INTEGRATING SUSTAINABILITY EDUCATION INTO A HIGH SCHOOL
EARTH/ENVIRONMENTAL SCIENCE COURSE

A Dissertation
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Abstract

INTEGRATING SUSTAINABILITY EDUCATION INTO A HIGH SCHOOL

EARTH/ENVIRONMENTAL SCIENCE COURSE

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This action research study investigated ways to incorporate sustainability education into a rural public high school's Earth/Environmental Science course. State essential standards were organized around four sustainability themes with the goal to teach students to understand the interconnectedness of Earth's cultural, economic, and ecologic systems. Student responses to the action were analyzed. Results revealed that sustainability-based thematic teaching allowed for space to explore complex sustainability content that interwove ecological literacy, economic system critique, and equity/social justice. It also allowed for diverse, critically questioning perspectives that were often rooted in a local context, encouraging students to become engaged, critical thinking citizens of their local and global communities. The restructured thematic course provided a more flexible curriculum that enabled more time to engage in a participatory and experiential teaching and learning process. The public action step involved the creation of a publicly accessible pacing and curriculum guide that can be utilized by other educators.

Keywords: Sustainability Education; Secondary Education; Earth/Environmental Science

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I am grateful for my adopted home of Boone – the first place of my many homes where I intentionally and successfully set in roots. Its mountains held and helped re-ground me when giving up seemed like the only option. Appalachian State University's Sustainable Development department inspired me to care and fight for the place I so dearly love. I want to thank Chuck Smith for believing in my 23-year-old self when he allowed me to teach my first Sustainable Development class. That trust set me down the path that has led me here.

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Dedication

To my son, Aiden, for always reminding me what truly matters.

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Chapter I

Defining the Problem

Widespread drought, famine, war, wildfires.

Rising temperatures. Snowless winters. Slow erosion of topsoil and community.

Insatiable consumerism as worldwide mantra.

Top 1% owning more wealth than the rest of the 99% combined.

Standardized tests valued more than critical thinking.

In a world where today's realities can lead to an overwhelming sense of despair, what are we to do as educational leaders to create meaningful change? As a public-school teacher, educational leader, researcher, and activist living in a rural mountain community of Southern Appalachia, I am committed to helping awaken minds to the injustices of the world while also fostering hope and inspiration. The focus for this research originates from my longstanding belief that education has the potential to combat the ecological and humanitarian challenges our planet faces now and in the future.

Background of the Problem

To address planetary challenges, we must first recognize "that the crisis of global ecology is first and foremost a crisis of values, ideas, perspectives, and knowledge, which makes it a crisis *of* education, not one *in* education" (Orr, 2004, p. 126). Currently, mainstream education does not adequately prepare students to consider and confront the planet's most pressing issues, despite daily headlines of climate chaos and social inequity (Evans, 2012; Gruenewald, 2003, 2008). As Orr (1992, 2004) argues, the neoliberal influence on the Western modern education system has resulted in an obsession with creating capitalist-minded workers prepared to compete in the global economy.   This misdirected

focus fails to hold a space for imagining and creating an alternative future. Our current consumerism-oriented educational paradigm requires that the learner is prepared to measure natural resources by their economic value and rarely emphasizes the importance of environmental health or issues of social justice (Evans, 2012). Furthermore, by equating "progress" with production, profit, and consumption, we have created a culture that seeks to conquer and convert the natural world, oblivious to the reality that our health and well-being depend on its fragile ecosystem services (Bowers, 2012; Evans, 2012; Orr, 2004; UNESCO, 2012).

Sustainability education provides an alternative to the misguided goals of the dominant educational paradigm. Rooted in critical theory, sustainability education examines consumerism-based hegemonic structures, is global in scope, intimate with place, interdisciplinary, transformative, and aims to create engaged citizens—not voracious consumers (Evans, 2012; Sippos, Battisti, & Grimm, 2008; Sobel, 2005).

Statement of the Problem

As a relatively new public high school science teacher who felt the pressures of the dominant, consumerism-oriented educational structure, I undertook an action research project to develop an alternative Earth/Environmental Science pedagogy that allowed students to see the interconnections between economic activities, social inequities and environmental impacts (UNESCO, 1997). Informed by critical pedagogy and rooted in sustainability education, my action research can empower other passionate educators who feel bound by an education system obsessed with accountability, metrics, competition, and a misguided focus. My work aims to demonstrate that it is possible for teachers to incorporate a more meaningful and transformative type of education within the existing educational paradigm.

Another Way: What is Sustainability Education?

Just as ecologists understand that the *interactions* among biotic (living) and abiotic (nonliving) factors are what form and maintain an ecosystem, sustainability education affirms that students must comprehend the infinite interactions among our planet's social, economic, and environmental realms. Sustainability education aims to create just economic systems that respect and honor the ecosystems in which they exist and depend (McBride, Brewer, Berkowitz, & Borrie, 2013).

Sustainability education seeks to transform Western culture's affinity toward linear design and emphasizes the circular, diverse, and interconnected web. It goes beyond its counterparts of environmental education, critical pedagogy, and education for social justice (among others) by emphasizing the requirement to understand the deeply interconnected realities of our social, economic, and ecological systems. This preference for complexity and celebration of diversity is rooted in systems thinking that underpins the sustainability education movement (Bowers, 2012; Capra, 2002; Meadows & Wright, 2008; Orr, 2004). Sustainability Education also teaches students and teachers to recognize their previously unexamined habits of mind which have been shaped by the dominant culture – a culture designed to destroy and consume resources for economic gain (Bowers, 2012).

With a strong footing in critical theory (Evans, 2012), sustainability education is more than simply *knowing* about sustainability. It also involves action, critical thinking and questioning, analyzing assumptions and values, systems-thinking, and personal engagement with innovative solutions that honor traditional and local knowledge (Tilbury, 2011). With a plethora of appropriate praxes, "there are many ways to implement ESD [Education for Sustainable Development] successfully to help communities and countries meet their

sustainability goals and attend to the wellbeing of the planet and all its living inhabitants" (McKeown & Nolet, 2013, p. 7). Above all, sustainability education should empower students to not only know about sustainability related content but to also "prepare them how to engage in these complex issues and become problem solvers and change agents" (Burns, 2011, p. 1). This means that teachers are not able to "deliver" sustainability education to students but must reconsider the entire educational endeavor.

The Gap: Sustainability Education in Public K-12 Classrooms

While sustainability education has been growing in popularity and application over the past two decades, the most significant gains have been in the areas of higher education. Post-secondary classrooms are not tied to the strict, state mandated curricula or standardized-tests that secondary teachers must adhere to. This, along with many other factors, is one of the reasons this action research is so needed.

In the United States, the dominant K-12 education system is designed drastically different than the natural world in which it exists. While nature is complex and interconnected, mainstream teaching and learning could be best described as linear (Bernier, 2015). Each subject is compartmentalized, and rarely are students encouraged to see the interrelatedness of the multiple disciplines they are studying. Product is valued over process, and standardized tests are used to gauge student and teacher abilities. Both teachers and students in public schools are held hostage to high-stakes testing that prioritizes content over higher-order thinking (Au & Tempel, 2012). Since Congress passed the No Child Left Behind legislation in 2002, teachers have been expected to feed students information, and students have been expected to demonstrate mastery by selecting the correct multiple-choice question on a standardized test (Ackoff & Greenberg, 2008). School districts and teachers are rated based on test scores, creating an incentive to focus mainly (and often *only*) on

material that will be tested (Ravitch, 2013). This compartmentalized, competitive, and linear system of education discourages a broad understanding of the interconnectedness of social, economic, and natural systems in which schools and all humans exist.

There is a significant gap in the field documenting how sustainability pedagogy might be integrated into public high school classrooms. As a longtime advocate for K-12 sustainability education, I was provided a perfect opportunity to put theory to action when I was hired to teach Earth/Environmental Science in a public high school in North Carolina. As it turned out, my yearlong classroom action research project suggests that Earth/Environmental Science is an ideal incubator project for the efficacy of sustainability education in a public-school setting.

Action Research Purpose

Though the North Carolina Essential Standards for Science (NCDPI, 2016) do not dictate how to teach Earth/Environmental Science, the standardized final exam pushes many teachers toward an objectivist mode of teaching. In contrast, sustainability education requires that pedagogical techniques must shift far away from objectivism by fully embracing both constructivism and critical theory. This means the teacher must be creative, flexible, and have a solid understanding of the complexity found within sustainability education. In order to document and assess my journey of implementing both constructivism and critical pedagogy into my sustainability education course make-over, I utilized action research methods.

"Action" is the key of action research and requires that the practitioner/researcher develop a final or evolving plan of action to ameliorate an identified issue in the lived experience of the situation at hand (Herr & Anderson, 2014). Emancipatory in nature, action research has a moral imperative to fight for a better, freer world; not just publish theories

(Reason & Bradbury, 2001; Stuhmcke, 2012). Fighting for change can be understood on a sliding scale of personal to global. According to Kemmis (2009), an action researcher can aspire for change in three ways: change in their individual practice, a shift of personal conception of their practice, and/or changing the conditions in which they practice. In this way, action research is intentionally political and requires that practitioner/researchers take ownership for their actions (McNiff, Lomax, & Whitehead, 2003).

My choice of utilizing action research was both personal and political: practitioner-based research values the on-the-ground work of classroom teachers rather than relying on an outside 'professional' researcher to observe and interpret what is occurring within the study. Action research demands that the practitioner/researcher remain committed to the scholarly process of data collection, evidence-creation, disciplined reflection, and making claims to knowledge by drawing conclusions based on the collected evidence (McNiff, 2013). Action research is a way to articulate one's personal values and demonstrate how those values are coming to life through practice (McNiff, 2013).

Teacher research is reflective in nature, requiring that the practitioner/researcher constantly reflect on their own teaching practices and their understanding of students as learners (Burnaford, 2001). Ultimately, improved teacher practice is expected due to the ongoing reflection, problem solving, and constant self-reflective professional development that occurs during the study and beyond (Whitehead & McNiff, 2006). Through problem solving and curriculum improvement, teachers engaging in action research can bring about change in classrooms, schools, and communities (Burnaford, 2001). By focusing on solving problems through strategic and disciplined practitioner/research, significant improvements are inevitable.

I value the importance of educating youth about their interconnected role in the natural and cultural Earth and seek to live that value in my classroom. Action research was the ideal methodology for this endeavor because it required that I reflected on my reasons and purpose for integrating holistic sustainability education into the state-sanctioned curricular standards, documented my process, continually collected data and student-feedback on how the intervention was affecting my research participants (students), and implemented changes as needed to better my practice for the greater good of my classroom community.

Action research methodology allowed me to document, reflect, and analyze my journey of integrating sustainability themes that taught the intersections of social, ecologic, and economic influences into a pre-existing high school course; it also led to palpable change in both my classroom and my own personal practice. I remain optimistic that this project also made a positive change throughout my broader community. Theoretically, embracing sustainability education in the science classroom can help return science to its roots— the natural philosophy that encouraged an exploration of the natural world and invoked our sense of wonder and connection to nature— and away from its destructive path of science-as-a-tool-to-sell-more-products and compete in the global economy. It offers a potential antidote to the historical problems caused by a K-12 educational reform system that continues to aim at misdirected goals.

Research Questions and Significance

My goal, as a teacher and researcher, was to incorporate sustainability education— that investigates the linkages of society, ecology, and economies— into a rural North Carolina public high school Earth/Environmental Science course. Believing in the power of transformative education, I reimagined the secondary science classroom as supporting a new

generation of empathetic citizens who understand the interconnectedness of our planet's cultural, economic, and ecological systems.

Given these goals and my unique position as teacher-researcher, the following research questions guided my year-long action research project:

- RQ1: How can sustainability education that interweaves ecological literacy, economic system critique, and social justice be integrated within a state-sanctioned Earth/Environmental Science curriculum?

- RQ2: How do first-year high school students respond to sustainability education themes in a rural public high school Earth/Environmental Science course?

Below, I contextualize each research question, framing it in terms of significance to me, my students, fellow secondary science teachers, and the field of sustainability education scholarship more broadly.

In RQ1, I explored how to include sustainability education into a US public high school science course by incorporating economic and social justice literacy without compromising the state-sanctioned NC Essential Standards for Earth/Environmental Science (EEn). While the state-mandated EEn curriculum requires direct exploration of how humans impact the biosphere, lithosphere, hydrosphere, and atmosphere—sustainability education goes further, suggesting that it is complementary, and critically important, to support students in understanding the drivers behind human impacts on our shared water, air, land, and biotic resources. This is significant because the United States languishes in its national efforts to encourage and promote education for sustainable development, compared with other developed countries (Lee, Williams, & Stimpson, 2013). Educational leaders and teacher educators within the public K-12 system have not widely embraced the importance of sustainability education. Some individuals, locales, or even regions have adopted

environmental education goals, but few have made wide-scale commitments to adopt holistic sustainability educational goals that include social justice and a critical examination of mainstream economic norms. This first goal of this research project was to show that it is possible to weave sustainability themes throughout the semester without compromising student achievement on standardized tests.

In RQ2, I explored how the transformative nature of sustainability education resulted in a high degree of student engagement, critical reflection, and cross-disciplinary connections (connecting science with other disciplines such as humanities, civics and economics, specifically). The goal was for my students to benefit from not only the knowledge found within sustainability literacy but also from a combination of constructivist and emancipatory approaches to teaching and learning. This goal is rooted in the belief that it is beneficial for both students and all of posterity to share a holistic understanding of the interconnections between ecological health, social wellbeing, and just economic systems. By examining student-produced artifacts that were collected during the delivery of the redesigned curriculum, I was able to demonstrate the profound impact such an approach was able to make in terms of a shift in student perspectives and a growth in student knowledge. I am hopeful that I successfully inspired – and will continue to inspire – both students and teachers to pursue sustainability goals in their own lives.

Teacher as Researcher

As the teacher and researcher in this study, I refer to myself in the first person throughout this dissertation. I have been dedicated to studying and implementing formal and informal sustainability education throughout my adult career. My interest in sustainability and education was fostered during my time teaching in a post-secondary classroom where I taught twelve semesters of a university level course called Principles of Sustainable

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Development. My work as an informal educator began in 2013, when I created and directed

a school garden support program in my local community that directly supported six outdoor

garden classrooms. I was inspired to do this work because I strongly believe in the power of

connecting students to the natural world and growing food is one of the most direct

connections to nature that all humans share. During this time, I led many community and

teacher workshops aimed at promoting hands-on, outdoor learning. In 2016, I was hired to

teach an Earth/Environmental Science course as a full-time public-school teacher at a rural

high school. This career transition gave me the opportunity to put my passion to practice and

made it possible to investigate ways of interweaving sustainability principles into a

secondary public school science classroom.

As the start of this action research project that took place during the spring semester

of 2017, I was beginning my second-year teaching Earth/Environmental Science at a public

high school. During the spring and fall semesters of 2016, I began informally phasing in

sustainability related themes that incorporated social justice and economic studies into the

curriculum. With a long-standing commitment to education for sustainability, I began this

action research journey because I was interested in exploring whether my students were

positively affected by learning about the interconnections between science, ecology,

economics, and social justice. Ultimately, I have long been interested in finding practical

ways to create significant change because creating spaces for alternatives to flourish within

the mainstream is hard work. Some argue that the only solution to combat the gross

inequities and inefficiencies that plague the modern educational landscape involves a

complete and radical overhaul to our current educational systems (Childress & Amrofell,

2017; Gross & Gross, 1969); however, as a teacher positioned within a public school, I was

interested in exploring possibilities for integrating an alternative educational paradigm within

the existing system. I felt strongly that public school classrooms were a prime location to begin transforming young minds, shifting motivations away from the goals of consumption-obsessed culture and towards altruism, empathy, diversity, and interconnectedness.

Implications: Contributions to Scholarship and Professional Practice

Overall, this study contributes scholarship in four main ways: First, it demonstrates how to include sustainability education into a US public high school science course by incorporating economic and social justice literacy without compromising the state-sanctioned NC Essential Standards for Earth/Environmental Science. By providing an exemplar of 'ways to do' sustainability education in a science classroom, others may follow suit. This first goal shows that it is possible to weave sustainability themes throughout the semester without compromising student achievement on standardized tests. Second, it demonstrates that the transformative nature of sustainability education results in a high degree of student engagement, critical reflection, and cross-disciplinary connections (connecting science with other disciplines such as humanities, civics, and economics, specifically). Third, it has provided me with opportunities as a practitioner/researcher to reflect on my own teaching style, allowing me to integrate more constructivist, critical, and transformative pedagogical practices. Lastly, this project demonstrates that teachers are researchers and can make powerful, significant changes to their own practice while teaching, while also demonstrating the important role action research plays in this praxis-improving journey.

While it was not the goal of this action research study to make claims about long term impacts of the redesigned Earth/Environmental Science curriculum on student behavior, I was interested in identifying short term changes in student attitudes and my own personal journey of attempting to influence my students in this way. As McNiff (2013) describes, "Action research is about putting ideas into action, not only talking about them" (p. 51). As a

long-time sustainability education advocate, I was able to generate my own theory of living by putting my ideas to action while simultaneously conducting practical research that matters to me, my students, and the larger educational community. I remain hopeful that other science educators will find this sharing of a journey helpful and perhaps even relevant to their own practice. If sharing my journey can help others deepen their desire and build their confidence to interweave sustainability education into their course, I will feel beyond accomplished. If this journey positively affected at least one of my students, I will also consider this a successful endeavor.

Chapter Summary

This introductory chapter has highlighted the rationale for this study. The purpose of sustainability education was discussed as well as issues with the current trends in mainstream public K-12 education. The need for finding ways to incorporate sustainability education into public school classrooms was established. The research questions were developed from this identified need, and a brief overview of the researcher and research design was discussed.

Chapter II provides further literature related to the fields of sustainability and science education, including an in-depth discussion of the foundational framework for this study, the Burns model of sustainability pedagogy (Burns, 2011). Chapter III details the purpose, reasoning, and execution of the Action Research methodology utilized for this study. Chapter IV discusses and analyzes data for RQ1 by exploring the rationale for course restructuring and the creation of the pacing and curriculum guide. Chapter V discusses and analyzes RQ2 by examining student work and teacher reflections. Chapter VI provides a synthesis and conclusion to the study.

Chapter II

Literature Review

Integrating sustainability education into secondary schools represents a key strategy for ensuring that the public is more fully knowledgeable about the ways in which our most pressing environmental, economic, and social problems are intimately connected (Burns, 2011; UNESCO 2012, 2014). Identifying and delivering effective age-appropriate sustainability pedagogy for adolescents is an essential first step in helping students understand this truth and feel inspired to take action. Such a pedagogy must include transformative elements that engage students to understand complex sustainability issues and inspire them to work towards personal and systemic change. If the ultimate goal is to recruit public school teachers and districts to embrace this new educational approach, it is imperative to demonstrate that it is possible to implement transformative sustainability pedagogy without neglecting state-sanctioned objectives.

Before presenting evidence that this goal is possible, a review of relevant literature provides a theoretical and contextual foundation for the implemented curricular redesign of this action research project. To begin with, the key terms utilized in this dissertation are defined. Second, an overview of the background of sustainability and sustainability education is discussed, including international, national, regional, and local educational initiatives. Third, sustainability pedagogy is explored in order to lay a theoretical foundation for the restructured curriculum. Lastly, a variety of pedagogical techniques are discussed that allow for the incorporation of sustainability education into public secondary schools.

Defining and Historically Tracing Key Terms

Sustainability education, also known as Education for Sustainable Development (ESD) and Education for Sustainability (EfS), has been growing in popularity since its roots

were established at the 1992 Earth Summit in Rio De Janeiro. Sustainability education, ESD, and EfS are internationally recognized terms used by policy-makers and educators around the globe (Australian Research Institute for the Environment and Sustainability, 2017). The term 'sustainability education' is utilized by numerous peer-reviewed journals and higher education programs that have been established within the past decade (Journal of Sustainability Education, 2017; Prescott College, 2017).

While debate likely exists about which is the best term to use, many agree that the terms can be used interchangeably and that it is more important to focus on the goals and pedagogical processes rather than the term used (Australian Research Institute for the Environment and Sustainability, 2017). For the purposes of this research project, sustainability education will be predominantly used as a reference point to express the overarching goal of new kinds of curricula that seek to inspire and prepare students to become active citizens who work towards a more just, healthy, sustainable world for all life. Similarly, the term 'sustainability pedagogy' refers to the process of teaching and learning sustainability in order to achieve such goals (Burns, 2011).

I have intentionally decided against identifying sustainability education as a proper noun so as to demonstrate that I do not believe there is one proper way to implement nor achieve education for sustainability. Sustainability education can exist in both the formal (institutional) and informal (everyday) realms (Prescott College, 2017) and can be pursued in a wide variety of ways and means. The strength of education for sustainability is that its overarching goal is a noble one: "to alert educationists, broadly defined, to a shared concern for the future of both the planet and local communities" (Lee, Williams, & Stimpson, 2013, p. v). Additionally, transformative sustainability education refers to the broad goal of sustainability education, which is to promote and inspire individual, communal, and societal

change. In other words, to transform individuals, communities, and societies. What makes education transformative will be discussed in more depth later in this chapter.

History of Sustainability, Sustainable Development, and Sustainability Education

Sustainability embodies an age-old tradition that has been practiced by many communities around the world and throughout history (Cirillo & Hoyler, 2015). It refers to the notion that communities seek to improve the quality of life for all by simultaneously attending to environmental, social, and economic needs. Unfortunately, not all societies understand the importance of maintaining ecological health and promoting an equitable society. By the early 1980s, global pollution and poverty problems had reached a tipping point due to the rapid industrialization of the nineteenth and twentieth centuries. This led to the creation of the United Nations' World Commission on Environment and Development, which was charged with creating a "global agenda for change" to help guide the international community to adopt "common and mutually supportive objectives that take account of the interrelationships between people, resources, environment, and development" (Brundtland & The World Commission on Environment and Development, 1987, p. ix). Led by Norway's Prime Minister, Ms. Gro Harlem Brundtland, the commission created the seminal work *Our Common Future*. Often referred to as the Brundtland Report, the publication called for international cooperation to ensure a sustainable future for all (Brundtland & The World Commission on Environment and Development, 1987). The report highlighted how the rapid environmental destruction from the preceding century was harming the Earth's ability to sustain life and that the benefits of economic growth were not being shared equally around the globe (Brundtland & the World Commission on Environment and Development, 1987). Referred to as "the interlocking crises," the report argued that the falsely perceived

barriers between global issues must be broken down (Brundtland & The World Commission on Environment and Development, 1987, p. 4):

> Until recently, the planet was a large world in which human activities and their effects were neatly compartmentalized within nations, within sectors (energy, agriculture, trade), and within broad areas of concern (environmental, economic, social). These compartments have begun to dissolve… these are not separate crises… they are all one.

The Brundtland Report's international team of leaders called for a new type of development that balanced economic growth with environmental health and social well-being. They referred to this new way as 'sustainable development' and defined it as "meeting the needs of the present without compromising the ability of future generations to meet their needs" (Brundtland & The World Commission on Environment and Development, 1987, p. 8). The report also called for regular international meetings in which solutions would be proposed and discussed and progress would be assessed. The first international meeting that answered this call took place in Rio de Janeiro in 1992 and resulted in Agenda 21, a non-binding action agenda that proposed a framework to help implement sustainability goals on the local, regional, and international level (UNESCO, 1992). Chapter 36 of the document "Promoting Education, Public Awareness, and Training" placed explicit emphasis on the important role that education serves in working towards a sustainable future.

Ten years later, the World Summit for Sustainable Development re-emphasized the importance of education in the sustainability journey:

> Education not only informs people, it can change them. As a means for personal enlightenment and for cultural renewal, education is not only central to sustainable

development, it is humanity's best hope and most effective means in the quest to achieve sustainable development. (UNESCO, 2002, p. 8)

Koichiro Matsuura, the Director-General of UNESCO at this time, described the pathway towards sustainable development as a process of social change that requires *social learning,* meaning that individuals and cultural leaders must reflect on and reevaluate established mental models and assumptions (UNESCO, 2002, p. 28). UNESCO (2012) suggested moving beyond merely education and training and utilize "policy and legislation as opportunities for teaching and encouraging new forms of personal, community and corporate behaviour" (UNESCO, 2002, p. 28). Matsuura described four key lessons in our attempts to implement sustainable development as a social learning endeavor from its inception in 1987 until the World Summit on Sustainable Development in 2002. First, sustainable development is a "catalytic vision for social change rather than a neatly defined, technical concept" (UNESCO, 2002, p. 28). Second, it is both moral and scientific: "It is linked as much with notions of peace, human rights and fairness as it is with theories of ecology or global warming" (UNESCO, 2002, p. 28). Third, sustainability is inextricably linked to cultural understandings: what we value in terms of our relationships to each other and the natural world. Fourth, we must understand the interdependent reliance between humans and nature: the protection of nature cannot be more important than the wellbeing of humans and the exponential satisfaction of human desires must not deplete ecosystems.

Thus, the overarching takeaway from the first decade of international discussions on sustainable development was that our main challenge is to link social, economic and environmental concerns. Yet as Matsuura explained, "Creating such links demands a deeper, more ambitious way of thinking about education than perhaps we are used to" (UNESCO, 2002, p. 28). It also requires that a wide variety of education professionals participate: from

teachers to teacher educators; from curriculum developers to education policy-makers — all must be involved to help promote a new system of ethics and values that honors diverse cultures and the natural world.

Educating for a sustainable future is a formidable challenge. How do we meet the often conflicting demands of economy, society, and the environment? How do we teach students about the never-ending and complicated interactions within our Earth's systems? How do we reach equitable economic and social systems? The reality is that there is no one answer and that the process of asking such complex questions will ultimately lead to a new way of thinking about the world so that we can begin to redefine and reorient our common goals, values, and systems (UNESCO, 2002). This focus on sustainability as a process of learning – rather than a destination — underpins the essential nature of sustainability education.

Emergence of Sustainability Education as an International Goal

The acknowledgement of the importance of education in reaching sustainability goals resulted in organizations such as the United Nations to make an explicit effort to promote sustainability education. In fact, the United Nations declared 2005-2014 as the UN Decade of Education for Sustainable Development (ESD), promoting goals that focused on fostering peace, fighting global warming, increasing access to education for women and girls, decreasing inequalities between the global north and south, fighting poverty, and creating a new, more sustainable vision for the planet (UNESCO, 2005). UNESCO argued that education in all forms and at all levels should attempt to promote a different vision of the world that values quality of life for all through the reconciliation of economic growth, social development, and environmental protection (UNESCO, 2005). Such a goal requires an improvement in both access and quality of education in all communities around the globe.

The challenge also called for a reorientation of education programs from pre-K to post-secondary to focus on sustainability themes and issues. It called for a shift in public awareness through civic discussions, informal education, and responsible media. UNESCO (2005) also promoted improvements to vocational and technical training in that they should also be focused on sustainability themes and issues.

To support this focus on reorienting education to help achieve sustainability goals, UNESCO created a free online training tutorial called "Teaching and Learning for a Sustainable Future," intended for educators of all types, including textbook creation professionals and decision makers (www.unesco.org/education/tlsf). As explained on the website's welcome section:

> Teacher education is a priority for UNESCO and, indeed, for the international community as a whole… UNESCO [aims to] help teachers worldwide not only to understand sustainable development concepts and issues but also to learn how to cope with interdisciplinary, values-laden subjects in established curricula. (Matsuura, 2010, para 4)

This training program developed by UNESCO consists of 100 hours of professional development divided into 27 modules related to a variety of sustainability topics from women's issues to indigenous knowledge, from agriculture to consumer health, and from climate change to sustainable tourism.

The online professional development program begins with a comprehensive curriculum rationale which fully explains the reasons and purpose of a global effort to promote education for sustainable development. It then explains the importance of taking a comprehensive approach to educational reform and that sustainability education should extend beyond disciplinary boundaries. An entire training module is dedicated to illustrating

ways in which sustainability education can be successfully integrated into and across 12

different disciplines. The third module provides nine contemporary issues that can be

integrated into any curriculum to help emphasize a sustainable future. Some of the

interdisciplinary themes include culture and religion for a sustainable future, indigenous

knowledge & sustainability, women & sustainable development, population & development,

understanding world hunger, sustainable agriculture, sustainable tourism, sustainable

communities, globalization, and climate change (UNESCO, 2010). The final learning

module offers teaching and learning strategies that can help students practice a wide range of

objectives that support sustainability education goals. Pedagogical practices promoted by the

UNESCO training program include experiential learning, storytelling, values education,

inquiry learning, appropriate assessment, future problem solving, learning outside the

classroom, and community problem solving (UNESCO, 2010).

Much international progress was made thanks to UNESCO's concerted effort in

promoting education for sustainable development. The following section highlights findings

from the final report that summarized the efforts made during the United Nation's Decade of

Education for Sustainable Development.

International efforts towards sustainability education

At the conclusion of the United Nation's Decade of Education for Sustainable

Development, UNESCO (2014) published a final Global Monitoring and Evaluation Report

that mapped "the achievements and challenges of a decade of progress and action on ESD

[Education for Sustainable Development] at the global, regional, national and local levels —

and within all areas and levels of education" (p. 9). The report compiled survey responses

from 144 stakeholder countries and revealed that 80% of respondents reported appointing an

ESD focal point and that 66% of UNESCO member states had a national ESD strategy or plan (UNESCO, 2014).

A major focus of the Global Monitoring and Evaluation report was on policy related to sustainability education. On a regional level, major initiatives took place in all five United Nation regions (UNESCO, 2014). For example, the Council of the European Union encouraged Member States to mainstream sustainable development into curriculum and to promote whole-school sustainability initiatives at the local, regional, or national level (UNESCO, 2014). On the national level, many countries developed strategic frameworks during the last decade around sustainability education. Exemplars include Mauritius, Costa Rica, Finland, Kenya, New Zealand, Sweden, United Kingdom, Canada, Netherlands, and Australia (Tilbury & Cooke, 2005; UNESCO, 2014).

Taking New Zealand as an example, the Ministry of Education continues to promote a sustainability pedagogy that "equips young people to identify and think critically about sustainability issues and the choices necessary to secure a decent and humane future" (Te Kete Ipurangi, 2015, para. 3). New Zealand secondary educators are encouraged to model and promote five key competencies in Education for Sustainability: 1) To think critically about the social, environmental, economic, and cultural aspects of themselves and their communities; 2) To communicate in diverse ways about sustainability issues that can promote change; 3) To set individual goals to act towards sustainability; 4) To work collaboratively with others towards sustainability goals; 4) To understand the interdependence of society and the environment and how individuals can create sustainable or unsustainable futures (Te Kete Ipurangi, 2015).

The UNESCO final report revealed many promising details about the prevalence of sustainability education/ESD around the globe, as highlighted in the report's executive summary:

> In many countries, governments are integrating ESD into education to prepare their citizens to address the sustainability challenges that lie ahead. Meanwhile, individuals, schools, institutions of higher education, community-based organizations, international NGOs and the private sector have all joined in the challenge to advance learning towards a broader and deeper understanding and practice of sustainability… Moreover, positive advances can be seen in early childhood care, even at the earliest stages of education. Investments are being made in both policy and practice to strengthen the capacities of people of all ages and from all walks of life. (UNESCO, 2014, p. 9)

However, what was particularly disheartening about this final report was that the United States was barely mentioned in all 187 pages of the document. Only one US-based sustainability education program was mentioned in the entire report: The Association for the Advancement of Sustainability in Higher Education (AASHE), a leader in encouraging sustainability education and initiatives in post-secondary institutions. The next section explores the numerous, and often disjointed, efforts to integrate sustainability education into public schools within the United States.

National efforts towards K-12 sustainability education

While there is uncertainty about why the United States was practically absent within UNESCO's seminal report on the state of global sustainability education efforts, it can be deduced that on an international level, the United States is not a leader in K-12 sustainability education. Because the focus of this research project is on sustainability education in the

formal K-12 education system, this section will focus primarily on this aspect of education within the United States.

While plenty of pockets of sustainability education are thriving and strong throughout the country, the United States has not been as successful at institutionalizing sustainability into the K-12 system nationwide. Conceived in 2003, the US Partnership for Education for Sustainable Development created a Sector Team dedicated entirely to K-12 & Teacher Education. As of 2018, the K-12 & Teacher Education Sector website appeared neglected and outdated. The Sector's aims are mainly network-based: connecting K-12 educators interested in sustainability education with other practitioners with similar interests. The website also contained a couple dozen resources, three outdated webinars, and half a dozen assessment tools. The last blog entry was from Feb 7, 2013, over four years from the time of writing this summary (US Partnership for ESD, n.d.). The larger US Partnership for ESD had a similar lapse of updates spanning from 2014 until the latest 2017 newsletter update (US Partnership for ESD, n.d.). However, the 2017 newsletter did not provide any details about national, regional, or local K-12 sustainability education initiatives suggesting that national efforts to maintain integration of sustainability into K-12 curricula is no longer a priority or focus. It did provide updates on broad initiatives including a "Beyond Doom and Gloom" video launch, integration of sustainability into university level academic disciplines, job descriptions, and rating mechanisms (US Partnership for ESD, n.d.).

The most recent example of the organization's effort to highlight sustainability efforts in the K-12 sector was found in the 2014 newsletter. The newsletter explained that the US Partnership for ESD had created a set of National Education for Sustainability K-12 standards, yet the link to the standards documents was broken. The newsletter also highlighted that Next Generation Science Standards included "quite a bit about sustainability,

thanks to the efforts of many sustainability champions" (US Partnership for ESD, n.d.). In 2014, it was noteworthy that only a handful of states had established education standards that included explicit sustainability goals. In fact, the only state for which the link was still active on the K-12 & Teacher Education Sector site was Washington State. At quick glance, the Washington K-12 Sustainability standards are comprehensive and multidimensional, including the sustainability triad of social, economic, and environmental systems (see: http://www.k12.wa.us/environmentsustainability/Standards/default.aspx). Other states leading the way have included Vermont, according to Sustainable Schools Project (2014), which was the first state in the country to adopt a sustainability standard. The standard was adopted in 2000 and developed by a consortium know as Cultivating New Partnerships. Massachusetts and Oregon also have made notable steps towards statewide progress around K-12 education for sustainability (Federico & Cloud, 2009). Even with these notable statewide strides, there remains an overall lack of a national coordinated effort (Federico & Cloud, 2009).

North Carolina, the context for my action research project, matches the overall U.S. pattern of lacking K-12 institutional support for sustainability education. Also similar to the national trend, the state's institutions of higher education have embraced sustainability education, offering top-down commitments to energy reduction, zero waste, green buildings, and over 58 university degree program options throughout the state (AASHE, 2018). However, the state does feature a robust state-level Environmental Education program that includes a North Carolina Environmental Education Advisory Council, Office of Environmental Education, and a well-integrated network of environmental education advocates throughout a diversity of public and private educational institutions, parks, and museums (NC Office of Environmental Education, 2007). While this emphasis on

environmental education is a step in the right direction, such an approach does not successfully encourage students to consider the complex relationships between the economic drivers of environmental destruction nor the unjust societal distribution of environmental consequences (Saylan & Blumstein, 2011).

With the lack of coordinated effort by states on the national level, many US based non-governmental organizations (NGOs) have stepped up to fill the gap. Numerous organizations and nonprofits have emerged in the United States to promote sustainability education in K-12 schools. Among the leaders include the Center for Ecoliteracy, The Cloud Institute for Sustainability Education, Rethinking Schools, Facing the Future, the Center for Green Schools, and the Green Schools National Network, to name a few (Smith, 2015). All with similar missions, each organization has a different approach in promoting sustainability education in K-12 schools. For instance, Facing the Future, Rethinking Schools, and the Center for Ecoliteracy have a strong emphasis on offering professional development and designing curriculum to be utilized in the K-12 classrooms, whereas the Green School initiatives advocate for a whole school approach. Green Schools promote the idea that the buildings in which students spend their time during the school day should model sustainability. This whole school approach has a double benefit in that not only do students learn about the importance of reducing environmental footprints, there is real reduction in energy consumption. The Green School programs also promote interdisciplinary, community-, and project-based learning approaches that recognize the multidimensionality of sustainability. As of 2016, the US Department of Education coordinates a Green Ribbon Schools Program that even rewards schools for their sustainability efforts.

Nonprofits such as Center for Ecoliteracy and LifeLab promote edible school gardens as a platform for sustainability education in the K-12 setting. Perhaps partly due to this

advocacy, school gardens have been on the rise in the K-12 sector (Turner, Eliason, Sandoval, & Chaloupka, 2016). In fact, the USDA conducted a farm-to-school census in 2015 and found that 44% of the school districts surveyed reported that they maintain gardens where students learn about how food grows, an increase of 42% from previous reports (USDA, 2015). The conversion of asphalt and manicured lawns into biologically diverse gardens allows schools to serve as a living laboratory for a multitude of lessons to blossom. Learning gardens on school grounds allow for a variety of critical, meaningful conversations related to local economies and traditions, ecology, food systems, hunger and health, and a variety of other sustainability themes (Williams & Brown, 2012). In fact, Portland State University created a Master's degree program called Leadership for Sustainability Education in 2010 with a heavy focus on how gardens can serve as a platform for sustainability pedagogy (Williams, Burns, & Kelley, 2014). Students in the program are required to take pedagogy and curriculum courses called Integrating STEM and Sustainability Education through Learning Gardens, Permaculture and Whole Systems Design, Urban Farm Education, and Leveraging Policy and Research to Cultivate Garden-Based Education in Practice (Williams, Burns, & Kelley, 2014).

As the above discussion suggests, efforts to infuse sustainability education into formal k-12 education are diverse in both geography and methods. Because of the diversity of methods and lack of organized best practices, it becomes a challenge when deciding on *how* to incorporate sustainability education into a school or course. The next section provides an overview of sustainability pedagogy— the process of teaching and learning about sustainability.

Sustainability Education: Connecting Theory and Practice

Since education plays an integral role of ensuring a sustainable future (Orr, 2004), what *should* sustainability education look like? In short, there is no one 'right' way to approach education for sustainability (Tilbury & Cooke, 2005; UNESCO, 2005). A plethora of formal approaches have emerged and been promoted since the rise of sustainability education as an international goal. However, education that promotes the wellbeing of all is not something new (Cirillo & Hoyler, 2015). Service learning, environmental education (Capra, 2002), school gardens (Williams & Brown, 2012), place-based education (Sobel, 2005) and critical pedagogy (Friere, 1987) are just a tip of the iceberg in terms of existent educational paradigms that seek to promote environmental and social wellbeing. In a way, sustainability education uses these justice-seeking pedagogical approaches and is ultimately concerned with promoting a different world view that values quality over quantity, community over selfishness, and caring over dominance (Burns, 2011; Orr, 2004).

Sustainability education as a field is an evolving concept that can and should be specialized based on local needs and evolving issues (Tilbury & Cooke, 2005). It requires an entire reorientation of educational goals that empower everyone "to make decisions and act in ways that are culturally appropriate and locally relevant to address the problems threatening our common future" (UNESCO, 2002, p. 29). In other words, the overarching goal of sustainability education should be to promote transformative learning—education that leads to a complete internal and external shift of motivation, goals, understandings and actions. The following section provides a brief overview of Mezirow's (1978) Transformative Theory for adult learners and how it contributes to sustainability pedagogy for adolescents.

Transformative Teaching and Learning

Sustainability education is more than simply knowing about sustainability. It also involves action, critical thinking and questioning, analyzing assumptions and values, systems-thinking, and personal engagement with innovative solutions that honor traditional and local knowledge (Tilbury, 2011). McKeown and Nolet (2013) explain how there's no one right way to achieve sustainability education: "There are many ways to implement ESD successfully to help communities and countries meet their sustainability goals and attend to the wellbeing of the planet and all its living inhabitants" (p. 7). Above all, sustainability education should empower students to not only know about sustainability-related content but to also "prepare them how to engage in these complex issues and become problem solvers and change agents" (Burns, 2011, p. 1). This means that teachers are not able to "deliver" sustainability education to his/her students but must foster transformative learning.

Mezirow (2000) describes transformational learning as the "process by which we transform our taken-for-granted frames of reference…to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action" (p.7-8). While originally designed as a pedagogy for adult educators, Mezirow's (2000) Transformative Theory is about "reformulating reified structures of meaning by reconstructing dominant narratives" (p. 19). He refers to this process as "learning to think like an adult" (Mezirow, 2000, p. 3). I argue that learning to think like a mature adult is what high school is all about.

As children mature into adults, Kitchener (1983) identifies three levels of cognitive processing. The first level consists of rote memorization and basic comprehension related to computation and the ability to read. In the second level, referred to as metacognition, individuals are able to monitor their own progress as they engage in first-order cognition.

The third level, called epistemic cognition, emerges in late adolescence but can continue to grow and change into adulthood as described by Kitchener (1983): "Epistemic cognition has to do with reflection on the limits of knowledge, the certainty of knowledge, and the criteria of knowledge" (p. 230). In other words, it is the ability to critically examine our own mental models as well as the larger societal influences that helped to create those models. Enabling students to be able to see these invisible molding forces allows them to become justice-seeking critical thinkers because transformative learning results in empathy, compassion, and a desire for action, a direct outcome of sustainability education initiatives (Burns, 2011).

Objectivist, constructivist, and transformative views of education.

To accomplish this, teachers must be supported to go beyond the traditional, objectivist view of teacher-student relationship and embrace both the constructivist and critical views of educational theories (Stuhmcke, 2012). MacNaughton (2003) connects pedagogical views with what she terms "curricular positionings," connecting educational theoretical lenses with the ways teachers design and implement their curricular goals (Table 1).

An objectivist pedagogical view adheres to a conforming curriculum positioning and sees education as a way to maintain the status quo by teaching students to conform to societal norms (Kincheloe, 2012). In this view, knowledge exists outside of the learner and can be transferred from master to student. Mastery is achieved if teacher successfully explains concepts and pupil successfully repeats new knowledge back in some form, typically on a test. I would argue that true sustainability education cannot exist in a conformist context. Such an approach would be a superficial comprehension of sustainability at most and would consist of students reciting learned sustainability-related concepts.

Table 1

Objectivist, constructivist and critical views of learning and their corresponding approaches to teaching

Pedagogical View	Curricular positioning	Knowledge...	Students...	Learning is successful when students can...
Objectivist view	Conforming society	...exists outside of individuals and can be transferred from teachers to students.	...learn what they hear and what they read. If a teacher explains abstract concepts well, students will learn those concepts.	...repeat what is taught.
Constructivist view	Reforming society	… has personal meaning. It can be created individually and socially. The teacher acts as a facilitator.	...co-construct knowledge by looking for meaning and order; they interpret what they hear, read, and see based on their previous learning habits. Students who do not have appropriate backgrounds will be unable to accurately "hear" or "see" what is before them.	...demonstrate a conceptual understanding.
Critical view	Transforming society	...is generated through student questioning, exploring issues, problems and critical thinking.	...learn through active participation, open interchange of ideas and opinions, exercising political literacy, challenging attitudes and values. The learning process, rather than product is valued.	...reason critically and problem solve.

Note. Adapted from Stuhmcke (2012)

A constructivist approach to teaching stems from child-centered philosophies such as Dewey (1916, 1938). In this view, children construct knowledge, the teacher is a facilitator, hands-on/project-based learning is most valued, and students' prior knowledge and experiences are heavily tied to student comprehension (Stuhmcke, 2012). MacNaughton (2003) refers to constructivist teaching as a "reforming society" curriculum position in that

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education delivered with individualized instruction is capable of creating independent, competent, successful students. For example, "a reforming teaching approach to education for sustainability would involve children co-constructing knowledge and demonstrating their understanding about sustainability" (Stuhmcke, 2012, p. 57).

Critical theory is an emancipatory approach to teaching and learning in that it is ultimately concerned with creating change and examining the status quo. MacNaughton (2003) describes this curriculum position as 'transforming society' which seeks to "change existing practices, rules, traditions and understandings in order to achieve greater equity and social justice" (Stuhmcke, 2012, p. 57). Teaching practices to support such goals are participatory in nature and could include problem-solving, experiential learning, and action-taking (Stuhmcke, 2012). Transformative approaches to sustainability education allows for spontaneity, flexibility, and a critique of current power and economic systems.

The next section discusses how recent trends in science education and education in general have created conditions that favor the objectivist view of teaching and learning. Thus, the ultimate task of this research project is to shift the traditional conforming science classroom from an objectivist view to a blend of constructivist and critical techniques so that true transformative sustainability *education* can emerge.

Challenges & Opportunities for Sustainability Ed: Standardization & Accountability

The post-world-wars national obsession with competing in the global economy has led to a market-based approach of educational reform. Since the mid-1980s, the goal of education has been aimed at eradicating the problems identified by the seminal Reagan-era report A Nation at Risk (Ravitch, 2013; Strohl, 2015; US National Commission on Excellence in Education, 1983). Standards in all disciplines were created in response to the report in an effort to improve US children's performance and rank in global testing results.

No Child Left Behind Act (NCLB) of 2002 narrowed the curriculum to emphasize mainly reading and math and brought in a new era of accountability where students were tested annually, factual information was privileged over process/inquiry, and teachers and schools were punished if their students did not perform well (Dorph et al., 2007; Johnson, 2009; Strohl, 2015).

Unfortunately, such emphasis on test-taking instead of learning has negatively affected teachers and students and has left little room for institutional support for inquiry-based learning that holistic sustainability education could offer (Strohl, 2015; Williams & Brown, 2012). Instead, teachers are compelled to adopt more of an objectivist view that knowledge can and should be transferred from teacher to student, that students are to digest what is provided to them verbally or visually and should then regurgitate the knowledge back to the teacher in order to accurately demonstrate mastery (MacNaughton, 2003).

Opportunities for Sustainability Education in Secondary Earth Science Classrooms

Incorporating a sustainability curriculum that bridges economic, social justice, and ecological themes is fully possible without distracting students from the specified academic standards found within state sanctioned curricula. The state of North Carolina adopted new NC Essential Standards for science and all other subjects in 2010 (Appendix A). By the 2012-2013 school year, all public schools in North Carolina were expected to teach and assess students by the new Common Core State and NC Essential Standards (NCDPI, 2011). However, a close examination of the goals of North Carolina's new science curriculum reveals an interesting mix of opportunities and challenges. On one hand, the long list of standards compels teachers to feel obligated to objectively deliver their learning targets and ensure students can recite them back (Jennings & Bearak, 2014). On the other hand, though, there is also a very clear focus on understanding natural phenomenon, local decision-making,

and participation in civic and cultural affairs — all concepts that allow for more of a transformative curriculum positioning. In fact, the North Carolina State Essential Standards for Earth/Environmental Science (EEn) contain ample opportunity to insert sustainability themes throughout the curriculum.

The nine compulsory EEn standards contain direct references to sustainability in the forms of environmental stewardship, ecology, renewable energy, water quality, sustainable agriculture, and an overall critical assessment of the relationship between humans and the natural world (Table 2). In fact, I argue that every one of the nine EEn standards are directly related to the goals of sustainability education because each of the nine main standards contain numerous sustainability-focused clarifying objectives. Twenty-two of the thirty clarifying objectives could be directly-tied to sustainability goals. Science education, therefore, allows for those of us with sustainability sentiments to have hope.

Table 2

North Carolina State Essential Standards for Earth/Environmental Science

Standard	Description
EEn.1.1	Explain the Earth's role as a body in space
EEn.2.1	Explain how processes and forces affect the lithosphere.
EEn.2.2	Understand how human influences impact the lithosphere.
EEn.2.3	Explain the structure and processes within the hydrosphere.
EEn.2.4	Evaluate how humans use water
EEn.2.5	Understand the structure of and processes within our atmosphere.
EEn.2.6	Analyze patterns of global climate change over time.
EEn.2.7	Explain how the lithosphere, hydrosphere, and atmosphere individually and collectively affect the biosphere
EEn.2.8	Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth.

Source: NCDPI, 2016

The EEn curriculum requires direct exploration of how humans impact the biosphere, lithosphere, hydrosphere, and atmosphere. North Carolina's environmentally focused Earth/Environmental Science curriculum presents an opportunity to encourage young learners to embrace the importance and interconnections found within sustainability education. My action research posited that a focus on the interrelated knowledge of economic, social justice and ecological themes was (and is) possible and does not distract from achievement of the mandated state standards. There is ample opportunity to encourage students to consider how a healthy economy depends on a healthy ecosystem and how some people bear the brunt of environmental degradation more than others. Students can also be taught to understand that humans' impact on our shared water, air, land, and biotic resources requires an investigation into local and global economic drivers.

Pedagogical Techniques to Support Sustainability Education

To fully embrace the transformative, emancipatory, and holistic nature of sustainability education, not only content has to adjust. Sustainability education also requires that pedagogical techniques must shift far away from traditional objectivist modes of teaching by fully embracing both constructivism and critical theory. This means the teacher must design lessons around student needs first, provide ample opportunities to model and practice critical thinking, and have a solid understanding of the complexity found within sustainability education. The following section discusses a few leading techniques to help educators put these goals into practice.

Understanding the theoretical and pedagogical foundations that are necessary for a critical, transformative sustainability pedagogy to thrive is essential. However, designing courses that reflect such nontraditional approaches can be challenging, especially in a public-

school setting that has a strong emphasis on teacher and student accountability through standardized tests.

Burns Model of Sustainability Pedagogy

The Burns (2011) model of sustainability pedagogy provides a practical approach to course design that can be incorporated into to any discipline (Figure 1). The Burns model is rooted in ecological principles of interconnections, cycles, energy flows, organic change/flexibility, and balance (Capra, 2002) and offers four key dimensions for educators to consider when designing curriculum: 1) content, 2) perspectives, 3) context, and 4) process.

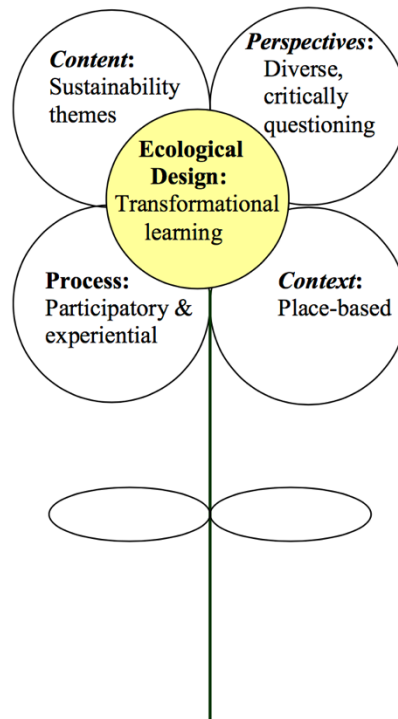*Figure 1.* Burns model of sustainability pedagogy (Burns, 2011)

Teachers should select and focus on *content* that presents a diverse look at a variety of complex issues we currently face. The second key dimension is allowing space for students to think critically about dominant paradigms and power structures from a diversity of *perspectives*. The third goal of the Burns model of sustainability pedagogy is to "increase

learners' understanding of and connection with the geographical place and the community in which they live" (Burns, 2011, p. 7) by situating the sustainability content within the local *context* that is relevant to the students and school. The fourth goal of the Burns model is to support an experiential and participatory learning *process* in which content and perspectives can be applied in useful ways to improve civic and environmental problems and issues. Lastly, teachers should design the course structure and learning environment in a way that is rooted the ecological principles of interconnections, flexibility, flow, and balance and results in students feeling empowered, inspired, and transformed by their learning (Burns, 2011).

The Burns Model was developed by Heather Burns (2009) as a way to infuse sustainability education into post-secondary classrooms. I argue that with some slight adjustments, the model can also serve as a useful tool in designing courses in the secondary classroom as well so that adolescents can benefit from the critical and transformative components of such a curriculum design model.

The following sections discuss the pedagogical techniques, supported by previous research, that can help public school science teachers incorporate sustainability themes into their classrooms. Each technique relates to the Burns model (2009) but has been slightly modified so that it is relevant in a high school setting.

Content: Thematic teaching. Sustainability education should be multidimensional, avoiding the traditional fragmentation of ideas into separate and distinct disciplines (Stock & Burton, 2011). Dividing knowledge into distinct disciplines was the prominent practice during the twentieth century (Klein, 2006). Historical reasons for disciplinarity are twofold: functionality and to uphold systems of power. Disciplinary habits and traits such as discipline-specific language (often referred to as jargon), exemplars, theories and laws,

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methods, procedures and skills all help to establish distinct discourses and worldviews. Institutional structures, validity criteria, cultural norms, legacies, labor markets, prestige, and economic perceptions and allocations are all traits that define, determine, and perpetuate disciplinary systems of power (Klein, 2006). While some exceptions exist, most disciplines seek to uphold these structural and functional norms (Van den Besselaar & Heimeriks, 2001).

While such divisions enabled significant advances in our understanding of the natural, social, and technological world, presenting knowledge in separate silos to children and young adults is no longer sufficient for twenty-first century problems (Miller & Boix-Mansilla, 2004). Disciplinarity is unable to solve many of the complex problems we face today such as global warming, resource strains from a growing population, rising financial and educational disparity gaps, and increased soil, water, and air pollution (Martusewics, Edmundson, & Lupinacci, 2015). Teaching students that disciplines are distinct entities that do not relate to each other leads to a lack of understanding about the intricately connected world in which we live (Evans, 2012).

Sustainability education should be transdisciplinary so that students understand that real-world problems and their solutions require holistic thinking that spans across the traditional disciplines created by Western-based academia. Broadly speaking, solving environmental issues requires understanding the complex ecological interactions as well as the economic and social drivers and outcomes.

So how does one teach beyond disciplines in a discipline-specific curriculum? A common approach in the sustainability education movement centers around the idea of the integration of key themes into any curriculum (Burns, 2011). Often referred to as being transdisciplinary, teaching with themes provides a grounding anchor to explore the

intersections of a variety of disciplines and is an effective way to incorporate sustainability pedagogy (Burns, 2011; Evans, 2012). "Transdisciplinary studies, research, and action focus attention on thematic threads that inform complex, real-world issues and challenges such as globalization, climate change and sustainability" (Evans, 2012, p. 240). A successful model of such transdisciplinary course design comes from the Vermont-based Shelburne Farms' Sustainable School Project, a leader in the sustainability education movement. The Sustainable School Project promotes 12 *Big Ideas* of sustainability (Cirillo & Hoyler, 2015, p. 2). "Education for Sustainability is about integrating the *Big Ideas* and principles of sustainability into our work as educations—into the heart of the curriculum itself—as well as into our institutional practices, culture, and community partnerships" (Cirilo & Hoyler, 2015, p. 4). As demonstrated in Figure 2, the *Big Ideas* include concepts such as diversity, interdependence, cycles, carrying capacity limits, sense of place, equilibrium as a state of balance, and are all meant to support the "intertwined goals of economic prosperity, environmental integrity, and social equity" (Cirilo & Hoyler, 2015, p. 2).
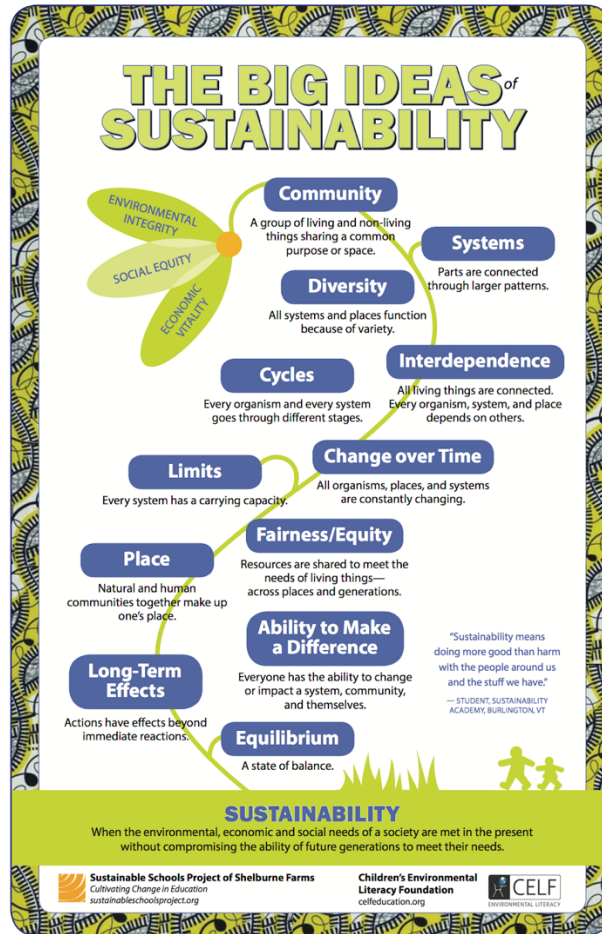
Figure 2. The Big Ideas of Sustainability. Shelbourne Farms' Sustainable School Project promotes that these twelve big ideas should be integrated into any sustainability curriculum. (Shelbourne Farms, 2014)

The Burns model of sustainability pedagogy (Burns, 2011) advocates that the content in any higher education course can be adapted to sustainability themes. I posit that public school teachers bound by strict state-sanctioned standards can also reorganize course content around sustainability themes. In fact, many leading educational theorists argue that thematic teaching has benefits over simply teaching each essential standard one by one (Wiggins & McTighe, 1998). Grouping standards through common themes allows students to see the big picture and gain a deeper understanding of not only the material, but also the applicability of the content's' underlying concepts (McTighe & Wiggins, 2013). For example, half of the

required North Carolina Earth/Environmental science standards can be grouped around four main sustainability themes: 1) Ecology & Interconnectedness, 2) Understanding Sustainability, 3) Energy and Climate Change, and 4) Consumerism and Agriculture. My process of identifying and leveraging these themes to design curricula are discussed in detail in Chapter 4. In my case, each theme had a focus on real world problems and students were charged with working together to understand the systematic nature of those problems and to then design possible solutions to help alleviate those problems.

When the goal is transformative sustainability education, organizing a course around sustainability themes allows students to explore the complex and integrated systems that underlie, uphold, and exacerbate some of our most pressing sustainability issues (Burns, 2011; Evans, 2012). Students can then begin to see, understand, and apply that conceptual knowledge to real world problems. This is the heart of transformative teaching and learning (Burns, 2011; Evans, 2012; Pace Marshall, 2006). A key part of understanding the systemic structure of the world's problems lies in questioning unjust systems of power. The next section describes both critical thinking and critical pedagogy as necessary tools to accomplish such a goal.

Perspectives: Critical thinking and critical pedagogy. Sustainability pedagogy should support students in building critical thinking skills (Burns, 2009). Critical thinking is most succinctly described as being aware of one's own thinking (Paul & Elder, 2009). It requires effective communication and problem-solving abilities and "a commitment to overcoming our native egocentrism and sociocentrism" (Paul & Elder, 2009, p. 2). Today's adolescents have grown up with an unfathomable amount of information and viewpoints at their fingertips and are often unequipped to decipher fact from fiction, nevertheless that

which is "distorted, partial, uninformed or down-right prejudiced" (Paul & Elder, 2009, p. 2).

Critical thinking is essential to a vibrant democracy. Critical thinking used to be reserved for the intellectual elite who had the time and resources to consider their own thinking (Marin & Halpern, 2011). However, technology, access to information, and a growth in opportunities and voting access has made the practice of "relying on a small segment of the population to be the thinkers for society… obsolete" (Marin & Halpern, 2011, p. 3). It is now more important than ever to equip students with the necessary skills to think critically about the surfeit of information they are now faced with.

In addition to being able to sort through all the noise, students should also be enabled to see and question the power structures that exist all around us. This pedagogical approach is promoted by critical theorists who believe the goal of educational institutions is to raise questions about such systems of power and injustice (Barbules & Berk, 1999). In other words, all education is political, claim critical pedagogues such as Freire (1987):

> There is no such thing as a neutral education process. Education either functions as an instrument which is used to facilitate the integration of generations into the logic of the present system and bring about conformity to it, or it becomes the "practice of freedom," the means by which men and women deal critically with reality and discover how to participate in the transformation of their world. (p. 34)

Because critical theory is an emancipatory approach to teaching and learning that is ultimately concerned with creating change and examining the status quo, MacNaughton's (2003) curriculum position of 'transforming society' should allow for a critique of current power and economic systems. Meaning, the goal of the *perspectives* dimension of sustainability pedagogy is to allow students to first see the metaphorical boxes that exist

throughout our society and to encourage students to think outside those boxes. Howard Zinn (2011) explained in his keynote speech to social studies teachers:

> I can't think of anything more important we can do in education than to get students to challenge these fundamental premises which keep us inside a certain box. We want people to think outside of that, because if they don't things will never change… A world of war and hunger and disease and inequality and racism and sexism. We want to move away from that and so we have to re-examine these premises. (00:04:59)

So how do educators ensure critical thinking and critical pedagogy—both of which support diverse and critical perspectives—are alive in their classrooms? As Marin and Halpern (2011) assert, critical thinking can be taught in two ways: through explicit or embedded instruction. Both methods are highly advocated for and are not mutually exclusive (Kuhn, 1999; Marin & Halpern, 2011). Cognitive scholars argue for what Kuhn (1999) refers to as working "from both ends at once— from a bottom-up anchoring in regular practice of what is being preached so that skills are exercised… as well as from a top-down fostering of understanding and intellectual values that play a major role in whether these skills will be used" (p. 24). Humans, however, are not simply creatures of habit; their beliefs and values regarding what is important help to shape their behavior. In the end, people think carefully and reflectively not out of habit, because such thinking is not an effortless habit to maintain, but because they are convinced of the value of doing so.

The Burns model of sustainability pedagogy argues for incorporating diverse and critical *perspectives* into the postsecondary classroom (Burns, 2011). Helping guide students to practice critical thinking is necessary for them to have meaningful engagement with diverse and critical views and is also a prerequisite for meaningful critical pedagogy to thrive. However, young adults and adolescents have significant differences in their cognitive, and

thus, critical thinking, abilities (Anderman, Sinatra & Gray, 2012). It is vitally important that teachers remain aware of the developmental abilities of their students (Anderman, Sinatra & Gray, 2012). For high school students, modeling critical thinking is of utmost importance. Most high school students are still in the early stages of being able to think critically. Adolescents still see the world dualistically and see knowledge as being transferred by authorities (Anderman, Sinatra & Gray, 2012). Merely providing multiple perspectives without supporting students in questioning their own culturally and family-created paradigm will not result in transformative sustainability learning to question dominant power structures and paradigms (Burns, 2011). Fung (2017), in a study of 140 high school students, found that the following techniques best fostered students' critical thinking dispositions: collaborative group work, teacher support, and explicit instruction. The study considered constructivism as an integral part of building critical thinking skills.

Organizing content thematically, presenting a variety of diverse viewpoints, and modeling and supporting critical thinking are necessary practices for transformative sustainability education to flourish in high school classrooms. However, as Burns (2011) argues, teaching and learning must also be situated in a local *context*. Place-based education is the next integral pedagogy to be included in course design that includes transformative sustainability education.

Context: Place-based pedagogy. By considering child development theories related to ecological awareness and place, transformative sustainability educators can better understand why such an approach is beneficial to not only the health of the planet and posterity, but also to the academic, social, and mental wellbeing of individual children.

Place-based education is an age-old tradition that dates back millennia; before the invention of schools and formalized curriculum, all education was unique to the places and

spaces where unique cultural traditions were passed down from elders to posterity. Education was about how to survive in each unique environment. In this way, place-based education is not a new phenomenon. From Aristotle to Rousseau, history demonstrates how education was birthed in place and only began to include information outside of its own home roots with the advent of long distance travel (Elfer, 2016). Earliest globalization brought new challenges to place-based education as world explorers began conquering the world, bringing back stories, specimens and knowledge from afar (Smith, 2002). After the advent of formalized education, now, "teachers direct children's attention away from their own circumstances and ways of knowing and toward knowledge from other places that has been developed by strangers they most likely will never meet" (Smith, 2002, p. 586). To learn something now often means reading about it, hearing about it, or watching it on screen rather than through experience in full-bodied tactile engagement with real places and events.

Based on his research witnessing children in outdoor environments including his creation of an outdoor preschool, Sobel (2005) asserts that children experience nature differently than adults and are prone to transcendental experiences: "Their experiences were transcendent in that the [child] often felt connected to or merge with the natural world in some highly compelling fashion" (Sobel, 2005, p. 13). Sobel's (1996) theory of child consciousness development consisted of three stages: a) building empathy with the natural world (ages 3-7) through objective interactions with nature; b) encouraging exploration (ages 7-11) so that children begin to consider the interconnectedness of living things; c) social action (ages 11+) where children can handle abstract "tragedies" and begin to learn that they are capable of enacting change and making a difference in their own communities. Despite slight differences, Piaget (1952) and Sobel would agree that physical reality—touching,

smelling, seeing, doing— is of utmost important in healthy development of children and adolescents. For this, place-based educators are at an advantage by operating from the assumption that tangible, real-world experiences offer the best opportunity for deep learning. "One transcendent experience in nature is worth a thousand nature facts" (Sobel, 2005, p. 13).

Understanding various child development theories can help critical, place-based educators understand why blending ecological awareness, place, and critical pedagogy is a beneficial task. An education strategy rooted in place improves the academic, social, and mental wellbeing of individual children as well as the health of the planet and posterity. For adolescents, providing opportunities for them to understand and positively contribute to solving their own community's problems can build empathy, empowerment, and citizenship (Buxton, 2010; Sobel, 1996). A study of 23 adolescent participants who engaged in the Social Problem Solving through Science project, revealed that a place-based approach of creating public service announcements about locally relevant environmental health issues, enhanced both science content knowledge and local citizenship awareness (Buxton, 2010). Similarly, the Adolescent Diversion Project has documented over 30 years the ways in which involving young adults in service-learning leads to productive and active citizens and future community leaders (Davidson, Jimenez, Onifade, & Hankins, 2010).

The next section provides an overview of how important it is to foster an experiential process that is rooted in constructivism so that all the other key dimensions of sustainability education can be incorporated successfully into a secondary classroom.

Process: Active & participatory instructional model (constructivism).

Sustainability education should inspire and equip students to make a well-informed positive impact in their communities (Evans, 2012). This goal requires that classrooms model such desired outcomes. Experiential and participatory instructional models that allow students to be active participants in their learning process is necessary (Burns, 2011). The fourth goal of the Burns model of sustainability pedagogy is to "enhance learners' civic responsibility and intentions to work toward sustainability through active participation and experience" (Burns, 2011, p. 8).

There are a variety of ways to offer participatory and experiential learning in a high school setting including service learning, project-based learning, problem-based learning, case studies, field trips, role playing, and any other pedagogical technique that allows students to directly interact with the course content, each other, and their surroundings. However, as Tilbury, Coleman and Garlick (2005) warn, eco-action without reflection can promote superficial understandings of complex issues. Merely offering students problem-solving approaches to environmental and social problems can lead to what Jensen and Schnack (1997) refer to as 'action paralysis,' where students can become disengaged from environmental issues because their efforts do not present results (Tilbury, Coleman, & Garlick, 2005). For this, it is crucial to support sustainability-focused experiential learning with critical reflection and appropriate context so that students do not develop a sense of hopelessness from their school-based attempts to positively impact the world. Examples of eco-action without reflection include tree planting and river clean-up days. While such activities would be considered hands-on and experiential, they should not be considered transformative sustainability education if they do not include critical

discussions and reflection about the limitations of such actions as well as the systematic causes of pollution and deforestation (Tilbury, Coleman, & Garlick, 2005).

It is also imperative that constructivist educational philosophy underpin any attempts to successfully integrate participatory educational processes in a sustainability focused classroom. Constructivism recognizes that knowledge is actively co-created by the learner (Ernest, 1993). Constructivists understand that students are not passive receivers of knowledge; they are active participants in their own knowledge creation. Instead of being blank slates, students are already full of biases, opinions, attitudes, feelings and previously constructed knowledge (Burns, 2011). These pre-existing pieces must be built upon, molded, or reexamined and thrown out when new knowledge is presented (Ernest, 1993). Learners are constantly testing new ideas against their preconceived conceptions. "The objective of a constructivist model, therefore, is to provide students with experiences that make them reconsider their conceptions" (Ansberry & Morgan, 2011, p. 29). Constructivist educational philosophy advocates for connecting new knowledge to previous understanding for the learner to build a more accurate and thorough understanding of how the world works (Burns, 2011).

5E Instructional Model: Experiential learning in the science classroom. In the field of science education, a leading experiential learning technique based in constructivist theory is the 5E Instructional Model. Developed by the Biological Sciences Curriculum Study (BSCS), the BSCS 5E instructional cycle consists of 5 stages that progressively build upon students' previous knowledge and works to correct misconceptions (Bybee, et al., 2006). The BSCS 5E Instructional Model is founded in solid educational theory and cognitive psychology and is backed by substantial educational research evidence (Bybee et al., 2006). It builds on the work of other instructional models dating back to the early 1900s (Bybee et al., 2006). The five stages of the 5E learning cycle are: engagement, exploration, explanation, elaboration, and evaluation and are discussed in more depth below (Bybee, et al., 2006).

Engage. The first stage of the learning cycle is meant to capture the students' interests and spark their curiosity (Ansberry & Morgan, 2011). This introductory stage should aim to identify student misconceptions but should not attempt to solicit or provide correct answers. The teacher should focus on offering probing questions but should not attempt to offer explanations.

Explore. Once the students' interest has been piqued, hands-on exploration activities should be offered to allow students to build upon a common experience. The common experiences shared in this stage can then be further questioned and explained in the next state of the learning cycle. "The teacher's role in the exploration phase is that of facilitator or coach. The teacher initiates the activity and allows the students time and opportunity to investigate object, materials, and situations based on each student's own ideas of the phenomena" (Bybee et al., 2006, p. 9). Concrete, hands-on materials and experiences should be utilized in this stage.

Explain. Teachers should first ask students to attempt to explain what was happening during the first two phases of the learning cycle. The teacher should guide students towards common language and concepts that help foster student comprehension of the goal learning objective. The goal is for students to be able to explain what they learned to others using the common language and conceptual understanding imparted by the teacher, but this will likely not happen right away because learning for understanding takes time (Bybee et al., 2006).

Elaboration. The goal of this stage is for students to be able to apply their new knowledge to similar but different situations (Bybee et al., 2006). This stage should rely heavily on group collaboration so that students are able to express their understandings and receive peer feedback (Bybee et al., 2006). "Generalizations of concepts, processes, and skills is the primary goal" (Bybee et al., 2006, p. 10), meaning students should be able to demonstrate they fully understand a concept by transferring it to related situations.

Evaluation. Informally evaluating student comprehension should occur throughout all phases of the learning cycle, but this last stage offers an opportunity for students to demonstrate their mastery of the content knowledge (Bybee et al., 2006). Teachers should provide students with feedback for improvements during this phase. Formal assessments can come in many forms and depend on many factors including student, teacher, and larger school system needs. However, the focus of the assessment should center around metacognitive tasks rather than mere rote memorization and lower level cognitive thinking (Bybee et al, 2006).

Even though the five stages are listed in linear order, the 5E instructional model is meant to be used as a cycle (Ansberry & Morgan, 2011). Instruction during the explain state should continually refer back to the engagement and exploration activities, even offering opportunities to revisit and redo the activities if time and student needs allow. This cyclical

nature of teaching and learning contrasts with more objectivist methods that view teaching as a way to dispense information to students. In the 5E model, "the traditional roles of the teacher and student are virtually reversed… Students take on much of the responsibility for learning as they construct knowledge through discovery" (Ansberry & Morgan, 2001, p. 31). Instead of viewing the teacher as the source of knowledge and testing for memorization of isolated facts, the 5E cycle causes students to create and build upon existing knowledge with the teacher serving as more of a coach or guide (Ansberry & Morgan, 2001).

The 5E instructional model is an ideal tool for designing integrated sustainability-science courses for secondary classrooms. The 5E lesson cycles can easily support thematic teaching because the lesson cycles can be easily adapted around timeframes, unit structures, and pacing guides (Bybee et al., 2006). The emphasis on identifying and questioning misconceptions is an ideal instructional method for supporting critical thinking, reflection, and bias identification. The fact that the engagement and exploration stage encourage hands-on, concrete learning allows for ample place-based exploration that situates learning into a local context. And lastly, the 5E learning cycle values collaborative learning that allows for peer-based critical reflection and a connection and building-up of classroom community--both essential elements of any attempt to support sustainability education.

Chapter Summary

Since the early 1990s, education for sustainability has been a primary focus of international attempts to work towards global sustainable solutions. While international organizations such as the United Nations and some national governments have taken great strides to create policy to encourage top-down sustainability education integration, the United States has not taken such steps. However, sustainability education can and should be included in secondary classrooms so that young people are made aware of the important role

humans play in ensuring a sustainable, just future for all. While this requires a reorientation of public school classrooms, it does not take an entire overhaul of the larger public-school system. This study aimed to explore how sustainability education can be interwoven into existing secondary school classroom structures without distracting from required curricular goals.

Supporting adolescents in their quest to build critical thinking skills, become active citizens, engage with their communities, and feel empowered are worthy goals that should be encouraged. Utilizing the Burns model of sustainability pedagogy (Burns, 2011) and the BSCS 5E instructional model (Bybee et al., 2006) provides a useful framework for how to put these goals into practice and assess their effectiveness. The following chapter provides an overview of the research methods used in this study.

Chapter III

Methodology

This chapter explains the rationale for utilizing action research as this study's methodology. It begins with an overview of qualitative research and provides the situational context for this research project. Action research is then discussed in depth, making a case for why the methodology was chosen for this study. The action research cycle, including project timeline, is explained. Data collection and analysis methods are discussed as well as research ethics, validity, and limitations.

Research Design: Leveraging Action Research & Case Study as a Teacher-Researcher

This study was qualitative in nature due to its broad research questions focused on human experience. Qualitative research is ideal for studies in which the main interest is to observe what is occurring in a naturalistic setting with minimal intrusion to the normal routine (Stuhmcke, 2012). Because qualitative research is interpretive in nature and is grounded in the lived experiences of research participants and researchers, this study did not seek to be predictive or generalizable (Stuhmcke, 2012). It did seek to explore both teacher and student perspectives of incorporating sustainability educational themes into a rural Earth/Environmental Science high school course and to share this information with teachers as a way for them to determine and explore what might work well in their own individual contexts.

Action Research

This study was primarily an action research study because as a teacher-researcher, I had a desire to create change in my classroom directly and in community broadly. 'Action' is the key of action research and requires that the practitioner/researcher develop a final or evolving plan of action to ameliorate an identified issue in the lived experience of the

situation at hand (Herr & Anderson, 2014). Emancipatory in nature, action research has a moral imperative to fight for a better, freer world, not just to publish theories (Reason & Bradbury, 2001; Stuhmcke, 2012). Fighting for change can be understood on a sliding scale of personal to global. According to Kemmis (2009), an action researcher can aspire for change in three ways: change in their individual practice, a shift of personal conception of their practice, and/or changing the conditions in which they practice. In this way, action research is intentionally political and requires that practitioner/researchers take ownership for their actions (McNiff, Lomax, & Whitehead, 2003).

The uniqueness of action research also lies in the fact that it is practitioner-based and does not rely on an outside 'professional' researcher to observe and interpret what is occurring within the study. In this way, "action research arises out of critique of the very assumptions, values, and approaches that ground traditional social science, university-based research" (Herr & Anderson, 2014, p. xii). Action research shifts the focus away from observing and explaining towards "showing the reasons and intentions of the person that inform the [action]" (McNiff, 2013, p. 33). Action researchers believe credible knowledge does not only exist in the minds of trained researchers from the academy and acknowledge that all people are capable of critically reflecting on their own behavior and producing new knowledge. Thus, action research is based in a commitment to democracy, where not only outside researchers own and create knowledge but practitioner-researchers are able to explain their own values and desires behind their actions. McNiff (2013) writes, "It is pointless to produce abstract models of social change and expect other people to apply them to their own circumstances or locate themselves within the models" (p. 35).

Teacher research is reflective in nature, requiring that the practitioner/researcher constantly reflect on their own teaching practices and their understanding of students as

learners (Burnaford, 2001). Ultimately, improved teacher practice is expected due to the ongoing reflection, problem solving, and constant self-reflective professional development that occurs during the study and beyond (Whitehead & McNiff, 2006). Through problem solving and curriculum improvement, teachers engaging in action research can bring about change in classrooms, schools, and communities (Burnaford, 2001). By focusing on solving problems through strategic and disciplined practitioner/research, significant improvements are inevitable.

However, as with all inquiry, the focus on improving a problem is inherently subjective and value laden. What constitutes improvement is not always self-evident especially in politicized and highly debated areas such as education. Therefore, it is of utmost importance that the practitioner/researcher engage in systematic and thorough investigations of their own positionality and assumptions, maintaining constant reflexivity in their assessments (Herr & Anderson, 2014; McNiff, 2013). The researcher must continually question the benefits and potential drawbacks of the intervention, always assessing who is the beneficiary and what/who gets left out. This challenge highlights the importance balance needed between rigor and relevance (Herr & Anderson, 2014).

Action research demands that the practitioner/researcher remain committed to the scholarly process of data collection, evidence creation, disciplined reflection, and making claims to knowledge by drawing conclusions based on the collected evidence (McNiff, 2013). The practitioner/researcher should not only provide descriptions of activities but should also provide reason and purpose behind the intervention activities. Documenting the *why* behind the *what* and *how* is an essential component to the action research project because it connects the project back to the inescapable values that underlie any attempt to create change. Action research is a way to articulate one's personal values and demonstrate

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how those values are coming to life through practice. "This idea of showing how you are trying to live your values in your practice is at the heart of debates about demonstrating and judging quality and validity in action research" (McNiff, 2013, p. 26).

Case Study

Alongside action research, this study utilized case study methods as they allow for an in-depth investigation of a particular program, person, trait, or other specific interest bounded by location and time (Lichtman, 2012). Stake (2005) identifies three broad categories of case studies: intrinsic, instrumental, and collective. Intrinsic is most limited in scope and scale. Instrumental case studies seek to provide insight into a larger issue by investigating a specific case. Collective case studies are a combination of instrumental cases. This study was an instrumental case study because this form of investigation is more concerned with the issue than the particular case (Stake, 2005). Even though the case (high school earth/environmental science class) was explored in great detail and depth, it is of secondary interest. The primary interest was in the issues being explored: incorporating sustainability into the state sanctioned curriculum, student reactions to the approach, and teacher reflections about the project.

<div align="center">

Action Research Context

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The educational context for this study was an Earth/Environmental science course consisting of mostly ninth-grade students at a rural public high school in western North Carolina. During the spring of 2017, I taught three Earth/Environmental science courses in block format (1.5 hour classes for an 18-week semester). Two of the courses were considered 'standard' Earth/Environmental Science and one was considered 'honors-level' Earth/Environmental Science. Class size ranged from 21-29 students per class.

The high school serves the entire county in which it is situated, an area of approximately 313 square miles. With just over 1300 majority-white students (89%), 25-30% of all students are on free and reduced lunch (Public Schools of North Carolina, 2016). The high school is located within the town limits of the county seat that is also home to a state university. The town's population is just under 20,000 residents, and the county's population is near 54,000, not including the university's 17,000 students (NC Cooperative Extension, 2017). The town is considered the economic hub of the region that mainly centers around tourism, education, and medical services.

Despite the mountainous landscape, agriculture has a strong presence in the county. There are nearly 600 small-scale farms throughout the county, with an average size of 78 acres per farm (NC Cooperative Extension, 2017). Frasier fir trees are a leading crop, as well as cattle and vegetables because of community-based efforts to build a strong local food economy (NC Cooperative Extension, 2017). This is demonstrated through community-wide support for local farmers' markets and other direct farmer-to-consumer markets (NC Cooperative Extension, 2017). This emphasis on supporting local small-scale agriculture extends into a broader appreciation for the environmental treasures of the region. Woodlands cover approximately 68.7% of the county's 200,038 acres, with the mountainous and forested terrain being major draws for the high tourism in the area (NC Cooperative Extension, 2017). The county is home to headwaters to four different river systems, making water quality and environmental protection major concerns to many county leaders and citizens (NC Cooperative Extension, 2017).

Research Participants

The key research participants were students enrolled in my three Earth/Environmental Science classes in Spring 2017 who gave informed consent. The students (N = 45) were a

mix of male, female, and transgender students aged between fourteen and sixteen years. The students were informed of the nature of the study and were encouraged to provide additional reflections, feedback, and suggestions beyond what was asked of them. They understood that their work was being documented and were encouraged to also reflect on their personal growth throughout the study. The constructive and critical pedagogical approach that were utilized during this study allowed the students to become active participants in their learning process. By keeping and reflecting on their work throughout the duration of this study, students were encouraged to monitor their own 'learning journeys' as well as reflect and evaluate collaboratively with the teacher (Stuhmcke, 2012).

Political Context

In terms of politics, the county in which this research occurred has historically voted Republican during presidential elections. Of the last 27 presidential elections, county citizens only voted for a Democrat 7 times (Politico, 2018). However, the expanding university has helped to increase the progressive influence of the county, turning it into a viable swing county. Clinton, Obama, and Clinton carried the county in 1992, 2008, and 2016. However, the only county precincts that voted for Clinton in the 2016 presidential election were located around the university and town center. This suggests that a progressive influence is still limited within the county's main town limits.

Since I had attended graduate school and later taught as an adjunct at the local university, my perception of the area was that it was a progressive hub, nestled in a rural, southern setting. However, my experience was limited to what is often referred to as the 'university bubble.' Once I began teaching at the high school, it became clear that the progressive influence of the university was quite limited. It was apparent that students with

university ties were brought up with very different political leanings than many of their peers whose family might be considered more native to the area.

It should also be noted that the political atmosphere during the time of this research project was especially contentious. The 2016 presidential election was unlike anything that had come before. A divisive campaign based on demonizing 'the other' had dominated media and community talk. The school did not escape the hatred and bigotry that transpired. In the aftermath of the election, there were reports of students threatening to deport immigrants and to 'keep them out with a wall'. School administration sent out notices to faculty and staff to report hate speech. Flyers and safety pins were passed out to communicate that classrooms were safe, supporting places to all people and then the safety pins and flyers were banned due to parental complaints – another sign of the divided nature of our school and community.

During the semester preceding the start of this study, I attempted to find a way to respectfully express my own hurt and disappointment about the reports of harassment and abuse. During the two weeks following the election, I dedicated the beginning of every class towards reminding students how to be compassionate, kind, and thankful. We hung kindness flags around the classroom that had compliments towards specific students written on them. I emphasized how kindness must overpower hatred.

In addition to the atmosphere of intolerance, the political climate fostered an acceptance of questioning the legitimacy of science. This created a unique challenge in a science classroom as many of the students in my class were being exposed to messaging from their parents, peers, political leaders, and media outlets that blatantly disregarded scientific consensus on topics such as climate change, pollution, and vaccination. It was often very apparent which students were being exposed to messaging on either side of the political spectrum, as students often felt empowered to speak up about their beliefs and would

vocalize their distrust in science. Such comments closely resembled messaging they were hearing from political leadership of the time.

<p align="center">**Action Research Methods: Timeline, Data Collection, & Analysis:**</p>

This section details the action research that took place for this study. Action research is cyclical in nature, meaning the researcher and participants are in a constant cycle of inquiry, data collection, and analysis (Schwalback, 2003). "This cycle of activities forms an action research spiral in which each cycle increases the researchers' knowledge of the original question, puzzle, or problem and, it is hoped, leads to its solution" (Herr & Anderson, 2005, p. 5). Often referred to as a process similar to "designing the plane while flying it" (Herr & Anderson, 2005, p. 69), action research is an evolving methodology that is alive, adaptive, and responsive to the lived experiences of the researcher and participants (Herr & Anderson, 2005).

Action Research Cycle

This study utilized three iterations of the action research cycle (see Figure 3). Each cycle consisted of definitive inputs that were necessary before the cycle could begin. The final output consists of this 'finished' dissertation as well as a fully adaptable and open-sourced curriculum and pacing guide (Appendix B).

Cycle 1: Learning, experimenting, & strategizing. The first cycle (January to December 2016), occurred before the official data collection phase of this action research project. Inputs to Cycle 1 included previous knowledge and experiences related to teaching and learning about sustainability education as well as the situational circumstance of being hired to teach Earth/Environmental science at a public high school. Cycle 1 consisted of a continual cycle of learning about, experimenting, with, and strategizing how to incorporate sustainability themes with the state-sanctioned Earth/Environmental Science curriculum

standards. This cycle also involved a continual personal learning process of familiarizing myself with both the content of the course and how to best manage and engage high school students.
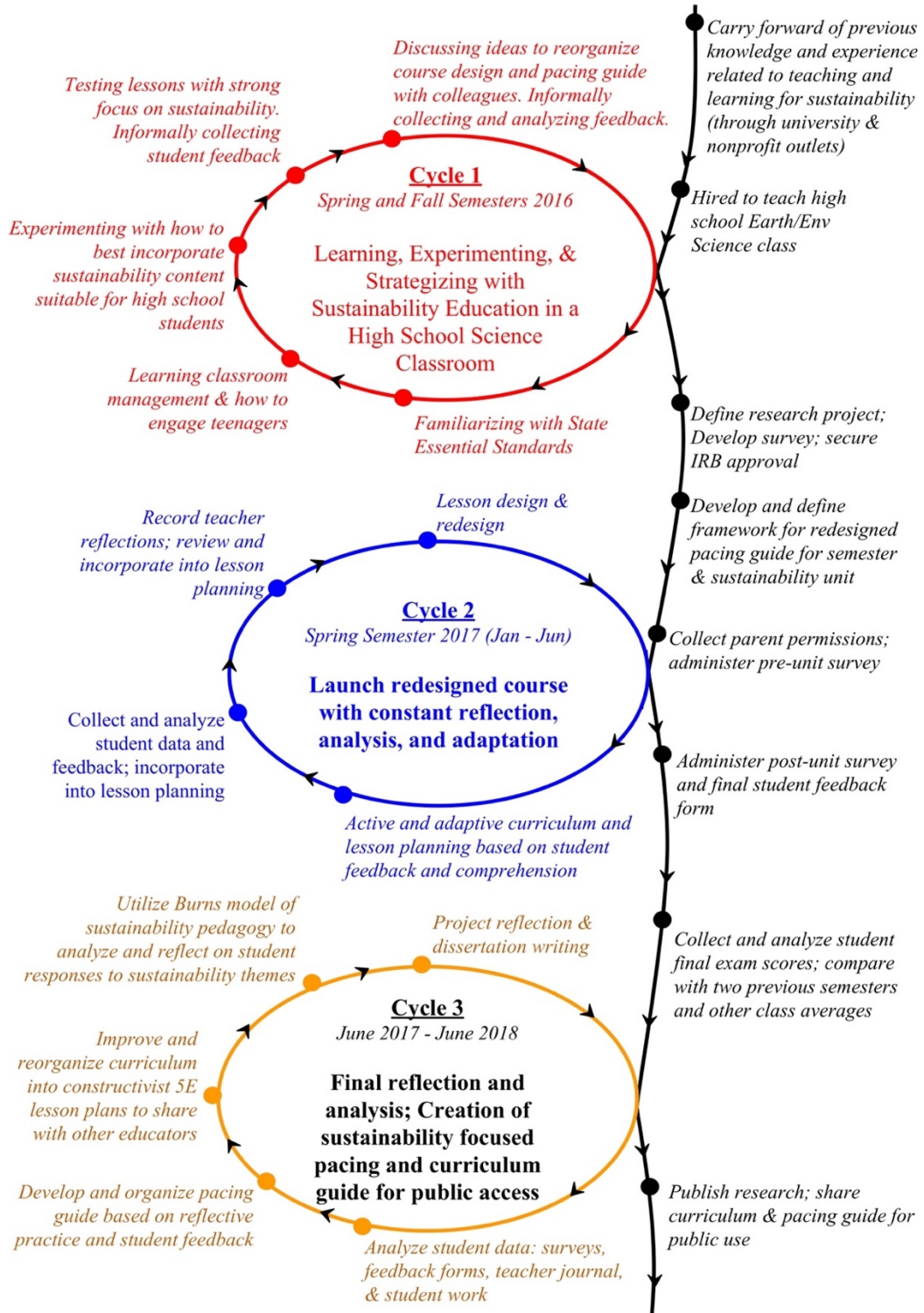
Figure 3. The study's Action Research cycle.

Cycle 2: Data collection, reflection, & adaptive course design. The second cycle was the official data collection period (January to June 2017), in which I launched the newly designed curriculum and pacing plan, which will be discussed in more detail in Chapter 4. The first definitive step that was completed before this cycle began was defining the research project. This included deciding on the research questions, developing data collection techniques – including designing the pre- and post- survey instrument—and securing IRB approval. The second definitive step that was accomplished before beginning Cycle 2 was defining a general framework for how I would organize and present content standards. My goal in this redesign was to allow for an effective integration of sustainability themes. Based on my own reflections and feedback from both students and colleagues during Cycle 1, I felt confident in how I decided to restructure the course into two main units (Unit 1: Earth Systems & Cycles; Unit 2: Human Impacts & Consequences) and the four main sustainability themes I decided upon for Unit 2. Such organization allowed for flexibility during the cyclical and reflective lesson planning process I employed during Cycle 2. The last definitive step I completed before beginning Cycle 2 was to inform both parents and students of the research project and gain their permission to be included in the research study.

Cycle 2 consisted of constant and continual inquiry, reflection, and adaptation of how and what I was teaching. It also involved a constant analysis and adaptation based on how students were responding and comprehending to the sustainability content, themes, and delivery methods. The next section details the variety of data that was collected based on the two research questions.

I followed a flexible approach to data collection for this action research project, while keeping three key questions at the forefront of my inquiry: "What do I see? What do I need to know that I cannot always see? What does it mean?" (Burnaford, 2001, p. 41). The majority of data collected was descriptive, non-numerical and reflected the complex interactions that occurred within the classroom and the practitioner/researcher's mind (Stuhmcke, 2012). In addition to the descriptive data, standardized forms of data through the NC Final Exam scores was used to demonstrate whether or not incorporating sustainability education inhibits or does not inhibit student mastery of NC State Essential Standards. The data collected was grouped into two categories related to the two research questions: RQ1: *How can sustainability education that interweaves* ecological *literacy,* economic *system critique, and* equity *(social justice) be integrated within a state sanctioned earth/environmental science curriculum?*; and RQ2: *How do first year high school students respond to sustainability education themes in a rural public high school Earth/Environmental Science course?*

Data collection for RQ1: Curriculum related data. As the teacher-researcher, I kept a detailed journal that documented my process, considerations and decisions while designing and delivering the sustainability related curriculum. I documented my interpretations of the pacing, schedule, delivery, student reception, and student reactions. I retained all of my lesson plans and used them to determine what worked and did not work with each group of students. These reflections included notes about my assumptions, preconceptions, and evaluations related to pedagogy (MacLean & Mohr, 1999). These reflections included Burnaford's (2001) suggested teacher-researcher inquiry questions: "What do I see? What do I need to know that I cannot always see? What does it mean?" (p. 41).

Another useful data collection technique was in my adaptive lesson planning strategy. My decisions of when to cover what were organic and flexible to support student

comprehension and engagement. I utilized sticky notes on poster board that allowed for

flexibility and adaptability depending on student needs and their paths to understanding (see

Figure 4). I would write general guiding ideas that I wanted students to understand on

sticky-notes. I would then space out those sticky notes based on how long I predicted we

would need for mastery. I could then easily move the sticky notes and reformat the delivery

as needed. This system proved to be a great way to practice the flexible, organic nature of

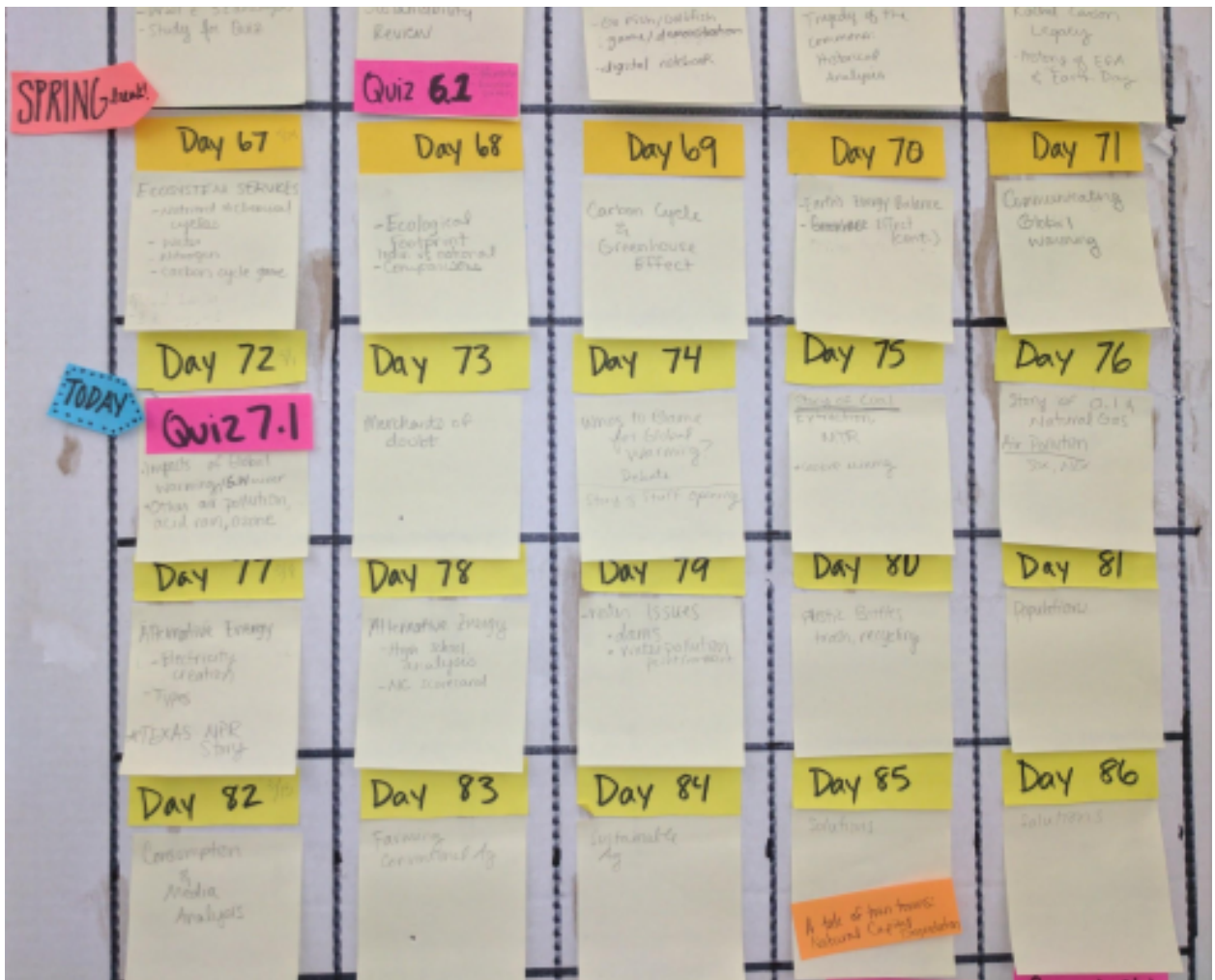sustainability pedagogy (Burns, 2011).

Figure 4. Sticky note planning system, a useful strategy for flexible curriculum planning based on student understanding

Additional curriculum-related data included daily lesson plans, teacher notes (twice weekly), class Twitter feed, photos, and the evolving pacing guide was collected and assessed. Lesson plans consisted of a collection of daily Google Slide decks and the online course organization page. Daily teacher notes were recorded in the notes section of the Google Slide decks as well as in a digital notebook file and occasional audio files. The pacing guide evolved from the sticky note calendar format and was then cleaned up and condensed into a more generalizable guide for other teachers to utilize and modify as desired.

In my reflections, I also included student anecdotal remarks or feedback given to me as well as my observation of students' responses to prepared lessons. This included statements that students made about the lessons and my observations of their engagement with the lesson materials. If students seem disengaged or non-responsive to lessons, I took note. If students were engaged and excited about the lesson, I noted such details as well. These notes were made on a daily basis, at the end of the day within the notes section of the Google Slide lesson plans. This reflective practice was useful to communicate my own perspectives on lessons and daily activities and highlighted what worked or did not work in my daily lessons and units. This detailed note keeping was invaluable during Action Research Cycle 3, when I was determining the scope and sequence of the pacing and curriculum guide I was able to create thanks to this action research project.

In addition to keeping regular notes related to creating and incorporating sustainability concepts into the course, I also spent a minimum of one hour per week critically reflecting on the project, its political complications, my own bias and positionality, my thoughts about student reactions, and other critically inclined thought processes. I recorded and expanded upon such thoughts in both a digital and handwritten reflective research journal.

Data collection for RQ2: Student related data. In order to show student growth related to sustainability education, all students enrolled in my high school Earth/Environmental Science course were asked to complete a pre- and post-survey that gauged their knowledge, attitudes, and behaviors related to sustainability concepts. The survey consisted of 45 multiple choice questions and took no longer than 30 minutes to complete (see Appendix C). Students were asked to complete it at the beginning of the Sustainability unit and once again at the conclusion of the course. The Likert-style survey tool was originally created by a team of researchers from Appalachian State University's Office of University Sustainability and the University Sustainability Council's Data and Assessment Sub-committee. The original survey was designed for first year college students attending the town's University in order to track longitudinal progress goals of the university's strategic plan (Faircloth, 2014). The Likert-style survey questions were "designed to uncover levels of understanding of various sustainability topics including social justice, environmental conservation, and economic stability" (Faircloth, 2014, p. 15). Survey questions fell in one of three categories: 1) assess knowledge about sustainability related themes, 2) to gauge how participants identify with certain sustainability related values, and 3) identify frequency of habits, actions, and behaviors that demonstrate a commitment to sustainable lifestyles. The survey was tested for validity and reliability during the fall of 2014 and was distributed to the incoming freshmen class in the fall of 2015. There are plans to administer the same survey to the graduating class of 2019 with hopes of identifying any shifts of knowledge, attitudes, or behaviors towards sustainability after students spent four years as a student at Appalachian State University.

I slightly modified the university survey to be appropriate for high school freshmen. Questions related to whether or not they chose this school because of its

sustainability commitments were removed. Questions relating to topics that require participants to be a certain age (voting, driving, buying goods and services, etc) were modified to be appropriate for younger high school students. The survey consists of 45 Likert-style and multiple-choice questions with 2 open ended questions (see Appendix C).

Student classwork, including daily warm-ups, reading reflections, lab reports, daily feedback, lesson reflections, and creative projects, was collected, dated, reviewed, and analyzed to gauge student progress at regular intervals across the 13 weeks of the course.

Lastly, students' North Carolina Earth/Environmental Science Final Exam data was analyzed, kept anonymously, and used to consider whether incorporating sustainability themes negatively affected a student's chance of passing the state-sanctioned final exam. As a North Carolina public school, it is expected that teachers design the semester's curriculum to ensure that students are able to demonstrate mastery of NC Essential Standards for corresponding subjects. Mastery is gauged based on student ability to pass the North Carolina Earth/Environmental Science Final Exam. NC Final Exams were created to replace locally developed assessments to provide teachers and administrators with a common statewide measure to compare student growth measures using the Educational Value Added Assessment System (EVAAS) (NCDPI, 2016). As mandated by the school district, standardized final exams are worth 25% of students' final course grade and are administered during the last week of the semester under very strict test administration protocol: "North Carolina Final Exams for High School Science courses will measure students' academic progress in the NC Essential Standards, adopted by the North Carolina State Board of Education in February 2010" (NCDPI, 2016, p. 1).

It should be clearly noted that, while I was critical of the purposes and impacts of these final exams, I was required to adhere to such policies in order to remain employed with

the public school system. The exams encourage the objectivist view of education that preferences the teacher-to-student transmission of knowledge. If I wish for the students to earn the highest grade possible for the course, I must 'teach to the standards,' since 25% of their final grade is determined by their performance on the NC Final Exam. As mentioned before, one of the goals of this action research case study was to show that it is possible to incorporate sustainability themes of critical economic and social justice study without compromising thorough coverage of the state sanctioned standards.

  Cycle 3: Final reflection and analysis & public action step. This final cycle came into full swing once the Spring 2017 semester wrapped up in June. However, portions of this final cycle were also happening during Cycle 2 in that both Cycle 2 and Cycle 3 included reflective analysis of teacher/student feedback and student work. Beginning steps for Cycle 3 included administering the post-unit survey and soliciting final student reflections.

  Data analysis for RQ1: Curriculum related data. Pre-unit survey data was compared to post-unit survey data to assess if participating in my Earth/Environmental science course improved not only their knowledge about sustainability but also to identify any shifts in attitudes and behaviors. The open-ended questions were analyzed and coded to identify any positive or negative themes within students' perceptions and reactions to the topics addressing ecojustice and sustainability. Results of this data analysis are found in Chapter 4.

  Final exam data was also analyzed and compared to previous semesters as well as other Earth/Environmental Science courses that were not following my redesigned pacing and curriculum format. This data was kept anonymously and was used to consider whether incorporating sustainability themes negatively affected a student's chance of passing the state-sanctioned final exam.

Action Research Cycle 3 led to a thorough and thoughtful analysis of how effective the integration of sustainability themes was and ways in which the course design could be improved. Digital lesson plans and the sticky note planning board seen in Figure 4 were analyzed, condensed, and converted into the final pacing guide found in Chapter 6. When considering how to best format my lesson plans to share with a wider audience, I discovered the 5E Instructional Model, developed by the Biological Sciences Curriculum Study (Bybee, et al., 2006). I decided to organize my thematic lesson plans around this model because it provided an evidence-based pedagogical model that easily supported my natural, constructivist teaching style. Upon researching the 5E Instructional Model, I realized that the majority of my self-created lesson plans fell very closely into this instructional strategy that builds upon prior student knowledge and focuses on identifying and correcting student misconceptions.

Data analysis for RQ2: Assessing student comprehension & response to sustainability themes. Student work was collected and analyzed to better understand if students were able to comprehend and communicate the relevant connections between the environment, economy, and social justice. Every assignment was dated, sorted, and filed during Action Research Cycle 2. It was then assessed through the four dimensions of the Burns model of sustainability pedagogy (Burns, 2011) to see if students demonstrated a growth in sustainability literacy. The Burns model of sustainability pedagogy promotes complex co-created content, a diversity of critical perspectives, experiential participation, and emphasizes a place-based and local context. In analyzing student work, it was found that many students were able to demonstrate their understanding of these concepts through a variety of contexts and topics. A variety of sustainability issues were investigated, and the students explored

and articulated their visions for action (Burns, 2011). Results from this analysis can be found in Chapter 5.

Validity in Action Research Projects

Validity in qualitative research differs greatly from that of quantitative research but is in no way less valid (Kincheloe, 2012). The positivist terms of internal/external validity, reliability, and objectivity are replaced with the qualitative terms of credibility, transferability, dependability, and confirmability (Denzin & Lincoln, 1994). Herr and Anderson (2005) argue that action research should not be judged by the same criteria that are used for the entirely different practice of research stemming from the positivist camps. The goals of action research help to define the validity criteria in which quality action research may be deemed distinct from sub-par research. According to Herr and Anderson (2005), the goals of action research are to 1) generate new knowledge; 2) achieve action-oriented outcomes; 3) educate both researcher and participants; 4) create results that are relevant to the local setting; 5) employ a sound and appropriate research methodology. These goals help to define the five validity criteria for action research as defined by Herr and Anderson (2005): process validity, outcome validity, catalytic validity, and democratic validity.

Process validity deals with the integrity of the research process. Gathering data from a variety of sources (triangulation) served to validate findings, as did constantly seeking input from my peer mentor and professional learning team that were assigned to me at the beginning of the year. I also kept records of reflections, discussions and evaluations with colleagues and administrators.

Outcome validity involves the integrity of the resulting action that comes from the research project (Herr & Anderson, 2005). Outcome validity also acknowledges that the goal of action research is not to necessarily 'solve' the identified problem but to lead to a

reframing of the problem so that additional questions and action steps may be identified. This continual reframing of the problem is perhaps the main fountainhead for the common spiraling nature of action research projects. Based on outcomes of this research, new questions and problems have been identified, leading to the potential for additional spiral phases of future complimentary action research projects.

Catalytic validity gauges scope and scale of how much participants reorient their understandings of reality. "The most powerful action research studies are those in which the researchers recount a spiraling change in their own and their participants' understandings" (Herr & Anderson, 2005, p. 56). Keeping a research journal and soliciting continual feedback and reflection from research participants is an effective way to record and measure catalytic validity, both practices that were employed by this research project.

Democratic validity deals with issues of ethics and social justice (Herr & Anderson, 2005). To be considered democratically valid, a research project should include a diversity of voices and outcomes should be relevant and beneficial to the studied group(s). My research project relied heavily on student voices to help direct and create future lessons and the overall curriculum guide. I am also hopeful that the resulting pacing and curriculum guide may become useful to other high school science student in the future.

Research Limitations

The previous section identified criteria for measuring this research project's credibility. It is also important to identify the three main limitations of this study: generalization, problematic data collection, and the impact of the researcher's presence on the study.

This research is limited to the results that were generated from the study on three high school classes of one Earth/Environmental Science course and thus will not be generalizable

to all secondary courses. Additionally, my own interpretations of student feedback and data could be analyzed differently by others within the field. For example, my assessment of a student comment may differ drastically from another person's interpretation of the same comment. Walsh and Gardner (2005) recommend that action researchers test their interpretations by allowing in the judgment of others. I regularly sought feedback and shared anonymous student data with colleagues at my school. This would happen regularly during department meetings and within our designated professional learning teams. As a beginning teacher, I also was assigned a mentor who I spoke with on a regular basis every day. Unique in context, results from this study will not be replicable in differing contexts, which was not a goal of this research project. Instead, I aimed to produce a document which synthesized ways in which to integrate sustainability education into a public school science classroom.

The sheer amount of available data presented complex challenges. Due to the dynamic design of this action research study, it was difficult to define or know what types of data would be the most valuable for data analysis. The volume of data generated, and the pacing of data collection, made data analysis a challenging task as well. To offset these challenges, I limited data collection to one action research cycle, and utilized the Burns model of sustainability pedagogy to help identify four relevant lessons in which to analyze student data.

Personal subjectivity must be acknowledged in any research study, especially qualitative research, and most especially in action research when the researcher is also the practitioner. The differences between bias and perspective are important to identify and name. We all operate with bias; problems arise when biases go unexamined. My personal biases include my belief that education can and should serve as a solution to our world's most pressing problems. I also believe that all people deserve to live in a world that provides a

clean environment, fair economy, and respectful and diverse society that honors the dignity and importance of all living things. These beliefs are what motivated me to partake in this study. I regularly practiced self-reflexivity when analyzing student work, always reminding myself that every human comes to every experience with their own set of diverse perspectives and biases.

An overarching limitation of this study is that data related to the long-term impact of adolescents' experiences with sustainability education were not collected given the timeframe and range of this study. Such a study would be a valuable addition to this research endeavor.

Chapter Summary

I value the importance of educating youth about their interconnected role in the natural and cultural Earth and seek to live that value in my classroom. Action Research was the ideal methodology for this endeavor because it required that I reflected on my reasons and purpose for integrating holistic sustainability education into the state-sanctioned curricular standards. I was required to document my process, continually collecting data and student-feedback on how the intervention was affecting my research participants (students). I had to continually implement changes as needed to better my practice for the greater good of my classroom community. While it was not the goal of this study to make claims about long-term impacts of the curriculum on student behavior, I was interested in identifying short-term changes in student attitudes and my own personal journey of attempting to influence my students in this way. As McNiff (2013) describes, "Action research is about putting ideas into action, not only talking about them" (p. 51). As a long-time sustainability education advocate, I was elated to generate my own theory of living by putting my ideas to action while simultaneously conducting practical research that matters to me, my students, and hopefully the larger educational community. I am hopeful other science educators find this

sharing of a journey helpful and perhaps even relevant to their own practice. If sharing my

journey can help others deepen their desire and build their confidence to interweave

sustainability education into their course, I will feel beyond accomplished. If this journey

positively affects at least one of my students, I will also consider this a successful endeavor.

Being a work-based study, action research was a perfect fit because it is a

practitioner-based methodology that involves critical self-reflection with a desired result of

improved educational outcomes. My personal goals for this action research project were to

demonstrate how to incorporate sustainability themes with state sanctioned standards,

positively impact students, and reflect on my own 'learning journey' as well as benefit the

greater good of ecological and humanitarian wellbeing (Ferrance, 2000; McNiff, 2013).

Chapter IV

Creation of The Pacing & Curriculum Guide

The purpose of this chapter is to discuss and analyze the findings of RQ1: *How can sustainability education that interweaves* ecological *literacy,* economic *system critique, and* equity *(social justice) be integrated within a state sanctioned earth/environmental science curriculum?* The findings for RQ1 could be shared in a variety of formats—some more 'formal' or 'academic' than others, but given that this was an action research project, I chose to develop a pacing and curriculum guide that reflect a possible vision for how sustainable education can be woven into mandated high school science curricula. This decision honors my deep commitments as a researcher to share findings directly with the communities/audiences most impacted by the research, which in this case is high school teachers (and their students). The final pacing guide and curriculum guide, developed in response to RQ1, involved engaging in three iterative cycles, allowing the curriculum shared here to evolve over multiple semesters (see Table 3). Below, I outline the problems of following a traditional curriculum sequence and explain my rationale behind my proposal of a newly designed curriculum structure. I then discuss the results of implementing the reorganized course structure through qualitative data analysis.

Table 3

Timeline of creation, implementation, and assessment of integrated sustainability curriculum

	Fall 2016	Spring 2017	Summer 2017
Curriculum used	"Traditional" curriculum that follows same order of Standards Document	"New" curriculum that was restructured to incorporate sustainability	N/A
Action Step(s)	Curriculum analysis of 'traditional' curriculum Began drafting ideas for restructuring course	Restructured and delivered course to fully integrate sustainability into curriculum	Designed and created sharable pacing guide Analyzed student & teacher data

Data analyzed	North Carolina Final Exam (NCFE) scores Informal teacher notes Informal student responses to end-of-course survey	Ongoing student feedback through assignments, performance, and in-class comments Teacher research journal	North Carolina Final Exam (NCFE) scores Student responses to sustainability survey/end-of-course survey Teacher research journal Student work

Reorganizing Course Structure

The first goal of this action research project was to explore strategies for integrating sustainability education into a state-sanctioned earth/environmental science curriculum. To accomplish this goal, I had to begin with two foundational tasks: to review and study the NC State Essential Standards for Earth/Environmental Science and to learn about the theory and practice of sustainability education. The following section documents how I was able to build upon and interweave the state sanctioned curriculum standards with a sustainability education framework that emphasized the interconnections between ecological literacy, equitable social structures, and economic system critique.

Curriculum Analysis of 'Traditional' Curriculum (Fall 2016)

During the first semester of the 2016-2017 school year, I covered the NC State Essential Standards for Earth Science by dividing them into five units (Table 4). The five units mimicked the same order that the standards are presented by the NC Department of Public Instruction (Appendix A). Each unit began with an overview of how the natural system (air, land, water, or ecosystem) functions. Students would then investigate how humans can negatively and positively impact each system. Wiggins and McTighe (2012) warn of this common tendency of teachers to present the standards in the same order they are

listed in standards documents. Teachers tend to view standards documents as being

prescriptive because the standards are listed in such an analytical and hierarchical way

(Wiggins & McTighe, 2012). Teaching each standard in isolation or focusing on either the

top or bottom tiers of each group of standards are common teacher misinterpretations of such

documents (McTighe, Seif, & Wiggins, 2012; Wiggins & McTighe, 2012). These

misconceptions lead to "needlessly isolated and ineffective teaching and assessment"

(Wiggins & McTighe, 2012, p. 7). Just as whole-body nutrition is much more than merely

consuming a hierarchical list of vitamins and minerals, a truly integrated curriculum cannot

simply march through a list of standards, checking each one off and then moving on

(Wiggins & McTighe, 2012).

Table 4

Original course structure (Fall 2016)

Unit	NC State Essential Standards
1: Earth in Space	EEn.1.1 Explain the Earth's role as a body in space
2: Lithosphere	EEn.2.1 Explain how processes and forces affect the lithosphere.
	EEn.2.2 Understand how human influences impact the lithosphere.
3: Hydrosphere	EEn.2.3 Explain the structure and processes within the hydrosphere.
	EEn.2.4 Evaluate how humans use water
4: Atmosphere	EEn.2.5 Understand the structure of and processes within our atmosphere.
	EEn.2.6 Analyze patterns of global climate change over time.
5: Ecology & Sustainability	EEn.2.7 Explain how the lithosphere, hydrosphere, and atmosphere individually and collectively affect the biosphere
	EEn.2.8 Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth.

    As a first year public school teacher, I fell victim to such habits and

misconceptions. An informal analysis of student engagement following the Fall 2016

semester suggested that my students were not experiencing an integrated curriculum. They

were not making the necessary connections between the Earth's interconnected spheres nor were they feeling inspired to act and/or learn more about the importance of sustainability. When asked to rate their favorite unit, the majority (55.1%) of students responded that Astronomy/Earth in Space was their favorite. This revealed to me that I had not inspired them to care about issues here on Earth related to sustainability. When asked to select their least favorite unit, 49% of students selected either the sustainability/ecology, hydrosphere, or atmosphere/climate change unit as their least favorite unit. It became clear to me that if so many students disliked learning about hydrologic, atmospheric, and sustainability issues, I was not accomplishing my goals. I knew I had to come up with a different way to organize and present the material. Taking seriously Wiggins (2012) and McTighe and Wiggins' (2013) critique, I set out to revise my use of the standards by re-ordering them and integrating them into my theoretical framework more purposefully.

Additionally, an informal analysis of my own teacher reflection revealed that I struggled with deciding where relevant case studies should fit within the original segmented organization. My main issue with covering the material in a hierarchical format was that it presented the Earth's natural processes as separate and distinct when in reality they are constantly interacting in complex, interconnected systems (Capra, 2002; Meadows & Wright, 2008; Orr, 2004). Such a fragmented delivery made it difficult for students to see how human activities such as mining, deforestation, agriculture, energy usage, and consumption/disposal affect all of the Earth's systems simultaneously (Evans, 2012; Martusewicz, Edmundson & Lupinacci, 2015). For example, most people understand that burning coal contributes to air pollution, but the mining and shipment of coal and the disposal of coal ash also have significant impacts on air, soil, and water quality, as well as

contributing to climate change and human health and social justice problems (Bigelow &

Swinehart, 2014).

Professional Action Step: Restructuring a "New" Curriculum (Spring 2017)

In order to emphasize the interconnectedness of Earth's systems and to encourage

students to see how human activities impact all of Earth's systems concurrently, I

intentionally reorganized the delivery of the content standards for Spring 2017. Within this

new structure, the first half of the semester was focused on how Earth systems and cycles

function and then the second half of the semester on how humans impact those systems and

cycles (see Table 5). Each curriculum unit was structured around a sustainability theme with

supporting driving essential questions. These essential questions were derived from the State

Essential Standards they were tied to. Each essential question was then supported by guiding

ideas (subunits) that were linked to relevant essential standards. As explained in Chapter 2,

designing curriculum around themes and essential questions is a strategy advocated by many

leading educational researches (Graff, 2011; Taba, 1962; Tyler, 1949; Wiggins & McTighe,

2012).

Table 5

New structure of course (Spring 2017)

1st Nine Weeks (Block Schedule, 90 min classes, 18 week semester)		
Theme (Unit)	**Essential Questions**	**Standards**
Science Principles & Space 101: Questioning and the **Exosphere**	What is science? What is Earth's location in the Universe? How does the sun impact the Earth?	EEn.1.1.1 - 1.1.4
History of the Earth: Geology & the **Lithosphere**	What can patterns in nature tell us about our past? How can patterns found in nature help predict the future? Why do people live in geologically hazardous areas?	EEn.2.1.1 - 2.1.4

Our Water Planet: Hydrology & the **Hydrosphere**	How does the cycling of water impact the natural world? How does water help move energy around the globe?	EEn.2.3.1 -2.3.2
The "ocean" of air around us: Meteorology & the **Atmosphere**	How are weather patterns created? How do air mass movements affect landscapes?	EEn.2.5.1 - 2.5.4 EEn.2.6.1-2.6.2

2nd Nine Weeks

Ecology & Interconnections	What are the connections found in nature? What are the connections between humans and nature? What is the value of the natural world?	EEn.2.2.1 EEn.2.7.1 - 2.7.3
Understanding Sustainability	What is sustainability? What are the historical and conceptual foundations of environmental science and sustainability?	EEn.2.7.3 EEn.2.8
Energy & Climate Change	How do humans use energy? How are humans impacting the climate? How will a changing climate impact humans and non-humans? How are humans impacting air quality? How does air quality impact humans and non-humans?	EEn.2.2.2 EEn.2.4.1 EEn.2.5.5 EEn.2.6.3 EEn.2.6.4 EEn.2.8.1
Consumerism & Sustainable Solutions	What is the story of our stuff? What drives our consumption patterns? How do our consumption patterns impact the natural world and other humans? How do our food choices impact the natural world and other humans? What can humans do to limit/improve our impacts on the environment, each other, and future generations?	EEn.2.4.1 EEn.2.4.2 EEn.2.8.2 EEn.2.8.3 EEn.2.8.4

Reorganizing the content in this way allowed more flexibility and time devoted to the standards related directly to sustainability concepts such as climate change, consumerism, ecology, and the social and economic systems that lead to ecological destruction. I thought that once students gained a basic understanding of how natural systems functioned during the first nine weeks of the course, they would be better prepared to understand human impacts on the natural world. Having the entire second nine weeks to devote to sustainability concepts

allowed us to dive more deeply into a variety of case studies. For example, students could now explore the full story of coal that includes much more than simply adding carbon dioxide to the atmosphere. In the traditional earth science curriculum sequence (Fall 2016), I struggled with where to fit in a discussion about the impacts of using coal as an energy source. Did it best fit within water pollution? Air pollution? Habitat destruction? In order for students to even begin to understand the many impacts fossil fuels have on eco-, social-, and economic systems, they would need to be allowed to explore the full scope of the many interconnections among coal's impacts to humans and the natural world (Bigelow & Swinehart, 2004). The new structure of the course allowed for an entire sub-unit on mountaintop removal, where we discussed the full story of coal and all of its many social, environmental, and economic impacts.

Reorganizing the course also allowed for a constant revisiting of past material to help with student comprehension and retention. This cycling back was another attempt to avoid the linear model of education that the assessment-driven models promote (David, 2008; Wiggins, 2012). By regrouping learning outcomes around themes related to human impacts and interconnectedness, students were better able to realize how affecting one sphere of the natural world affected all others. Polluting the hydrosphere (water) will affect the lithosphere (soil), atmosphere (air), and biosphere (life).

This reorganization also allowed students to move beyond just studying the environmental impacts of the Earth's four main spheres. Sustainability education involves investigating the interactions between the environment/ecology, equity/social justice, and the economy (Burns, 2011; Evans, 2012; UNESCO, 1997, 2005, 2012). We were able to delve deeply into a variety of thematic sub-units such as deforestation, consumption, mountaintop removal, and agriculture so that we could see how each of these human activities affected

more than just the ecology of a place. We were able to explore how economics drive such human activities and how their impacts affected different people in different ways. Because ultimately, environmental concerns do not exist in a vacuum. One cannot begin to understand environmental impacts without looking at the economic and social (and political) drivers and effects (Evans, 2012; Martusewicz, Edmundson, & Lupinacci, 2015).

Public Action Step: Creation of a Pacing Guide

Documenting and sharing this new reorganization strategy was a critical goal of this action research project. Since the aim of RQ1 was to investigate how to interweave sustainability education into the state sanctioned Earth/Environmental Science curriculum, creating a pacing guide to share with others was an obvious and beneficial outcome of this project. However, I did not want to create a document that encouraged the traditional objectivist, linear-style of teaching and learning (David, 2008; Stuhmcke, 2012). For one, true sustainability education is the antithesis to such pedagogical praxes (Evans, 2012; Orr, 2004; Pace Marshall, 2006), and two, I did not want to box teachers in with a prescriptive, step-by-step guide since I understand that every teacher, school, classroom, and student is different. I wanted to create a pacing guide that mimicked the sustainability principles of being dynamic, flexible, adaptable, engaging, and helpful (David, 2008; Wiggins, 2012). The next section documents the process of creating the pacing guide and how it is different than traditional pacing guides.

Pacing guides for Flexibility and Sustainability

In thinking about how to organize and deliver a pacing and curriculum guide for an integrated sustainability-earth/environmental science course, I began researching what an ideal pacing guide, in general, might look like. Then, I intended to adapt that model for one suited for sustainability education. Wiggins (2012) argues against pacing guides that

prioritize covering the material at a specified pace without an awareness of how the students are understanding the material. Such an input-driven strategy is a flawed approach to teaching because it encourages memorization and not mastery, quantity and not quality, knowing and not understanding (Wiggins & McTighe, 2005).   Pace Marshall (2006) would describe this as the difference between shallow and deep learning. Transformational sustainability education requires deep learning that immerses the "learner in the interdependence and wholeness of the world and meaningfully engag[es] her in the big ideas, questions, paradoxes, and ambiguities of the human experience" (Pace Marshall, 2006, p. 45). Burns (2011) argues for course designs that mimic ecological principles through multidisciplinary *content*, participatory *process*, critical *perspectives* and place-based *context*. Such an ecological curriculum design is flexible, diverse, and is rooted in the natural world to allow for deep learning (Burns, 2011). When designing my pacing guide for an integrated sustainability-earth/environmental science course, I used the Burns Model of Sustainability pedagogy (Burns, 2011) as a way to help foster Pace Marshall's goal of deep learning because "Deep learning provides a context of connections and wholeness that reconnects children to all the ways they come to know and reestablishes their physical, cognitive, and spiritual intimacy and resonance with the natural world and one another" (Pace Marshall, 2006, p. 45).

Another goal for my pacing guide design was for it to be student-centered. Poorly designed pacing guides not only lead to shallow learning but can also lead to superficial teaching and undue teacher stress (David, 2008). Teachers can feel so pressured to cover all of the material and stay on schedule that they rush through the material whether or not the students have mastered the content or not. Teacher-centered lessons that focus on covering content instead of student mastery tend to be more efficient and predictable but do not

necessarily lead to depth of understanding (David, 2008). Teaching for understanding on the other hand, emphasizes the importance of student-centered learning that can often be more time-consuming such as long-term projects and in-depth analysis (David, 2008). The Burns Model of Sustainability Pedagogy prioritizes in-depth analysis of complex issues from a variety of critical perspectives in order to help students feel connected with their community so that they become engaged citizens (Burns, 2011). I made sure that my pacing guide included these crucial tenets of sustainability education.

Lastly, Wiggins suggests that a genuine pacing guide should "provide advice on which lessons and units to highlight, downplay, repeat, or even skip, based on formative results and year-end goals" (Wiggins, 2012, para. 14). Ultimately, a meaningful pacing guide should focus on results and not inputs by allowing the teacher to adjust and modify based on how the students are mastering the content. My pacing guide clearly articulates which lessons should be covered in-depth, reduced or skipped based on time.

Previously available NC earth/environmental pacing guides. I conducted a search for publicly available Earth/Environmental pacing guides in an effort to see how other teachers and districts in North Carolina suggested the State Essential Standards for Earth/Environmental Science should be covered. While my search was by no means exhaustive, I found two main common themes: 1) pacing guides for Earth/Environmental Science are either non-existent or not publicly available or 2) the pacing guides that are available suggest covering the standards in the same order as they are presented in the State Essential Standard Guide: outer space, land, water, air, ecology/resource use. Some schools would include an intro unit and move the exosphere (outer space) to the end of the course. As discussed earlier, delivering the content standards in the same order they are presented in the standards document is misguided for multiple reasons. In terms of sustainability

education, such an approach runs contrary to the goal of increasing student ecological literacy. Ecological literacy relies upon understanding the interconnections between and among the earth's natural systems (Capra, 2002). Teaching a unit on water, a separate unit on air, and a separate unit on ecology does not help students understand the interconnections of these natural systems. Furthermore, presenting the standards in this way does not allow for a deeper investigation of the causes of ecological destruction (economic drivers) nor the variable impacts ecological harm has on differing communities (social justice). Sustainability literacy is reliant upon a thematic course structure that allows for in-depth investigations that cut across disciplines (Burns, 2011; Evans, 2012; Pace Marshall, 2006).

It became clear that my reorganization of standards was a different approach and could possibly be a beneficial tool for other teachers in my district and the state. It was also clear that a new style of a pacing guide for Earth/Environmental Science that followed the suggestions of Wiggins (2012), David (2008), Burns (2011), and Pace Marshall (2006) might be useful to me.

Guidelines for the creation of pacing guides. To avoid the common mistakes so often found in traditional pacing guides, I decided to create my own template that included driving questions, guiding ideas, clear connections to student objectives, formative assessment suggestions, and a key that identified which concepts/lessons were most important and which could be condensed or skipped under time constraints. To emphasize the importance of interconnections between concepts and ideas, related content standards were also identified. Each sustainability theme has a section with suggestions for transformational learning that includes various ways to incorporate sustainability education through *content, context, perspectives, and process* (Burns 2011).

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When creating the pacing guide, as part of the larger action research project, I kept in mind what kind of document would be helpful for me as a teacher. I had looked for such a guide as a first-year teacher and ended up relying mostly on teacher blogs which were helpful but were not as flexible, comprehensive, or as adaptable as I would have liked. It was also important that my pacing guide be flexible, not prescriptive. I wanted it to be accessible to those outside of the science discipline because sustainability education can and *should* be included into all course disciplines.

The pacing guide focuses on the second half of the semester, covering 15 of the 32 Earth/Environmental Essential Science standards in which sustainability education was the main focus. It does not cover what I've identified as the Earth Science section of the curriculum—the 17 standards that mainly focus on understanding how Earth systems and cycles function. Including those standards into this pacing guide was outside the reach of this action research project and would have created a longer and more complicated pacing guide. However, those additional 17 standards were utilized and reviewed extensively throughout the second half of the course because understanding Earth's systems and functions are essential for understanding how humans impact those systems. Refer to Table 5 for an overview of how I structured the first half of the semester.

Process of pacing & curriculum guide creation. The process of creating the pacing & curriculum guide was rigorous and analytical. It required revisiting and analyzing daily lesson plans, student work, my reflection journal, other curriculum guides, and student feedback. To begin, I reviewed numerous lesson plan and pacing guide templates found online and from colleagues within my school district. I created my own template following the guidelines described above. Because I wanted the template to be accessible and adaptable, I played around with multiple formats until I was pleased with the overall

layout. For ease and readability, I created a one-page overview of the sustainability-related standards. These standards were organized into four main sustainability themes, serving as the four units used in the second half of the semester. As seen in Table 6, each sustainability theme includes two to five essential questions and two to five lessons (referred to as Guiding Ideas). The one-page pacing guide includes the related NC State Essential Standards for Earth/Environmental Science and a key that identifies which Guiding Ideas (lessons) are essential or are okay to condense or skip under time constraints (Table 6).

Table 6

One-page overview pacing guide

Theme	Essential Questions	Guiding Ideas	Standards
Ecology & Interconnections	What are the connections found in nature? What are the connections between humans and nature? What is the value of nature?	Ecology and Biodiversity: Connections and Threats 🌍🌍🌍 What is the Value of a Forest? 🌍🌍	EEn.2.7.1 EEn.2.7.2 EEn.2.7.3 EEn.2.2.1 EEn.2.4.2
Understanding Sustainability	What is sustainability? What are the historical and conceptual foundations of environmental science and sustainability?	The 3 Es of Sustainability & the 3E Goggles 🌍🌍🌍 Tragedy of the Commons 🌍 Evolution of Environmentalism: Rachel Carson, the EPA, and Sustainable Development 🌍 What's My Impact? Ecological Footprint 🌍🌍	EEn.2.8 EEn.2.7.3 EEn.2.8.4
Energy & Climate Change	How do humans use energy? How are humans impacting the climate? How will a changing climate impact humans and nonhumans? How are humans impacting air quality? How does air quality impact humans and nonhumans?	Understanding the Greenhouse Effect 🌍🌍🌍 Evidence & Impacts of Climate Change 🌍🌍🌍 Story of Coal, Oil & Natural Gas 🌍🌍 Impacts of Air Pollution 🌍🌍🌍 Solutions to Climate Change 🌍🌍 Renewable Energy	EEn.2.6.3 EEn.2.6.4 EEn.2.8.1 EEn.2.2.1 EEn.2.4.1 EEn.2.5.5
Consumerism & Sustainable Solutions	What is the story of our stuff? What drives our consumption patterns? How do our consumption patterns impact the natural world and other humans? How do our food choices impact the natural world and	Materials Economy & Life Cycle Assessment 🌍🌍🌍 Consumption & Media Literacy 🌍 Story of Trash & Food Waste 🌍🌍 Sustainable vs. Industrial Agriculture 🌍🌍🌍 Lexicon of Sustainable Food 🌍 Water Access and Water Quality 🌍🌍🌍 Story of Solutions & Sustainability Heros 🌍🌍	EEn.2.8.4 EEn.2.8.2 EEn.2.4.1 EEn.2.4.2 EEn.2.8

other humans?

Note: While the above order of sustainability themes is suggested, the teacher may reorder the delivery of themes and guiding ideas as he/she sees fit.

In keeping with the design principles of ecological course design (Burns, 2011), I avoided assigning specified days or lengths of time to spend on any particular lesson. As Wiggins (2012) suggested, I created a three-tiered key utilizing small earth images that communicated which guiding ideas are *essential* to cover (🌐🌐🌐), which can be *condensed* under time constraints (🌐🌐), and which can be *skipped* if pressed for time (🌐). This allows for teachers to be in control of their own classroom and to design their own curriculum based on the needs of their students.

I was also intentional about avoiding numerical titles to any section of the Pacing & Curriculum Guide because I did not want to prescribe a rigid chronological order. Transformative sustainability education and effective pacing guides should be flexible, adaptable, and catered to student needs, as the goal should be understanding, not mechanical coverage of content (McTighe & Wiggins, 2013; Pace Marshall, 2006; Wiggins, 2012). This student-centered fluidity is what the Burns Model of Sustainability Pedagogy refers to as ecological course design (Burns, 2011).

Public Action Step: Creation of Curriculum Guide

Even though my intention was to not provide a prescriptive curriculum that would dictate teacher decisions, I did want to provide some guidance of activity and assessment ideas for educators who might not be familiar with sustainability education. I successfully

created eight shareable lessons for two of the four sustainability themes. These curriculum guides serve as both an example of implementation and as guiding templates. The publicly-accessible lesson plans are formatted around the constructivist 5E instructional model, developed by the Biological Sciences Curriculum Study (BSCS) (Bybee, et al., 2006). Due to time constraints and a shifting of life circumstances, I did not complete example lesson plans for all four of the sustainability themes. The two themes without completed lesson plans are very important and should not be overlooked. Both the Climate Change theme and Consumerism & Agriculture theme contain important concepts that should be included in a course with sustainability education goals. Even though I did not provide example lesson plans for all four themes, the completed pacing guide and eight shareable lesson plans serve as a foundation and spring board for others to utilize.

In addition to creating a sharable pacing guide, a complimentary goal of this action research project was personal reflection and improvement. The process of assessing and preparing my lessons to share with a wider audience taught me a great deal about my strengths and shortcomings. Outcomes of creating the curriculum guide will not only benefit other Earth/Environmental Science teachers but was also greatly beneficial to my own reflective praxis.

Design & format

The opening for each thematic unit listed the driving questions, relevant state essential standards, related standards, and essential vocabulary (see Figure 5).

THEME: Understanding Sustainability

Essential Questions
- What is sustainability?
- What are the historical and conceptual foundations of environmental science and sustainability?

State Essential Standards
- EEn.2.8 Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth
- EEn.2.7.3 Explain how human activities impact the biosphere.
- EEn.2.8.4 Evaluate the concept of "reduce, reuse, recycle" in terms of impact on natural resources.

Related Standards
- EEn.2.2.1 Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present.
- EEn.2.5.5 Explain how human activities affect air quality
- EEn.2.8.2 Critique conventional and sustainable agriculture and aquaculture practices in terms of their environmental impacts.
- EEn.2.4.1 Evaluate human influences on freshwater availability.

Essential Vocabulary

Bioaccumulation	Ecological	Equity	Sustainable Development	3E Goggles
Biocapacity	footprint	Global Commons	Sustainability	
Carbon Footprint	Economy	Rachel Carson	Tragedy of the Commons	
	EPA			

Figure 5. Sample theme overview from curriculum guide

Incorporating 5E Instructional Model

In reviewing my lesson plans, I noticed how my natural constructivist leanings caused my lessons to look very similar to the 5E learning cycle developed by (BSCS). As discussed in Chapter 2, the BSCS 5E Instructional Model is a student-centered lesson design tool rooted in the constructivist tradition, backed by research, and promoted by leading science educators (Bybee, et al., 2006). It consists of 5 stages that progressively build upon students' previous knowledge and works to correct misconceptions (Bybee, et al., 2006). The five stages of the 5E learning cycle are: engagement, exploration, explanation, elaboration, and evaluation (Bybee, et al., 2006).

I did not originally design my lessons by using the 5E Instructional Model because I had not been aware of the tool beforehand. I found the model to be helpful when reviewing my lessons and preparing them to share with other teachers. This process helped me to consider how well I was actually practicing my constructivist praxis and helped me realize where I was falling into objectivist teaching patterns that I had been trying hard to avoid. Because of my constructivist teaching habits, I was able to easily restructure my suggested lessons into the 5E model. Even though I organized and formatted the lessons for

sharing, I remained careful to not be too prescriptive, using suggestions instead of strict language, as I did not want to not box teachers into a strict delivery or pace (David, 2008; Wiggins, 2012).

Overview of Course Sustainability Themes

This section will provide an overview of two of the four sustainability themes that structured the second half of the course. In describing the reasoning behind the design of these two themes, it is my hope that the reader can come to better understand the process of how I chose to engage students with both the required Earth/Environmental science content and the integrated sustainability themes. The proceeding discussion provides numerous samples of the ways in which sustainability education can successfully be interwoven within a state sanctioned curriculum.

Theme 1: Ecology and Interconnections. The "Ecology and Interconnections" theme was divided into two main 5E learning cycles with the first being mainly focused on biodiversity and ecological literacy (see Table 7).

Table 7

Learning cycles for ecology and interconnections theme

Guiding Idea	Assessment Ideas
Ecology & Biodiversity: Connections and threats 🌍🌍🌍	Ecology & Biodiversity Learning Cycle: Connections and threats (link to full lesson) • Engage: Biotic and abiotic factors of North Carolina's biogeographic regions • Explore: NC ecosystem energy pyramid and biodiversity mural • Explain: Understanding ecosystems and threats to biodiversity • Elaborate: Invasive species research and web of life game • Evaluate: Habitat loss project
What is the value of a forest? 🌍🌍	What is the value of a forest? Learning Cycle (link to full lesson) • Engage: 1) Do humans play a role in natural disasters? 2) Deforestation in the Amazon. • Explore: Rainforest deforestation case study • Explain: Can we put a price on nature? • Elaborate: How do trees collaborate?

- Evaluate: Reflection & Action: Should we turn rainforests into hamburgers?

Learning cycle one: Ecology & biodiversity. Ecological literacy involves understanding the connections within the natural world (Capra, 2002). The first 5E learning cycle within this theme emphasized this concept through a variety of engaging activities that ended with a group project exploring habitat loss. Within this project, students began to explore how human impacts negatively impact the natural world but I did not specifically ask for them to expand on this concept. Instead, I was hoping the project would appeal to their affective domain, connecting them emotionally to the natural world. I attempted to accomplish this by providing research links about how climate change is affecting small mammals. While not every student chose to investigate climate change's impact on small mammal habitat, many were moved by this topic as a quote from my journal reveals:

> At the end of the day, there was a group of students competing to find the cutest small mammal. They were calling the animals by name and ooing and awwing about how cute they are. That was a great thing to see. (Researcher journal entry, April 3, 2017)

Ecological literacy also involves understanding how humans are a crucial thread within nature's tapestry. Trying to encourage students to see that humans are, in fact, a part of nature is a key component of sustainability literacy (Evans, 2012; Orr, 2004). However, during this theme, I focused more on making sure students understood how harming one part of the natural world inevitably harms other areas because of the interconnections found within the natural world. I focused more on the concept that humans are a part of nature in the next course theme, Understanding Sustainability.

Learning cycle two: What is the value of a forest? The second learning cycle within this theme began to incorporate more of the multiple dimensions of sustainability by introducing economic and social justice themes. Teachers can encourage students to begin to

see the connections between humans and nature by considering how the effects of some natural disasters such as landslides can be worsened by human activities such as deforestation. Students also can begin to see how negative impacts from such natural disasters do not affect all humans equally and that is is often the poor who suffer more. From there, students can begin to think about how to associate costs with nature by considering what values are associated with a forest. There's the price of lumber, labor, and transportation but there's also costs associated with the loss of habitat, oxygen, and bank stabilization. How do you put a price on things such as clean air? How do you create policies that begin to consider intangible values such as beauty, safety, and clean air, water, and soil? A rainforest deforestation case study puts these ideas into action when they must consider multiple perspectives (logger, indigenous farmer, and environmentalist) when trying to decide what to do with a tract of land covered by rainforest. Students are then encouraged to consider their own connections to rainforest deforestation when they look at which companies carry meat that has been raised on cleared rainforest land.

        Theme 2: Understanding Sustainability. The "Understanding Sustainability" contained four 5E learning cycles (Table 8). The first learning cycle builds upon the rainforest case study from the previous theme. Students are asked to consider what they think sustainability means and are then introduced to the foundation of sustainability: understanding issues and solutions as being an integration of societal, economic, and ecological concerns.

Table 8

Learning cycles for Understanding Sustainability theme

Guiding Idea	Objectives. Students will be able to...	Lesson Suggestions
The 3 Es of Sustainability	Explain that the purpose and process of	*Lesson: 3Es of Sustainability* ([link to full lesson](#)) • Engage: What does sustainability mean to

& the 3E Goggles 🌍🌍🌍	sustainability is to balance ecological, economic, and social equity issues, concerns, and solutions.	you? • Explore: Logger vs. farmer vs. environmentalist • Explain: 3Es of sustainability & the 3E goggles • Elaborate: letter to the future & official definition of sustainable development • Evaluate: 3E analysis of Wall*E; Sustainability Review
Tragedy of the Commons 🌍	Describe the meaning, provide examples, and explain the causes of the "tragedy of the commons" concept	*Lesson: Tragedy of the Commons* (link to full lesson) • Engage: Help yourself! Take as much as you like! • Explore: Claim your gold(fish) • Explain: What are the "commons"? • Elaborate: Additional tragedy of the commons activities • Evaluate: Digital notebook slides
Rachel Carson's Legacy: Earth Day and the EPA 🌍	Summarize the historical connections between Rachel Carson, early U.S. environmentalism, Earth Day, & the EPA.	*Lesson: Rachel Carson's Legacy* (link to full lesson) • Engage: What is DDT? • Explore: Take a stand • Explain: Read "A Fable for Tomorrow" (Ch 1 of Rachel Carson's *Silent Spring*); Watch part of 1960s documentary; Bioaccumulation video & demonstration • Elaborate: Rachel Carson's Legacy: How did the US look before EPA? First Earth Day and establishment of the Environmental Protection Agency • Evaluate: Choice menu- Rachel Carson's legacy
What's My Impact? Ecological Footprint 🌍🌍	Explain that an ecological footprint is a tool to measure individual and group resource use and impact of waste. It considers population and biocapacity of the Earth. Consider how consumption patterns impact the biosphere and society.	*Lesson: Ecological Footprint* (link to full lesson) • Engage: Think, Pair, Share: What is an ecological footprint • Explore: Calculate your ecological footprint • Explain: Guided notes, video, reading & keyword summary • Elaborate: Individual vs. national and global footprints. How does the U.S. compare to other countries? • Evaluate: Can you create a scenario that leaves enough for everyone? Evaluate the ecological footprint tool by using your 3E goggles.

This theme helps students build upon the ecological principles that were explored in the previous theme. The Ecology and Interconnectedness theme encouraged students to understand how humans are an integral *part* of ecosystems, and not separate from the natural

world. This second theme works to deepen that understanding to include an exploration of how economic drivers can lead to ecologic destruction and how power differentials result in some people/groups to suffer more from environmental harm than others.

Learning cycle one: The 3 Es of Sustainability and the 3E Goggles. This lesson is coded as the only essential (identified with the symbol of: 🌎🌎🌎) learning cycle within this theme, demonstrating the importance of this lesson in helping students understand the goals and meaning of sustainability. All five steps (engage, explore, explain, elaborate, and evaluate) of this learning cycle are discussed and analyzed in-depth in the preceding chapter (Chapter X) including student examples and rich description. Because of the depth of detail found within the next chapter, I will not expand on this lesson here.

Learning cycle two: Tragedy of the commons. This lesson is coded as "can be *skipped* if pressed for time" (identified with the symbol of: 🌎) but does provide engaging activity ideas that will help students to think deeply about why ensuring ecologic health is both difficult and essential. It utilizes Garrett Hardin's (1968) "Tragedy of the Commons" as the foundational principle to understand what the commons are and what is the tragedy. At the opening of class, before even being introduced to the concept of the tragedy of the commons, they experience a classroom-scale tragedy of the commons, when I set out an open bowl of goldfish that said, "Thanks for being awesome students! Help yourself!" The bowl of goldfish quickly disappeared before all students had a chance to enjoy the treat. This activity prompted an in depth exploration of what other "commons" might be within our own school and community. We then also connected the idea to more global environmental commons such as clean air, clean water, fisheries, etc.

While this lesson cycle could be skipped due to time constraints, it does provide an essential foundational principle that helps adolescents really consider how taking or polluting

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too much can seem okay to a short-sighted individual, but will end up harming the whole group.

Learning cycle three: Rachel Carson's Legacy, Earth Day, and the EPA. The goals of this lesson cycle are to help students recognize the historical connections between Rachel Carson, early U.S. environmentalism, Earth Day, & the Environmental Protection Agency (EPA). Concepts within this lesson help students understand how and why environmental regulations began in the United States and the difference that such regulations have made. Suggested activities within this unit include students looking at images of what the United States looked like before the EPA and articulating their own thoughts related to regulation, environmental health, and the government's role in keeping citizens safe and healthy.

Learning cycle four: What's my ecological footprint? The learning goals of this lesson cycle should enable students to be able to explain that an ecological footprint is a tool to measure individual and group resource use and impact of waste. Students are able to calculate their own ecological footprint to consider how their own consumption patters may impact the biosphere and society. They also compare and contrast ecological footprints to other countries and discuss what cultural, contextual, population, and demographic factors might impact a region's footprint. Students are also challenged to think of ways in which individuals and groups could work towards reducing their ecological footprints.

Chapter Summary

This chapter has focused on the results of this study's findings related to part of RQ1. The chapter explained the reasoning and process of restructuring the state sanctioned essential standards into thematic units based on sustainability themes, situating the process within the goals of action research, to create change in my classroom directly and in community broadly (Herr & Anderson, 2014). Providing an explanation of the pacing guide

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and a sample of the curriculum guide highlighted the emancipatory nature of action research: its moral imperative to fight for a better, freer world; not just to publish theories (Reason & Bradbury, 2001; Stuhmcke, 2012). The tangible outputs discussed in this chapter highlight how this action research sought change in three ways: a shift in individual practice, a shift of personal conception of personal practice, and/or a change in conditions in which practice takes place (McNiff, Lomax, & Whitehead, 2003).

By implementing the suggestions provided by leading curriculum designers (Wiggins & McTighe, 2007) and transformative sustainability education advocates (Burns, 2011; Pace Marshall, 2006; Sipos, Battisti, & Grimm, 2008), I feel confident that I have created a pacing and curriculum guide that can serve as a foundation for teachers interested in fostering transformative sustainability education in their own classrooms. However, in keeping true to holding ecological design as the foundation for teaching and learning, I am certain that this will remain a work in progress and is by no means a concrete, cookie-cutter solution to sustainability curricular implementation. I hope that myself and other passionate educators who believe in the power of education to help transform our world into a more healthy, just, sustainable world will continue to explore and experiment with ways to engage, enlighten, and inspire our students to become active citizens of their communities and the world.

To view this forever working draft of my integrated sustainability-environmental science pacing and curriculum guide see: tinyurl.com/eensustainability.

Chapter V

Student Response to Restructured Course

The purpose of this chapter is to discuss and analyze the findings of RQ2: *How do first-year high school students respond to sustainability education themes in a rural public high school Earth/Environmental Science course?* I analyzed four key sources of data to help understand how the newly restructured curriculum affected the course goals and student outcomes. The data analyzed included: 1) quantity of time and assignments devoted to sustainability, 2) students' pre-/post-course multiple choice survey data examining knowledge, attitudes, and behaviors related to sustainability concepts, 3) students' post-course student self-reporting survey, and 4) students' North Carolina Final Exam scores. Each of these points of analysis help better understand how the integration of sustainability education impacted students' knowledge of and attitudes towards sustainability and whether adequate coverage of the required course content was achieved. In each section below, analysis of the data and findings are discussed.

Quantity of Time and Assignments Devoted to Sustainability

One of the key challenges faced during Cycle 1 (Fall 2016) was the lack of time available to devote the necessary depth of sustainability related issues. In an attempt to allow for more depth of sustainability topics, my decision to group the required standards around sustainability themes ended up buying me more time. By restructuring the course around sustainability themes, I was able to spend more time and students were able to experience a more in-depth study of topics such as deforestation, mountaintop removal, climate change, consumerism, agriculture, and renewable energy. To come to this conclusion, I calculated the time spent on sustainability themes during Spring 2017 (semester two) and compared it to the same measure of semester one. Because I kept accurate records of daily lesson plans during

semester one, I was able to calculate and compare this measure quite easily. Table 9

compares the number of class days spent on sustainability themes between semester one and

two. It is important to note that the fall semester had 9 fewer days than the spring

semester. Because of this discrepancy, the percentage of days spent on sustainability themes

was calculated for both semesters to provide a more accurate comparison.

When reviewing and comparing lesson plans between semester one and semester two,

I also calculated the number of class periods I took the students outside and the number of

guest speakers we had. This data helps reveal information about the increased diversity in

educational opportunities allowed with the new course structure. Numerous research studies

show that outdoor learning experiences have positive impacts on children (Rickinson, et. al,

2004). The real-world experience and variety of perspectives presented by guest speakers

can also help to inspire and engage high school students (Goodnough & Cashion, 2006). I

cannot say for certain that these methods increased student engagement empirically, but my

anecdotal observations revealed that students were more engaged during these lessons. Table

9 also compares the amount of total graded assignments and formal summative assessments

(tests and quizzes) as an additional comparative measure.

Table 9

Multi-semester quantitative analysis of time and assignments devoted to sustainability themes

	Original course structure (Fall 2016)	New course structure (Spring 2017)
Units	5	8
Class periods devoted to sustainability themes	20/80= 25%	37/89= 42%
Total graded assignments	50 (+1 extra credit)	56 (+9 extra credit)
Formal summative assessments (tests & quizzes)	15	15
Outdoor explorations	4 outdoor activities	9 outdoor activities
Guest speakers	1	6

As demonstrated in Table 10, the new course structure allowed for more time outdoors and more guest speakers. An increase of five new outdoor explorations and five additional speakers was implemented in Spring 2017. The course restructuring also allowed for more class periods devoted to sustainability themes without taking away from more traditional course activities such as graded assignments or summative assessments.

Comparison of Pre/Post Survey Results

To assess student comprehension of sustainability interconnectedness, a key instructional goal of the reorganized course structure, specific questions were selected and analyzed from the pre- and post-course survey. Three questions from the pre/post survey were chosen to analyze because they were specifically geared toward assessing student comprehension of the interconnectedness of the three Es of sustainability: ecology/environment, equity/social justice, and economic critique. The three questions chosen for closer analysis are found in Tables 10, 11, and 12. When post-course survey data was compared to pre-unit survey data, the data showed improvement of student comprehension related to the definition of sustainable development and the interconnections of the 3Es of sustainability.

The first survey question chosen for analysis was a recall question about the most commonly used definition of sustainable development. As the data shows, a higher percentage of students selected the correct answer, "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland & The World Commission on Environment and Development, 1987), at the end of the course than before the unit began. There was an increase in correct answers of nearly 37 percentage points in the post-course survey. While memorizing the most widely accepted definition of sustainable development does not necessarily mean students understand the significance or

concept of sustainability, this is one indicator that students learned this definition of sustainability.

What's interesting about the results is that on both the pre- and post- survey, the same percentage of students selected the incorrect choice about "creating a government welfare system that ensures universal access to education, healthcare, and social services." Because of anonymity of the data, it is not possible to know if this misconception remained throughout the entire semester or if some students came to their own understanding of what sustainable development might mean.

Table 10

Pre- and post-unit survey data related to sustainability literacy: Question 1

Question	Possible answers **bold** = correct	Pre-Unit Answers	Post-Course Answers
Question 2: Which of the following is the most commonly used definition of sustainable development?	***Meeting the needs of the present without compromising the ability of future generations to meet their own needs***	33.3% (N=19)	70.2% (N=33)
	Creating a government welfare system that ensures universal access to education, healthcare, and social services	19.3% (N=11)	19.1% (N=9)
	Setting aside resources for preservation, never to be used	1.8% (N=1)	6.4% (N=3)
	Building a neighborhood that is both socio-demographically and economically diverse	3.5% (N=2)	6.4% (N=2)
	Don't know	42.1% (N=24)	(option not available)

I chose to analyze this second survey question (Table 10) because I was interested in whether students grew in their understanding of the interrelatedness of the three E's of sustainability. I would have liked to have seen 100% of the students select all three of the options on the post-course survey. Even though this was not the result, the post-course

results did reveal an increase in percentage of students who chose equity (1% increase) and economics (11% increase). What's especially interesting about these results is how more students selected economics (94%) than the environment (92%) during the post-course survey. The slight increase (1%) in the percentage of students who selected equity is not as much of a boost as I would have liked to see, but it is better than no increase at all. My interpretation of these results is that I was more successful at teaching students how economics plays a major role in sustainability than teaching them the meaning and importance of equity as a sustainability goal.

Table 11

Pre- and post-unit survey data related to sustainability literacy: Question 2

Question	Possible answers	Pre-Unit Answers	Post-Course Answers
Question 1: I commonly associate the term "sustainability" with...	Ecology/Environment	93%	92%
	Equity	73%	75%
	Economics	83%	94%

The third survey question chosen for analysis was also related to three Es of sustainability but was framed through an economic/business lens (Table 11). Most students (54.4%) chose "I don't know" on the pre-unit survey question about the "triple bottom line" and only 29.8% selected the correct response, "environmental, social, and financial performance." More students (62.5%) selected the correct response on the post-course survey. I would have liked to see a higher percentage of students select the correct response, but I did not spend much time talking about the triple bottom line specifically. However, if students fully grasped the concept of sustainability and the 3 Es, they could have easily

chosen the correct response even though the specific words of "ecology," "economics," and "equity" were not listed in the answer. It is promising that most students did demonstrate that they understand that sustainable businesses seek to incorporate environmental and societal concerns into their business performance measures.

Table 12

Pre- and post survey data related to sustainability literacy: Question 3

Question	Possible answers *bold* = correct	Pre-Unit Answers	Post-Course Answer
Question 3: Sustainable business development implies a commitment to measuring and reporting on the "triple bottom line", which includes...	Three different measures of non-financial performance	1.8% (N=1)	12.5% (N=6)
	Environmental, social and financial performance	29.8% (N=17)	62.5% (N=30)
	Three different measures of financial performance	7% (N=4)	4.2% (N=2)
	All of the above	7% (N=4)	20.8% (N=10)
	I don't know	54.4% (N=31)	(option not available)

Content Analysis of Students' Self-Assessments on Open-Ended Post-Course Survey

Students were asked to respond to four open-ended questions on the post-course survey that were aimed specifically at student knowledge and attitudes about sustainability (see the first column in Table 13 for a list of the open-ended questions). The anonymous student self-assessment data was reviewed and analyzed to gain a better understanding of student perceptions of the new course structure's emphasis on sustainability. As discussed in Chapter III, self-assessment is a valuable educational tool that can improve student engagement in their own learning process (Dochy, Segers, & Slujsmans, 1999).

Table 13

Positive, negative/neutral student responses to open ended post-course survey questions

Open response question	Positive responses	Negative/ neutral response	% Positive
In what ways has your KNOWLEDGE about sustainability changed since taking this course?	40	7	85%
In what ways has your ATTITUDES/OPINIONS about sustainability changed since taking this course?	25	22	53%
How has this course impacted you as a person? Have you been impacted in any way from learning about some of this material? Explain.	47	11	81%
What are your thoughts about sustainability in general? Hopeful? Confident? Confused? Etc.	51	9	85%

To analyze this rich data, I conducted a content analysis of student responses. Content analysis is process of analyzing qualitative data that involves decontextualization or reduction (Glanz, 2014). Decontextualization or reduction occurs when the researcher carefully and thoroughly reviews qualitative data, looking for patterns, themes, and/or categories (Glanz, 2014). This is often accomplished through a process known as coding. The first step of coding involves reviewing the qualitative data multiple times until categories/themes emerge. These themes become the "codes" that are then assigned to the data if they fit the specific rules defined by each code (Glanz, 2014). When analyzing student survey responses, I utilized two layers of coding. I first organized student feedback into two columns, positive responses and negative/neutral responses. Positive responses included reference to gaining or changing something due to exposure to course content. Responses were coded as negative or neutral if they explicitly mentioned that there was no change or improvement from exposure to course content or they felt negatively affected from exposure to sustainability content (i.e. boring, waste of time, already knew the information, etc.). I then put the data through another review and assigned "perspective

codes," where I was looking for common themes related to student perspectives (Glanz, 2014). A discussion of these emergent themes is found below.

Most students (over 80%) communicated a positive response about their growth in sustainability knowledge, how the course impacted them as a person, and their feelings toward sustainability in general. When asked about how their attitudes about sustainability changed since taking the course, 53% of the 47 student responses were positive. When reviewing student comments, I identified five common themes among the positive responses: 1) intellectual growth, 2) affective domain, 3) interconnectedness, 4) imperativeness, and 5) advocacy. A discussion of student responses is included below.

Theme 1: Intellectual growth. The first interesting theme I found when coding student responses was student awareness of their own intellectual growth. As discussed fully in Chapter II, a key tenant of transformational sustainability learning is to fully engage the learner's cognitive domain (Sippos, Battisti, & Grimm, 2007). When students are asked to self-assess their own intellectual growth, they become better able to reflect on and take more responsibility for their own learning (Dochy, Segers, & Sluijsmans, 1999).

Within this theme of intellectual growth were sub-groups that represent different aspects of self-perceived intellectual growth.   Evidence of this theme and its corresponding sub groups are summarized in Table 14 and discussed below.

Table 14

Open-response answers related to intellectual growth

Theme Sub groups	Student Response: Intellectual Growth Theme
Critical thinking/ perspective shift	This class has impacted me by showing me new ways to think, giving me a better understandings of certain topics, and helped me enjoy our earth. It has changed my perspective I've learned and understood a lot more, and gained a new perspective on things I hadn't fully understood before.

Better informed about real-world issues	I think I've learned a lot more about science and have more of an understanding about it
	I feel much more informed on real world issues
	I feel smarter, and more educated about the world's problems that we have created.
Debunking Misconceptions	When first starting the unit, I only thought of sustainability as a means of conserving natural resources. Throughout the unit I came to realize that this subject does not just [affect] nature, but society as a whole.
	Before this course, I related sustainability to big machines. Now i know what it is.
	I learned that it's much more than just government policy and organizations, and that we all affect it as individuals.
	I have been taught all my life that you can change the world by just recycling or that your individual actions can help, but honestly an individual can't change the world.
	I thought it was boring and just meant not using anything now i know that's not what it means.
Deeper knowledge of specific areas	I did not know nearly as much about sustainability before I took this course.
	I think that my whole understanding of this concept has been broadened and i think that I have learned the different types of renewable energy more deeply.
	One impact of this class upon my life is how I view the packaging of products. Often they are filled with lies to influence the buyer to buy something they don't quite understand.
	It helped me understand more about climate change and food products
	I have become more aware of more environmental issues and the way we are affecting the environment not only negatively, but positively as well. I have learned, also, how our actions are affecting species that can be thousands of miles away from us.

As discussed in Chapter 2, Evans (2012) emphasizes the importance of encouraging critical thinking within any attempt at sustainability pedagogy. The Burns Model of Sustainability Pedagogy reiterates this necessity-- one of its four main goals is to provide

learners with diverse perspectives to challenge dominant paradigms (Burns, 2011). The Burns Model also suggests making sure that the process of education enhances student perspective of their civic responsibility by providing learning opportunities that relate to real-world global and local issues (Burns, 2011). It was pleasing to see specific comments about feeling more "connected to real world issues" and being "more educated about the world's problems that we have created."

It was especially interesting to see responses that identified their own misconceptions about sustainability and how those misconceptions were corrected by the end of the semester. Debunking misconceptions is an integral part of education (National Research Council, 1997). The first student response within this subcategory, "When first starting the unit, I only thought of sustainability as a means of conserving natural resources. Throughout the unit I came to realize that this subject does not just [affect] nature, but society as a whole," reveals a quite common misconception about sustainability. For many, sustainability is specifically related to environmental concerns (Little, 2014). It was pleasing to see this student respond to one of my main goals in the sustainability unit-- to make sure students understand that true sustainability involves all of society including social justice and economic issues (Dresner, 2008).

Theme 2: Affective domain. Transformative sustainability learning also depends on supporting a shift in the affective domain (Sippos, Battisti, & Grimm, 2007). Sustainability education must reach more than just the minds of students; it must reach their hearts as well. The student responses listed in Table 15 reveal that my course did reach students in this way.

When coding student responses, I identified three subgroups within the affect theme (see Table 15). The first three responses in Table 15 show that these three students now have

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a greater capacity for empathy and compassion for others. Increasing compassion and empathy are necessary for social justice so are therefore essential for creating a more just, healthy, sustainable world (Segal, 2011). The second subgroup is related to empathy and compassion because these students commented on how they realized how their actions affect others. One student even mentioned that we should be concerned about how our actions affect future generations, a key component of the original definition of sustainable development (Brundtland & The World Commission on Environment and Development, 1987). The third subgroup contains responses with the keywords of "care," "important," and/or "better." These students communicated that they have had a shift in how much they care about sustainability issues and have a desire to make the world a better place.

Table 15

Open-response answers related to affective domain

Subgroups	Student responses revealing a shift in affect
Empathy/ compassion	It's made me realize how some of the places in the world are in need it makes you think about others more
Impact on others	....this has inspired me to learn more about local farms and how companies are treating their workers. I have learned that my actions affect others, I have started to save more energy and water/ food around my house. I now really understand how important it is to be sustainable for the purpose of future generations. I think there is a future where we have a sustainable lifestyle that protects and meets everyone needs.
Increased concern (keywords: care, important, better)	I have started to realize that my actions to the environment has an impact on my life and everyone around me. I learned how important it is to care about our environment and save energy I understand more about the world's problems and why [they're] important I think it has made me a better person

	It has changed the way I look at life and appreciate it a lot more.
	yeah a little makes me want to make the world a better place
	I have learned a lot and has helped change my views on life for the better.

Theme 3: Interconnectedness. A variety of student responses revealed that they began to identify the importance of interconnectedness when understanding sustainability. One student even specifically referenced the the 3Es of sustainability: ecology, economy, and equity/social justice. As mentioned above, there is a common misconception that sustainability means "going green" by reducing environmental impact (Dresner, 2008). I repeatedly emphasized and provided numerous learning opportunities in an attempt to get rid of this misconception. Table 16 demonstrates many students were successfully leaving class with a solid understanding of the connected and complex realities of sustainability. After taking my course, many students understood that true sustainability requires an understanding of the interplays among ecological, social, and economic systems.

Table 16

Open-response answers related to interconnectedness of the three pillars of sustainability

Student Response	Data Analysis
I now know why it is important to see all sides equally and know how it [affects] our economy	While this student did not specifically mention the 3Es of sustainability, he/she references "all sides" and the economic connections.
I learned that sustainability is very important in all aspects of life.	Recognition that sustainability is relevant to "all aspects of life."
I've learned more about our true current situation in the world, and learned about all the different branches and sections to sustainability.	This comment could be showing that this student understands the diversity and complexity of sustainability. However, it could also be read as the student thinking the diverse "sections" and "branches" are distinct and separate.
Now I know that we must pay attention to the 3 E's (economy, environment, equity) to create a sustainable society.	Without provocation, this student identifies the importance of the 3Es and the goal is to create a "sustainable society," not to just "save the environment."

Theme 4: Imperativeness. David Orr (2004) reminded us that "even in this time of ecological concern, high schools, colleges, and universities continue to turn out a large percentage of graduates who have no clue how their personal prospects are intertwined with the vial signs of the earth" (p. 126). I integrated sustainability education into my public-school science course because I wanted to help my students understand how they are a part of nature and therefore their health and wellbeing depend upon the health and wellbeing of local and global ecosystems. It was promising to see that numerous students seemed to pick up on how imperative it is for societies to transition to more sustainable ways. Table 17 summarizes and discusses student responses that focused on how crucial it is to incorporate sustainability into current and future decisions.

Table 17

Open-response answers related to imperativeness of practicing sustainability

Student Response	Data Discussion
I think it's really important	This response is representative of the 19 students that included "important" in their answer.
I am hopeful that sustainability will be practiced more to save the Earth.	20 student responses included the word "hopeful." This response also emphasizes how sustainability will "save" the Earth, a sentiment shared by 6 other responses.
Sustainability is a big deal in my opinion, it should always be watched and changes should always be made when needed.	This student uses the term "big deal" to communicate the imperativeness of sustainability.
That it's not as easy to stay in a sustainable state and most countries aren't. Also the rate in which we are going none of will be for too much longer.	This response communicates the imperativeness of sustainability by suggesting a pending doom if changes are not made.
has been said that it is the only option left	Similar to the response above, this statement communicates that there are no options other than implementing sustainable solutions.

Theme 5: Advocacy. Similar to identifying how imperative sustainability is, many students communicated how they now felt more inspired, prepared, and/or confident to help

make the world more sustainable. They now had increased confidence and/or desires to better communicate, act, and advocate for sustainability (see Table 18). Burns (2011) argues that the ultimate purpose of education is to empower and inspire learners "to be able to solve complex problems and make changes that regenerate and sustain places and communities" (p. 4). Advocacy can involve a variety of activities and has an ultimate goal of gaining support for a certain cause (Center for Community Health and Development, 2017). When reviewing student responses, I decided to code all comments related to communicating, performing action, or the desire to make a difference as "advocacy" because communication and action are important components of advocacy (Center for Community Health and Development, 2017).

Table 18

Open-response answers related to advocacy

Subgroups	Student responses related to advocacy
Communication	I have learned many ways that I can help my home be sustainable, and I think I could explain it to someone who asked about it pretty well.
	I am more inclined to discuss things with people and share my opinion.
	I have a better understanding of how everything works and could explain it to family who doesn't understand
	I learned so many stuff about the earth environmental issues, I started to think about how to protect our environment more, and I also started to talk with my family and friends about the environmental issues more frequently.
Action	I now understand not only what sustainability actually means but how to put into action as well.
	I have learned a lot more about how my actions can be changed to be more sustainable. I also learned about sustainable energy.
	I think that now its very important to be careful on my impact on the world.
	I try to do less things now that will harm the environment but, it's really hard to do because i don't buy or choose what food I eat or where my electricity comes from.
Advocacy	It has grown from not even knowing the definition to being able to persuade people's decisions about it.

> I understand more about what it is and how to help people know what is happening and how to work towards a solution.
> I now want more of a push locally for a way to become sustainable, achieved in ways such as clean power and local food.
> This course has helped me stress the urgency that is Global Climate Change, and how we can as a whole can help prevent this from happening.
> My thoughts in sustainability in general is confident. I am confident in what I do and what I can do to make things better in the world.
> Yes , it made me want to pursue something within sustainability

Communicating sustainability is a challenging task, even for educators (Little, 2014). While these comments do not provide information about how convincing the students are able to be, the desire to communicate and advocate for sustainability principles is a meaningful indicator of student involvement (Kagawa, 2007). I was pleased to see that not only did these students gain the confidence to communicate their sustainability knowledge and act to make a difference, but they felt compelled to become sustainability advocates as expressed in the response, "it made me want to pursue something within sustainability." I am hopeful that other students will also aspire to pursue a career that seeks to make their local and global community more ecologically healthy, socially just, and economically fair.

Summary of Students' Post-Course Self-Assessment Data

By analyzing student responses to the four open ended questions, it became clear that the restructured course was successful in numerous ways. While I am certain that not all students were transformed during our shared semester together, the anonymous responses to the post-course survey revealed that many students were positively affected by the addition of the integrated sustainability curriculum. Just as suggested by the *content* component of the Burns Model of Sustainability Pedagogy (Burns, 2011) and the cognitive *head* domain of TSL (Sipos, Battisti, & Grimm, 2008), learners identified their own intellectual growth regarding the 3Es and complexities of sustainability education. The restructured course

successfully reached their *hearts* or affective domain (Sipos, Battisti, & Grimm, 2008) because there was numerous evidence of increased empathy, compassion, care, and concern for others. The Burns Model of Sustainability Pedagogy would support such outcomes through its *perspective* lens which promotes the incorporation of diverse views, perspectives, and empathic thinking. Students revealed that they felt the urgency of the environmental, social, and economic issues facing us today and were compelled to speak, act, and advocate for a more sustainable world. Both the TSL and Burns Model of sustainability pedagogy would applaud such outcomes. The TSL model would refer to this as the *hands* of transformative sustainability learning in that students are engaged and called to act. Burns (2011) would consider this evidence of both a participatory *process* and a place-based *context* that encourage students to become civically-minded participants in their communities through communication, action, and advocacy.

Overall, I was pleased to see an overwhelmingly positive response from the students regarding their perceptions of their own sustainability knowledge and attitudes. Most students also gave positive responses about how they were personally affected by the course and their feelings about sustainability in general.

It is also important to assess students' comprehension and recall of the state sanctioned portion of the course. In the next section, I discuss the results of students' learning of the NC State Essential Standards for Earth/Environmental Science.

NC Final Exam Scores

The last section of data I analyzed was to see whether state standards were adequately covered. Because RQ1 was interested in understanding how sustainability education can be integrated within a state sanctioned earth/environmental science curriculum, a reasonable indicator would be to look at NC Final Exam Test Scores. If there was no decline in test

scores, it could mean that the sustainability curriculum did not distract or take away from student comprehension of the NC State Essential standards.

Table 19 compares Fall 2016 average scores on the Earth/Environmental NC Final Exam with Spring 2017 average scores. The restructured course and more in-depth integration of sustainability themes did not harm final exam scores. As Table 19 communicates, exam scores were higher in all classes with the newly structured course. This descriptive statistical data supports the argument that incorporating sustainability themes does not distract students from the state standards that are included on the NC Final Exam.

When comparing this data, it is important to note that I taught three standard Earth/Env courses in the Fall of 2016 whereas I taught two standard classes and one honors course during Spring 2017. As I referenced in Chapter III, other factors could affect final exam scores that are unrelated to the reorganization of the course and the associated incorporation of sustainability themes.

Table 19

NC Final Exam comparative score data: Fall 2016 and Spring 2017

	Fall 2016	Spring 2017
Class 1	78.5%	82.25%
Class 2	74.125%	81.172%
Class 3	80.4%	91.04% (honors)
Semester Avg	77.675%	84.82%

Overall Impact of Restructured Course

I restructured my Earth/Environmental Science course to include four main sustainability themes to allow for deeper exploration and transformational learning that would reach students' heads, hands, and hearts (Sipos, Battisti, & Grimm, 2007). Thematic

teaching allowed for space to explore complex sustainability *content* that interwove ecological literacy, economic system critique, and issues related to equity/social justice (Burns, 2011).   It also allowed for diverse, critically questioning *perspectives* that were often rooted in a local *context* to encourage students to become engaged, critical thinking, citizens of their local and global communities (Burns, 2011). The restructured thematic course provided a more flexible curriculum that enabled more time to engage in a participatory and experiential teaching and learning *process* (Burns, 2011).

Evidence of this success was measured using four key sets of data. First, I compared time devoted to sustainability lessons, number of assignments, number of summative assessments, outdoor explorations, and guest speakers of semester one versus the restructured semester two. The comparative analysis showed that the restructured course format allowed for more time devoted to sustainability themes, more outdoor explorations, and more guest speakers, without taking away from the number of summative assessments or graded assignments. This reveals that it is not necessary to cover state standards chronologically as they are listed in the standards document. It shows that grouping standards thematically allows for more in-depth, exploratory learning that models the high-level inquiry that students need to be able to do on their own in order for transformative sustainability learning to occur (McTighe & Wiggins, 2013; Pace Marshall, 2006; Sipos, Battisti & Grimm, 2007).

Secondly, pre- and post- survey data provided evidence that by the end of the course, the majority of students comprehended that sustainability involves the complex interplay of ecological literacy, economic system critique, and equity/social justice. Restructuring the course around sustainability themes provided me more time to offer students the opportunity to see this interplay in action. Each theme allowed for them to explore the complex interactions of the 3Es of sustainability.

Thirdly, a content analysis of post-course open-ended survey question revealed that students' self-perceptions of their own sustainability knowledge and attitudes improved from taking the course. Most students also felt positive about sustainability in general and felt that they were positively impacted by learning about sustainability.

Lastly, NC Final Exam scores provided evidence that state standard content was adequately covered by the new course structure because average test scores were above average and were overall higher than the first semester.

Chapter Summary

This chapter provided evidence showing the positive impact of the integrated sustainability curriculum. By analyzing four key data sets, I was able to understand how the newly restructured curriculum affected the course goals and student outcomes. By comparing the quantity of time and assignments devoted to sustainability, students' pre-/post-course survey and students' North Carolina Final Exam scores, it was shown that students gained sustainability knowledge without compromising their comprehension of the state sanctioned curriculum. Analyzing data from post-course self-reporting survey revealed that most students were positively impacted and often compelled to take positive action towards sustainability goals. Each of these points of analysis help better understand how the integration of sustainability education impacted students' knowledge of and attitudes towards sustainability and whether adequate coverage of the required course content was achieved. I feel confident sharing this sustainability-focused thematically structured course with other Earth/Environmental Science teachers. Keeping true to the practical philosophy (McNiff, 2013) of action research, I adhere to the action research mantra of "generating knowledge in action for action" (McNiff, 2013, p. 87). The next chapter expands upon these results in a

more in-depth way, using the rich descriptive data and the Burns model of sustainability

pedagogy as a guiding framework.

Chapter VI

Microanalysis of Teacher's and Students' Experiences With Sustainability Curriculum

Redesign

This chapter takes a deeper look at RQ2, providing a more in-depth analysis of student and teacher experiences during the research project. Whereas the last chapter provided a look at the before and after of the restructured course, this chapter takes a deep dive into student artifacts to better understand how those changes came about. The goal of this chapter is to take the reader inside the classroom by looking closely at student artifacts, lesson plans, and teacher reflection to more thoroughly understand the depth of transformative education that was occurring as well as the many challenges and missteps. Exemplar sustainability education lessons are presented, each of which are then followed by an in-depth analysis of student artifacts and learning experiences. To find evidence that transformative sustainability education was present, I utilize the Burns model of sustainability pedagogy (2011) as a guiding framework to analyze student artifacts that were a result of the course redesign and incorporation of sustainability themes.

The Burns Model of Sustainability Pedagogy

Burns (2011) promoted the Burns model of sustainability pedagogy as a practical approach to course design that can be incorporated into any discipline (Figure 6). Designed for post-secondary classrooms, the Burns model is rooted in ecological principles of interconnections, cycles, energy flows, organic change/flexibility, and balance (Burns, 2011; Capra, 2002). As seen in Figure 6, it offers four key dimensions to consider when designing curriculum. First, teachers should select and focus on *content* that presents a diverse look at a variety of complex issues we currently face. The second key dimension is allowing space for students to think critically about dominant paradigms and power structures from a

diversity of *perspectives*. Students should be encouraged to think about the *process* in which content and perspectives can be applied in useful ways to improve civic and environmental problems and issues. Lastly, teachers should *design* the course structure and learning environment in a way that is rooted the ecological principles of interconnections, flexibility, flow, and balance and results in students feeling empowered, inspired, and transformed by their learning (Burns, 2011).
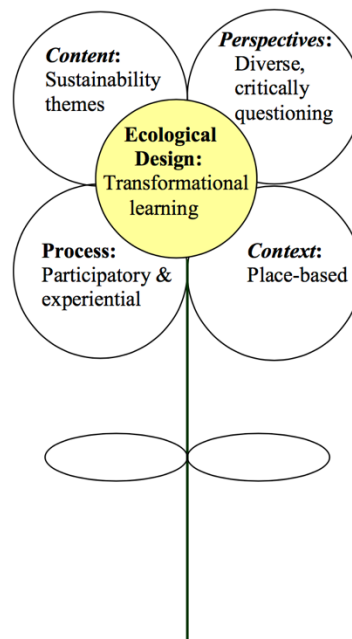
Figure 6. Burns model of sustainability pedagogy (Burns, 2011)

Because the Burns model was originally designed for post-secondary students, I made slight modifications to the model to make it more age-appropriate for my students and easier to reference during my analysis (see Figure 7). I modified the presentation of the model, including clarifying descriptions of each dimension. For the perspectives dimension, I included 'modeling and encouraging critical thinking skills' since, as discussed in Chapter II, adolescents are still developing their critical thinking capacity.

To begin the microanalysis of the different sustainability themes, one lesson cycle from each of the four thematic units (see Table 20) was selected for analysis based on both

teacher approach and student artifacts. Lessons were selected based on what I identified as

an exemplary approach to either multidimensional sustainability *content*, diverse and critical

perspectives, place-based and cultural *context*, or participatory/experiential educational

process. Each selected lesson cycle was analyzed in depth using the lens of one focal

dimension of the adapted Burns model (see Figure 7). The data informing the microanalysis

of this chapter include the newly created pacing guide, student work produced during

lessons, direct student reflections, and my teacher reflection journal.
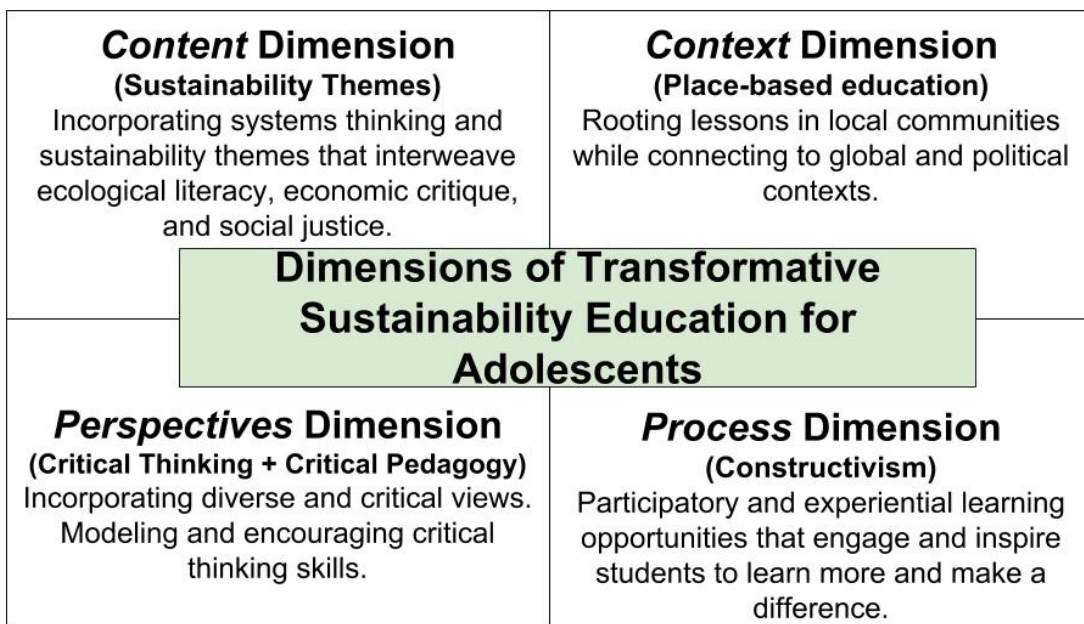
Figure 7. Dimensions of Transformative Sustainability Education for adolescents. Adapted

from Burns Model of Sustainability Pedagogy (Burns, 2011)

Using the Burns Model to Analyze Student Response to Thematic Units

During the process of creating the curriculum guide, I closely analyzed every lesson

within each theme by reviewing student work, lesson plans, photos, and my own teacher

reflections. As discussed in Chapter IV, I restructured my lessons to follow the BSCS 5E

Instructional Model (Bybee et al., 2006). The process of restructuring my lessons into the 5-

step learning cycle caused me to reflect deeply on how successful my lessons were in

encouraging constructivist and transformative sustainability education to thrive in my classroom or not. Because the 5E learning cycle is rooted in constructivist pedagogy that supports student discovery instead of objectivist knowledge transfer, it was easy to identify areas where I was relying too heavily on traditional objectivist tendencies. Once I identified shortcomings, I reorganized the engaging, constructivist-based lessons into the 5E learning cycle model: engagement, exploration, explanation, elaboration, and evaluation. Through this process I also considered the ways I was successful at incorporating all four aspects of the Burns model and the many ways in which I fell short. I also looked for evidence that students were in fact experiencing my transformative education efforts in an impactful way.

When assessing how well I was able to present complex sustainability *content* and support students in building upon and developing their own understanding of these complexities, I looked for student work that provided evidence of a holistic understanding of the sustainability triad. Meaning, I was specifically looking for student responses that revealed a growing understanding of the interplay between ecology, economics, and social equity. I also highlighted my own attempts at reminding students of this interplay. I continually referenced what I called the "3E Goggles" as a way to consider the complex interactions of nature, society, and commerce. As expected, students became more and more capable of identifying these complex connections as the semester progressed. When assessing how students were responding to the incorporation of diverse and critical *perspectives*, I looked for evidence of critical thinking, reflectiveness, and empathy. To understand how they responded to locally-based *context*, I looked for evidence of a desire to make a difference in their own communities. I had to rely more on my own teacher notes to find out how students were responding to my attempts at offering an experiential/participatory *process*. There were a few assignments where I had specifically

asked students to provide feedback on the assignment/activity, so I was able to reference that

feedback in my analysis as well. A summary of lesson selection for each dimension of the

Burns Model of Sustainability Education is found in Table 20.

Table 20

Summary of lesson selection for each dimension of Burns Model of Sustainability Pedagogy

Dimension	Criteria for selection	Lesson chosen for analysis
Content	Exemplary model of how to incorporate and consider the sustainability triad: ecological literacy, economic critique, and social justice (Burns, 2011).	3Es of Sustainability and the 3E Goggles: learning cycle that moved students from their original unexamined understandings of sustainability to applying the critical multidimensional lenses of the sustainability triad to popular culture.
Perspectives	Exemplary model lesson of incorporating diverse and critical views. Encourages examining own cultural biases and perspectives (Burns, 2011).	The people behind our meals: Engagement step of a food system learning cycle that encourages students to think about the diversity of people involved in our food production system. Students consider their own preconceptions and stereotypes and how their views compare to the many real challenges that farmworkers face.
Process	Exemplary model lesson that is participatory and experiential and enhances student civic responsibility and desire to work towards sustainable solutions (Burns, 2011).	Renewable energy exploration: learning cycle that begins with students thinking about where their electricity comes from and how important it is to them. They tour renewable energy technologies found on their own school's campus and consider how they work and what the district should invest more into.
Context	Exemplary model lesson that helps students understand and connect to their own community and geographical place (Burns, 2011).	Lexicon of sustainable food: Learning cycle that allows students to consider the full lifecycle of food including the people involved and how different types of agriculture affects communities in different ways. Students create suggestions for what type of agriculture should be promoted in their own communities.

In each of the following sections, I first provide an overview of the exemplar lesson

cycle and then move on to analyze students' learning experiences in relation to the goals of

sustainability education. For the sake of clarity and organization, I stay focused on analyzing

each lesson cycle through only one focal dimension of the Burns model of sustainability pedagogy (Burns, 2011), though it should be noted that each lesson does, and should, contain elements of each dimension. Each lesson analysis below includes evidence and a discussion of student artifacts and their experiences in relation to one dimension at a time. Meaningful, transformative sustainability learning should strive to include sustainability *content*, through diverse/critical *perspectives* in a local *context* through an experiential/participatory *process* in every lesson.

Content Dimension: Benefits of Thematic Teaching

As discussed in Chapter 2, sustainability education should be multidimensional, avoiding the traditional fragmentation of ideas into separate and distinct disciplines (Stock & Burton, 2011). I encouraged students to utilize what I called 'sustainability goggles,' where they looked at any problem and solution possibilities through multiple lenses. I aimed to help them view the world concurrently through ecological, economic, and equity lenses so that they could see the complex and intricately connected social, economic, and ecologic spheres.

Sustainability education also requires that students acknowledge, examine, and build upon their own understandings of what sustainability means (Burns, 2011). This constructivist style of pedagogy recognizes the value in meeting students where they are and helps them construct their own knowledge. By using the 5E instructional model in my lesson designs, I was helping to ensure that students were building upon and correcting previous misconceptions where needed. The example below provides an in-depth discussion of how the 5E instructional model fostered transformational sustainability education through multidimensional sustainability content that built upon students' prior knowledge, allowing them to make connections between ecology, economics, and societal issues.

Lesson Cycle Analysis: The 3Es of Sustainability and the 3E Goggles

The following lesson cycle was chosen as an exemplary of the integration of sustainability *content* because it explicitly communicated the economic, social, and environmental triad of sustainability. As discussed below, the lesson has students consider what they think they know about sustainability, explore what problem solving from different perspectives requires, learn about the multidimensionality of what sustainability means including a brief overview of the history of the word in context, and then allows them to put the multi-lens framework to practice. The five steps of the lesson cycle and student responses to each are discussed below.

Engage: What does sustainability mean to you? The second thematic unit introduced students to the concept and historical foundation of sustainability. Students were first engaged by completing an online question that asked, "what does sustainability mean to you?" I utilized an online program called Answer Garden that would cause common words to grow larger if the word was used more than once. Students could see which terms were most popular once they submitted their answer. The words maintain, balance, reuse, wildlife, and ecosystem were popular terms (see Figure 8).   As Figure 8 shows, understanding of sustainability was superficial at best and was limited to the more common usage of the term, sustain, as meaning to keep up, or maintain (Merriam-Webster, 2015).

Figure 8. Student responses to engage question: What does sustainability mean to you?

By allowing students to consider what their previous knowledge of sustainability was, I was employing the constructivist strategy of building on prior knowledge and encouraging students to identify their own misconceptions (Bybee et al., 2006; Ernest, 1993). Once students acknowledged their own prior knowledge, the second stage of the 5E learning cycle allowed them to explore the units guiding question, What is Sustainability?, on their own, with limited teacher explanation (Bybee et al., 2006).

Explore: Logger vs. environmentalist vs. indigenous farmer. The exploration phase of this learning cycle built upon the rainforest case study that students investigated during the preceding Ecology & Interconnections Theme. Working in groups of six, each member or pair in a group took on the perspective of a forester, wildlife biologist or indigenous farmer. They worked with their group to decide what should happen to a small tract of Amazonian rainforest that they all had interest in. They were asked to examine the benefits of clearing or not clearing the land from the diverse perspectives and were also provided a list of land use options that included potential costs and benefits for each option.

Student responses revealed that they were able to consider the needs and wants of each unique stakeholder (Figure 9). Summaries revealed distinct perspectives relating closely

to an environmental, economic, and family motivated wants. However, they also noticed that these diverse viewpoints all needed similar things. This realization helped them think about common struggles with what might originally look like a foe. When overhearing students discussing this, I helped them acknowledge how they were practicing empathy and critical thinking by considering these multiple views. This multi-perspective and empathetic talk combined with the slight teacher guidance I provided is supported by adolescent critical-thinking best practices as supported by the work of Fung (2017).

When students began to come up with solutions, most of them suggested an even split of the tract of land. It was inspiring the hear how students were eager to come up equitable solutions just from considering themselves in someone else's shoes. Such a demonstration of empathy through working through a shared problem is what Marin and Halpern (2011) call embedded instruction. As they assert, both embedded and explicit instruction of critical thinking are necessary for proper development of critical thinking skills in adolescents (Marin & Halpern, 2011). Students also demonstrated their critical thinking skills when they came up with creative, out-of-the box solutions of encouraging non-timber resources for the farmer to make a living on, and a take one, plant one strategy to ensure forest health. Overall, this activity encouraged students to think about diverse perspectives while also realizing how difficult it can be to find solutions when conflicting needs and wants are at play (Burns, 2011).
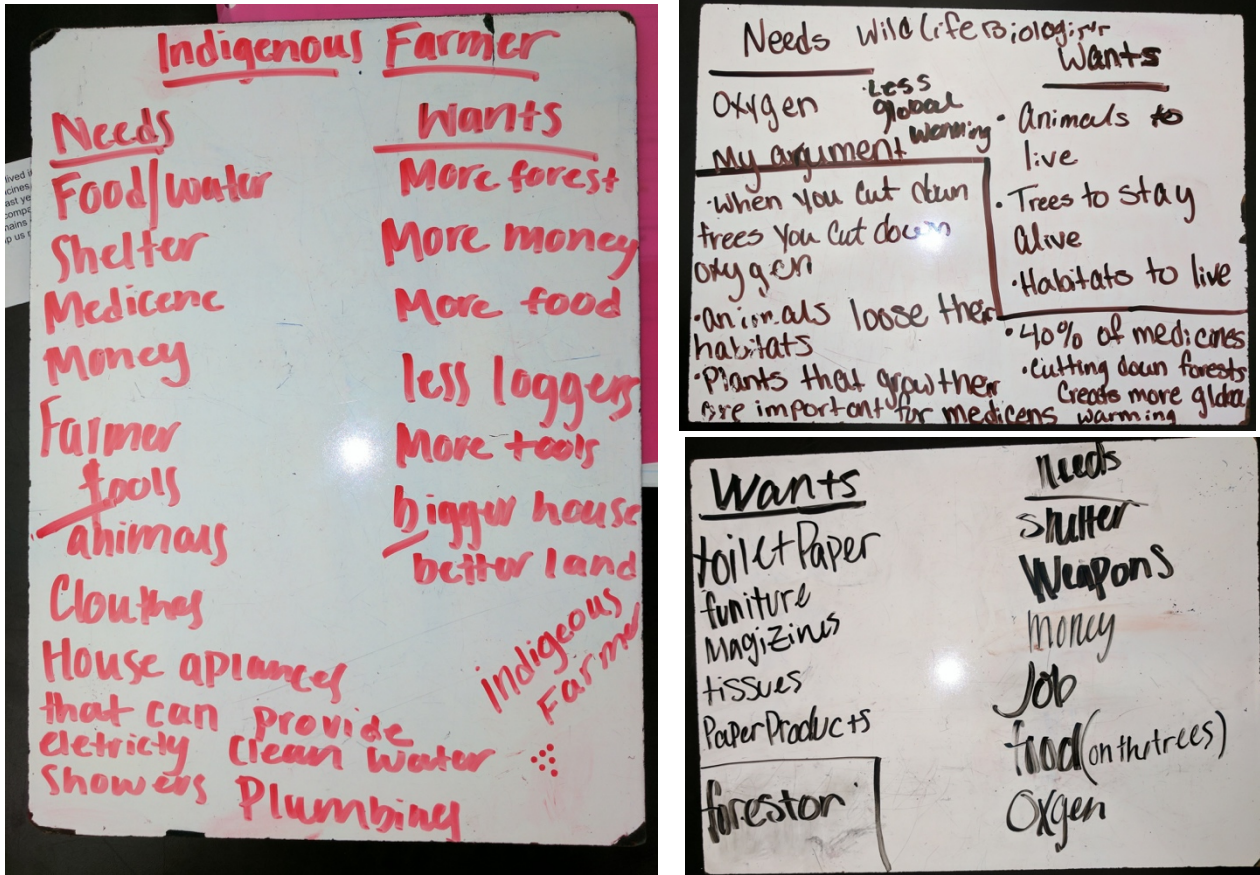
Figure 9. Student summaries of various stakeholders needs and wants from an economic, ecologic, and cultural viewpoint.

Explain: The 3Es of sustainability and the 3E goggles. After participating in the rainforest case study that provided an environmental (biologist), economic (logger), and equity (indigenous farmer) lens on a real-life situation, students were then guided through a brief lecture about the triad of sustainability. They were shown different visuals of how to communicate the sustainability triad including the three-legged stool in which all three aspects of sustainability should remain in balance (Figure 10) and a Venn diagram that shows the goal of sustainability is found in the overlap of economy, ecology, and equity (Figure 10). I then provided them with an analogy that I created while teaching the Sustainable Development course at the university level called the "3E Goggles" (Figure 11). I explained

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that if we look at the world through merely an economic lens, we would see one set of problems and one set of solutions. If we look at the world through only an environmental lens, we would see a different set of problems and solutions. Same for a social justice/equity lens. But if we put on our 3E goggles, then we can begin to see that all issues are connected and that often what might be considered a solution in one area could exacerbate problems in another area. It is our goal then, to see the world through our 3E goggles so that we can consider solutions that consider the social, economic and environmental aspects of all issues (Dresner, 2008).
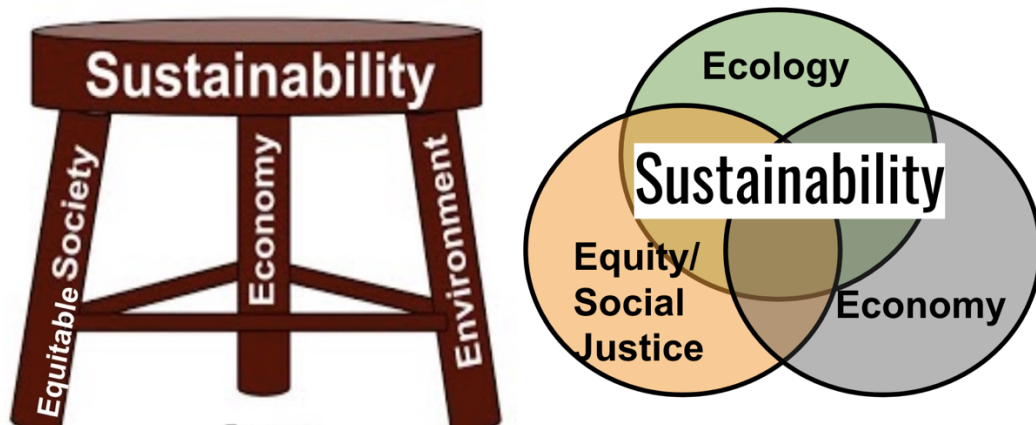
Figure 10. Stool and Venn diagram model of the sustainability triad.
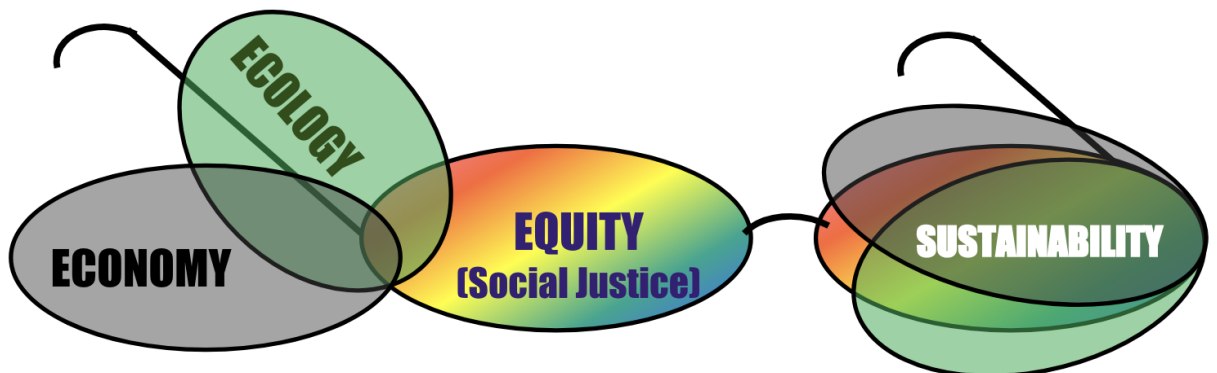
Figure 11. 3E Goggle metaphor for understanding sustainability triad.

Students were then provided an opportunity to consider what types of questions should be asked from each of the three lenses of the 3E Goggles. In an effort to promote constructivist pedagogy and avoid objectivist pedagogy through too much lecture, I created manipulatives that the students could discover themselves what questions should be asked from each perspective (see Figure 12). I emphasized that for an activity or solution to be sustainable, questions from all three lenses should be taken into consideration (Evans, 2012). The goal should be causing the least amount of harm and greatest benefit to all three areas (Dresner, 2008).
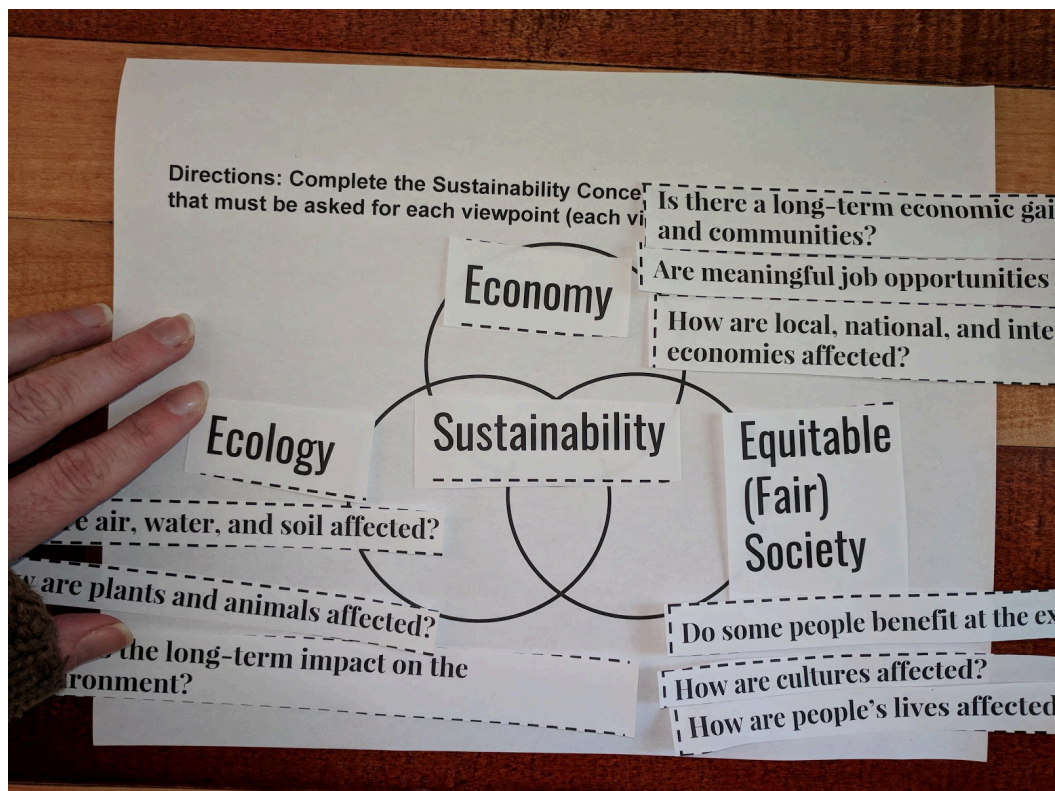
Figure 12. Manipulative to help students consider key questions of sustainability triad.

My journal entry from this time revealed that I found this activity to be a useful teaching tool. This journal entry also reveals how I was continuously reflective of my desire to move away objectivist teaching practices:

The manipulative 3E opener was useful and showed me how some students still

needed some practice. I then asked them to summarize the goggle and stool metaphor,

stand-pair-share, and then class discussion. I will include this same essay style

question on the quiz tomorrow. This is my attempt to move away from the traditional

multiple-choice quiz I had been doing and add more of a reflective piece. (C. Baines,

personal communication, April 10, 2017)

While walking around the room, most students appeared to understand how various questions

fit within the corresponding lenses. Multiple students pointed out that many of the question

options could fit into multiple categories. In particular, "are meaningful job opportunities

provided?" and "how are air, water, and soil affected?" could fit within both their respective

ecology/economic lenses *and* within the equity lenses because of how they affect people. I

agreed with them fully. This led to a meaningful discussion that this was exactly the point:

you cannot separate impacts to the economy, ecosystems, and society—they are all

interconnected (Burns, 2011; Evans 2012).

Elaborate: Letter to the future and the official definition of sustainable

development. This step of the learning cycle began with students considering what the future

would have to say to our current generation. Since understanding the importance of

intragenerational connection is a key component of understanding sustainability (Brundland

& The World Commission on Environment and Development, 1987; Dresner, 2008), I asked

students to imagine what they would write to today's generation if they were alive 200 years

in the future. The assignment instructions were to create a letter from the future that describes

how you think future generations will feel about us and what they will say. Student

responses varied greatly in their creativity, writing ability, effort, and critical thinking. Most

of the responses focused on trees, oxygen, and animals such as the example below:

Dear People of 2017,

Hello, I am writing to you on behalf of the future. From what I have learned history

books and recorded evidence of the past I have gathered that you lived a vastly

different life than we do now. Today, we cherish the environment and have huge

swaths of land set aside for major rehabilitation. We are still suffering the

consequences of your environmental mismanagement. Since you cut the population

of world trees to a mere 1% of what it once was, we now have to slowly replant

billion of them and use oxygen supplements because of horrible air quality. We also

ask you to watch out all the animals on the planet because now, in my time, we only

have the massed produced ones and there is no wildlife. Please remember that your

actions also impact the generations of the future and we will suffer from your current

actions if you don't change things.

Sincerely,

The future (9th grade student, April, 2017)

From their letters, it was clear that many students still considered sustainability from

an ecological lens and were still not fully able to communicate the potential dangers of not

considering issues of economic and social disparities (Stock and Burton, 2011). As explained

by Burns (2011) and Evans (2012), even college students struggle getting over this

preconceived misconception that sustainability and environmentalism are mutually exclusive.

By reviewing student work at this time, I realized they needed more in-depth exploration and

practice about how the triad of sustainability worked in practice (Evans 2012).

However, despite student lack of demonstrating that they could envision economic

and social problems related to sustainability, the practice of thinking about how we are

connected to future generations is an exercise of thinking about equity in terms of our

responsibility to posterity (Dresner, 2008) and is tied directly to the official definition of

sustainability: "meeting the needs of the present without compromising the ability of future

generations to meet their needs" (Brundtland & The World Commission on Environment and

Development, 1987).

After sharing their letters from the future, I provided a short lecture about this

definition and a brief overview of the historical context of the document in which this

definition emerged. The focus of the class discussion surrounding this lecture was on what

the term "*needs"* actually meant. I guided them through a critical thinking process by asking

questions such as, "How do we decide whose needs are met: Poor or rich people? The

environment or the corporation? People living in cities or in the countryside? People in one

country or another? This generation or the next? When there has to be a tradeoff, whose

needs are more important?". In reflecting on this lecture and discussion, I wrote in my

research journal:

> Very lively debates took off during 4th block when we discussed the definition of
>
> "needs." I could tell they wanted to debate more about it, so I definitely need to
>
> create plenty of opportunities for them to engage in more of debate style discussions.
>
> (C. Baines, personal communication, April, 18, 2017)

The letters from the future helped students really consider what it would be like if we

continue using resources without having empathy or regard for future generations (Dresner,

2008). However, when it came to encouraging them to have empathy for different people

from within our current generation, I vividly remember feeling anxiety about bringing up

how to decide which country's needs should be met. I contribute this anxiety to the negative

and decisive political talk that took place during the 2016 presidential election cycle and

since the 2016 election in which the "America First" rhetoric became so powerful and

controversial. I had been using an image of planet earth with only the United States displayed (see Figure 13) since I began teaching in the Sustainable Development department in 2008, but I had never felt so nervous about the feelings it might excite inside my students until this school year.   Ultimately, I decided to keep the image in my presentation. When the image appeared on the screen, student chatter increased. In all three classes, I chose to not discuss the image specifically, perhaps out of my own fear and discomfort with what might be said. I explore these political tensions and themes in more depth in Chapter VII.

We are not alone.

Figure 13. Image first used as geography campaign and since utilized in my presentation to consider "whose needs?"

Evaluate: 3E analysis of Wall*E. The final stage of the learning cycle was a chance for students to put their new knowledge of the interconnected triad of sustainability to practice, as students should be active participants in their learning process (Burns, 2009).   I showed two main scenes from the Disney/Pixar animated film Wall*E, a film about what has become of planet Earth nearly a century after humans had to leave because of pollution. Not only did the storyline relate well to the letter-from-the-future activity students completed in the Elaboration step of this learning cycle but was also relevant to the intergenerational

concepts of sustainability (Dresner, 2008). When I asked for a show of hands of how many had already seen the film, the majority of the students raised their hands and expressed excitement that we would be watching some of it in class. However, I let them all know that no matter how many times they had seen it before, they would be watching it through a different, more critical lens: what Marin and Halpern (2011) would classify as explicit critical thinking instruction. Because of this engaging process and critical reflection, it should be noted that I consider this activity to also be an exemplar in both the process and perspectives dimensions of the Burns model of sustainability pedagogy (Burns, 2011).

Students were instructed to make two columns on a page of notes and to title one column, observations, and the second column, hidden messages (Table 21). I explained that they would be making observations about what they see in the movie and then they would come up with ideas for what the image might mean and/or why the movie designers chose to create that image. For example, one observation in the opening scene shows wind turbines on huge piles of garbage. A potential hidden meaning of this might be that without dealing with over-consumption, renewable energy will not save us. We discussed the difference between the objective nature of their observations versus the subjective nature of their own meaning-making of their observations; an important distinction for adolescents to understand when developing their critical thinking skills (Kuhn, 1999). During the first six to eight minutes of the film, I would stop every one to two minutes to give them all a moment to write their observations and hidden meanings and then we would discuss what they saw; encouraging both explicit and embedded critical thinking instruction, a best practice when teaching adolescents critical thinking skills (Kuhn, 1999; Marin & Halpern, 2011). Table 21 shows a sampling of some of the student responses.

Table 21

Sampling of student responses for Wall*E film analysis

Observations	Hidden messages
No green left in North America	Everyone deforested in North America
Money littered on ground	Money is worthless because [environment is destroyed]
Buy-n-Large	One company took over everything (monopoly)
B-n-L jingle is upbeat, "plenty of space up in space!"	Do worry about all the trash, we will take care of it (shift of responsibility)
Global CEO is smiling about pollution on cover of newspaper	Shows lack of concern for environment by global leaders
Machines advertised to "dig you out"	Humans don't care enough to fix it themselves
Axium Starliner (spaceship to take people away from polluted earth)	Shows tons of wealth on ship, not everyone can afford, less activity

Once students had their lists of objective observations and subjective hidden

messages, I asked them to look at their list through the three lenses: environmental, economic,

and equity (Dresner, 2008). They organized their observations into the three categories and

were encouraged to discuss at least three hidden messages for each lens. Table 22 shows a

sampling of student responses to this portion of the activity.

Table 22

Student responses to 3E analysis of Wall*E

Environment/Ecology *What do you see that tells the story of environmental impacts?*	Equity/Social Justice *What do you see or what questions arise relating to social justice?*	Economy *What do you see that relates to economic impacts or issues?*
If we don't address the destruction of nature, we will create an unlivable place North America is deforested because people started to only care about the 'now' instead of future generations. The world was too far gone when they decided to start cleaning up. It was too late.	Advertisement for escape of planet when the harm was done by the rich and they are the ones who have enough money to leave. Who got to go on the spaceship? What happened to the poor who couldn't afford a ticket? Whose responsibility is it to clean up all the trash?	Buy N Large holds a monopoly on everything and that prevented economic diversity Machines take over human jobs and cause wage loss; also it cuts costs for Buy N Large On the spaceship, there is an "economy" section that shows that even in

Renewable energy is not enough if we don't address consumption.	Who made the mess and who paid the price?	space, there is a consumerism mindset
		Money ultimately became litter showing that money is useless after disaster strikes.

I was impressed and pleased with student responses to this activity. Most students did require extra help—explicit critical thinking guidance (Marin & Halpern, 2011)—to articulate how some of their hidden message ideas could be viewed through an equity lens. I guided them through thinking about what aspects of the film raised questions about fairness and mentioned that it might take looking beyond what is actually shown in the film. For instance, I asked them to describe how the rescue spaceship was marketed, how expensive they would think an all-inclusive five-year space cruise would cost. I then asked them to think about whether or not all people would be able to afford such a luxury cruise. I also asked them to consider who was responsible for the majority of the trash from all the purchased goods. Who has the greatest buying power? The rich or the poor? From there, students began to connect the dots between the causes and effects of overconsumption; who's responsible and who suffers most. This critical analysis of the film taught students to raise questions about often hidden systems of power and injustice (Barbules & Berk, 1999). I was pleased that they were able to make this connection because I would be asking them to make similar connections when we began talking about the causes and effects of climate change.

Overall, this evaluation activity allowed students to view media they've likely viewed many times before through a variety of new lenses, a goal of sustainability education (Burns, 2011; Evans, 2012; Martusewicz, Edmundson, & Lupinacci, 2015). Because most of the students had watched this film for entertainment, they were somewhat shocked at how many possible hidden messages they were able to pick out from the film. As one student

commented, "I'd never seen Wall*E in this way before. I'd never really thought this deeply or critical about it" (personal communication, April 10, 2017). By modeling critical thinking and guiding students through a 3E film analysis, students put the sustainability triad to practice by analyzing the film through an economic, environmental, and social justice lens (Burns, 2011; Dresner, 2008; Marin & Halpern, 2011).

One downside of this activity is that even though it guided students through understanding how to view situations through the three lenses of the sustainability triad, it did not allow them opportunities to consider the complex interconnections between the lenses when trying to come up with sustainable solutions. Looking back at my approach to this activity, I realize that if the teacher does not emphasize the importance of identifying the interconnections between the economic, environmental, and equity lenses (Brundtland & The World Commission on Environment and Development, 1987) students will surely not see the connections either. As originally designed, the goal of this activity was not to come up with solutions to the lifeless earth, but perhaps incorporating some kind of extension activity that emphasizes how sustainability is about coming up with solutions that consider all three lenses could help students see the ultimate purpose of sustainability.

Summary of 5E learning cycle: The 5E learning cycle discussed above provided students with explicit instruction and engagement with the definition and meaning of sustainability. In staying true to the constructivist underpinnings of the 5E learning cycle strategy, students began with the engage step of the cycle by considering their previous knowledge & misconceptions about sustainability (Bybee et al., 2006). They were then able to explore what problem solving from different perspectives requires by viewing the same problem through the lens of an indigenous farmer, rainforest conservationist, and logger. This multi-perspective activity primed students to consider how the simultaneously

considering multiple dimensions of sustainability is complex and diverse (Burns, 2011; Dresner, 2008). They were then provided explicit instruction of what sustainability means in the explanation stage of the learning cycle (Bybee et al., 2006). This stage included a brief overview of the historical context and purpose behind the term (Dresner, 2008). Students were then provided an opportunity to elaborate on what they learned by considering what future generations would have to say to today's humans. This activity encouraged them to practice empathy for future generations and also consider long term consequences of our current actions (Dresner, 2008). Lastly, the evaluation stage allowed them to put their new knowledge to practice by utilizing critical thinking skills, diverse perspectives, and the multidimensions of sustainability (Burns, 2011).

I provided this in-depth overview of the entire 5E learning cycle in an effort to demonstrate how useful this constructivist pedagogy technique is for identifying misconceptions and building upon previous knowledge. However, for the next three dimensions of the Burns Model of Sustainability Education, I will only focus on one lesson from each learning cycle instead of analyzing each of the 5 lessons that were contained within each. Choosing one exemplary lesson from each of the four sustainability units provides sufficient qualitative evidence and description of the type of sustainability education praxis that could be useful to meet the goals of each dimension.

Perspectives Dimension: Building Critical Thinking Skills

Sustainability pedagogy should support students in building critical thinking skills (Burns, 2011), which can be accomplished by modeling critical thinking, and by examining and critically questioning diverse viewpoints and unexamined biases (Burns, 2011; Kuhn, 1999; Marin & Halpern, 2011). It is vitally important that teachers remain aware of the developmental abilities of their students (Kuhn, 1999). For high school students, modeling

critical thinking is of utmost importance given they are still in the early stages of being able to think critically (Anderman, Sinatra & Gray, 2012; Kuhn, 1999; Marin & Halpern, 2011). Adolescents still see the world dualistically and see knowledge as being transferred by authorities (Anderman, Sinatra & Gray, 2012). Merely providing multiple perspectives without supporting students in questioning their own culturally and family created paradigm will not result in transformative sustainability learning to question dominant power structures and paradigms (Burns, 2011).

To support my students in building their critical thinking skills, I offered numerous role-playing and case study activities where students took on different perspectives and then worked with peers to compromise and find solutions based on the differing perspectives. I also found success by utilizing constructivist principles where students would first consider their own views on a topic, then engage with differing perspectives of that topic, and finally reflect on how diverse viewpoints might have changed their original preconceptions.

The following section provides an analysis and discussion of one of my most successful lesson cycles in fostering critical thinking, bias examination, and perspective shifts.

Activity Analysis: From a Farmworker's Perspective

Instead of analyzing all five lessons within the "People Behind Our Meals" learning cycle, I have chosen to focus on only the opening activity from the learning cycle. I feel this particular lesson sufficiently demonstrates the power of incorporating critical and diverse views into a science classroom to support transformative sustainability education.

This activity was the engagement step of the agriculture-focused learning cycle within the Consumerism and Sustainable Solutions Theme. In order to understand a baseline

of student views and to practice constructivist pedagogy, I asked students to take a short survey about food systems.

Pre-lesson perspectives. The survey included 21 questions related to land use, local foods, hunger, and farm labor. It was administered toward the end of a class period the day before we began the food system lesson. The analysis for the perspective dimension will be focused on questions and responses to farm labor questions (Table 23). As Table 23 reveals, the majority of students agree that farm work is hard work and that they would be upset to know that people involved in their food production were mistreated. When it came to understanding labor availability, most students did not know if there were plenty of American citizens available for farm worker jobs. The last question, "migrant farm workers are stealing jobs from American citizens had an interesting split with 38% disagreeing, 44% unsure, and 19% either agreeing or strongly agreeing.

Based on these results, I knew that I wanted to help students identify their own biases and misconceptions, an integral step of critical pedagogy (Marin & Halpern, 2011; Paul & Elder, 2009). The following discussion will be focusing mainly on the shifts in perspectives related to farm labor issues.

Table 23

Results of pre-lesson survey related to perspectives of farm labor

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I would be upset to learn that the people harvesting and processing my food are mistreated.	0%	4.3% (N=3)	10.1% (N=7)	55.1% (N=38)	30.4% (N=21)
Harvesting fruit and vegetables on large farms is hard work that deserves a fair wage.	0%	2.9% (N=2)	7.2% (N=5)	55.1% (N=38)	34.8% (N=24)
There are plenty of American workers willing and available to harvest American-grown crops.	0%	10.1% (N=7)	58% (N=40)	24.6% (N=17)	7.2% (N=5)

| Migrant farm workers are stealing jobs from American citizens. | 13% (N=9) | 24.6% (N=17) | 43.5% (N=30) | 13% (N=9) | 5.8% (N=4) |

Changing perspectives through empathy & critical thinking. In an effort to practice constructivist pedagogy by helping students identify and acknowledge their previous ideas & misconceptions (Bybee et al., 2006), I opened the activity by showing students their responses to the pre-activity survey. When I read the question, "Are immigrants taking jobs away from Americans?" a loud, "Yes!" erupted from the audience. I seized on the opportunity to explicitly demonstrate critical thinking (Marin & Halpern, 2011). An excerpt from my research journal demonstrates my approach:

> I broke the question down with them, asking if there was a way to find an answer to this question. Where would we seek an answer? Is there a real answer? Who would we ask? What data would we need to find? I helped guide them to answers such as, "Are there any crop harvester jobs available in the US?" "Are there Americans harvesting crops?" "Were American workers turned down for jobs in the harvesting industry?" etc. (C. Baines, personal communication, May, 10, 2017).

Such guiding questions helped students to consider and even see the invisible power structures that exist all around (Barbules & Berk, 1999) as well as to consider diverse perspectives (Burns, 2011).

I then asked students to imagine they were responsible for harvesting tomatoes on a large farm in Florida. My aim here was to encourage students to practice empathy and consider diverse and critical views, a necessary skill for sustainability education (Burns, 2011; Marin & Halpern, 2011). I provided each student with a notecard and asked them to write down their thoughts about what that job would be like (Figure 14).

Name _____ Date _____
1. Imagine your job was to harvest tomatoes from a large industrial farm in Florida. ==Describe what you think the work would be like.==
   a. How long would you have to work?
   b. How much do you think you'd get paid?
   c. How would your body feel?
   d. Would you be exposed to any dangerous working conditions?

Figure 14. Student prompt for engagement activity related to farmworkers.

Student responses varied widely but numerous students wrote that they guessed a typical day would be 8-5 and the pay would be about minimum wage. Students listed ailments such as backaches and sunburns. A handful of students mentioned exposure to pesticides would be a concern. In response to the question, "Would you be exposed to any dangerous working conditions?," one student responded, "Not really unless you are stupid enough to go in front of the tractor." Such shortsighted responses reveal a lack of empathy and understanding for the plight of the farmworker, but are not surprising given the wide range of cognitive abilities and critical thinking capacities of adolescents (Anderman, Sinatra & Gray, 2012; Kuhn, 1999). Because critical theory is an emancipatory approach that is ultimately concerned with creating change and examining the status quo, helping students see beyond such limited views is a goal of sustainability education (Barbules & Berk, 1999; Burns, 2011; Dresner, 2008; Zinn, 2011).

After a brief discussion about some of their responses, I showed them three short documentary clips that highlighted the poor working conditions of migrant workers who harvest our food. This was in an effort to help students see the situation from diverse perspectives; an important step in building critical thinking and sustainability education

(Burns, 2011; Kuhn, 1999). After a student guided discussion in which I contributed probing questions to get them to think critically, (e.g. describe the living conditions of the workers; how much were they actually getting paid? How would you describe their work ethic? What would your situation have to be for you to work in those types of conditions? etc), I then asked them to reflect on how their perspective changed after thinking about the situation from a different viewpoint (Figure 15).

On the back of your card...
● How has your understanding of food harvesting changed since considering these perspectives?
● Describe your thoughts/opinions about immigrant farm laborers. Explain any change of opinion if you've had any.
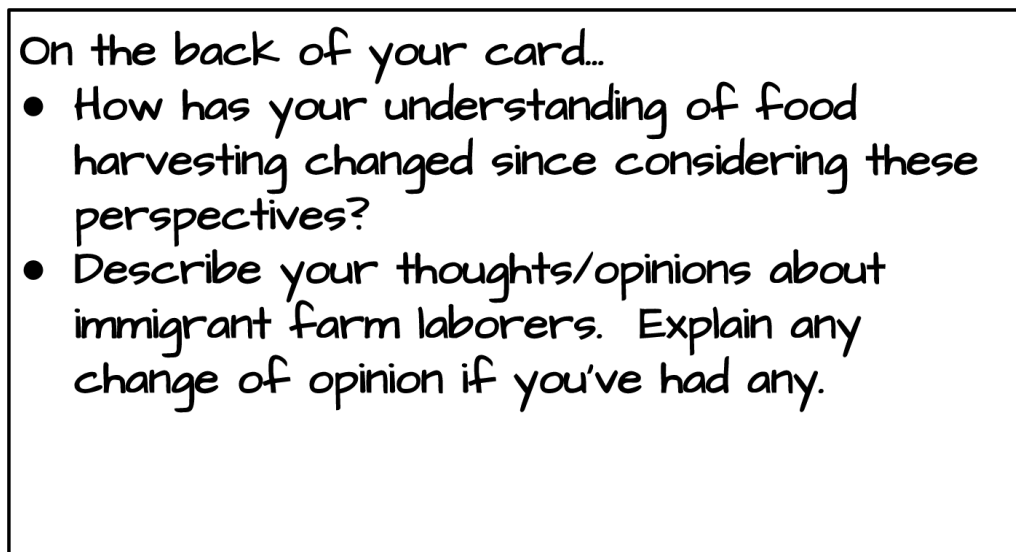
Figure 15. Student prompt to consider changes in understanding and opinion of migrant workers.

Student responses revealed a variety of interesting themes. Because the high school is located in a rural mountainous area, many students had connections to farms. One response in particular, written by a Latino male student in the 9th grade, caught my attention because the student revealed that we were basically watching images of his family: "I already had an idea of how this works because my family used to do the same. It wasn't an easy job. [Migrant workers] just need to be treated better." I was left wondering how this student may have been feeling emotionally about this activity. I hope that this student felt empowered that others were openly expressing a change in their opinions towards migrant workers and

building their empathy and respect for the hard work that goes into food

harvesting. However, it is also possible that this student may have felt feelings of shame and

embarrassment. As I read his response months after the conclusion of the course, I am still

left to wonder how he interpreted the day we discussed the plight of migrant workers in

science class. In reflection, transformational teaching has the potential to touch students on a

personal level. While this should be considered a goal of effective, inspirational education,

teachers must also be prepared to appropriately support students who may need extra help

navigating difficult emotions that may arise. When I offer this lesson in the future, I will be

intentional about allowing for space and opportunities for support so that students know I am

there for them.

Many responses suggested that there had been a shift in understanding and opinion

from considering these different perspectives. For example, one student wrote:

I haven't really thought about any of this until these past two days. I don't think

[migrant workers] are stealing Americans' jobs. I don't think it's fair that they work

their butts off and barely get any money. They're not stealing our jobs, they're just

willing to do the hard work to try to support their families.

Another student who had openly expressed an American-first belief, wrote, "Food

harvesting is very hard, time consuming job. I never knew that workers were treated so

terribly. I now know that immigrants aren't taking Americans' jobs, it's just that Americans

can't handle the work that has to be done." I was impressed and a bit surprised to see this

particular student's response because of his previous blatant expressions of nationalism. For

him to express empathy and a realization that food systems are more complex than one might

first expect felt like a success.

Post-activity perspectives. Further evidence that there was a shift in student understanding and opinions of migrant workers can be seen by comparing the informal pre- and post-survey about food labor. As Table 24 reveals, students who strongly agree that they would be upset to learn that people harvesting their food were mistreated rose by nearly 10 percentage points after considering the diverse perspectives. Students strongly agreeing that harvesting food is hard work and deserves a fair wage increased by 12.7 percentage points. There was a growth of twenty percentage points of students strongly disagreeing that there are plenty of American workers willing and able to harvest American-grown crops. The most significant shift was in response to the statement that migrant farm workers are stealing jobs from American citizens: students strongly disagreeing grew by nearly 30 percentage points after being exposed to diverse perspectives.

Table 24

Percent change in pre/post assessment questions to gauge student preconceptions of farm workers

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I would be upset to learn that the people harvesting and processing my food are mistreated.	0.0	-1.8	-0.1	-7.6	+9.6
Harvesting fruit and vegetables on large farms is hard work that deserves a fair wage.	0.0	-2.9	-4.7	-5.1	+12.7
There are plenty of American workers willing and available to harvest American-grown crops.	+20.0	+17.4	-35.5	+0.4	-2.2
Migrant farm workers are stealing jobs from American citizens.	+29.5	-2.1	-23.5	-0.5	-3.3

Beyond what the numbers in Table 24 suggest, there were multiple note card reflections that suggested students felt compelled to make personal changes based on these new perspectives. A white male put it as simply as, "It makes me feel like I want to help."

Another high performing female white student reflected, "[it] changes the way I think of eating (not picking a tomato off my sandwich and throwing it in the trash). [It] makes me feel really bad and guilty. I never thought about where the food I eat comes from." These responses show that the incorporation of sustainability education led to students connecting what they were learning to personal action, a key goal of transformative teaching (MacNaughton, 2003; Stuhmcke, 2012).

As the evidence presented above suggests, the power of this learning experience was palpable. On the final course reflection, I asked the questions, "What was the most disturbing thing and most interesting thing you learned in this class?" As the following response demonstrates, this particular learning experience about farmworkers resonated with students:

> The most heart-wrenching thing I learned in this class was that there are people working for like $0.70 an hour and they aren't being treated well. This shakes me to my core because I couldn't imagine working for $0.70 an hour or being in the situation of the people who do it.

However, merely providing diverse perspectives and then allowing students to reflect on how their own opinions may have shifted after considering those new points of view is not enough for adolescents who are still developing their critical thinking skills. Even though many students communicated a shift in thinking, there was also plenty of evidence of flawed or blocked perspective shift. As further discussed in Chapter Six, the anti-immigration political climate had a clear effect on some of the students. A white female student responded:

> My thought on food harvesting hasn't changed much. I've been aware of the pay and hard work in farmers. They should be paid much more than they do. Immigrant

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farmers should not be asked to come to the U.S. to work. Americans are capable of doing as much work as immigrants. What are Mexicans and Americans gonna do when the wall gets built??????

The above response is riddled with misconceptions about food and labor systems as well as a basic understanding of what the documentary clips were attempting to communicate. If left unaddressed, such strong and misguided perspectives could continue to perpetuate misunderstandings. While it is unfeasible to expect teachers to be able to personally address all culturally and politically misguided understandings, it is important to be aware of what misconceptions exist in the classroom and to continue to model the critical thinking process that is necessary to break down such stereotypes and single-minded thinking.

The Burns model of sustainability pedagogy (Burns, 2011) emphasizes the importance of identifying and critiquing dominant power structures. In reflecting upon my approach to this lesson, I failed to shine light on structural issues of power in regard to the plight of migrant workers. However, when considering how to better approach this activity in future classes, I am unsure if I would attempt to discuss the power structures involved in this issue because I of the complexity involved in such a discussion. While this activity provides a perfect opportunity to explore the power structures that create injustice for migrant workers, I am not confident that my mostly fourteen-year-old students are adequately prepared to understand such complexity. Instead, the main goal of this activity is for students to consider their how own preconceptions of food harvesting can change once they view the situation from a migrant worker's point of view. This process of practicing empathy and critically considering how different perspectives can help expand our understanding is an important step in being able to understand dominant paradigms.

Process Dimension: Participatory & Experiential Learning

The third goal of the Burns model of sustainability education is to "enhance learners' civic responsibility and intentions to work toward sustainability through active participation and experience" (Burns, 2011, p. 7). Ultimately, transformative sustainability education should inspire and empower students to enact change, on the personal, communal, and/or societal levels (Sipos, Battisti, & Grimm, 2007). Incorporating multidimensional sustainability *content* and exploring diverse and critical *perspectives* should be supported by an engaging process that encourages action (Burns, 2011).

As discussed in Chapter Two, there are a variety of ways to encourage participatory and experiential learning such as field trips, service learning, problem-based learning, and student projects (Burns, 2011). Offering engaging activities that allow students to be active participants in real world problem solving can help them build confidence and skills to confront sustainability challenges (Burns, 2011). However, it is important that students do not come away thinking that complex environmental, economic, and social issues can be solved with simple solutions (Tilbury, Coleman, & Garlick, 2005). To be effective, any action-oriented approach to education should allow students to understand why the action is needed, involvement in the planning and decision-making of the action, and space for reflection about the limits, effectiveness, and possible improvements of the action (Tilbury, Coleman, & Garlick, 2005).

Attempting to design all my lessons to be experiential is one of the biggest challenges I faced as an educator and curriculum designer. In theory, all lessons should be engaging and transformative. In practice, time and money constraints, student behavior and involvement, and the pressure to cover all content remains a real issue for me and other educators. While I would like to think that I successfully provided numerous opportunities for participatory and

experiential learning to thrive in my classroom, I know that I more than often fell short of my expectations. Upon reflection I realize that there remains much room for improvement even in what I consider to be one of my best examples of active learning described below.

Activity Analysis: Renewable Energy Exploration

The activity utilized the participatory and experiential technique of engaging students with an exploratory field trip where they investigated all of the renewable energy sites found on their own school's campus (Burns, 2011). The activity began with the constructivist tool of KWL (Know, Want to know, Learned) chart (Figure 16). A KWL chart is an ideal tool for constructivist teaching strategies because it begins with students acknowledging their already established understandings and misconceptions about a topic (Ernest, 1993). By having them begin with considering their own knowledge about where electricity comes from, many of them recognized that they actually did not know the source of the power that fueled their precious technology. Student responses revealed a wide range of knowledge and misconceptions about energy. Responses included "it comes from power lines" (student, grade 9); "It comes from the sun" (female student, grade 9); "it comes from a power station near your house" (male student, grade 9). The Want to Know column also had a wide range of requests, yet the overarching question was to understand how electricity is generated.
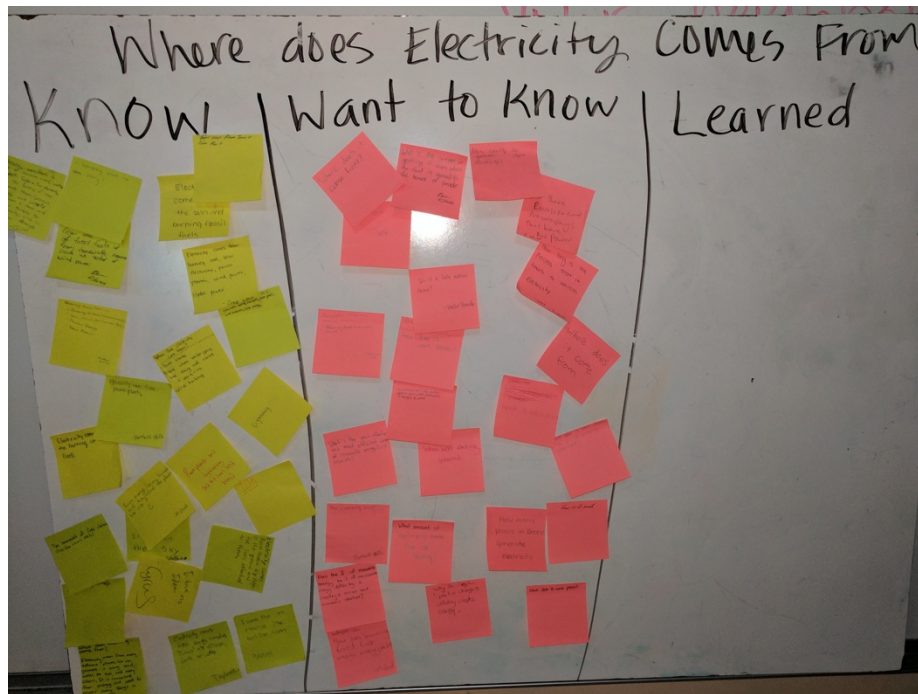
Figure 16. Where does electricity come from? KWL chart. May 2017

Once students identified their own curiosities and misconceptions, they were given a clipboard with energy source exploration sheet and instructed that they would be exploring a variety of energy technologies found within their school. My reasoning behind utilizing their own school as the learning lab, was rooted in the goals of place-based education: to create active, engaged citizens who care deeply about protecting and improving the communities in which they live (Sobel, 2005).

The students then engaged in an interactive tour of four different renewable energy sites around their school that focused on a different renewable energy technology at each one. They were instructed to write down details of how each device worked and what type of energy conservation was taking place. Station 1 was a tour of the geothermal heat pump technology found in the attic of the school. A diagram was also provided that explained how the constant 55 degree air found beneath their baseball field was continually being used to either cool or heat their school through a series of tubes and pumps that were constantly

exchanging energy through the temperature of the water being pumped throughout the tubes. Students then investigated the solar tubes that were over 20 feet long, connecting the roof to their 3rd floor science classroom, allowing sunlight to light their classrooms instead of electric lights (Figure 17). We then traveled to the third station which was the on-site wind turbine. Students considered and discussed how wind might be converted into electricity. The fourth station was exploring the solar powered cameras and photo transmitters that were installed inside a series of birdhouses placed throughout campus.

Figure 17. Renewable energy school tour. From left to right: geothermal heat pump system, solar tubes, wind turbine, solar powered camera and photo transmitter on bird house.

I designed this activity in this way to "provide students with experiences that make them reconsider their conceptions" (Ansberry & Morgan, 2011, p. 29). Students enjoyed getting out of the classroom and seeing parts of the school they didn't know existed. Many of them did not know that their school had so many innovative technologies. When students revisited their KWL chart when we returned to the classroom, the most common response

was how surprised they were to learn of the diversity of renewable technologies found at their own school.

To support students in building their critical thinking skills and to come up with an action plan towards sustainability (Burns, 2011), I helped guide students through a debrief and reflection discussion at the end of the activity. During the discussion students came to a consensus that our school was a long way from being able to supply its own energy. Since the goal of the process dimension of sustainability education is to "enhance learners' civic responsibility and intentions to work toward sustainability through active participation and experience" (Burns, 2011, p. 8), students were encouraged to come up with a plan of action. For me, the most exciting takeaway from this activity was how excited some of the students became in coming up with their plan of action. Many of them were eager to find out more about what it would take to be an energy independent school. By making their introduction to renewable energy a personal experience through this experiential learning process, I am certain that more students were inspired to learn more than had I just told them about renewable energy technologies or asked them to read about them in a book (Tilbury, Coleman, & Garlick, 2005).

Context Dimension: Rooting lessons in local communities

Connecting student learning to their local communities is the fourth goal of the Burns model of sustainability pedagogy. "Place-based education not only helps learners understand who they are, but to value the places they live and thus to value themselves within that place" (Burns, 2011, p. 8). As a leading advocate for place-based education, Sobel (2005) argues that studying local communities is the best way to connect students to the natural world, themselves, and others. It is key in creating active, engaged citizens who care deeply about protecting and improving the communities in which they live (Sobel, 2005). Place-based

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education is about "reeducating people in the art of living well where they are, in learning to be an inhabitant of a place from which an organic reciprocal relationship with place can grow" (Burns, 2011, p. 8). To allow sustainability pedagogy to flourish, the sustainability *content* that has been analyzed through diverse and critical *perspectives* and engaged with through an active and participatory *process* must be relevant to the real lived lives of students by connected to the local *context* (Burns, 2011). Since many adolescents are still living in the places of their birth, high school is an ideal time to deepen students' love and connection to place. Whether they remain, leave, or return to their high school communities, connecting to place can happen wherever one decides to place roots. What matters is awakening individuals to the importance of paying attention to where they are and providing "a way to explore and question economic, ecological, social and political relationships through the lens of local places" (Burns, 2011, p. 8).

For instance, when discussing effects of climate change, it is meaningful to explore ways in which a changing climate might affect local communities. I saw a shift in engagement once I brought up the potential of more mosquitoes migrating up the mountain to our higher elevation community. How camping in our backyards could eventually feel like camping in the piedmont (lower elevation) with the annoying mosquitoes and their nonstop buzzing and biting. We discussed how the potential for less snowfall might impact our local winter economy that relies heavily on ski tourism. We also discussed how the increase of flooding has been affecting our infrastructure and farming families. Once we shifted the discussion of global climate change impacts onto the local stage, previously unengaged students became active participants in the discussion.

It should be emphasized that many (all) places are deeply affected by dominant power structures that institute oppressive systems such as racism, resource exploitation, over-

consumption, and socioeconomic inequality (Gruenewald, 2003). It is crucial that educators support students in their discovery and critical analysis of these power structures to make visible what is often masked through privilege and unjust cultural norms.   Integrating diverse and critical *perspectives* that help expose injustice and power structures is necessary when connecting learning to place (Gruenewald, 2003). The farmworker lesson highlighted earlier in this chapter would be an example of such a strategy.

Activity Analysis: Lexicon of Sustainable Food

This lesson analysis looks at the Explain, Elaborate, and Evaluate steps of the agriculture-focused learning cycle within the Consumerism and Sustainable Solutions Theme. Students were first asked to think about what the word "lexicon" might mean. Once we all arrived at the common understanding that the Lexicon of Sustainability (see lexiconofsustainability.com) is a shared language to help us understand and reach sustainable lifestyles and systems, we watched a handful of short films from the Lexicon of Sustainability series. Each short film (3-5 minutes in length) explained a different sustainability term, in-depth, by utilizing photos and stories of individuals to provide a visual demonstration about what seemingly complex terms look like in practice.

Before watching the films, students were instructed that "you are an agricultural consultant in your community. A young couple is looking to return their family's farmland back into a working farm. Provide them guidelines about how they should design and operate their farm."

After watching the films, students were asked to visit the Lexicon of Sustainability website and choose at least two concepts to include in their sustainable farm plan (Figure 18). The purpose for this was to encourage students to connect what they were learning to real life context (Sobel, 2008).
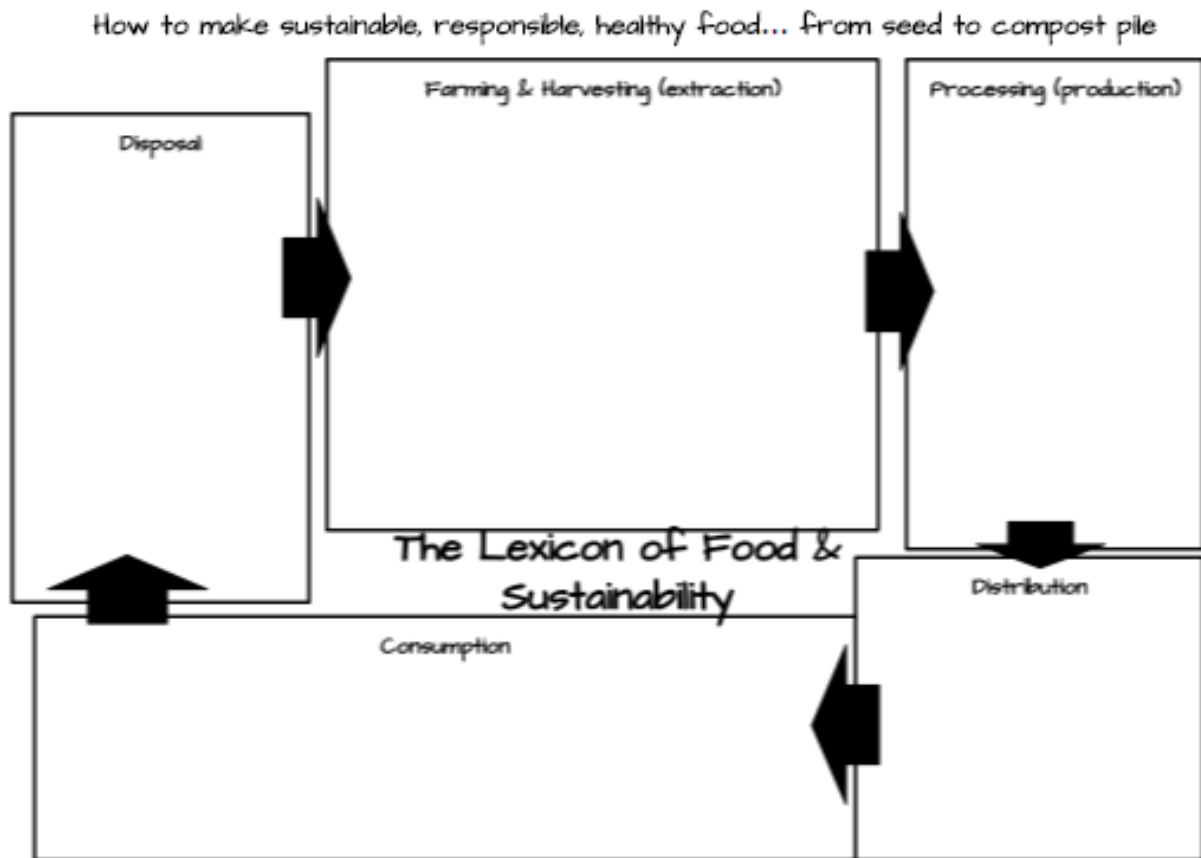
How to make sustainable, responsible, healthy food... from seed to compost pile

Disposal

Farming & Harvesting (extraction)

Processing (production)

The Lexicon of Food & Sustainability

Distribution

Consumption

Figure 18. Designing a sustainable farm from seed to compost pile

As one of the last days in the semester, this activity was not given enough engagement time. However, student feedback revealed that despite the rushed nature of the activity, the films and consideration of sustainable food system design made a lasting impact on many students. In fact, the majority of positive feedback received in regards to "how do you plan to make a difference?" was related to their desire to make a change to our food system. The following reflection made by a female student, grade 9, serves as evidence for this observation:

My understanding of food systems have changed in these ways: Before taking this class I didn't even think about where my food came from, now I consider the 3 E goggles when I get my parents to buy something. I now have a heart for locals and making sure I support them! Locavore if you will :)

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What is especially satisfying about the above reflection is the inclusion of the 3E goggles. The above quote also reveals a shift of affect that will hopefully stay with this student as she continues to grow and mature.

Chapter Summary

This chapter has discussed and analyzed a more detailed analysis of the findings for RQ2. To understand more fully how the newly restructured curriculum affected student comprehension of sustainability, I conducted an in-depth analysis of student work using the Burns model of sustainability education as a guiding framework for analysis.

Results from this analysis revealed that thematic teaching allowed for space to explore complex sustainability *content* that interwove ecological literacy, economic system critique, and issues related to equity/social justice (Burns, 2011). It also allowed for diverse, critically questioning *perspectives* that were often rooted in a local *context* to encourage students to become engaged, critical thinking, citizens of their local and global communities (Burns, 2011). The restructured thematic course provided a more flexible curriculum that enabled more time to engage in a participatory and experiential teaching and learning *process* (Burns, 2011).

The concluding chapter of this research project provides a summary and reflection of lessons learned, suggestions for future research, and anticipated impact of this action research study.

Chapter VII

Conclusions & Implications

Education plays an integral role in ensuring the health of the planet (Orr, 2004). The equitable wellbeing of its ecosystems and society depend on creating an engaged citizenship that understands how human-designed economic systems drive ecologic destruction that impacts different communities in unjust ways. I believe schools can serve as a catalyst for change that can help to grow empathetic citizens who care about their fellow humans and the ecological health. Sustainability education challenges, supports, and inspires students to understand Earth's interconnected social, economic, and ecologic issues. This action research project has demonstrated that it is possible to integrate sustainability education into a public high school classroom without compromising test scores. In fact, this research has shown that test scores actually rose after an in-depth study of sustainability issues.

Chapter IV explained the reasoning and process of restructuring the state sanctioned essential standards into sustainability themed units to create change in my classroom directly and in community broadly (Herr & Anderson, 2014). Providing free access to the pacing and curriculum guide for other teachers to use and edit highlights the emancipatory nature of action research: its moral imperative to fight for a better, freer world; not just to publish theories (Reason & Bradbury, 2001; Stuhmcke, 2012). By implementing the suggestions provided by leading curriculum designers (Wiggins & McTighe, 2007) and transformative sustainability education advocates (Burns, 2011; Pace Marshall, 2006; Sipos, Battisti, & Grimm, 2007), I feel confident that I have created a pacing and curriculum guide that can serve as a foundation for teachers interested in fostering transformative sustainability education in their own classrooms and I hope that they find, use, and edit my framework and ideas. I am certain that this will remain a work in progress and is by no means a concrete,

cookie-cutter solution to sustainability curricular implementation. I hope that myself and other passionate educators who believe in the power of education to help transform our world into a more healthy, just, sustainable world will continue to explore and experiment with ways to engage, enlighten, and inspire our students to become active citizens of their communities and the world. The forever working draft of my integrated sustainability-environmental science pacing and curriculum guide is easily found at: tinyurl.com/EENsustainability.

Chapter V provided evidence showing the positive impact of the integrated sustainability curriculum. I analyzed four key data sets to better understand how the newly restructured curriculum affected the course goals and student outcomes. By comparing the quantity of time and assignments devoted to sustainability, students' pre-/post-course survey and students' North Carolina Final Exam scores, it was shown that students gained sustainability knowledge without compromising their comprehension of the state sanctioned curriculum. Analyzing data from the post-course self-reporting survey revealed that most students were positively impacted and often compelled to take positive action towards sustainability goals. Each of these points of analysis helped to better understand how the integration of sustainability education impacted students' knowledge of and attitudes towards sustainability and whether adequate coverage of the required course content was achieved. Conducting this analysis of student data left me feeling even more confident in sharing and encouraging other Earth/Environmental Science teachers to adopt this sustainability-focused thematically structured course.

Chapter VI provided a microanalysis of teacher and student experiencers with curriculum redesign. It discussed a more detailed analysis of the findings for RQ2 by conducting an in-depth analysis of student work using the Burns model of sustainability

education as a guiding framework. This fine-tuned analysis allowed me to understand more fully how the newly restructured curriculum affected student comprehension of sustainability. Results from this analysis revealed that thematic teaching allowed for space to explore complex sustainability content that interwove ecological literacy, economic system critique, and issues related to equity/social justice (Burns, 2011).   It also allowed for diverse, critically questioning perspectives that were often rooted in a local context to encourage students to become engaged, critical thinking, citizens of their local and global communities (Burns, 2011). The restructured thematic course provided a more flexible curriculum that enabled more time to engage in a participatory and experiential teaching and learning process (Burns, 2011).

While I hope that this project will make an impact on the teaching profession, I am positive that this action research project has left a lasting impact on my teaching praxis. The following section discusses the key lessons learned and the ways in which I was transformed by this journey.

Implications of Action Research: Making a Difference

I value the importance of educating youth about their interconnected role in the natural and cultural Earth and am dedicated to living that value in my classroom. Action Research allowed me to continually reflect on this intention and check in to see if I was able match praxis with theory.   As an engaged teacher researcher, documenting my process and continually examining data was a critical component of remaining true to the moral imperative that is the foundation of action research: to fight for a better, freer world, not just to publish theories (Reason & Bradbury, 2001; Stuhmcke, 2012). I had to continually implement changes as needed to better my practice for the greater good of my classroom community.

While it was not the goal of this study to make claims about long term impacts of the curriculum on student behavior, I was interested in identifying short term changes in student attitudes and my own personal journey of attempting to influence my students in this way. As McNiff (2013) describes, "Action research is about putting ideas into action, not only talking about them" (p. 51). As Chapters IX and X have documented, many students were positively impacted by my very intentional and reflective teaching that was a result of this action research project.

At the end of the semester, I received a letter from a student that helped to reinforce that what I was seeing, and documenting was truly happening:

> I just wanted to take a few and say I appreciate you so much! I have never been so amazed at a teacher and how passionate about what she teaches as I have been with you. You taught me facts (that were very helpful)… I love your love for sustainability education and how much of a difference you strive to make. Maybe you aren't told this enough but I appreciate your class and you. I guess what I'm saying is thank you! Thank you for believing in me…thanks for teaching me to be a lifelong learner. Teachers like you who teach us things about people… are what schools need. Most of all, thank you from the bottom of my heart for being a teacher! (personal communication, June 6, 2017)

While it is certain that not all students were compelled in this way to express their gratitude, it was validating to know that my dedication and passion for teaching sustainability did not go unnoticed. The course did inspire some students to make a difference in their communities, as demonstrated from this quote from a male student, grade 9, "I want to support locals, I want to make sure I do my part in making sure we preserve the earth."

The reflective nature of the action research process constantly reminded me to ask the questions, "What do I see? What do I need to know that I cannot always see? What does it mean?" (Burnaford, 2001, p. 41). Such an awareness of looking for the unseen encouraged me to consider aspects of teaching and well-being that are not found within the curriculum guides. As the excerpt from the following journal entry reveals, I also found myself

incorporating mindfulness practices into my teaching as I found they fit easily within the

sustainability themes.

> Today was successful. I knew I wanted the students to learn about Rachel Carson's story and to consider multiple sides of the debate regarding pesticides. I asked students to sit quietly for 2 minutes and pay attention to what they hear. I then asked them to journal about what they heard, being descriptive in a way that is similar to Rachel Carson (I mentioned that she was a talented writer in addition to being a great scientist). I then found different versions of the reading in order to differentiate the assignment. I realize that not all students read as in depth as I would have liked but I am certain that some students did and perhaps got something out of the reading. It would be great if some of them became inspired by Rachel Carson's work but that is something I may never know … When we returned to class, I asked them how they felt about sitting in stillness for 2 minutes. Overall, a majority of the students enjoyed the experience and said it was nice and relaxing. I think I set the stage for being able to walk them through some breathing and relaxation techniques. I asked them if they were able to notice what their minds were doing… could they quiet their minds enough to only focus on sounds or were their heads full of thoughts even while they were listening? I asked them if they were able to remain fully present. I mentioned that yoga is a great tool to practice being present. (C. Baines, personal communication, April 7, 2017)

The expanded reflection above demonstrates many interesting internal conversations

that were taking place while deciding how to design the daily lesson. In my commitment to

connecting students to the natural world, I had the desire to hold class outside, but hesitated

because I came up with a beneficial academic/critical thinking exercise that at first, I thought

I would have to have access to technology. Due to this action research process that was in a

sense, holding myself accountable to the values I hold, yet don't always follow, I came up

with a solution to hold the class outside while also sticking to my engaging critical thinking

exercise. The on-the-fly decision to incorporate mindfulness demonstrates how my habits of

mind to incorporate a variety of skills and lessons simultaneously, was in full swing. I wish I

could say that I had such innovative and impactful on-the-spot ideas every day, but alas, there

were plenty of days that I knew I fell short. Luckily, I captured those struggles in real time

thanks to the disciplined journal writing that became habit due to action research.

Barriers to Incorporating Sustainability Education into a High School Science Course

Challenging Political Climate

From the first day of class, it was clear that the contentious political atmosphere was not only affecting adults. Students in my honors class were given self-directed station activities to complete on their first day, one of which involved an online competition requiring students to enter their name. Numerous students decided to write "Trump" and "Trump Train" as their identifier. I had a suspicion that this incident would not be the last. As the journal entry from 2/22/17 reveals, I was experiencing internal struggles with how to deal with the unique divisive environment:

> Today was an interesting day. I got a call from a parent who wanted to view the survey that was given to the students. She said she had concerns about what was in the survey and wanted to see it. This was particularly alarming to me because this parent has already identified herself as an ardent Trump supporter and her son has exhibited clear disapproval for anything relating to environmental concerns. I got really nervous about the political atmosphere that we are currently existing in within education. It brought back memories of the debate about the book a few years ago here at the high school. The debate made national news. While the teacher ultimately came out on top, it must have been draining and exhausting to have to defend her choices in the classroom. The conversation with the mother today brought up some internal fears that I have for conducting this research and for attempting to teach in an interdisciplinary way. The fact that my entire research project is based on the idea that it is very important to tie concepts in one class to concepts in other disciplines may be the very reason why a parent could try to shut down my attempts to teach about holistic sustainability. (C. Baines, personal communication, February 22, 2017)

Luckily, this situation turned out just fine and there were no further complications related to the survey, the parent, or the student. However, the fear never really went away. When teaching students about accomplishments of the EPA, there were national leadership calls to dismantle the EPA. When I was teaching about climate change, the United States withdrew from the Paris Climate Agreement. When I was teaching about the human and environmental costs of mountaintop removal coal mining, out top commander in chief was promising to put all coal miners back to work.

Perhaps one of the most interesting class activities that revealed a perplexing reality was when I opened class with an NPR story about wind farms in North Carolina. The two-minute radio story was discussing how the largest windfarm in the southeast would soon be built near the east coast of North Carolina. The story also mentioned how federal policy might impact the wind farm and that there were still many unknowns due to Trump's seemingly hostile stance toward wind, based on his litigation against windfarms near his golf courses in Scotland. Before listening to the short news story, I asked students to create a notecard summary that included an overview of the story, how interesting it was, and what questions they still may have. What I found to be shocking was that more than one student heard and wrote that, thanks to Trump, North Carolina will soon have the largest windfarm in the southeast. In other words, for some students, hearing the word Trump within a story causes them to automatically connect his name with to the 'winner' of the story, in this case, he created the wind farm. While attempting to understand the reasons behind this false association is beyond the purview of this study, I found it very interesting how many students made similar interpretations. As a second year public school educator, I was unsure how to address such blatant misinterpretations of a basic storyline. This experience was revealing, however, and reminded me that everything I say and hear gets filtered through many different interpretations.

In thinking about how these experiences can help other teachers who find themselves in a similar situation, I would say that setting aside time to work one-on-one with students who display such misguided understandings will help them to critically analyze the reasons behind their misunderstandings. While such an approach may be worthwhile, it is difficult for teachers with already overflowing plates to be able to take such personalized steps to help their students. But based on my experience, I would encourage teachers to find the time, as

modeling such direct, critical, and focused dialogue will help students navigate such issues into their future.

Deep Teaching & Learning is Hard Work

Another real challenge in my attempt to improve my teaching and document my journey was that it became very clear that providing engaging, meaningful, and critical learning opportunities takes much more effort than a more traditional 'deliver and recite' methods of objectivist teaching strategies (Ansberry & Morgan, 2001). There were many times that resorted to a more objectivist style of teaching. In reflecting on why I continued to practice teaching methods that I was trying to move beyond, I think the reasonings are numerous. The excerpt below gets at one reason:

> Today was one of those days where the whole day went to the objectivist trap that I feel stuck in. In order to demonstrate student learning in an "objective" way, I felt compelled to give them a quiz to see whether or not they were understanding what is being taught. In a way, it's also kind of a way to 'scare' them into doing the required work… or reward them for doing their work through studying, paying attention, etc. When student motivation is a major concern, what methods do we have to reach all students? It's easy to talk about ideas to make school more engaging and meaningful, but as a teacher, it is really tough to try to pull it off in a system that is not set up to support such goals. This entire day was devoted to review and assessment. An objectivist approach would applaud such dedication to 'comprehension' but I could tell the students were bored, unengaged and some were even nervous. I could/should have made the review more interactive, but it was a case of time available versus measurable benefit. I could have made it fun but would that have resulted in higher quiz scores? Ugh. This whole self conversation is frustrating because I am not operating in a way that matches my philosophy and ideal way I'd like to teach. On a positive note, I did try to incorporate more co-constructivist and critical questions into the quiz. I also included an open response which will take much more time for me to grade. (C. Baines, personal communication, April 11, 2017)

As demonstrated above, the lack of student motivation makes it challenging for constructivist and critical techniques because deep learning requires student engagement and can pose challenges in how to implement accountability (Stuhmcke, 2012).

A second reason I often found myself utilizing objectivist teaching strategies, was that I was often tired and/or lacked the patience required to work with each student individually:

I'm going to be honest about a very real struggle I had today. I gave the students time today to work on their projects rather than moving forward with additional content. While I do know conferencing with the students was useful to the ones I got to conference with, it left me feeling exhausted and questioning whether or not it's worth it to allow for more in-depth independent study. It's like I have this person in my head going "it would be so much easier to just give them the information! This stuff isn't that hard! It should only take like 15 min!" But then the compassionate, progressive, non-objectivist side of me comes in and says, "No, Courtney… even though there are some students wandering, allowing them time to explore, experiment (in this case with technology more than anything), and create on their own is very valuable, even though it may not be directly measurable. (C. Baines, personal communication, April 3, 2017)

Maintaining teacher motivation and commitment to putting in the extra effort to go beyond objectivist teaching is necessary to foster critical and constructivist learning (MacNaughton, 2003). However, I found that it was difficult to always put in extra time and effort. I remained aware of how prevalent teacher burnout is (Shen, McCaughtry, Martin, Garn, Kulik, & Fahlman, 2015) and wanted to make sure I took care of myself as well as my students.

Lastly, a real challenge in incorporating more subjective and critical investigations within a science class is that there are many parts of science that are objective and not up for debate (Bybee et al., 2006). As the journal excerpt below demonstrates, I found it challenging to find a way to teach and assess students about scientific principles—such as the physics behind greenhouse gas—with more innovative and constructivist or critical techniques.

I feel like I'm relying too heavily on videos, demonstrations, and lectures which are not inspiring students to care about climate change. I do think it is important for them to understand the basic science behind climate change (carbon cycle, greenhouse effect, and energy balance) but I'm not sure it's working the way I'm presenting it. I have a feeling that the ones who already get it are bored and the ones who have been taught to not 'believe it' or not trust science are not even open to learning. 4th block was both productive and frustrating. Far too many side conversations. Classroom management issues seem to be my main struggle. As a new teacher, I am not sure if this kind of behavior is normal for high school students or not. I feel exhausted and unengaged myself. I need to set up better methods for engagement and participation. (C. Baines, personal communications, April 28, 2017)

I often found myself in this conundrum of needing students to fully understand the objective facts behind basic science concepts (greenhouse effect; chemistry of our atmosphere) before they could consider the social, economic, and political drivers and consequences of the science. As a teacher committed to such lofty goals of inspiring students to become engaged citizens who aspire to make the world a more just, sustainable place for everyone, it quickly becomes overwhelming. I often had to remind myself that my while my own goals were worthy of the effort, teenagers have their own set of very different goals, and that's ok. Attending to student needs and creating a culture of care can and should be just as important as my agenda of scientific concepts and critical thinking goals.

Despite the many challenges, this endeavor of incorporating sustainability themes into a public-school classroom was a worthwhile project. I see many opportunities for such a tactic to be utilized by other practitioners and teacher/researchers. The next section discusses suggestions for further research related to this action research project.

Suggestions for Further Research

Understanding long term impacts of adolescent exposure to sustainability education would be useful, albeit challenging contribution to the field. Longitudinal studies of young adults who were exposed to sustainability education during adolescence would help tell the story of long term impact and the transformative potential of such an approach to education. Research into the lasting impact of transformative teaching and learning approaches could contribute further insight into how adolescents are inspired to continue to enact change as they get older.

It would also be a worthwhile contribution to the field to conduct a study about how to incorporate sustainability education into different high school disciplines. Is it also possible to reorganizing history (or English or math or biology) standards around

sustainability themes? As I've argued throughout this action research project, sustainability education can – and should – be integrated within all disciplines. It would be interesting to see how another teacher/researcher might attempt to restructure an entirely different set of curriculum standards around similar sustainability themes that were presented within this action research project.

Another area of need is to better understand teacher buy-in. Are other teachers open to redesigning their courses to incorporate sustainability themes? What would be required to prepare a teacher to feel comfortable incorporating these types of themes and concepts if it falls outside of their knowledge base/comfort zone? When thinking about the fact that I brought nearly a decade of experience with teaching and learning about sustainability themes into my classroom, it is reasonable to assume that a teacher without such background would feel overwhelmed with the idea of incorporating such radically new structures and concepts into their teaching. Would it be possible to recreate that depth and comfort of knowledge within a shorter timeframe for a teacher unfamiliar with sustainability concepts? Better understanding the drawbacks and barriers to teacher buy in and ways to help overcome those challenges would be a useful research contribution.

Lastly, it would be fascinating to explore more into the inner conflicts that face when teaching sustainability topics in highly contentious political times. This research study briefly touched upon my own personal struggles and frustrations faced when teaching about environmental and social justice topics during a time when political leaders were openly questioning the legitimacy of climate change science and were actively working to divide people based on race and nationality. A study looking into the challenges teachers face while educating during highly politically polarized times would be yet another great contribution to the field.

Final Action Step: Sharing Curriculum

My decision to complete an action research project was rooted in my desire to create change in my classroom directly and in community broadly. Because action is the key of action research, it requires that the practitioner/researcher develop a final or evolving plan of action to ameliorate an identified issue in the lived experience of the situation at hand (Herr & Anderson, 2014). I will share my pacing and curriculum guide along with the eight complete lesson cycles through various teacher resource outlets such as Teacher Pay Teachers and practitioner teacher journals. Since action research has a moral imperative to fight for a better, freer world, not just to publish theories (Reason & Bradbury, 2001; Stuhmcke, 2012), my hope is that other teachers will feel inspired and supported when they find this free and accessible lesson guides that will always be accessible at tinyurl.com/EENsustainability.

Conclusion

In the opening problem statement, I asked "In a world where today's realities can lead to an overwhelming sense of despair, what are we to do as educational leaders to create meaningful change?" I've settled on the fact that my work as a teacher-researcher is not to completely overhaul the education system, but to make it more equitable and sustainable in small, significant ways. I'm not going to be able to awaken all students and educational leaders to make them critically aware of perilous issues such climate change, imperialism, white supremacy, and patriarchy. Once I was able to let go of the lofty goals of a systemic moral/philosophical overhaul, I was able to get to work and create meaningful change in my own sphere of influence, no matter how small it may be. Many of my like-minded friends will argue against this, arguing that the only solution is revolution, that a complete reimagining and restructuring of the way our schools are designed is the only way to save our children and planet (that or homeschool, as many of them have chosen as their own

solution). While I may have agreed with them in the past, I have since realized that we must do what we can now and not get lost in the vision (and distance!) of where we wish to be. We can become paralyzed if we continually focus on what's wrong with our education system and even become combative, argumentative, and angry, constantly on a rant about what's wrong with the world. Such action can trap us in a cycle of negativity, without the allies we need to build positive change in our own classrooms.

My action research project was rooted in this idea that we must work from where we are, from within existing systems. By rearranging the typical delivery of the required curriculum, I was able to successfully incorporate sustainability themes and make a meaningful impact at a public school without revolting against the system or causing a scene. While revolutions, overhauls, and combative strategy may have their place in certain situations, my experience shows that there is a strategic and peaceful alternative that can happen right away within any classroom. I remain hopeful that others may feel inspired by my story and find their own way forward without waiting for top-down policy to be more aligned with their ideals.

As a long-time sustainability education advocate, I was elated to generate my own theory of living by putting my ideas to action while simultaneously conducting practical research that matters to me, my students, and what's sure to be the larger educational community. Even though life circumstances have resulted in me no longer serving in the public school sector, I remain hopeful that other science educators find this sharing of a journey helpful and perhaps even relevant to their own practice. I was intentional in creating my pacing, curriculum, and lesson guides in a way that enables teachers from all disciplines to take, edit, and use my work to help them reach their own goals. And if sharing my journey can help others deepen their desire and build their confidence to interweave sustainability

education into their course, I will feel beyond accomplished. If this journey positively affects at least one of my students, I will also consider this a successful endeavor.

Perhaps as a final affirmation of my work, I was in a pet store recently and ran into a student from my honors class. He immediately said, "I've been meaning to tell you that I'm thankful for your advice about the CSA (community supported agriculture)! I convinced my parents to get involved and sign up! The farmer is right next to us. She knows you. Her daughter is so cute!"

What was so amazing about this exchange is that while I was teaching this particular student, I wasn't really sure I was getting through to him. He always seemed to have a contradictory comment to whatever I presented to the class. He seemed very skeptical of nearly everything related to sustainability. What's also pretty amazing is that this student has likely lived near this farm maybe his whole life but didn't really investigate or get involved in the CSA until taking my class. If I were to have analyzed this outcome by utilizing the four dimensions of the Burns Model of sustainability pedagogy, I would have found that the effect my course had on this student met all four dimensions. Now he's met the farmer and knows about her life (perspectives dimension). He demonstrated that he was taking his knowledge from classroom home to his parents to create change in his own life and his community (process dimension). He was learning about his neighbor and was proud to be supporting a local farm family (context dimension). He was actively participating and aware of his place within his local food system (content dimension). And perhaps the best part of all of this was that transformation had occurred within a student's life even though it appeared he was apathetic at best, and resistant at worst, to many of the concepts while they were being presented to him during class. If this type of impact is possible with what seemed to be a disengaged student, I can only imagine what may occur in the lives of the many students who

were openly embracing and excited about the sustainability concepts we were exploring during the course.

Public schools are capable of preparing our future citizens and leaders to create a more just, healthy, sustainable, and compassionate world. This action research project demonstrated an applicable strategy to engage and inspire public high school students to understand complex local and global issues and to work to make a difference. My hope is for a future in which all teachers feel supported and empowered enough to utilize their classrooms as transformative platforms for the greater good. The health and future of our planet depend on it.

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North Carolina Essential Standards: Earth/Environmental Science

Standard	Description	
EEn.1.1	Explain the Earth's role as a body in space	**EEn.1.1.1** - Explain the Earth's motion through space, including precession, nutation, the barycenter, and its path about the galaxy. **EEn.1.1.2** - Explain how the Earth's rotation and revolution about the Sun affect its shape and is related to seasons and tides. **EEn.1.1.3** - Explain how the sun produces energy which is transferred to the Earth by radiation. **EEn.1.1.4** - Explain how incoming solar energy makes life possible on Earth
EEn.2.1	Explain how processes and forces affect the lithosphere.	**EEn.2.1.1**- Explain how the rock cycle, plate tectonics, volcanoes, and earthquakes impact the lithosphere. **EEn.2.1.2** - Predict the locations of volcanoes, earthquakes, and faults based on information contained in a variety of maps. **EEn.2.1.3** - Explain how natural actions such as weathering, erosion (wind, water and gravity), and soil formation affect Earth's surface. **EEn.2.1.4** - Explain the probability of and preparation for geohazards such as landslides, avalanches, earthquakes and volcanoes in a particular area based on available data.
EEn.2.2	Understand how human influences impact the lithosphere.	**EEn.2.2.1** - Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present. **EEn.2.2.2** - Compare the various methods humans use to acquire traditional energy sources (such as peat, coal, oil, natural gas, nuclear fission, and wood).
EEn.2.3	Explain the structure and processes within	**EEn.2.3.1** - Explain how water is an energy agent (currents

	the hydrosphere.	and heat transfer). **EEn.2.3.2** - Explain how ground water and surface water interact.
EEn.2.4	Evaluate how humans use water	**EEn.2.4.1** - Evaluate human influences on freshwater availability. **EEn.2.4.2** - Evaluate human influences on water quality in North Carolina's river basins, wetlands and tidal environments.
EEn.2.5	Understand the structure of and processes within our atmosphere.	**EEn.2.5.1** - Summarize the structure and composition of our atmosphere. **EEn.2.5.2** - Explain the formation of typical air masses and the weather systems that result from air mass interactions. **EEn.2.5.3** - Explain how cyclonic storms form based on the interaction of air masses. **EEn.2.5.4** - Predict the weather using available weather maps and data (including surface, upper atmospheric winds, and satellite imagery). **EEn.2.5.5** - Explain how human activities affect air quality.
EEn.2.6	Analyze patterns of global climate change over time.	**EEn.2.6.1** - Differentiate between weather and climate. **EEn.2.6.2** - Explain changes in global climate due to natural processes. **EEn.2.6.3** - Analyze the impacts that human activities have on global climate change (such as burning hydrocarbons, greenhouse effect, and deforestation). **EEn.2.6.4** - Attribute changes in Earth systems to global climate change (temperature change, changes in pH of ocean, sea level changes, etc.).
EEn.2.7	Explain how the lithosphere, hydrosphere, and atmosphere individually and collectively affect the biosphere	**EEn.2.7.1** - Explain how abiotic and biotic factors interact to create the various biomes in North Carolina. **EEn.2.7.2** - Explain why biodiversity is important to the biosphere. **EEn.2.7.3** - Explain how human activities impact the

biosphere.

EEn.2.8	Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth.	**EEn.2.8.1** - Evaluate alternative energy technologies for use in North Carolina. **EEn.2.8.2** - Critique conventional and sustainable agriculture and aquaculture practices in terms of their environmental impacts. **EEn.2.8.3** - Explain the effects of uncontrolled population growth on the Earth's resources. **EEn.2.8.4** - Evaluate the concept of "reduce, reuse, recycle" in terms of impact on natural resources.

North Carolina Department of Public Instruction, 2015

APPENDIX B
PACING & CURRICULUM GUIDE: SUSTAINABILITY UNITS

Theme	Essential Questions	Guiding Ideas	Standards
Ecology & Interconnections	• What are the connections found in nature? • What are the connections between humans and nature? • What is the value of nature?	• Ecology and Biodiversity: Connections and Threats 🌍🌍🌍 • What is the Value of a Forest? 🌍🌍	• EEn.2.7.1 • EEn.2.7.2 • EEn.2.7.3 • EEn.2.2.1 • EEn.2.4.2
Understanding Sustainability	• What is sustainability? • What are the historical and conceptual foundations of environmental science and sustainability?	• The 3 Es of Sustainability & the 3E Goggles 🌍🌍🌍 • Tragedy of the Commons 🌍 • Evolution of Environmentalism: Rachel Carson, the EPA, and Sustainable Development 🌍 • What's My Impact? Ecological Footprint 🌍🌍	• EEn.2.8 • EEn.2.7.3 • EEn.2.8.4
Energy & Climate Change	• How do humans use energy? • How are humans impacting the climate? • How will a changing climate impact humans and nonhumans? • How are humans impacting air quality? • How does air quality impact humans and nonhumans?	• Understanding the Greenhouse Effect 🌍🌍🌍 • Evidence & Impacts of Climate Change 🌍🌍🌍 • Story of Coal, Oil & Natural Gas 🌍🌍 • Impacts of Air Pollution 🌍🌍🌍 • Solutions to Climate Change 🌍🌍 • Renewable Energy	• EEn.2.6.3 • EEn.2.6.4 • EEn.2.8.1 • EEn.2.2.1 • EEn.2.4.1 • EEn.2.5.5
Consumerism & Sustainable Solutions	• What is the story of our stuff? • What drives our consumption patterns? • How do our consumption patterns impact the natural world and other humans? • How do our food choices impact the natural world and other humans?	• Materials Economy & Life Cycle Assessment 🌍🌍🌍 • Consumption & Media Literacy 🌍 • Story of Trash & Food Waste 🌍🌍 • Sustainable vs. Industrial Agriculture 🌍🌍🌍 • Lexicon of Sustainable Food 🌍 • Water Access and Water Quality 🌍🌍🌍 • Story of Solutions & Sustainability Heros 🌍🌍	• EEn.2.8.4 • EEn.2.8.2 • EEn.2.4.1 • EEn.2.4.2 • EEn.2.8

KEY: 🌍🌍🌍= **Essential to cover**   🌍🌍=**Can condense under time constraints**   🌍=**May skip under time constraints**

THEME: Ecology & Interconnections

Essential Questions	• What are the connections found in nature? • What are the connections between humans and nature? • What is the value of nature?
State Essential Standards	• EEn.2.7.1 Explain how abiotic and biotic factors interact to create the various biomes in North Carolina. • EEn.2.7.2 Explain why biodiversity is important to the biosphere. • EEn.2.7.3 Explain how human activities impact the biosphere. • EEn.2.8.3 Explain the effects of uncontrolled population growth on the Earth's resources.
Related Standards	• EEn.2.4.2. Evaluate water quality of NC streams (chemical, physical properties, biotic index). • EEn.2.4.2. Evaluate issues of ground and surface water pollution, wetland and estuary degradation, and salt water intrusion. • EEn.2.2.1 Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present. • EEn.2.8 Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth

Essential Vocabulary	Abiotic Biotic	Biodiversity Biome	Biosphere Cost-benefit analysis	Ecology Ecosystem services	Externalized costs Habitat	Invasive species Trophic level

Guiding Idea	Objectives. Students will be able to...	Lesson Suggestions
Ecology & Biodiversity: Connections and threats 🌐🌐🌐	• Explain how biotic and abiotic factors determine biome classification (temperature, rainfall, altitude, type of plant, latitude, type of animals) *EEn.2.7.1* • Define the biosphere as all life on Earth. *EEn.2.7.2* • Explain effects of invasive nonnative species (plant or animal) on an NC ecosystem. *EEn.2.7.3* • Explain effects of human population growth, habitat alteration, introduction of invasive species, pollution and overharvesting on various plant and animal species in NC. *EEn.2.7.3*	Lesson: Ecology & Biodiversity-- connections and threats (link to full lesson) • Engage: Biotic and abiotic factors of North Carolina's biogeographic regions • Explore: NC ecosystem energy pyramid and biodiversity mural • Explain: Understanding ecosystems and threats to biodiversity • Elaborate: Invasive species research and web of life game • Evaluate: Habitat loss project
What is the value of a forest? 🌐🌐	• Explain how human activities impact the biosphere. *EEn.2.7.3* • Summarize ways to mitigate human impact on the biosphere. *EEn.2.7.3* • Explain the need for and consequences of various types of land use such as urbanization, deforestation and agriculture. *EEn.2.2.1*	Lesson: What is the value of a forest? (link to full lesson) • Engage: 1) Do humans play a role in natural disasters? 2) Deforestation in the Amazon. • Explore: deforestation case study • Explain: Can we put a price on nature? • Elaborate: How do trees collaborate? • Evaluate: Should we turn rainforests into hamburgers?

Suggestions for Transformational Learning: Ecology & Interconnectedness

CONTENT: Integration of the 3Es	CONTEXT: Place-based
• In **Do humans play a role in natural disasters?**, students are able to explore the economic and man-made drivers that can affect the impacts of natural disasters. They also consider if all people are affected equally. • Discussing what "value" means to different people from different perspectives, students are introduced to the 3Es of sustainability in **What is the value of a forest?** • Students are introduced to ecological economics in **Can we put a price on nature?** This helps them begin to see how economics and ecology are at the same time at odds and complimentary. • The **Rainforest Deforestation Case Study** introduces students to the idea of equity and social justice and how both environmentalism and economics can benefit some while displacing/harming others.	● Encourage students to find natural artifacts from their local habitat to add to the **biodiversity mural** ● Try to select current events that are related to your unique location. If this is not possible, be sure to encourage discussion about similar situations in your own area. ● Encourage students to consider what policies can be put in place to reduce negative impacts of environmental catastrophes. Who would support such policies? Who would disagree and/or be negatively impacted by such policies? Who 'loses', who 'wins'? ● Turning rainforests into hamburgers provides an opportunity for students to consider how they are connected to rainforest cattle ranching. They can consider what actions they can take to make a difference, or not.
PERSPECTIVES: Diverse and critically questioning	PROCESS: Participatory and experiential
• Through the **natural disaster current event,** students practice empathy by considering what it would feel like to be in someone's shoes who has been impacted by an environmental catastrophe. • In **How do trees collaborate?** students explore cutting edge science that is pushing boundaries of our understanding by considering an entirely new perspective about trees. They then work in small groups to talk through diverse individual perspectives of their peers. • **Deforestation in the Amazon Case Study** explores the causes of rainforest deforestation from five different historical perspectives and three different human perspectives (environmentalist, logger, and indigenous farmer). Students practice empathy through role play and collaboration through problem solving.	• The **biodiversity mural** can be made to be more experiential by taking students outside to find natural biotic and abiotic artifacts. • During the **habitat loss project**, remind students that music, poetry and art can be powerful communication tools that can reach beyond our logic and get at our emotions. Emotions are often what move people to act, so your goal is to get to people's emotional responses. • Utilize sticky notes and/or small erasable white boards to have students write down and compare their thoughts during group discussion of **How do trees collaborate?** • Encourage empathic thinking through role playing when exploring the **deforestation case study**. Have students volunteer to set the stage by reading scripts of the different perspectives.

THEME: Understanding Sustainability

Essential Questions
- What is sustainability?
- What are the historical and conceptual foundations of environmental science and sustainability?

State Essential Standards
- EEn.2.8 Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth
- EEn.2.7.3 Explain how human activities impact the biosphere.
- EEn.2.8.4 Evaluate the concept of "reduce, reuse, recycle" in terms of impact on natural resources.

Related Standards
- EEn.2.2.1 Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present.
- EEn.2.5.5 Explain how human activities affect air quality
- EEn.2.8.2 Critique conventional and sustainable agriculture and aquaculture practices in terms of their environmental impacts.
- EEn.2.4.1 Evaluate human influences on freshwater availability.

Essential Vocabulary

Bioaccumulation	Ecological footprint	Equity	Sustainable Development
Biocapacity	Economy	Global Commons	Sustainability
Carbon Footprint	EPA	Rachel Carson	Tragedy of the Commons
		3EGoggles	

Guiding Idea	Objectives. Students will be able to...	Lesson Suggestions
The 3 Es of Sustainability & the 3E Goggles 🌍🌍🌍	• Explain that the purpose and process of sustainability is to balance ecological, economic, and social equity issues, concerns, and solutions.	Lesson: 3Es of Sustainability (link to full lesson) • Engage: What does sustainability mean to you? • Explore: Logger vs. farmer vs. environmentalist • Explain: 3Es of sustainability & the 3E goggles • Elaborate: letter to the future & official definition of sustainable development • Evaluate: 3E analysis of Wall*E; Sustainability Review
Tragedy of the Commons 🌍	• Describe the meaning, provide examples, and explain the causes of the "tragedy of the commons" concept	Lesson: Tragedy of the Commons (link to full lesson) • Engage: Help yourself! Take as much as you like! • Explore: Claim your gold(fish)

		• Explain: What are the "commons"? • Elaborate: Additional tragedy of the commons activities • Evaluate: Digital notebook slides
Rachel Carson's Legacy: Earth Day and the EPA 🌎	• Summarize the historical connections between Rachel Carson, early U.S. environmentalism, Earth Day, & the EPA.	Lesson: Rachel Carson's Legacy (link to full lesson) • Engage: What is DDT? • Explore: Take a stand • Explain: Read "A Fable for Tomorrow" (Ch 1 of Rachel Carson's *Silent Spring*); Watch part of 1960s documentary; Bioaccumulation video & demonstration • Elaborate: Rachel Carson's Legacy: How did the US look before EPA? First Earth Day and establishment of the Environmental Protection Agency • Evaluate: Choice menu- Rachel Carson's legacy
What's My Impact? Ecological Footprint 🌎🌎	• Explain that an ecological footprint is a tool to measure individual and group resource use and impact of waste. It considers population and biocapacity of the Earth. • Consider how consumption patterns impact the biosphere and society.	Lesson: Ecological Footprint (link to full lesson) • Engage: Think, Pair, Share: What is an ecological footprint • Explore: Calculate your ecological footprint • Explain: Guided notes, video, reading & keyword summary • Elaborate: Individual vs. national and global footprints. How does the U.S. compare to other countries? • Evaluate: Can you create a scenario that leaves enough for everyone? Evaluate the ecological footprint tool by using your 3E goggles.

Description and suggestions for Transformational Learning: Understanding Sustainability Theme

CONTENT: Integration of the 3Es	CONTEXT: Place-based
The 3Es of Sustainability explicitly teaches students about the complex meaning of sustainability and sustainable development through the integrated lenses of ecology, economics, and equitable society. The **Tragedy of the Commons** lesson allows students to experience and explore causes and impacts of open access to the commons. They see for themselves the economic, ecologic, and equitable impacts of resource depletion from lack of regulation and desire for personal gain. **Rachel Carson's Legacy** specifically links human health with environmental health. Students also consider how the power of industry (money/economics) can intentionally try to mislead the public for their own profit. **Ecological Footprint** causes students to connect their own personal and cultural consumption habits with its effect on others around the globe. The start to consider the idea of equity in terms of, "if I have and waste too much, how might it directly/indirectly affect others?"	**3Es of Sustainability:** Consider conducting a 3E analysis of a current event in your community. For instance, maybe your county/town is considering installing a new factory. What are some of the ecologic, economic, and societal impacts of such a decision? **Tragedy of the Commons:** Identify the "commons" within your own school and local community. Have students think about and discuss what they would do and how they feel when their local commons are misused. Have them consider and discuss ways to reduce negative impacts to their local commons. **Rachel Carson's Legacy:** Have students create a "Fable for tomorrow" about their own community. Have students research/plan/participate in local Earth Day events. **Ecological footprint:** Have students come up with a plan to reduce their own footprint, their family's footprint, and/or their school's footprint.
PERSPECTIVES: Diverse and critically questioning	PROCESS: Participatory and experiential
3Es of Sustainability: is all about viewing situations from multiple perspectives. The "3E goggle" analogy is a way to help students put this multi-perspective to practice. The logger, farmer, & environmentalist activity is a useful practice of this skill as well. The 3E goggles should be referred to throughout the semester. **Tragedy of the Commons:** This lesson encourages students to consider how selfish motivations can harm individuals and the larger group. It encourages students to think critically about resource use from a variety of perspectives. **Rachel Carson's Legacy**: This lesson provides multiple opportunities for students to think critically about a historically and current controversial topic. The EPA is viewed very differently from different perspectives. Students should be guided to consider these multiple perspectives by using a variety of	Wherever possible, have students co-construct knowledge by first having them consider what they already know. KWL charts are a good tool to facilitate this process. **3Es of Sustainability**: Utilize role playing and manipulatives Tragedy of the Commons: Students experience first hand what the tragedy of the commons means when not all students are able to have some of the 'free' treat offered by the teacher. They then work with other students to consider strategies for preventing the tragedy of the commons. Digital notebook slides provide students an opportunity to work with technology and be self-directed learners. **Rachel Carson's Legacy**: Take a stand, bioaccumulation demonstration, and the choice menu all provide opportunities for

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reputable sources and diverse opinions. **Ecological footprint**: By helping students think about resources as being one big shared planetary network, they can think critically about their connection to others. Encourage students to think about what it might feel like to be born in a place without access to so many resources.	participatory and experiential learning. **Ecological footprint**: students calculating their own footprint are personally tied to the learning process. By coming up with ways to reduce their impact, they can fully participate in their knowledge creation.

APPENDIX C
HIGH SCHOOL SUSTAINABILITY SURVEY

Q1 Global sustainability issues (global warming, economic inequality, population growth, etc.) will have a negative effect on you in your lifetime.
- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

Q2 How would you rate this school's commitment to sustainability when compared to other high schools in the U.S.?
- Don't Know
- Bottom 10%
- Below Average
- Average
- Above Average
- Top 10%

Q3

	Strongly disagree	disagree	agree	Strongly agree
• I think it is important that sustainability principles and practices are part of a High School Education				
• I think it is important that this school is a school designed, operated, and maintained in a sustainable manner.				

Q4 I think it is important for my school to engage in the following initiatives.

	Strongly disagree	disagree	agree	Strongly agree
• Energy conservation				
• Renewable energy production				
• Water conservation				
• Carbon footprint calculation				
• Local food purchasing				
• Recycling				
• Zero waste & composting				
• Fair/living wages				
• Sustainable transportation				
• Stream restoration				
• Community outreach				

Q5 I commonly associate the term "sustainability" with:

	Strongly disagree	disagree	agree	Strongly agree
• The environment				
• Equity/Social justice				
• The economy				

Q6 I believe it is important for my school to support the following types of diversity.

	Not important	Somewhat important	Important	Very important
• Socioeconomic diversity (different income levels)				
• Racial/Ethnic diversity				
• Gender diversity				
• Religious diversity				

Q7 My school is a welcoming environment for:

	Strongly disagree	disagree	agree	Strongly agree
• Ethnically/Racially diverse students				
• LGBTQ students				
• Poor/Non-affluent students				
• Student athletes				
• Transfer students				

Q8 I believe service, community engagement or volunteering is important to my life.
- Not important
- Somewhat important
- Important
- Very important

Q9 I volunteer or participate in service projects
- More than once per month
- At least once per month
- Oncer per year or less
- Never

Q10

	Strongly disagree	disagree	agree	Strongly agree
• I am interested in participating in service projects or sustainability related student clubs while attending my school				
• My local actions can have a global impact.				

Q11 How important do you believe it is that our society address the following local and global issues?

	Not important	Somewhat important	Important	Very important
• Declining environmental resources				
• Access to health care				
• Access to healthy food				
• Access to local food				
• Access to education				
• Production of renewable energy (such as solar, wind, hydro, geothermal, etc)				
• Reduction of fossil fuel dependency (not relying so heavily on fossil fuels to meet our energy needs)				
• Access to clean water				
• Water scarcity				
• Climate change				
• Income inequality (a few people earning the majority of the wealth when many people earn barely enough to get by)				
• Corporate/political transparency (being 100% open and honest about practices, purposes, and policies)				
• Acceptance/respect of diversity				
• Healthy lifestyles				

Q12 How important do you believe it is that our society address the following local and global issues?

	Not important	Somewhat important	Important	Very important
• Biological diversity				
• Environmental conservation				
• Recycling/Zero waste				
• War/Armed conflict				
• Political gridlock (inability to pass policies due to differences in political views)				
• Energy conservation				
• Global population				
• Health and safety of factory workers				
• Access to sustainable				

transportation
- Health and safety of farmworkers
- Equal opportunity across all genders
- Women's rights
- High pollution levels in minority and low income communities
- Climate refugees (people having to leave their homes due to climate change related events such as flooding, fires, drought, etc)

Q13 The following groups/organizations need to accept responsibility for addressing the world's sustainability issues:

	Strongly disagree	disagree	agree	Strongly agree
• Nations acting individually				
• Nations acting collaboratively (together)				
• Individuals acting alone				
• Corporations (large businesses)				
• Environmental groups				

Q14 I am personally motivated to be involved in sustainability oriented behaviors because:

	Strongly disagree	disagree	agree	Strongly agree
• It is the right thing to do to make the world a safer place				
• I am feeling pressure from my peers.				
• It is important to protect my health.				
• It saves me and my family money				
• It is necessary to save the planet				
• I am inspired by others around me.				

Q15 Please indicate how often you have done the following sustainability oriented behaviors in the last 30 days.

	Never	Seldom	Some of the time	Most of the time	All of the time
• Bought or asked for locally-made products					
• Attempted to save fuel by carpooling, walking, or taking					

public transportation
- Spent a great deal of free time doing outdoor activities
- Written a letter to a public official or business leader about environmental concerns
- Participated in the activities of local environmental groups

Q16 Please indicate how often you have done the following sustainability oriented behaviors in the last 30 days.

	Never	Seldom	Some of the time	Most of the time	All of the time
• Eaten seasonal foods					
• Reduced electricity use by turning off lights when not in use, using energy-efficient bulbs, or unplugging appliances or charging devices					
• Cooked (or helped cook) a meal					
• Educated myself about environmental issues					
• Talked to friends, family or teachers about environmental issues					

Q17 Please indicate how often you have done the following sustainability oriented behaviors in the last 30 days.

	Never	Seldom	Some of the time	Most of the time	All of the time
• Bought, wanted, or asked for fairly traded products (coffee, chocolate, rice, etc.)					
• Reduced water use by taking shorter showers, turning off water when brushing teeth, full loads in washer, etc.					
• Performed moderate exercise at least 4 times per week					
• Considered voting for political figures on the basis of their pro-environmental positions					
• Educated myself about social issues					

Q18 Please indicate how often you have done the following sustainability oriented behaviors in the last 30 days.

	Never	Seldom	Some of the time	Most of the time	All of the time
• Eaten local foods					
• Reduced my net food energy consumption by eating less meat					
• Read food labels					
• Considered voting for political figures in favor of their pro-humanitarian positions such as immigration reform, less militarization, peaceful world policy, increased minimum wage, etc.					
• Talked to friends, family, or teachers about social issues					

Q19   What is meant by the term "carbon footprint"?
- It refers to the size of the carbon chain in a given quantity of gasoline.
- The carbon left on the ground each time you take a step
- The total sets of greenhouse gas emissions caused by an organization, event, product or person
- All of the above
- Do not know

Q20   Which of the following is a renewable resource?
- Oil
- Natural Gas
- Iron ore
- Coal
- Sunlight
- All of the above
- Do not know

Q21   Which of the following is the dominant source of energy for our regional electrical grid?
- Nuclear
- Coal
- Natural Gas
- Hydroelectric
- Solar
- Do not know

Q22   Sustainable business development implies a commitment to measuring and reporting on the "triple bottom line", which includes:
- Three different measures of financial performance
- Environmental, social and financial performance
- Three different measures of non-financial performance
- All of the above

- Do not know

Q23   Which of the following definitions best describe Fair Trade business practices?
- A social movement whose stated goal is to help producers in developing countries achieve better trading conditions and to promote sustainability
- A type of bargaining where each recipient receives equal value
- Trade practices between nations who demonstrate equal pay and benefits
- When businesses maximize profit by trading primarily in developing countries

Q24   Why do many economists argue that electricity prices in the U.S. are too low?
- Prices do not reflect the costs of pollution from generating electricity.
- Prices do not reflect government subsidies.
- Electric companies have monopolies in their service areas.
- They do not argue that prices are not too low.
- Don't know

Q25   What is the most common cause of pollution of streams and rivers in the United States?
- Dumping of garbage by cities
- Surface water running off yards, city streets, paved lots, and farm fields
- Litter near streams and rivers
- Waste dumped by factories
- Don't know

Q26   A technique to assess environmental impacts associated with all the stages of a product's life from cradle to grave (resource extraction through usage and disposal), is called:
- An annual review
- A thermal system analysis
- A life cycle assessment
- An energy audit
- Do not know

Q27   Which of the following statements about water is true?
- Globally, water for personal use such as washing dishes, doing laundry, and bathing is the major user of water resources.
- Globally, freshwater reserves (aquifers) are used faster than they are replenished.
- Floods and severe weather will increase the availability of clean drinking water.
- Because water is a free and abundant resource, it is not a major concern for most countries.
- Don't know

Q28   What is the current global human population?
- 1-2 billion
- 10-11 billion
- 4-5 billion
- 13-14 billion
- 7-8 billion

Q29   Which of the following is the most commonly used definition of sustainable development?
- Creating a government welfare system that ensures universal access to education, healthcare, and social services
- Meeting the needs of the present without compromising the ability of future generations to meet their own needs
- Setting aside resources for preservation, never to be used
- Building a neighborhood that is both socio-demographically and economically diverse
- Don't know

Q30   How much time does the average person spend in front of a screen (TV, games, computer, etc...) each day?
- 2 hours
- 6 hours
- 4 hours
- 8 hours

Q31   How much time does the average American spend indoors every day?
- 30% of their time
- 70% of their time
- 50% of their time
- 90% of their time

Q32   What is the recommended amount of exercise for adults ages 19-64?
- Moderate exercise for 1.5 hours per week and vigorous exercise for 1 hour per week
- Moderate exercise for 2.5 hours per week and vigorous exercise for 1.25 hours per week
- Moderate exercise for 3.5 hours per week and vigorous exercise for 1.75 hours per week
- Moderate exercise for 4.5 hours per week and vigorous exercise for 2 hours per week

Q33   Which of the following are examples of sustainable transportation? (Check all that apply)
- City bus network
- Skateboard
- Hybrid vehicle
- Bicycling
- Subway
- Single occupancy vehicle
- Electric vehicle
- Carpooling
- All of the above

Q34   Which of the following transportation fuel types are examples of renewable energy? (Check all that apply)
- Ethanol
- Hydrogen

- Biodiesel
- Fuel cell
- Gasoline
- Electricity
- Diesel

Q35   Which of the following transportation options has the lowest associated carbon footprint?
- Carpooling
- Taking a bus
- Living close to school/work and driving a car
- Biking
- Walking
- Skateboarding

Q36   Which of the following best describes the term Local Food?
- Food grown in your own state
- Food grown in your own continent
- Food grown in your own country
- Food grown within 100 miles
- Food grown in your own community
- Food grown within 500 miles

Q37   How many pounds of waste does the average American generate every day?
- 1-3 lbs.
- 10-12 lbs.
- 4-6 lbs.
- 13-15 lbs.
- 7-9 lbs.

Q38   What % of household waste is compostable?
- 15-30%
- 55-70%
- 35-50%
- 75-90%

Q39   Which of the following materials are generally not recyclable? (Check all that apply)
- Batteries
- Office paper
- Styrofoam cups
- Electronics/cell phones
- Chip bags
- Broken Frisbee
- ½ eaten sandwich
- Pizza box

Q40

	Strongly disagree	disagree	agree	Strongly agree

- I am hopeful the sustainability efforts of myself and others will make a difference to the world in my lifetime.

- I have the knowledge and skills required to make a difference with sustainability efforts and initiatives.

- I am dedicated to making a positive difference in my lifetime by addressing sustainability related issues.

Engage: Do humans play a role in natural disasters such as landslides?

Activity Guidance

- Part 1 encourages students to connect current events to class concepts. Find a story about a natural disaster that was exacerbated by human impacts related to deforestation (flooding, landslides, etc).
- Part II has students view and reflect on deforestation of the Amazon over time. This was originally provided as an online discussion but can be modified depending on class needs.

Part 1: Connecting class concepts to Current Events

Rescuers In Colombian Town Of Mocoa Search For Flood Survivors

<http://www.npr.org/2017/04/03/522424614/rescuers-in-colombian-town-of-mocoa-search-for-flood-survivors>

1. Listen to story as a class
2. Listen again and complete your current event summary and reflection on: **making connections journal**

Part 2: Deforestation of the Amazon over time

Visit **this NASA site**
<https://www.nasa.gov/mission_pages/landsat/news/40th-top10-amazon.html> and watch the 30 sec video.

Reflection suggestions:

1. What does the video show?
2. What patterns do you see (in what shape is deforestation happening?)
3. Find and paste one picture that you think represents the most healthy rainforest habitat.
4. Find and paste one picture that you think captures what rainforest deforestation means

Explore: Rainforest deforestation case study

Activity Guidance

- Students work in groups to examine leading historical reasons for rapid deforestation in Brazil.
- Activity instructions and handouts found here

Explain: Can we put a price on nature?

Activity Guidance

- Building upon rainforest case study, teacher helps guide students through the difficulties involved in forest management and maintaining human livelihoods. Students consider concepts such as ecological economics and other strategies for pricing and protecting nature.
- **Guided notes and reflection found here**

Elaborate: Do trees collaborate?

Activity Guidance

- This activity provides an alternative view on trees by exploring cutting edge research about trees' ability to collaborate and help each other survive.
- Students listen to this TED Radio Hour and co-construct meaning by identifying key concepts from story and then work in small groups to fine tune takeaways.


TED Radio Hour

1. Listen to and/or watch Suzanne Simard: **How do trees collaborate?**

   http://www.npr.org/2017/01/13/509350471/how-do-trees-collaborate

2. While listening, take notes about key themes she is discussing. For example:
   a. What was her main discovery?
   b. How did she figure it out?
   c. Why is this discovery important?
   d. How did she utilize the scientific method?
   e. Should this discovery change how we manage and utilize forests?
   f. Choose your two favorite themes from this story and write on a post-it note

Place sticky note on whiteboard and discuss with your table

2 coolest things
1.
2.
-Name
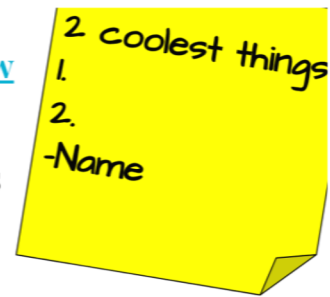
Evaluate:

Assignment Guidance
- Have students discuss and/or write responses to reflection questions
- Application/Action ideas:
  - Have students consider their own connection to cattle ranching on rainforest land and consider what they can do in response.
  - If time allows, reflect on an additional case study that documents a young man who protests clear-cutting of redwood forests.

Reflection questions

1. Evaluate the ways that peasant farmers, loggers, and conservation organizations approach land use.
2. Which do you agree with? Is there room for peaceful coexistence in the Amazon?
3. Support or criticize the use of benefit–cost analysis as a means of economic planning and as a means of preventing environmental degradation.
4. Do you feel that species have intrinsic rights to exist? Can such existence values be incorporated into environmental policy?
5. What does the world stand to lose by watching the destruction of tropical forests?

Turning rainforests into hamburgers. A good idea?

Some US companies have committed to NOT purchase beef grown on destroyed rainforest lands.
1. **Click here** to read the brief overview of how some US companies rank
2. Respond to the prompts below:
   - Does it make sense to raise beef on cleared rainforest land? Explain.
   - Which of the companies listed have you been to/eaten at?
   - What could you do as a consumer to help prevent the clearing of rainforests to graze cattle?
     - Option: provide a link to **this letter** written by the Union of Concerned Scientists as an example of what to do.

Protecting Wilderness: A case study on environmental activism

Clear-cutting and logging have detrimental effects to redwood forests and the environment, impacting the local biodiversity and creating frequent mass erosion. Environmental advocacy groups use creative strategies for wilderness preservation.

In this film, "Farmer," an activist for *Earth First! Humboldt* risks injury and incarceration to live in the canopy of an ancient redwood tree. The advocacy group based in Northern California is dedicated to preventing the clear-cutting and deforestation of redwoods by organizing tree-sits and roadblocks. In 2008, activists discovered a timber harvest plan that would have clear-cut 40 acres on the west side of the McKay Tract, a 7,500-acre forest near Eureka California known for the growth of unique redwood trees. Green Diamond Resource Company once owned the forest and the County of Humboldt proposed this area for residential development. The activist for Earth First! ultimately protects a rare redwood ecosystem, an important part of California's natural history. After four years into the tree sit, the Green Diamond Resource Company sold 1,800 acres of the McKay Tract to the trust for public land and the area now is a protected community forest.

Link to full lesson plan with ideas for student reflection and written responses.

Vita

Courtney Baines was born in Duluth, GA to Andrew Baines and Disa Corry. She graduated from Boyle County High School in 2002, earned a Bachelors of Science in Geography with a concentration in Environmental Planning and a GIS certificate from Western Kentucky University in 2007, and a Masters of Arts in Appalachian Studies with a concentration in Sustainable Development from Appalachian State University in 2008. In June 2013, she commenced work toward her Ed.D. in Educational Leadership at Appalachian State University.

Courtney has been an active member of her community in Boone, NC, serving as Farm Tour Coordinator and an Americorps member for Blue Ridge Women in Agriculture, is founder and co-director of the school garden support project, Lettuce Learn, and is currently Executive Director of Blue Ridge Women in Agriculture. She resides in Boone, NC with her son.