed, but further research is needed to synthesize and converge them. Five key competencies for sustainability were outlined by Wiek and colleagues (2011): systems-thinking, anticipatory, normative, strategic, and interpersonal competencies. Systems-thinking competency aids in the thorough understanding of sustainability challenges. Normative competence aids in the navigation of principles, values, and goals towards the development of sustainability visions. Anticipatory competency promotes the evaluation of future scenarios from different types of action in relation to the sustainability vision. Strategic competence guides action to implement the chosen solution toward the vision. Lastly, interpersonal competence is essential throughout the problem-solving process. Together, these competencies contribute to effective sustainability problem-solving

(Wiek et al., 2011). Subsequently operationalized into concepts, methods, and objectives for sustainability education to address (Wiek et al., 2016), these five key competencies provide a promising framework to assess sustainability competency.

However, validated, comprehensive quantitative measures of sustainability competence have yet to be developed. Following the release of the United Nations Sustainable Development Goals (2015), including goal 4 (Quality Education), which calls for all learners to acquire the knowledge and skills to promote sustainable development, a United Nations-affiliated organization began developing a measure of sustainability literacy called Sulitest (Sulitest.org, 2016). However, research on this tool is still limited. Qualitative assessment of sustainability competence may also give a deeper understanding of sustainability competence development, given the broad and abstract nature of the concept. A work group at the National Academies of Science is also currently in session to establish best practices for developing and measuring sustainability competence in higher education (National Academies of Science, Engineering, and Medicine, 2020). The project is set to be completed in 2020.

Future research may also investigate the development of sustainability competence in practicing nurses, which may face similar obstacles as in nursing students. For example, practicing nurses are also at risk of cognitive and emotional overload. Nurses bear witness and offer support in some of the most profound moments and intimate spaces in life: birth, illness, incarceration, education, death. Where other healthcare disciplines are necessarily specialized to specific aspects of human health and wellbeing, nurses are charged with integrating and healing the whole person – physical ailment, emotional burden, cognitive deficit, social isolation, spiritual

distress, and environmental hazard. This holism may be a double-edged sword. The same holistic thinking that makes nurses ideal change agents for sustainability, also burdens nurses with the perception of the whole range of patient needs. When patient suffering is immense, nurses perceive more need than they may humanly address, which can lead to nurse burnout (Nobre et al., 2019; Azevedo et al., 2019) and compassion fatigue (Lanier & Brunt, 2019). Under-resourced settings, such as hospital units with high nurse to patient ratios, exacerbate these difficulties (Cimiotti et al., 2012). If nurses do not have adequate time and resources to care for their patients and themselves, sustainability problem-solving to improve upstream and distal environmental conditions may be exceedingly difficult. Qualitative methods wil be helpful in understanding the complexity of the barriers and supports to the development of sustainability competence in nurses.

Lastly, we are not just interested in increasing sustainability competence among nurses. Ideally, increased competence will lead to sustainable solutions that improve health and wellbeing for generations. Therefore, further research is needed to investigate how increased sustainability competence among nurses affects individual, community, and population health and wellbeing outcomes. Kirkpatrick's levels of evaluation, previously described in Chapter 2, provides a hierarchy of the maturity of evaluation of learning interventions (Kirkpatrick, 1994) and can be applied to guide the trajectory of future research in this area. Figure 2.1 illustrates these levels – from initial evaluation of student reaction of an intervention, through learning, behavior change, and finally to results or impact on society, which is the most difficult and complex type of evaluation. The work of this dissertation resides in the second level – evaluation of

learning. Following higher-powered studies of the effect of sustainability learning interventions on sustainability competence, higher-order evaluation may examine connections between developed sustainability competence, sustainability problem-solving, solutions, and resulting impacts on human health and wellbeing.

A Final Note in 2020

The crisis of 1,4-dioxane contamination in Ann Arbor's groundwater has continued to unfold throughout this dissertation work. As recently as February 3, 2020 the Ann Arbor City Council voted to again delay seeking Superfund designation after a meeting with the judge in the consent agreement case with the original polluter, Gelman Sciences Corporation (Stanton, 2020). However, full cleanup of the contamination will likely take years and some citizens of Ann Arbor are pushing for a city-led cleanup in hopes of accelerating the slow pace of action in both the consent negotiations and Superfund option. The nursing students who participated in the SLI should now be better prepared to respond to this and other local water quality issues they may encounter, and to advocate for sustainable solutions that will protect health and wellbeing for citizens.

This dissertation is one small contribution to address the existential and direly urgent sustainability challenges we face as a global community. In 2020, fifty years after the first Earth Day celebrations, we now have less than 10 years to act to prevent global temperature rise from surpassing 1.5 degrees Fahrenheit. According to the Intergovernmental Panel on Climate Change (IPCC, 2018), further warming will lead to

irreversible ecosystem damage and climate crises disproportionately affecting our most vulnerable communities.

This year, 2020, has also been deemed by the World Health Organization the International Year of the Nurse and the Midwife. It is time to bring the nursing discipline and profession back in alignment with its roots, to reemphasize the role of environment in the nurse-environment-person-health paradigm (Dossey, 2015). Continued work in this area may help nurses and nursing students find their voices in the vital landscape of sustainability efforts. No doubt this will require some internal critical reflection, as the nursing discipline grapples with its own historical oppression and roles (Vestraci, 1999; Watson, 1981). Ideally, such reflection will promote an inclusive vision of nursing united under the goal of healing – from selves to Earth – and mend patterns of self-sabotaging lateral violence within the field, sometimes referred to in literatures and in vernaculars as “nurses eating their young” (Sauer, 2012; Lieper, 2005; Meissner, 1986).

Take a moment to imagine what could be possible if three million nurses in this country and millions more globally were empowered to proactively problem-solve to minimize the deleterious health and wellbeing effects of sustainability challenges. In the end, it is the patients, families, and communities, both locally and globally, who stand to benefit. A cadre of nursing professionals prepared with sustainability competence could touch nearly every patient, student, inmate, family, and every community in this country.

We also celebrate the 200th birthday of Florence Nightingale this year, one of the earliest Western nursing leaders. In her seminal work *Notes on Nursing* (1860), she wrote that, “every woman must at some time or other of her life, become a nurse” (p.xv).

In the context of increased broad social challenges and explicit discussions of patriarchy and the gender binary in our society, this may be reinterpretable as “every *human* must at some time or other of their life, become a nurse.” A deepened capacity to heal sustainability challenges in the nursing profession may serve as a well spring for community members as we collectively deepen our healing contributions.

The future of the nursing discipline is bound to our collective ability to achieve a sustainable future. The web of sustainability challenges we face is vast and complex, and everyone is needed if we hope to achieve solutions. As sustainability competence is furthered in nurses, we may integrate this capacity into our patient and community education. The healing wisdom and cultures of care embedded in the nursing discipline and elsewhere will be essential if we hope to heal our fractured world. A fractured world that is beset, at the time of this writing, with a looming pandemic, the origins of which are environmental and epizootic (World Health Organization, 2020). The costs, in human lives and for beleaguered health care professionals have yet to be clearly seen. As I finish this work at home, in a state of social distancing that will months, perhaps a year and more , I find myself hoping that the collective lessons we learn from this crisis will be remembered, and applied as we face the climate crisis and other sustainability challenges to come. Together, let us dare to prioritize and protect our environment and collective health and wellbeing.

APPENDICES

APPENDIX A: Pre-Intervention Survey

Statement of Voluntary Consent

Principal Investigator: Megan Czerwinski, PhD Candidate

University of Michigan School of Nursing

You were selected to complete this survey because you are a student at the University of Michigan School of Nursing (UMSN). To evaluate our culture regarding the issue of sustainability, you will be asked questions about transportation, food, the environment, and energy.

- You must be at least 18 years old to complete the survey. By completing the survey, you are acknowledging that you are at least 18 years old.
- Participating in this study is completely voluntary. You can skip any question and can stop at any time.
- Your participation or non-participation will have no effect on your grade in any course, or on your standing at the UMSN.
- The survey should take about 15 minutes to complete.
- There are minimal risks related to completing this survey because the topic is not inherently sensitive.
- The benefit to participating is that your responses will advance our understanding of sustainability culture.
- Your answers and personal information will be kept confidential.
- Your name will not be linked to your responses; you will be asked to create your own anonymous study ID code.
- You may be asked to complete a follow-up survey this December 2018.
- Upon completion of the survey, you will have the option to provide your email address to be included in a drawing to win one of fifty prizes of $25.
- You will also have the opportunity to opt in to receive one email with additional information about sustainability at the University of Michigan and School of Nursing.
- Your email address will not be linked to your responses. Record of your email address will be destroyed by the study team after the prize drawing and/or sustainability information email.

- This survey was developed by the University of Michigan Survey Research Center (SRC) Survey Research Operations (SRO) in cooperation with John Callewaert, PhD, Integrated Assessment Program Director at the Graham Sustainability Institute of the University of Michigan.
- It has been adapted by Megan Czerwinski, BA, BSN, RN, PhD Candidate at the UMSN.
- The data for this study are being collected by Megan Czerwinski for completion of her dissertation research, in cooperation with Robert Marans, PhD, of the University of Michigan Survey Research Center (SRC) Survey Research Operations (SRO) and John Callewaert, PhD, Integrated Assessment Program Director at the Graham Sustainability Institute of the University of Michigan.
- If you have any questions about the study, please contact: Megan Czerwinski, maczerwi@umich.edu.

Please click below if you voluntarily consent to participate in this study. Otherwise, please exit the survey by closing your browser now.

○ I voluntarily consent to participate in the above described research study.

Please create an anonymous individual identification code by following the instructions below. If you are eligible for a follow-up survey at the end of the semester, we will ask you to replicate this ID code so that we may match your responses at each time point.

Please use all lower case letters, no spaces.

- Number of siblings you have
- First two letters of your eldest parent's FIRST name (if N/A, enter XX)
- Last two digits of your phone number
- First two letters of your youngest parent's FIRST name (if N/A, enter XX)
- First two digits of your address

These questions are about travel and transportation.

(Sustainable Travel & Transportation Awareness)

How much do you know about the following?

	A lot	A fair amount	A little	Not much/ nothing
a. Bus, AATA/"The Ride" (Ann Arbor Transportation Authority schedules, routes, etc.)	○	○	○	○
b. Bus, U-M	○	○	○	○
c. Biking in Ann Arbor (bike lanes, rules of the road, etc.)	○	○	○	○
d. Renting a car by the hour (e.g. Zipcar)	○	○	○	○

(Travel Behavior)

Since the start of the fall semester, how do you most often travel to and from campus?

- ○ Drive a car
- ○ Park and Ride (the bus)
- ○ Walk
- ○ Bike
- ○ Ride the bus
- ○ Ride the bus and bike
- ○ Ride share (i.e. van / car pool, dropped off, etc.)
- ○ Motorcycle, moped, or scooter
- ○ Other *(please specify)*:

These questions are about waste prevention and conservation.

(Waste Prevention Awareness)

How much do you know about the following at U-M?

	A lot	A fair amount	A little	Not much/ nothing
a. Recycling glass	○	○	○	○
b. Recycling plastic	○	○	○	○
c. Recycling paper	○	○	○	○
d. Recycling electronic waste (i.e. computers, cell phones)	○	○	○	○
e. Property Disposition Services	○	○	○	○

(Conservation Behavior)

During the past year, how often did you do the following when you had the opportunity?

	Never	Rarely	Sometimes	Always/Most of the time	*Not Applicable*
a. Turn off lights when I leave the room	○	○	○	○	○
b. Use the power saving settings on my computer	○	○	○	○	○
c. Turn off my home computer when not using it	○	○	○	○	○
d. Use a motion sensor/ "smart" power strip	○	○	○	○	○

(Waste Prevention Behavior)

During the past year, how often did you do the following when you had the opportunity?

	Never	Rarely	Sometimes	Always/ Most of the time	*Not Applicable*
a. Print double-sided	○	○	○	○	○
b. Recycle bottles, containers, and paper products	○	○	○	○	○
c. Use a reusable water bottle, coffee cup, travel mug, etc.	○	○	○	○	○
d. Use U-M Property Disposition Services to obtain items such as computers, furniture, and equipment	○	○	○	○	○

(Natural Environment Protection Awareness)

These questions are about the natural environment.

How much do you know about the following?

	A lot	A fair amount	A little	Not much/ nothing
a. Disposing of hazardous materials (i.e. engine oil, medications, etc.)	○	○	○	○
b. Recognizing invasive plant species	○	○	○	○
c. Taking care of residential property in an environmentally-friendly way	○	○	○	○
d. Protecting rivers, streams, and lakes - their tributaries, habitat quality, and native species (e.g. Huron River)	○	○	○	○

(Protecting the Natural Environment)

During the past year, at your current residence, how often did you do the following?

	Regularly	Sometimes	Rarely	Never	*Not Applicable*
a. Use fertilizer on your lawn	○	○	○	○	○
b. Use commercial herbicides or pesticides	○	○	○	○	○
c. Water your lawn	○	○	○	○	○

(Sustainable Foods Awareness)

These questions are about food.

How much do you know about each of the following kinds of food?

	A lot	A fair amount	A little	Not much/ nothing
a. Locally grown or processed	○	○	○	○
b. Organic	○	○	○	○
c. Fair trade food	○	○	○	○
d. Food from humanely-treated animals	○	○	○	○
e. Food from animals that were not given hormones or antibiotics	○	○	○	○
f. Grass-fed beef	○	○	○	○
g. Fish from sustainable fisheries	○	○	○	○

(Sustainable Food Purchases)

During the past year, about how often did you (or other household members) buy the following?

	Always/ most of the time	Sometimes	Rarely	Never	*Don't know*	*I don't eat this*
a. Locally grown or processed	○	○	○	○	○	○
b. Organic	○	○	○	○	○	○

"Sustainable food" can be defined as one or more of the following: locally-sourced, organic, from humanely-treated animals, antibiotic- and hormone-free, grass-fed, from sustainable fisheries, or fair trade food.

During the past year, about how much of your grocery purchases were sustainable food?

- ○ All/most
- ○ More than half
- ○ Half
- ○ Less than half
- ○ None
- ○ I don't know

(Sustainability Engagement Generally)

These questions cover other activities and your opinions about sustainability.

Have you done any of the following during the past year to promote sustainability issues such as environmental protection, energy or water conservation, open space preservation, public or non-motorized transportation, etc.?

	Yes	No
a. Given money to an organization or advocacy group supporting one of the above issues?	○	○
b. Volunteered for an organization or advocacy group supporting one of the above issues?	○	○
c. Served in a leadership position for an organization or advocacy group supporting one of the above issues?	○	○
d. Voted for a candidate for public office because of her/his position on any of the above issues?	○	○

(Sustainability Encouragement)

During the past year how often have you encouraged your friends to do the following things?

	Never	Rarely	Sometimes	Frequently	*Don't Know*
a. Walk, bike, or take the bus rather than drive	○	○	○	○	○
b. Buy locally sourced or sustainable food	○	○	○	○	○
c. Conserve water	○	○	○	○	○
d. Conserve electricity	○	○	○	○	○
e. Reuse or recycle containers or bags	○	○	○	○	○
f. Buy fewer things	○	○	○	○	○
g. Buy things that are better for the environment	○	○	○	○	○
h. Use environmentally-friendly ways of controlling insects, weeds, and pests	○	○	○	○	○
i. Do something in order to reduce his/her greenhouse gas emissions	○	○	○	○	○

(Sustainability Disposition)

How much would you be willing to personally pay each year to:

	Nothing	$1 - $10	$11 - $20	$21 - $30	$31 - 40	$41 - 50
a. Expand waste prevention efforts, such as recycling and green purchasing at U-M	○	○	○	○	○	○
b. Expand alternative transportation efforts such as buses, bikes, and carpools at U-M	○	○	○	○	○	○
c. Expand efforts to lower greenhouse gas emissions at U-M through energy conservation and renewable sources	○	○	○	○	○	○

(Sustainability Commitment)

Overall, how committed are you to sustainability? Are you:

- ○ Very committed
- ○ Somewhat committed
- ○ Not very committed
- ○ Not at all committed

(U-M Sustainability Initiatives Awareness)

These questions are about sustainability at the University of Michigan.

How aware are you of U-M's efforts to:

	Very aware	Somewhat aware	Not too aware	Not at all aware
a. Conserve energy?	○	○	○	○
b. Encourage people to take a bus or bike?	○	○	○	○
c. Promote ride sharing?	○	○	○	○
d. Promote recycling?	○	○	○	○
e. Promote food from sustainable sources?	○	○	○	○
f. Reduce greenhouse gas emissions?	○	○	○	○
g. Maintain campus grounds in an environmentally-friendly manner?	○	○	○	○
h. Protect the Huron River?	○	○	○	○

(Sustainability Engagement at U-M)

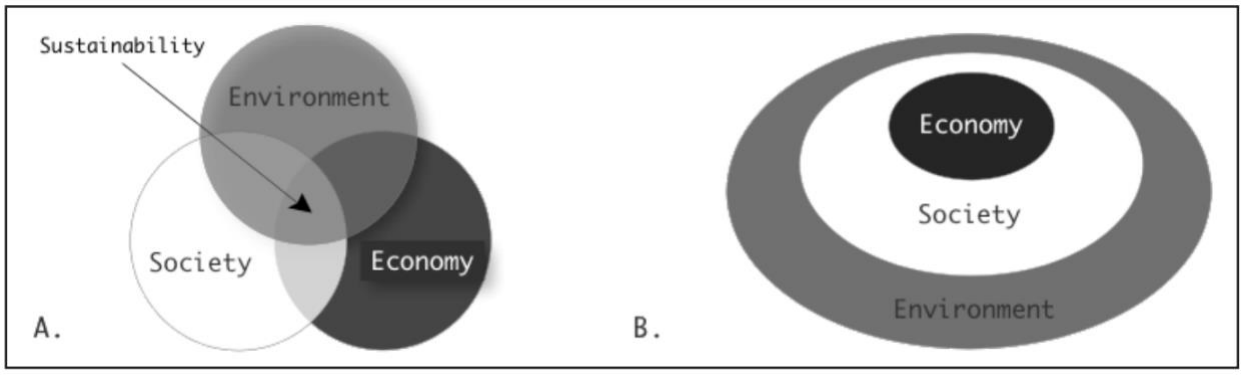
Have you ever participated in any of the following at U-M?

	Yes	No
a. Earthfest	○	○
b. A U-M organization dealing with sustainability	○	○
c. A U-M course that addresses sustainability	○	○

(Sustainability Visualization)

The visualizations below depict alternative relationships among economy, society, and the environment using two sustainability lenses. Please choose the visualization that best reflects your conceptualization of this relationship.

(Reprinted from Glasser & Hirsh, 2016)



○ A.

○ B.

(SANS – Sustainability Attitudes in Nursing Survey from Richardson et al., 2015)

"Sustainability in healthcare means designing and delivering health care that uses resources in ways that don't prejudice future health and wellbeing." (Naylor & Appleby, 2012, p. 2)

	Strongly disagree 1	2	3	4	5	6	Strongly agree 7
1. Climate change is an important issue for nursing	○	○	○	○	○	○	○
2. Issues about climate change should be included in the nursing curriculum	○	○	○	○	○	○	○
3. Sustainability is an important issue for nursing	○	○	○	○	○	○	○
4. Sustainability should be included in the nursing curriculum	○	○	○	○	○	○	○
5. I apply sustainability principles at home	○	○	○	○	○	○	○
6. I apply sustainability principles in my nursing practice	○	○	○	○	○	○	○
7. I am aware of unsustainable practice in my work/clinical environment	○	○	○	○	○	○	○
8. I challenge unsustainable practice in my work/clinical environment	○	○	○	○	○	○	○
9. I feel unable to challenge unsustainable practice in my work/clinical environment	○	○	○	○	○	○	○

(NEP – New Ecological Paradigm from Dunlap et al. 2000)

Please indicate your level of agreement or disagreement with the following statements:

	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1. We are approaching the limit of the number of people the earth can support.	○	○	○	○	○	○	
2. Humans have the right to modify the natural environment to suit their needs.	○	○	○	○	○	○	
3. When humans interfere with nature it often produces disastrous consequences.	○	○	○	○	○	○	
4. Human ingenuity will insure that we do not make the earth unlivable.	○	○	○	○	○	○	
5. Humans are severely abusing the environment.	○	○	○	○	○	○	
6. The earth has plenty of natural resources if we just learn how to develop them.	○	○	○	○	○	○	
7. Plants and animals have as much right as humans to exist.	○	○	○	○	○	○	
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.	○	○	○	○	○	○	
9. Despite our special abilities humans are still subject to the laws of nature.	○	○	○	○	○	○	

10. The so-called "ecological crisis" facing humankind has been greatly exaggerated.	○	○	○	○	○	○
11. The earth is like a spaceship with very limited room and resources.	○	○	○	○	○	○
12. Humans were meant to rule over the rest of nature.	○	○	○	○	○	○
13. The balance of nature is very delicate and easily upset.	○	○	○	○	○	○
14. Humans will eventually learn enough about how nature works to be able to control it.	○	○	○	○	○	○
15. If things continue on their present course, we will soon experience a major ecological catastrophe.	○	○	○	○	○	○

(Contextual control variables)

These questions are about you.

Are you a:

- ○ First-year student (Freshman)
- ○ Sophomore
- ○ Junior
- ○ Senior
- ○ Fifth-year (+) undergraduate student
- ○ Masters student
- ○ DNP student
- ○ PhD student

What is your age (in years)?

[ ]

What gender do you identify with?

- ○ Female
- ○ Male
- ○ Other
- ○ Choose not to respond

What is the highest educational level obtained by either of your parents?

- ○ Did not complete high school
- ○ High school diploma
- ○ Associate's degree
- ○ Bachelor's degree
- ○ Graduate or professional degree (PhD, Masters, MD, etc.)

Do you consider yourself a non-traditional student?

- ○ Yes *(please specify)* :

  [ ]

- ○ No

Are you a US or international student?

- ○ US student
- ○ International student

What race(s) do you identify with?

- ☐ Asian
- ☐ Black or African American
- ☐ Hawaiian or Pacific Islander
- ☐ American Indian or Native American
- ☐ White
- ☐ Two or more
- ☐ Other *(please specify)*:

- ☐ Choose not to respond

Do you identify as Hispanic or Latino/a?

- ○ Yes
- ○ No

Where have you lived since the start of the fall semester?

- ○ U-M residence hall
- ○ U-M community apartment
- ○ Off-campus apartment
- ○ Off-campus house
- ○ Off-campus Greek Life housing (sorority or fraternity)
- ○ Off-campus co-op housing
- ○ Parent's house
- ○ Other *(please specify)*:

What is your family's annual household income (before taxes)?

- ○ < $10,000
- ○ $10,000 - $29,999
- ○ $30,000 - $49,999
- ○ $50,000 - $69,999
- ○ $70,000 - $89,999
- ○ $90,000 - $109,999
- ○ $110,000 - $129,999
- ○ $130,000 - $149,999
- ○ > $150,000

Do you follow a certain diet all (or most) of the time?

- ○ Vegetarian
- ○ Vegan
- ○ Pescetarian
- ○ Paleo
- ○ Omnivore
- ○ Other *(please specify)*:

Please re-enter your anonymous study ID below.

Please use all lower case letters, no spaces.

- Number of siblings you have

- First two letters of your eldest parent's FIRST name (if N/A, enter XX)

- Last two digits of your phone number

- First two letters of your youngest parent's FIRST name (if N/A, enter XX)

- First two digits of your address

How satisfied are you with your survey experience?

- ○ Very satisfied
- ○ Somewhat satisfied
- ○ Neutral
- ○ Somewhat dissatisfied
- ○ Very dissatisfied

Any comments?

APPENDIX B: Post-Intervention Survey

Statement of Voluntary Consent

Principal Investigator: Megan Czerwinski, PhD Candidate

University of Michigan School of Nursing

You were selected to complete this survey because you are a student in the Community Health Nursing or Decision Science for Population Health course at the University of Michigan School of Nursing (UMSN). To evaluate our culture regarding the issue of sustainability, you will be asked questions about transportation, food, the environment, and conserving energy.

- You must be at least 18-years-old to complete the questionnaire.
- By completing the questionnaire, you are acknowledging that you are at least 18-years-old.
- Participating in this study is completely voluntary.
- You can skip any question and can stop at any time.
- Your participation or non-participation will have no effect on your grade in any course, or on your standing at the UMSN. It should take about 15 minutes to complete.
- There are minimal risks related to completing this survey, because the topic is not inherently sensitive.

- The benefit to participating is that your responses will advance our understanding of sustainability culture.
- Your answers and personal information will be kept confidential. Your name will not be attached to your responses; you will be asked to create your own anonymous study ID code.
- You were asked to complete a similar survey in September. Please try to replicate the study ID code you created in September.
- Upon completion of the survey, you will have the option to provide your email address to be included in a drawing to win one of thirty-two prizes of $25 (approximately 1 in 2 odds).
- You will also have the opportunity to opt in to receive one email with additional information about sustainability at the University of Michigan and School of Nursing. Your email address will not be linked to your responses. Record of your email address will be destroyed by the study team after the prize drawing and/or sustainability information email.
- This survey was developed by the University of Michigan Survey Research Center (SRC) Survey Research Operations (SRO) in cooperation with John Callewaert, PhD, Integrated Assessment Program Director at the Graham Sustainability Institute of the University of Michigan.
- It has been adapted by Megan Czerwinski, BA, BSN, RN, PhD-Candidate at the University of Michigan School of Nursing.
- The data for this study are being collected by Megan Czerwinski, for completion of her dissertation research, in cooperation with the Robert Marans, PhD, of

the University of Michigan Survey Research Center (SRC) Survey Research Operations (SRO) and John Callewaert, PhD, Integrated Assessment Program Director at the Graham Sustainability Institute of the University of Michigan.

- If you have any questions about the study, please contact: Megan Czerwinski, maczerwi@umich.edu.

Please click below if you voluntarily consent to participate in this study. Otherwise, please exit the survey by closing down your browser now.

○ I voluntarily consent to participate in the above described research study.

Which course section below were you enrolled in this term?

- ○ NURS456 PNE 401
- ○ NURS456 PNE 402
- ○ NURS456 PNE 403
- ○ NURS456 PNE 404
- ○ NURS456 PNE 406
- ○ NURS456 PNE 407
- ○ NURS456 PNE 408
- ○ NURS456 PNE 409
- ○ NURS456 PNE 410
- ○ NURS681 Decision Science for Population Health

Did you participate in the Ann Arbor dioxane groundwater contamination Michigan Sustainability Case in seminar this term?

- ○ Yes
- ○ No
- ○ I don't know.

Beyond this point the Post-Intervention Survey is identical to the Pre-Intervention Survey.

APPENDIX C: Aim 2 Regression Results

Table C-1: Aim 2 Total Sustainability Competence and Component Composite Regressions

	Total Sustainability Competence	Knowledge Composite	Skills Composite	Attitude Composite
Years of Education	-0.05	-0.054	-0.066	-0.03
	-1.18	-0.92	(2.01)*	-0.41
Age	0.024	0.02	0	0.051
	(2.15)*	-1.26	-0.05	(2.66)**
Gender: Male	0.474	0.609	0.16	0.653
	(2.47)*	(2.26)*	-1.07	-1.96
Race: Asian	-0.157	-0.264	0.074	-0.281
	-0.98	-1.17	-0.59	-1
Race: Black	-0.682	-0.926	-0.162	-0.957
	(2.12)*	(2.05)*	-0.65	-1.71
Hispanic Ethnicity	0.156	-0.166	0.058	0.576
	-0.62	-0.47	-0.3	-1.32
$30-70K	0.117	0.06	0.105	0.186
	-0.56	-0.2	-0.65	-0.51
$70-110K	0.354	0.18	0.282	0.601
	-1.6	-0.58	-1.64	-1.55
>$110K	0.109	0.016	0.119	0.191
	-0.52	-0.06	-0.73	-0.52
Parents' Education: Bachelor's Degree	0.057	0.177	0.126	-0.133
	-0.38	-0.84	-1.08	-0.51
Parents' Education: > Bachelor's Degree	0.12	0.23	0.147	-0.017
	-0.85	-1.16	-1.34	-0.07
International Student	0.473	0.489	0.289	0.64
	-0.88	-0.65	-0.7	-0.68
Off Campus Housing	-0.006	-0.282	0.096	0.167
	-0.04	-1.22	-0.75	-0.58
Greek Life Housing	0.176	0.103	0.001	0.424
	-0.62	-0.26	0	-0.86
Parents' House	0.106	0.032	-0.176	0.461
	-0.37	-0.08	-0.79	-0.91
Constant	4.284	4.303	5.253	3.296
	(8.30)**	(5.93)**	(13.12)**	(3.66)**
R_2	0.05	0.04	0.06	0.07
N	380	380	380	380

* $p<0.05$; ** $p<0.01$

Table C-2: Aim 2 Knowledge Index Regressions

	Sustainable Travel and Transportation Awareness	Waste Prevention Awareness	Natural Environment Protection Awareness	Sustainable Foods Awareness	U-M Sustainability Initiatives Awareness
Years of Education	0.002	-0.154	-0.037	0.153	-0.236
	-0.02	-1.77	-0.44	-1.63	(2.60)**
Age	-0.055	0.023	0.08	0.04	0.01
	(2.50)*	-1.03	(3.67)**	-1.62	-0.43
Gender: Male	0.941	0.801	1.144	0.088	0.071
	(2.45)*	(2.02)*	(3.02)**	-0.21	-0.17
Race: Asian	-0.269	-0.345	-0.337	-0.338	-0.032
	-0.83	-1.04	-1.06	-0.94	-0.09
Race: Black	-0.098	-0.752	-1.237	-1.388	-1.157
	-0.15	-1.13	-1.95	-1.94	-1.68
Hispanic Ethtnicity	-0.386	-0.498	-0.674	-0.028	0.755
	-0.77	-0.96	-1.36	-0.05	-1.4
$30-70K	-0.195	0.049	0.125	-0.002	0.322
	-0.47	-0.11	-0.3	0	-0.72
$70-110K	-0.117	0.264	0.444	-0.063	0.369
	-0.26	-0.58	-1.01	-0.13	-0.78
>$110K	-0.288	-0.106	0.125	0.26	0.09
	-0.69	-0.25	-0.3	-0.56	-0.2
Parents' Education: Bachelor's Degree	0.146	0.056	-0.187	0.556	0.314
	-0.48	-0.18	-0.63	-1.66	-0.97
Parents' Education: > Bachelor's Degree	0.194	0.388	-0.164	0.542	0.19
	-0.69	-1.33	-0.59	-1.73	-0.63
International Student	2.49	1.317	0.371	-2.6	0.867
	(2.32)*	-1.19	-0.35	(2.18)*	-0.75
Off Campus Housing	0.402	-0.143	-0.775	-0.816	-0.077
	-1.22	-0.42	(2.38)*	(2.22)*	-0.22
Greek Life Housing	0.739	0.032	-0.417	-0.223	0.385
	-1.31	-0.05	-0.75	-0.36	-0.64
Parents' House	0.268	0.294	-0.06	-0.596	0.256
	-0.46	-0.49	-0.1	-0.93	-0.41
Constant	4.231	5.351	1.957	1.585	8.391
	(4.09)**	(5.02)**	-1.92	-1.38	(7.57)**
R_2	0.07	0.04	0.1	0.07	0.07
N	380	380	380	380	380

* $p<0.05$; ** $p<0.01$

Table C-3: Aim 2 Skills Index Regressions

	Conservation Behavior	Travel Beavior	Waste Prevention Behavior	Sustainable Food Purchases	Protecting the Natural Environment	Sustainability Engagement at U-M	Sustainability Engagement Generally
Years of Education	-0.113	-0.658	-0.019	-0.073	-0.099	-0.045	0.008
	-1.52	(4.40)**	-0.39	-1.01	-1.1	-0.67	-0.08
Age	0.025	-0.161	-0.019	0.075	-0.053	-0.011	0.034
	-1.29	(4.11)**	-1.56	(4.02)**	(2.23)*	-0.63	-1.3
Gender: Male	-0.069	0.998	-0.164	0.378	0.072	0.295	0.022
	-0.2	-1.47	-0.76	-1.16	-0.18	-0.97	-0.05
Race: Asian	0.314	0.238	0.155	0.166	-0.316	0.261	0.111
	-1.11	-0.42	-0.86	-0.6	-0.92	-1.02	-0.29
Race: Black	-0.058	-1.092	-0.228	-1.046	1.208	0.334	-1.375
	-0.1	-0.96	-0.63	-1.91	-1.76	-0.66	-1.81
Hispanic Ethnicity	0.091	-0.133	0.01	-0.119	0.825	0.044	-0.649
	-0.21	-0.15	-0.04	-0.28	-1.54	-0.11	-1.09
$30-70K	-0.153	-1.445	0.278	0.29	0.021	0.348	0.284
	-0.42	-1.95	-1.18	-0.82	-0.05	-1.05	-0.57
$70-110K	0.038	-1.213	0.419	0.584	-0.103	0.566	0.664
	-0.1	-1.54	-1.68	-1.55	-0.22	-1.61	-1.26
>$110K	0.139	-1.108	0.395	0.467	-0.625	0.076	0.685
	-0.38	-1.49	-1.68	-1.31	-1.4	-0.23	-1.38
Parents' Education: Bachelor's Degree	0.148	1.115	-0.072	0.657	0.292	0.044	-0.267
	-0.56	(2.09)*	-0.42	(2.57)*	-0.91	-0.18	-0.75
Parents' Education: > Bachelor's Degree	-0.105	1.227	0.051	0.412	0.444	0.25	-0.075
	-0.42	(2.46)*	-0.33	-1.72	-1.47	-1.12	-0.23
International Student	0.357	2.525	-0.127	-0.373	1.296	-0.329	-0.983
	-0.38	-1.33	-0.21	-0.41	-1.13	-0.39	-0.78
Off Campus Housing	0.099	0.221	0.101	-0.06	1.385	0.054	-0.692
	-0.34	-0.38	-0.54	-0.21	(3.93)**	-0.21	-1.77
Greek Life Housing	-0.288	1.01	-0.049	0.144	-0.715	0.171	0.867
	-0.58	-1.01	-0.16	-0.3	-1.18	-0.38	-1.3
Parents' House	-0.041	-3.287	0.198	-0.17	-0.176	0.532	-0.821
	-0.08	(3.20)**	-0.61	-0.35	-0.28	-1.16	-1.2
Constant	7.452	20.34	7.35	4.227	9.524	1.084	1.014
	(8.21)**	(11.10)**	(12.67)**	(4.82)**	(8.63)**	-1.33	-0.83
R_2	0.02	0.36	0.04	0.08	0.12	0.04	0.05
N	380	380	380	380	380	380	380

* $p<0.05$; ** $p<0.01$

Table C-4: Aim 2 Attitude Index Regressions

	Sustainability Commitment	Sustainability Disposition
Years of Education	-0.094	0.034
	-1.14	-0.36
Age	0.061	0.042
	(2.82)**	-1.72
Gender: Male	0.783	0.524
	(2.10)*	-1.24
Race: Asian	-0.206	-0.356
	-0.66	-1
Race: Black	0.441	-2.356
	-0.71	(3.32)**
Hispanic Ethnicity	0.637	0.516
	-1.3	-0.93
$30-70K	0.385	-0.012
	-0.95	-0.03
$70-110K	0.451	0.751
	-1.04	-1.53
>$110K	-0.076	0.457
	-0.19	-0.99
Parents' Education: Bachelor's Degree	0.444	-0.71
	-1.52	(2.14)*
Parents' Education: > Bachelor's Degree	0.468	-0.503
	-1.71	-1.62
International Student	-0.165	1.445
	-0.16	-1.22
Off Campus Housing	0.167	0.167
	-0.52	-0.46
Greek Life Housing	0.537	0.31
	-0.98	-0.5
Parents' House	1.204	-0.282
	(2.14)*	-0.44
Constant	5.317	1.274
	(5.29)**	-1.12
R_2	0.07	0.09
N	380	380

* $p<0.05$; ** $p<0.01$

APPENDIX D: Aim 3 Regression Results

Table D-1: Aim 3 Total Sustainability Competence and Component Composite Regressions

	Total Sustainability Competence	Knowledge Composite	Skills Composite	Attitude Composite
Intervention Group	-0.311	-0.585	-0.49	0.141
	-0.82	-1.15	-1.62	-0.25
Post-Intervention Timepoint	-0.218	-0.684	-0.008	0.037
	-0.55	-1.05	-0.03	-0.08
Intervention Group * Post-Intervention Timepoint	0.84	1.76	0.489	0.271
	-1.9	(2.51)*	-1.35	-0.43
Constant	4.328	3.968	5.015	4
	(13.19)**	(8.98)**	(19.06)**	(9.20)**
R_2	0.07	0.12	0.08	0.01
N	70	70	70	70

* $p<0.05$; ** $p<0.01$

Table D-2: Aim 3 Knowledge Indices Regressions

	Knowledge Composite	Sustainable Travel and Transportation Awareness	Waste Prevention Awareness	Natural Environment Protection Awareness	Sustainable Foods Awareness	U-M Sustainability Initiatives Awareness
Intervention Group	-0.585	-0.954	-1.322	0.167	0.258	-1.074
	-1.15	-1.02	-1.23	-0.26	-0.24	-1.33
Post-Intervention Timepoint	-0.684	-0.093	-1.481	0.093	-0.688	-1.25
	-1.05	-0.1	-1.21	-0.12	-0.55	(2.40)*
Intervention Group * Post-Intervention Timepoint	1.76	2.432	2.456	0.869	0.816	2.228
	(2.51)*	(2.25)*	-1.89	-0.99	-0.62	(3.00)**
Constant	3.968	3.519	4.296	1.852	4.339	5.833
	(8.98)**	(4.21)**	(4.24)**	(3.55)**	(4.50)**	(8.30)**
R_2	0.12	0.17	0.07	0.08	0.02	0.06
N	70	70	70	70	70	70

* $p<0.05$; ** $p<0.01$

Table D-3: Aim 3 Skills Indices Regressions

	Skills Composite	Conservation Behavior	Travel Behavior	Waste Prevention Behavior	Sustainable Food Purchases	Protecting the Natural Environment	Sustainability Engagement at U-M	Sustainability Engagement Generally
Intervention Group	-0.49	-1.3	-2.35	-0.848	-0.006	-0.245	0.769	-0.78
	-1.62	-1.87	-1.9	-1.73	-0.01	-0.42	(2.25)*	-0.65
Post-Intervention Timepoint	-0.008	0.37	-5.222	-0.093	-0.543	-0.131	0.12	0
	-0.03	-0.56	(4.70)**	-0.16	-0.9	-0.23	-1.02	0
Intervention Group * Post-Intervention Timepoint	0.489	0.783	1.299	0.509	0.288	0.899	0.392	0.577
	-1.35	-0.96	-0.93	-0.8	-0.42	-1.31	-0.66	-0.41
Constant	5.015	7.037	8.889	7.963	5.983	8.458	0	2.222
	(19.06)**	(12.17)**	(11.57)**	(17.59)**	(18.26)**	(22.42)**	0	-2
R_2	0.08	0.09	0.34	0.07	0.01	0.04	0.07	0.02
N	70	70	70	70	70	70	70	70

* $p<0.05$; ** $p<0.01$

Table D-4: Aim 3 Attitude Indices Regressions

	Attitude Composite	Sustainability Commitment	Sustainability Disposition
Intervention Group	0.141 -0.25	0.1 -0.16	0.182 -0.21
Post-Intervention Timepoint	0.037 -0.08	0 0	0.074 -0.08
Intervention Group * Post-Intervention Timepoint	0.271 -0.43	0.128 -0.2	0.413 -0.36
Constant	4 (9.20)**	5.926 (12.37)**	2.074 (2.74)**
R_2	0.01	0	0.01
N	70	70	70

* $p<0.05$; ** $p<0.01$

APPENDIX E: Sensitivity Analysis – Aim 2 Regression Results without Age

Table E-1: Sensitivity Analysis - Aim 2 Total Sustainability Competence and Component Composite Regressions

	Total Sustainability Competence	Knowledge Composite	Skills Composite	Attitude Composite
Years of Education	0.007	-0.007	-0.065	0.093
	-0.21	-0.16	(2.54)*	-1.61
Gender: Male	0.492	0.623	0.16	0.692
	(2.56)*	(2.32)*	-1.08	(2.05)*
Race: Asian	-0.17	-0.275	0.074	-0.309
	-1.05	-1.21	-0.59	-1.09
Race: Black	-0.586	-0.847	-0.161	-0.75
	-1.83	-1.89	-0.65	-1.34
Hispanic Ethtnicity	0.194	-0.135	0.059	0.657
	-0.77	-0.38	-0.31	-1.49
$30-70K	0.089	0.036	0.104	0.125
	-0.42	-0.12	-0.65	-0.34
$70-110K	0.328	0.158	0.281	0.546
	-1.48	-0.51	-1.64	-1.4
>$110K	0.096	0.006	0.119	0.163
	-0.46	-0.02	-0.73	-0.44
Parents' Education: Bachelor's Degree	0.009	0.138	0.125	-0.235
	-0.06	-0.66	-1.08	-0.9
Parents' Education: > Bachelor's Degree	0.073	0.191	0.146	-0.119
	-0.52	-0.98	-1.35	-0.48
International Student	0.503	0.514	0.29	0.705
	-0.93	-0.68	-0.7	-0.75
Off Campus Housing	-0.051	-0.318	0.095	0.071
	-0.31	-1.38	-0.75	-0.25
Greek Life Housing	0.158	0.088	0.001	0.384
	-0.56	-0.22	0	-0.77
Parents' House	-0.025	-0.076	-0.179	0.179
	-0.09	-0.19	-0.82	-0.36
Constant	4.011	4.078	5.248	2.706
	(7.97)**	(5.80)**	(13.54)**	(3.07)**
R_2	0.04	0.04	0.06	0.05
N	380	380	380	380

* $p<0.05$; ** $p<0.01$

Table E-2: Sensitivity Analysis - Aim 2 Knowledge Index Regressions

	Sustainable Travel and Transportation Awareness	Waste Prevention Awareness	Natural Environment Protection Awareness	Sustainable Foods Awareness	U-M Sustainability Initiatives Awareness
Years of Education	-0.131	-0.098	0.155	0.249	-0.211
	(1.97)*	-1.45	(2.35)*	(3.39)**	(3.00)**
Gender: Male	0.899	0.818	1.204	0.117	0.078
	(2.33)*	(2.07)*	(3.13)**	-0.27	-0.19
Race: Asian	-0.238	-0.358	-0.381	-0.359	-0.038
	-0.73	-1.08	-1.18	-1	-0.11
Race: Black	-0.322	-0.657	-0.914	-1.228	-1.115
	-0.5	-1	-1.43	-1.73	-1.63
Hispanic Ethtnicity	-0.474	-0.461	-0.547	0.035	0.771
	-0.94	-0.89	-1.09	-0.06	-1.44
$30-70K	-0.129	0.021	0.029	-0.05	0.31
	-0.31	-0.05	-0.07	-0.11	-0.69
$70-110K	-0.058	0.239	0.358	-0.106	0.358
	-0.13	-0.52	-0.81	-0.21	-0.75
>$110K	-0.258	-0.119	0.082	0.239	0.085
	-0.61	-0.27	-0.19	-0.51	-0.19
Parents' Education: Bachelor's Degree	0.256	0.01	-0.346	0.477	0.294
	-0.85	-0.03	-1.16	-1.44	-0.92
Parents' Education: > Bachelor's Degree	0.304	0.341	-0.322	0.463	0.17
	-1.08	-1.19	-1.15	-1.49	-0.57
International Student	2.42	1.346	0.472	-2.55	0.88
	(2.24)*	-1.22	-0.44	(2.14)*	-0.77
Off Campus Housing	0.505	-0.187	-0.924	-0.89	-0.096
	-1.53	-0.55	(2.81)**	(2.44)*	-0.27
Greek Life Housing	0.781	0.014	-0.478	-0.254	0.377
	-1.37	-0.02	-0.84	-0.4	-0.62
Parents' House	0.573	0.165	-0.5	-0.815	0.199
	-1	-0.28	-0.88	-1.29	-0.33
Constant	4.869	5.082	1.036	1.128	8.273
	(4.82)**	(4.92)**	-1.03	-1.01	(7.71)**
R_2	0.05	0.04	0.07	0.07	0.07
N	380	380	380	380	380

* $p<0.05$; ** $p<0.01$

Table E-3: Sensitivity Analysis - Aim 2 Skills Index Regressions

	Conservation Behavior	Travel Behavior	Waste Prevention Behavior	Sustainable Food Purchases	Protecting the Natural Environment	Sustainability Engagement at U-M	Sustainability Engagement Generally
Years of Education	-0.053	-1.044	-0.065	0.108	-0.225	-0.071	0.09
	-0.91	(8.76)**	-1.76	-1.9	(3.19)**	-1.37	-1.15
Gender: Male	-0.05	0.877	-0.178	0.434	0.033	0.287	0.047
	-0.15	-1.27	-0.83	-1.31	-0.08	-0.95	-0.1
Race: Asian	0.301	0.326	0.165	0.125	-0.288	0.267	0.093
	-1.06	-0.56	-0.91	-0.45	-0.83	-1.05	-0.24
Race: Black	0.043	-1.743	-0.306	-0.74	0.995	0.29	-1.237
	-0.08	-1.51	-0.85	-1.34	-1.45	-0.58	-1.64
Hispanic Ethnicity	0.13	-0.387	-0.02	0.001	0.741	0.027	-0.595
	-0.3	-0.43	-0.07	0	-1.38	-0.07	-1
$30-70K	-0.183	-1.253	0.301	0.2	0.084	0.361	0.243
	-0.5	-1.66	-1.28	-0.55	-0.19	-1.1	-0.49
$70-110K	0.011	-1.04	0.44	0.503	-0.047	0.578	0.627
	-0.03	-1.3	-1.76	-1.31	-0.1	-1.65	-1.19
>$110K	0.125	-1.021	0.405	0.426	-0.597	0.082	0.667
	-0.34	-1.35	-1.72	-1.17	-1.33	-0.25	-1.34
Parents' Ed: Bachelor's Degree	0.099	1.435	-0.033	0.507	0.397	0.065	-0.335
	-0.38	(2.66)**	-0.2	-1.96	-1.24	-0.28	-0.95
Parents' Ed: > Bachelor's Degree	-0.154	1.545	0.09	0.263	0.548	0.271	-0.142
	-0.63	(3.06)**	-0.57	-1.09	-1.83	-1.23	-0.43
International Student	0.389	2.322	-0.151	-0.278	1.23	-0.343	-0.94
	-0.41	-1.2	-0.25	-0.3	-1.07	-0.41	-0.74
Off Campus Housing	0.052	0.523	0.137	-0.201	1.483	0.075	-0.756
	-0.18	-0.88	-0.74	-0.71	(4.22)**	-0.29	-1.95
Greek Life Housing	-0.307	1.133	-0.035	0.086	-0.675	0.179	0.84
	-0.62	-1.11	-0.11	-0.18	-1.11	-0.4	-1.26
Parents' House	-0.179	-2.401	0.305	-0.586	0.114	0.592	-1.009
	-0.36	(2.34)*	-0.96	-1.19	-0.19	-1.32	-1.5
Constant	7.163	22.191	7.573	3.359	10.13	1.21	0.622
	(8.14)**	(12.24)**	(13.44)**	(3.87)**	(9.42)**	-1.53	-0.52
R_2	0.02	0.33	0.03	0.04	0.11	0.03	0.04
N	380	380	380	380	380	380	380

* $p<0.05$; ** $p<0.01$

Table E-4: Sensitivity Analysis - Aim 2 Skills Index Regressions

	Sustainability Commitment	Sustainability Disposition
Years of Education	0.052	0.134
	-0.8	-1.84
Gender: Male	0.828	0.555
	(2.20)*	-1.31
Race: Asian	-0.239	-0.378
	-0.76	-1.06
Race: Black	0.687	-2.186
	-1.1	(3.10)**
Hispanic Ethtnicity	0.733	0.582
	-1.49	-1.05
$30-70K	0.312	-0.063
	-0.76	-0.14
$70-110K	0.385	0.706
	-0.89	-1.44
>$110K	-0.108	0.434
	-0.26	-0.94
Parents' Education: Bachelor's Degree	0.324	-0.793
	-1.11	(2.41)*
Parents' Education: > Bachelor's Degree	0.348	-0.585
	-1.27	-1.9
International Student	-0.089	1.498
	-0.08	-1.26
Off Campus Housing	0.054	0.089
	-0.17	-0.24
Greek Life Housing	0.49	0.278
	-0.88	-0.45
Parents' House	0.87	-0.512
	-1.56	-0.82
Constant	4.619	0.792
	(4.70)**	-0.72
R_2	0.05	0.08
N	380	380

* $p<0.05$; ** $p<0.01$

APPENDIX F: Sustainability Learning Intervention Evaluation Evidence Tables

Table F-1: Evidence Table - Identifying Existing Interventions

Intervention	Setting	Topical Themes	Pedagogical Themes
Single Day Interventions			
Plastic Resources Scenario (Richardson et al., 2014; Richardson et al., 2015; Grose & Richardson, 2016; Richardson et al., 2017)	Plymouth University (UK)	Natural resources; waste management; resource depletion; recycling; climate change; peak oil	Scenario-Based learning; practical; hands-on; skill session; E-learning; interactivity
Multidisciplinary Plastic Resources Scenario (Richardson et al., 2014; Grose et al., 2015)	Plymouth University (UK)	Natural resources; (healthcare) waste management; resource depletion; recycling; climate change; peak oil; sustainable healthcare; healthcare procurement; sustainability; environmental impact; carbon footprint; energy use; product life cycle assessment; geopolitical issues.	Scenario-based learning, interprofessional lens, multidisciplinarity; holistic; clinical skills stations/training; design-thinking; case study; experiential learning; complex problem-solving; contextual knowledge; situated learning theory; real-world opportunities; short talk/lecture; interactivity; informal user interviews; desk-based research; problem-based learning; communication; teamwork; active learning;
Multi-Day Sustainability Learning Interventions			
NurSus Toolkit (Álvarez-Nieto et al., 2018)	Plymouth University (UK), University of Jaén (Spain), University of Esslingen (Germany)	Environmental sustainability, climate change, resources	E-learning; digital technology, information technologies;
Sustainability Module (Aronsson, 2016)	Plymouth University (UK)	Social determinants of health, health inequalities, environmental sustainability, climate change, sustainable health promotion	Community engagement, interdisciplinary collaboration, reflexive approach, transformative sustainability learning, holistic learning;
Full Course Sustainability Learning Interventions			
Ecological Approach to Patient Care (Renigere, 2012; Bogdanova et al., 2017)	University of Latvia (Latvia)	Educational ecology; medical ecology; Sustainability/sustainable development, ecology of human development, deep ecology, ecosophy, value of human being & life; systemic thinking, living in harmony, professional empathy, I-Ego to I-Eco	Ecological approach, ecological competence, holistic approach; education for sustainable development;
Human Biology (de Souza e Silva, 2010)	Universidade Regional de Blumenau-SC (Brazil)	sustainable health promotion, promotion of life.	Eco-pedagogy, integral health, transdisciplinary approach, transformation, experiential learning, multimedia;
Nursing in the Global Context (Johnston et al., 2005)	York University (Canada)	Globalization, global health, environmental sustainability, health for all, global justice, limits of technology,	Experiential learning, active engagement;
Health Care Ethics and Leadership & Immersive Clinical (Woeber, 2013)	Emory University (USA)	Ecological footprints, personal behaviors, unsustainable habits, healthy behaviors,	Didactic exploration, Community Engagement, immersion clinical course, international engagement, site (needs) assessment

Table F-2: Evidence Table - Evaluating Rigor

Citation	Level of Evidence	Design	Time Point(s)	Control Group?	Sample	Measure(s)
Plastic Resources Scenario						
Richardson et al., 2014	VI	Descriptive, Qualitative	Post	No	N = 30 Undergraduates – child health (2nd year)	Observation and informal survey (quantitative & qualitative).
Richardson et al., 2015	III	Quasi-Experimental	Post	Yes	N = 57 Undergraduates – child & adult (control) (2nd year)	Formal survey with informal elements - SANS questionnaire - 6 Likert-type questions quantitative and qualitative.
Grose & Richardson, 2016	VI	Descriptive, Qualitative	Post	No	N = 293 – Undergraduates – child & adult health	Informal survey (quantitative & qualitative). 2 yes/no; room for comments; 2 open-ended
Richardson et al., 2017	VI	Descriptive, Qualitative	Pre & Post	No	N = 676 – Undergraduates (nursing & midwifery)	Formal survey with informal elements 7-point Sustainability Attitudes in Nursing Survey (SANS_2)
Multidisciplinary Plastic Resources Scenario						
Richardson et al., 2014	VI	Qualitative	Post	No	N = unspecified Nursing & design students	Informal, open-ended student responses and instructor statements - qualitative
Grose et al., 2015	VI	Descriptive, Qualitative	Post	No	N = 41 Undergraduates – nursing and design	Informal survey (quantitative and qualitative) Yes/no questions; room for comments.
NurSus Toolkit						
Álvarez-Nieto et al., 2018	VI	Descriptive, Qualitative	Post	No	N=299 nursing students N=22 professional evaluators	Spanish Standard for the assessment of Digital Educational Material Quality at University Level Questionnaire (COdA) (modified); open-ended questions (quantitative & qualitative)
Sustainability Module						
Aronsson, 2016	VI	Qualitative	Post	No	N = unspecified – Undergraduates	Informal, open-ended feedback on Post-Its.
Ecological Approach to Patient Care						
Renigere, 2012	VI	Descriptive	Pre & Post	No	N = 49 2nd years – nursing & medicine	Unvalidated (quantitative) survey.
Bogdanova et al., 2017	VI	Qualitative	Post	No	N = 30 1st & 2nd years – nursing & medicine	Informal (qualitative & quantitative) analysis of student essays-wrote about gains for personal growth, gains for professional development, and the relevance of the course in health care.
Human Biology						
de Souza e Silva, 2010	VI	Qualitative	Post	No	N = unspecified – Undergraduates – nursing & other disciplines.	Informal, open-ended student feedback post-course completion, observation.
Nursing in the Global Context						
Johnston et al., 2005	VI	Qualitative	Post	No	N = unspecified Undergraduates (4th year)	Informal course evaluations with open-ended questions (qualitative).
Health Care Ethics and Leadership & Immersive Clinical (2 consecutive courses)						
Woeber, 2013	VI	Descriptive, Qualitative	Post	No	N=30 Undergraduates	Informal (unvalidated) survey (quantitative).

Table F-3: Evidence Table - Assessing Outcomes

Citation	Evaluation	Component	Results and Conclusions
Plastic Resources Scenario			
Richardson et al., 2014	REACTION & LEARNING	-Knowledge	-Students demonstrated limited knowledge about natural resources in healthcare. -Students segregated waste appropriately. -All students found scenario helpful and realistic. -Nineteen reported being more aware of peak oil; 30 were more aware of risks if resources become unavailable; 30 reported greater awareness of healthcare waste management. -Comments indicated a high level of engagement and interest.
Richardson et al., 2015	REACTION & LEARNING	-Knowledge -Attitudes	-Students in both groups were positive about sustainability. -Intervention participants were more likely to correctly identify cost of waste disposal.
Grose & Richardson, 2016	REACTION	-----	-Large majorities of respondents reported the scenario both helpful and realistic.
Richardson et al., 2017	REACTION & LEARNING	-Knowledge -Attitudes	- Changes in attitude towards climate change, sustainability and inclusion of topics in nursing curricula (p=0.000); Participants demonstrated greater knowledge of natural resource use and the cost of waste disposal (p=0.000); Participants reported that sessions were realistic. -Students valued the interactivity; 73% of students strongly disagreed with preferring the session as a lecture.
Multidisciplinary Plastic Resources Scenario			
Richardson et al., 2014	REACTION	-----	-Positive reactions; Example response below: *"Skills sessions using sustainability scenarios can help nursing students to understand the effect climate change and resource scarcity will have on health care. Involving design students can encourage multidisciplinary working and help to find solutions to promote healthcare sustainability."*
Grose et al., 2015	REACTION & LEARNING	-Knowledge	100% thought the scenario was realistic and helpful/useful; 68.3% were more aware of peak oil; 97.6% were more aware of patient & system risks of resource scarcity; 100% were more aware of healthcare waste management; -Open-ended comments were largely positive. -e-tool prototype developed by design students and evaluated
NurSus Toolkit			
Álvarez-Nieto et al., 2018	REACTION & LEARNING	------	-Students, professionals, and technical experts considered the materials to be very good quality, especially r/t contents, format, and design; The Ability to generate learning was scored higher among students. -Statistically significant differences were found between the three universities (Welch: 11.69, $p < 0.001$).
Sustainability Module			
Aronsson, 2016	REACTION	-----	-Positive student reactions; Example response below: *"appreciated the reflexive approach … and holistic learning [though-provoking]."*
Ecological Approach to Patient Care			
Renigere, 2012	LEARNING	-Knowledge	- Improved knowledge and understanding on ecological approach in patients' care.
Bogdanova et al., 2017	REACTION & LEARNING	-Attitudes	-Student essays consistent with the forming and developing of ecological consciousness and competence.
Human Biology			
de Souza e Silva, 2010	REACTION	-----	-Positive student reactions
Nursing in the Global Context			
Johnston et al., 2005	REACTION	-----	-Positive student reactions; Example response below: *"We were continually encouraged to go beyond in nursing, to see further, care deeper."*
Health Care Ethics and Leadership & Immersive Clinical (2 consecutive courses)			
Woeber, 2013	REACTION & LEARNING	-Attitudes	-Positive student and faculty reaction; Students viewed sustainability as relevant for the curriculum

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